SMEP

Sustainable Manufacturing and Environmental Pollution Programme

# BEYOND THE TECHNICAL LOOP

## Driving the circular bioeconomy through global policy coherence

May **2025**


UK International Development
Partnership | Progress | Prosperity

CHATHAM HOUSE

switch to Circular Economy Value Chains

Funded by the European Union

Ministry for Foreign Affairs of Finland

Lorenzo Formenti, Patrick Schröder, Jack Barrie, and Henrique Pacini authored this brief.

This brief was produced under the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme, funded by the United Kingdom's Foreign, Commonwealth and Development Office (FCDO) and implemented in partnership with UN Trade and Development (UNCTAD). The brief was jointly prepared by UNCTAD and Chatham House in the context of the 9th World Circular Economy Forum 2025 (13-16 May, Sao Paulo, Brazil), and informed by field visits organised in early 2025 with SMEP projects in Uganda and Kenya. Field visits involved fact finding and data collection from project grantees and their supply chain actors, such as waste collectors and producers of bioeconomy products. The work was coordinated by Dr. Henrique Pacini, under the supervision of Dr. Chantal Line Carpentier. The research team was composed of Lorenzo Formenti (UNCTAD), and Dr. Patrick Schröder and Dr. Jack Barrie (Chatham House). This paper has benefitted from comments from Dr. Alexandre Strapasson (University of Brasília), Dr. Alessandro Sanches Pereira (i17), Ana Dimovska (UNIDO), Ana Yang (Chatham House), Dr. Atiq Zaman (Curtin University/UN Council of Engineers for the Energy Transition), Glen Wilson (South South North), Guilherme Suertegaray (Ellen McArthur Foundation), Maria Durleva (UNCTAD) and Suzannah Sherman (Chatham House). The research team is also grateful for the inputs from Ebenezer Amadi (Kenya Private Sector Alliance), James Boyd-Moss (Mananasi Fibre Ltd.), Tim Egan (Sanergy), Edwin Kamalha (Busitema University), Kimani Muturi (TEXFAD), Daniel Paffenholz (Taka Taka Solutions), Andrew Wallace (Chanzi Ltd.) and Dominic Wanjihia (Biogas International Ltd.).

Desktop formatting, layout and graphics were designed by Lia Tostes. Cover photo: © Greta Hoffman.

Disclaimer

This report is part of the Sustainable Manufacturing and Environmental Pollution (SMEP) Programme, funded by UK-FCDO and implemented in partnership with UN Trade and Development (UNCTAD). **Views expressed are those of the authors and do not reflect those of related institutions.**

This report was produced in cooperation with Switch to Circular Economy Value Chains, a project co-funded by the European Union and the Government of Finland, implemented by UNIDO, in collaboration with Chatham House, Circle Economy, and the European Investment Bank. For more information: switchtocircular.eu.

# Contents

# 1.

# Introduction

As of April 2025, 76 countries have adopted national strategies or roadmaps for the circular economy (Chatham House, 2025). These strategies reflect growing recognition of the need to address cascading environmental risks while unlocking new avenues for competitiveness, environmental protection, pollution reduction, and climate change mitigation. Typically, these national circular economy frameworks span multiple sectors and materials, often categorized in the literature as "technical materials"—such as plastics, metals, and electronics—and "biological materials," including organic waste, forest products, and agricultural residues. This conceptual distinction is well illustrated in the Ellen MacArthur Foundation's butterfly diagram (EMF, 2019).

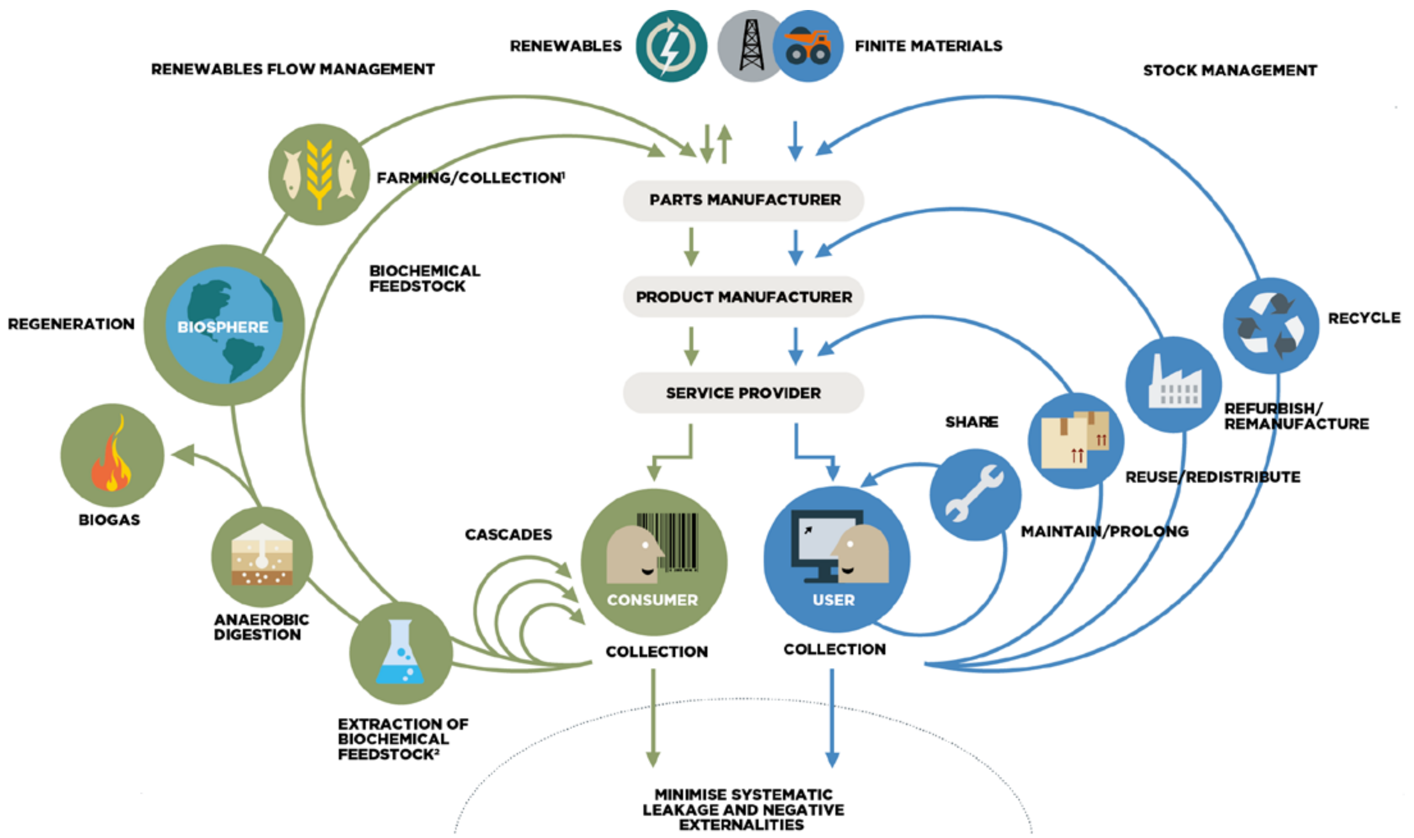
This brief explores the intersection of circular economy and bioeconomy concepts, advocating for an integrated circular bioeconomy approach. It underscores the risks of maintaining linear bioeconomy models, such as unsustainable biomass use that can lead to environmental degradation, soil depletion, and the loss of biodiversity-linked ecosystem services. At the same time, many developing countries are well-positioned to adopt circularity practices in the biological materials cycle, given the alignment with their existing economic structures and comparative advantages.

The brief makes the case for a circular bioeconomy that maximizes the efficient use of biomass through circular economy principles such as cascading use, reuse, recycling, and nutrient loop closure. It draws on previous analyses by Chatham House and UNIDO (Barrie et al.,, 2024), while incorporating new insights and case studies from UNCTAD and UNIDO that demonstrate the tangible benefits of integrating circularity with bioeconomy strategies. Finally, it outlines actionable pathways for policymakers—including the need to align and integrate national circular economy and bioeconomy policies—and concludes with practical recommendations to help scale circular bioeconomy models, particularly in the Global South.

↓ Image 1. Ellen MacArthur Foundation's butterfly diagram

*Source:* Ellen MacArthur Foundation (2019). **Circular economy systems diagram** [https://www.ellenmacarthurfoundation.org/](https://www.ellenmacarthurfoundation.org/)

*Note:* Drawing based on Braungart & McDonough, Cradle to Cradle (C2C).



# 2.

# Circular bioeconomy

## *Integrating circular economy and bioeconomy solutions*

The **bioeconomy** refers to an economy where the basic building blocks for industrial materials, chemicals and energy are derived from renewable biological resources such as trees, plants, animals and microorganisms and their by-products (BBIA, 2025). In most cases, bioeconomy practices rely on existing linear and extractive business models, which means they deplete biological resources and do not contribute to maintaining ecosystem services. On the other hand, the **circular economy** is an economic system aimed at eliminating waste and pollution, keeping products, components and materials in use for as long as possible, maintaining their value, while regenerating natural systems (EMF, 2021). The concepts of bioeconomy and circular economy have similar objectives, and they are interconnected, both emphasizing resource efficiency, waste reduction and re-use of wastes and other biological resources to displace fossil fuels and non-renewable resources, but neither is fully part of the other nor embedded in the other (Khanna et al., 2024). The bioeconomy is not complete without the circular economy, and vice versa.

The bioeconomy presents options to reduce systemic reliance on fossil fuels and synthetic materials, such as vegetable fibre for packaging that replaces plastics; biofuels that replace gasoline or diesel; or organic agriculture that may at time require more land but uses less fossil fertilizers. However, the Global Bioeconomy Assessment has shown that land-use changes tied to an extractive business-as-usual shift toward a bioeconomy can drive biodiversity loss (UNEP 2024). It's crucial that countries take a systemic view of sustainability, carefully weighing both the benefits and potential burdens of bioeconomy strategies. As we move toward a bio-based economy where economic systems depend more on renewable materials, food and energy, it becomes crucial to account for the complex relationships between biodiversity, land-use and bioeconomy innovations, such as the growing interest in natural materials that can substitute conventional plastics (UN Trade and Development, 2023). Avoiding harmful impacts requires diverse, well-rounded strategies that support both sustainability and the responsible growth of the bioeconomy. Furthermore, a collaborative approach that considers the trade-offs of the bioeconomy is needed to manage the deployment of innovations and any emergent competition for land and resources (Yang et al., 2024).

The concept of the circular bioeconomy refers to an economic system that integrates the principles of both the bioeconomy and the circular economy. It aims to maximize the value of biological resources by keeping them in use for as long as possible and minimizing waste generation (Carus and Dammer, 2018). This approach involves adjusting agricultural practices during the production phase, and changes to product design, including choice of materials. In cities and rural areas, the circular bioeconomy discourages practices such as landfilling organic waste or burning crop residues, promoting instead the cascading use of by-products along the value chain. These by-products can be used to generate additional value, or be transformed into new products, thereby enhancing the end-use value of organic residues. When returned to the natural environment, these organic residues contribute to restoring and regenerating natural capital by enhancing soil health and closing nutrient loops essential for long-term ecological resilience.

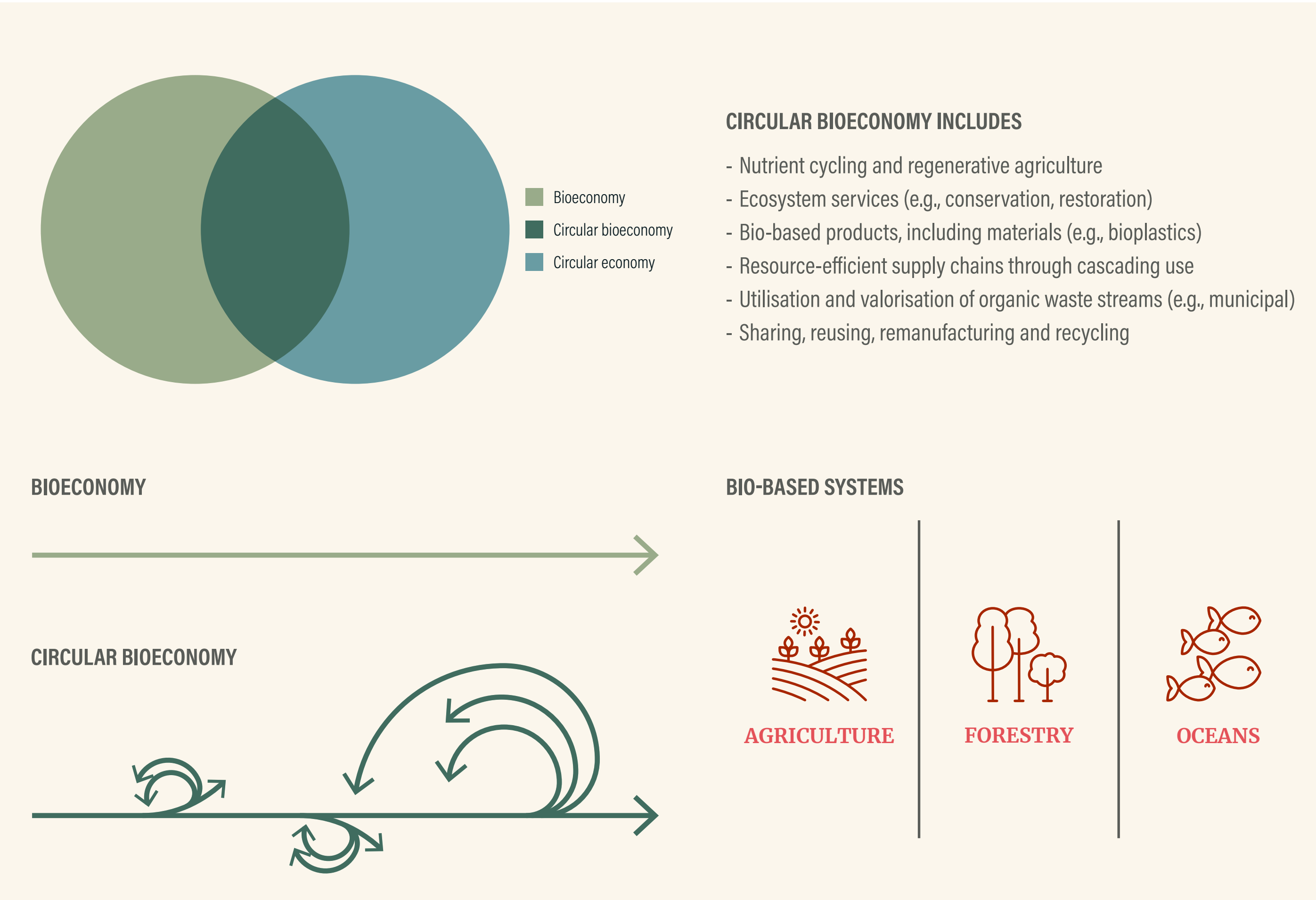
The circular bioeconomy focuses on the sustainable use and valorisation of biological resources, such as crops, agricultural residues and natural fibres to produce materials and goods. For example, organic residues such as household waste can be transformed into valuable compost and organic fertilizer or used to generate biogas through anaerobic digestion (Tsapekos et al.,, 2022). Furthermore, they can serve as feed for Black Soldier Fly larvae, which efficiently convert waste into protein-rich biomass that helps displace conventional animal feed such as corn or soybean. In the textiles sector, materials such as cotton, silk and hemp exemplify the role of natural fibres in the bioeconomy.  In a circular bioeconomy approach, residues from early-stage agricultural value chains can also be processed to extract textile fibres, such as those derived from banana pseudostems and pineapple leaves (SMEP, 2025 forthcoming). In addition, crop residues left on farmland can increase soil carbon content and moisture preservation, reducing the need for plastic mulch films. Similarly, agri-residues can be used for bioenergy production without significant impacts on land use change. In addition, animal wastes (e.g., cow dung, pig slurry, fish processing trimmings) can be used for biogas production, while also providing agricultural fertilizer, increasing carbon and nutrient circularity within farming systems (Strapasson, 2021).

Recent technological advancements further extend the circular bioeconomy's potential, such as microbial fermentation technologies converting organic residues into bio-based chemicals and bioplastics, alternative fibres reducing dependency on fossil-based resources (Ewig et al., 2022; Gong et al., 2024). Additionally, biochar production from crop residues and forest biomass not only sequesters carbon but also enhances soil fertility and water retention capacity, illustrating another valuable application within the circular bioeconomy framework (Li et al., 2023).

The circular bioeconomy approach integrates both end-of-life solutions, such as innovative methods for managing municipal solid waste (MSW), and early value chains solutions, such as the extraction of textile fibres from agricultural residues. The circular bioeconomy is thus a dynamic, interlinked economic system that reduces pressures on resources by creating cascading loops which recover value, avoid landfilling and reduce fossil input needs (Figure 1.).

↓ **Figure 1.** Circular bioeconomy principles and loops

*Source:* Authors, based on Carus and Dammer (2018)



## 2.1. Circular bioeconomy and regeneration of natural capital

Enabling the regenerative potential and achieving nature-positive outcomes requires a transition toward a circular bioeconomy. This aligns closely with global ambitions such as the Kunming-Montreal Global Biodiversity Framework, which calls for transformative change in how economies interact with nature.[1] To ensure that circular bioeconomy strategies deliver measurable nature-positive outcomes, it is essential to adopt robust frameworks that incentivize value-addition and assess positive contributions to biodiversity. Tools such as the IUCN's Nature-Positive Contribution guidance (IUCN, 2023) offer a starting point for aligning business practices, policy and investment decisions with quantifiable ecological regeneration goals and targets. Equally important is the acknowledgement and inclusion of indigenous knowledge and perspectives, which can offer insights into regenerative design and sustainable material use particularly in sectors like construction where biomaterials play a growing role. Sustainability standards, such as UN Trade and Development's BioTrade principles, which also address the fair redistribution of income also offer a foundation (UN Trade and Development, 2020).

Regulatory frameworks for municipal waste management are often focused on landfilling, with pay-per-landfilling models being predominant. For example, the United States have a landfill tipping fee system, with an average fee of 56 USD per tonne of waste disposed applied across the country (EREF, 2024). These models forego practices that prioritize value addition, such as reuse, recycling, and the creation of bio-based materials. To truly enable a circular bioeconomy, a fundamental shift in these contractual models is necessary, together with incentive schemes that encourage waste valorisation and capital investment. For instance, results-based financing can incentivize improved waste management by linking payments to specific outcomes such as increased recycling and resource recovery (World Bank, 2014).

Together, these elements can help shape a circular bioeconomy that not only reduces harm but actively restores and enhances the health of our planet, while creating jobs and improving livelihoods.

## 2.2. The role of biotechnology in enabling circular bioeconomies

Advancements in technologies for producing bio-based materials exemplify important circular bioeconomy solutions. These include processes such as cellulose recovery for bioplastic production, the use of renewables feedstocks like algae and jute, and specific biotechnologies such as anaerobic digestion for biogas production from waste or composting for soil enrichment. Not only do the resulting products offer greener alternatives to established products but also embody new technological pathways for resource utilization and waste valorisation.

Building on the principles of the circular economy and the bioeconomy, marine-based substitutes and alternatives to plastics (MBSAs) offer one such tangible pathway. These alternatives, including algae-based biopolymers, involve a redesign of the sources and systems commonly used to produce materials for the economy. This involves sourcing biomass from low-cost and low-impact sources, such as fish processing by-products that would otherwise be discarded (Nazar et al 2025; SMEP, 2025). This allows value to be extracted from waste, with a lower environmental footprint than fossil fuel-based plastics under certain lifecycle conditions. A recent UN Trade and Development study highlighted the small but growing market for these materials driven by local innovation and trade, particularly in seaweed-derived products (UN Trade and Development, 2025).

While global exports of MBSAs remain relatively small compared to traditional plastics, valued at

1 More information can be found in the official text of the Kunming-Montreal Global Biodiversity Framework (decision 15/4 of the 15th meeting of the Conference of the Parties (COP 15) of the Convention on Biological Diversity: https://www.cbd.int/gbf.

← Image 2. Women sorting seaweed for the production of biodegradable plastics.



$10.8 billion in 2022, certain sectors exhibit significant growth. Notably, exports of algae-derived biopolymers (agar-agar, alginates and carrageenan) nearly doubled between 2012 and 2022, showing a consistent upward trend, in contrast to the volatile synthetic polymer market (UN Trade and Development, 2025).[2] However, trade barriers, such as high tariffs on raw materials (e.g., 12.8% on jellyfish) and stringent sanitary and phytosanitary (SPS) measures on processed products (averaging eight measures per examined algae biopolymer), significantly impede market access (UN Trade and Development, 2025).

While marine resources offer potential, it's important to note that their technological readiness vary significantly. Several applications are at experimental stage, either at lab testing or early industry applications stage, and their commercial viability has yet to be proven. Despite these challenges, interviews with supply chain actors in Asia and Africa reveal vibrant entrepreneurial ecosystems. Local small and medium-sized enterprises (SMEs) are actively participating and innovating in downstream industries, bringing to market a range of products such as seaweed-derived bioplastics and seashell tiles. However, companies typically face high technology costs, limited economies of scale and regulatory gaps, which impede the widespread adoption of these products (UN Trade and Development, 2025). Examples include but are not limited to ambient-compostable bioplastics made from agricultural and marine feedstock (e.g., polyhydroxyalkanoates (PHA)) or from biofuels (e.g., ethanol-based polyethylene).

2 Amidst a significant year-on-year volatility of around 18% (as measured by the standard deviation of annual percentage changes), global exports of common synthetic polymers such as Polyethylene (HDPE, LDPE), Polypropylene (PP) and Polystyrene (PS) have declined by 3% between 2012 and 2022 (UN Trade and Development, 2025).

# 3.

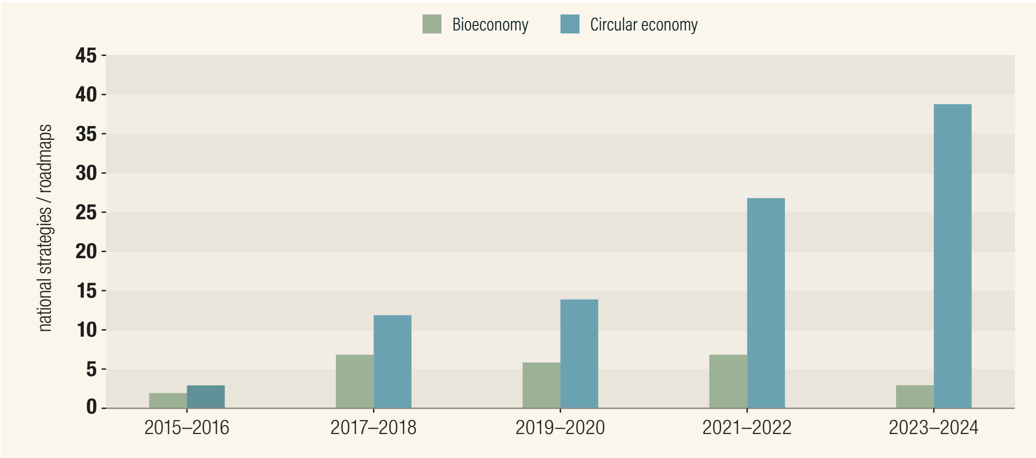
# Existing policy frameworks and roadmaps

**While both the circular economy and the bioeconomy are increasingly being incorporated into national policy frameworks, this integration often occurs in parallel rather than in a coordinated manner.** The circular economy has gained greater traction in policy agendas, with a marked increase in the number of national strategies and roadmaps over recent years. Between 2023 and 2024, approximately 40 countries had either developed or begun implementing a national circular economy strategy—up from just five in 2015–2016. In contrast, the bioeconomy has received comparatively less policy attention. The number of national bioeconomy strategies has remained limited, fluctuating over time and showing a slight decline in 2023–2024 (see Figure 2).

→ Figure 2. National circular economy and bioeconomy roadmaps and strategies planned or implemented globally, by year of launch (2015–2024)

*Source:* UN Trade and Development based on data from Chatham House's Circulareconomy.earth (2025) https://circulareconomy.earth/. *Accessed February 2025*

*Note:* Sub-national strategies and roadmaps and sectoral or categorical policies, e.g., waste management and recycling, are not included.




Overall, these strategies and roadmaps are programmatic documents designed to guide nations towards more circular and resource-efficient economic models. Strategies vary in scope and detail, reflecting different stages of development and ambition. Some documents outline the initial steps, such as national calls to action that aim to initiate dialogue and coordinate action on circularity, bioeconomy and related sustainability objectives. At a more advanced stage, roadmaps provide a qualitative long-term vision, outlining key priorities and policy actions. Usually adopted within an official government program, operational strategies offer the most detailed plans, specifying time-dependent actions, responsible parties, governance frameworks, and financial considerations.[3] Those are usually implemented in parallel to sectoral waste management and recycling policies, and producer responsibility and taxation schemes, highly relevant for the circular economy. **These policies and schemes are not directly linked to national strategies and roadmaps but are essential for achieving their objectives.**[4]

## 3.1. Overview of existing policy frameworks and international initiatives

National bioeconomy roadmaps and strategies cover a variety of areas, ranging from the conservation and protection of biological resources, to the promotion of new bio-based innovations and industries and utilization of bioenergy. Most countries use comprehensive approaches covering at least three focus areas (Table 1). Some countries take a targeted approach. This is the case for Japan and Latvia, which have targeted strategies and roadmaps on biotechnology and the bioeconomy, respectively. Focus areas are tackled in a variety of sectors, ranging from agrifood and forestry to chemical and textile industries through different policy instruments. These include but are not limited to R&D promotion, support to private sector and circular infrastructure.

3 For more information about strategies and roadmaps, see Chatham House's Circulareconomy.earth website: https://circulareconomy.earth/

4 Ancillary policies are not included in the analysis performed in this study.

Two types of enabling infrastructure are predominantly featured. These are dedicated facilities for the separation of waste streams and recovery of materials (e.g., paper, plastics), which enable their reuse as production inputs. Furthermore, biorefineries for the collection and utilization of feedstocks allow to channel low value residues such as municipal organic waste into bioenergy.

While national bioeconomy strategies are shaped by local priorities and contexts, they generally align with three overarching narratives: bioresources, biotechnology, and bioecology.

- **Bioresources** – Some countries see the bioeconomy as a means to drive economic growth and enhance resource security through the production and trade of biological resources. This includes sectors such as bioplastics, bioenergy, construction, and pulp and paper.
- **Biotechnology** – Other strategies prioritize innovation, focusing on emerging technologies like synthetic biology, AI, and advanced industrial processes. These approaches aim to secure market leadership and foster private sector involvement in developing new bio-based solutions.
- **Bioecology** – Bioecology-focused strategies centre on sustainability, emphasizing biodiversity conservation and healthy ecosystems. Countries with rich natural resources often use this approach to advance circular bio-based industries and align with biodiversity targets.

**While national bioeconomy strategies often reference sustainability, they tend to prioritize economic growth through use of bioresources and biotechnological advancement, with environmental objectives of a bioecology taking a secondary role (see Table 1).**

↓ *Source:* Chatham House based on data from Chatham House's Circulareconomy.earth (2025) https://circulareconomy.earth/.

*Note:* Focus areas are ranked by frequency. The analysis only includes national strategies and roadmaps.

Table 1. Focus areas of national bioeconomy roadmaps and strategies

| Country | Focus area 1 | Focus area 2 | Focus area 3 |
|---|---|---|---|
| Austria STRATEGY | Bioecology | Bioresources | Bioenergy |
| Austria IMPLEMENTATION | Bioeconomy | Bioresources | Bioindustry |
| Brazil | Bioeconomy | Bioindustry | Bioenergy |
| Canada | Bioeconomy | Bioindustry | — |
| China | Biotechnology | Bioenergy | — |
| Costa Rica | Bioecology | Biotechnology | Bioresources |
| Estonia | Bioeconomy | Bioresources | — |
| Finland | Biotechnology | — | — |
| France | Bioeconomy | Bioresources | Bioindustry |
| Germany | Bioresources | Bioeconomy | Biotechnology |
| India | Biotechnology | — | — |
| Ireland | Bioeconomy | Bioresources | — |
| Italy | Bioeconomy | Bioresources | Bioindustry |
| Japan | Biotechnology | — | — |
| Latvia | Bioeconomy | — | — |
| Namibia | Bioeconomy | Bioindustry | Bioecology |
| Netherlands | Bioresources | Bioeconomy | Bioindustry |

| Country | Focus area 1 | Focus area 2 | Focus area 3 |
|---|---|---|---|
| Portugal | Bioindustry | Bioresources | – |
| South Africa | Biotechnology | Bioresources | – |
| Spain | Bioeconomy | – | – |
| Sweden | Bioresources | Bioecology | – |
| Thailand | Bioeconomy | Biotechnology | – |
| USA | Bioindustry | Biotechnology | – |

↑ *Source:* Chatham House based on data from Chatham House's Circulareconomy.earth (2025). https://circulareconomy.earth/

*Note:* Focus areas are ranked by frequency. The analysis only includes national strategies and roadmaps.

## 3.1.1. Gaps and disconnects

Countries are already pursuing circular economy and the bioeconomy are doing so in a fragmented and uncoordinated way. **Of the 143 countries analysed, 76 have either adopted a national circular economy or a bioeconomy roadmap/strategy, or both (see Figure 2).** This is more than half of the sample, suggesting a relatively high level of interest in these issues. Interestingly, however, where countries are pursuing both the circular economy and the bioeconomy, they do so with separate strategies and roadmaps, i.e. have both a circular economy and a bioeconomy strategy/ roadmap. This is the case for 20 out of the 76 countries (26%), suggesting a lack of alignment and coordination between circular economy and bioeconomy policies, missing on opportunities of co-benefits between the two.

In the case of Austria, the Austrian bioeconomy strategy was adopted by the Council of Ministers in 2019. It is supposed to be an essential cornerstone of the climate and energy strategy, it supports the decarbonization of the economic system and makes a significant contribution towards resource conservation. The Austrian Circular Economy Strategy was developed and adopted by the Austrian Federal Government in December 2022, but it is not directly connected to the country's bioeconomy strategy.

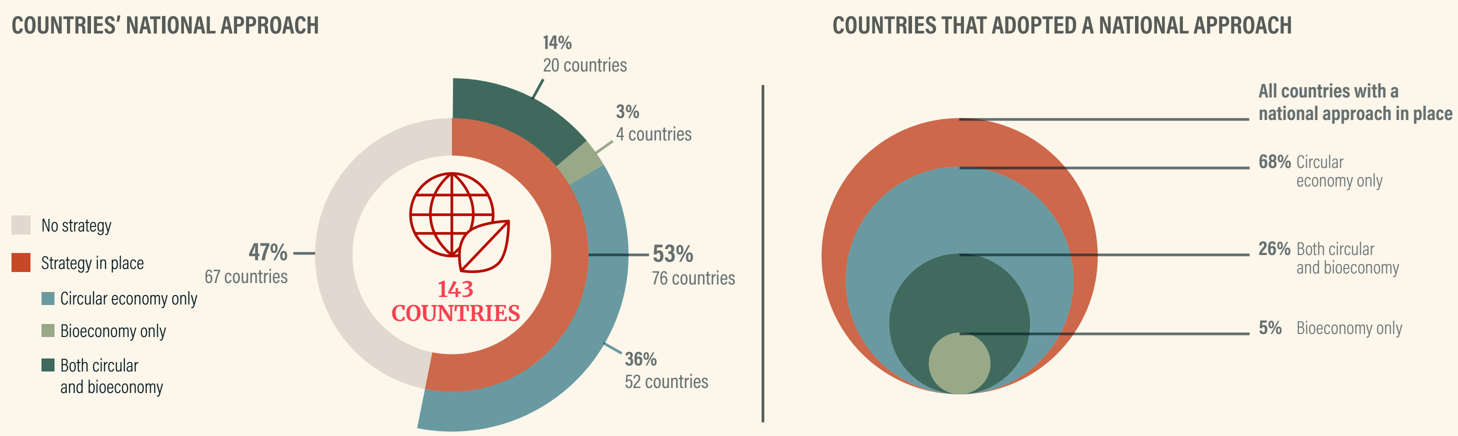
In Brazil, the government introduced a national policy aimed at promoting bioeconomy in June 2024. The strategy focuses on the sustainable use of biological resources, promoting practices that are environmentally friendly and economically viable. This includes the sustainable management of forests, agriculture, and marine resources. A core aspect of the strategy is to encourage innovation and technological advancement in the bioeconomy sector. This involves investing in research and development to create new bioproducts and bio-based processes, and sustainable alternatives for small farmers. Also in June 2024, the Federal Government of Brazil published Federal Decree No. 12.082/2024, which established the National Circular Economy Strategy. The initiative aims to promote the transition inside production chains from linear production models to a circular economy, including both organic and non-organic components.

↓ **Figure 3.** Country approaches for the circular economy and the bioeconomy

*Source:* UN Trade and Development based on data from Chatham House's Circulareconomy.earth (2025). https://circulareconomy.earth/

*Accessed February 2025*

*Note:* Chatham House's Circulareconomy.earth database com covers a sample of 143 countries. In addition to national strategies or roadmaps, the countries in the sample have sub-national strategies and roadmaps, sectoral or categorical policies, e.g., on waste management and recycling, which are not included in the analysis.



Capturing opportunities from these strategic overlaps requires harmonizing circular and sector-specific bioeconomy frameworks. In fact, circular economy concepts and principles are abundantly featured in bioeconomy roadmaps and strategies. Of the 23 bioeconomy roadmaps and strategies analysed, 18 explicitly refer to the circular economy (about 80%). [5] The keywords "circular" and "circularity" appear on average 22 times in each strategy, indicating a significant overlap. Countries with strategies with the most mentions are Estonia and the Netherlands, which have a joint "circular bioeconomy" roadmap and explicitly recognize their synergies, respectively. Interestingly, however, all the 18 countries except Namibia and Thailand also have a separate circular economy roadmap or strategy. This suggests missed opportunities for integrated approaches that could lead to a coherent regulatory approach that foster synergies and minimize trade-offs in policy design and implementation.[6]

## 3.2. Linking national circular economy policies and trade agendas

There is a strong need for improved collaboration between government departments to manage cross-ministerial coordination between circular economy and bioeconomy topics (Barrie and Kettunen, 2023).

Regional networks and strategies such as the EU Bioeconomy Strategy, the Nordic Bioeconomy Programme, and the East Africa Regional Bioeconomy Strategy will play a critical role in advancing circular bioeconomy approaches by fostering knowledge exchange, investment flows, and policy alignment across borders. These frameworks can also provide platforms for South-South, North-South and triangular cooperation.[7]

Recent initiatives like the African Circular Economy Alliance (ACEA) and the Africa Circular Economy Facility (ACEF), supported by the African Development Bank, have emerged as key platforms for integrating circular economy principles into regional trade agreements, such as the African Continental Free Trade Area (AfCFTA). Similarly, the Asia-Pacific Economic Cooperation's (APEC) adoption of the Bangkok Goals on the Bio-Circular-Green (BCG) economy underscores regional commitments toward harmonized circular economy standards and sustainable trade policies.

Geopolitical trends toward resource nationalism are potentially making collaboration on national and regional circular and bioeconomies more difficult, as some governments prioritize strategic autonomy and the control of critical raw materials and bio-based resources. In a fragmented global landscape, competition over resources can overshadow efforts to build shared frameworks for circularity. However, opportunities for progress remain. Multilateral platforms like the G20, which endorsed the High-Level Principles on the Bioeconomy in 2024, offer a foundation for coordinated action. The Brazilian government advanced the bioeconomy within the G20 with the G20 declaration on bioeconomy principles (SECOM, 2024). The upcoming COP30 climate summit in Belem presents a critical moment to align bioeconomic and circular economy strategies with global climate goals. Especially given that Brazil has carried some of the priorities from the G20 to the BRICS chairmanship and is likely to do so with climate.

Additionally, since 2021, the G20 has facilitated further integration between circular economy and trade agendas through initiatives like the Global Alliance on Circular Economy and Resource Efficiency (GACERE) and the Resource Efficiency Dialogue. The WTO's Trade and Environmental Sustainability Structured Discussions (TESSD) have also focused on aligning circular economy goals with trade policies, seeking to harmonize standards and eliminate barriers to trade in circular goods and services.

5 See Table 1. Austria is counted twice as it has separate frameworks for strategy and implementation.

6 It should be noted that some of these countries may (or may not) have integrated initiatives in practice, but not explicitly mentioning it in their official documents.

7 For more information, please see the full texts of the strategies: EU Bioeconomy Strategy, Nordic Bioeconomy Programme, East Africa Regional Bioeconomy Strategy.

On this basis, the G20 can work further towards integration of policy and trade agendas for a circular bioeconomy. Other multilateral approaches, such as the BRICS and international development banks can also play an important role. By fostering coherence between these two agendas on national and international level, policy can contribute to the development of definitions, cross-cutting goals, shared indicators, and coordinated funding mechanisms that enable synergies, avoid duplication, and enhance the overall impact of initiatives across sectors.

North–South cooperation mechanisms have also been strengthened, notably through the EU's Strategy for Sustainable and Circular Textiles and funding programs by international development banks, which emphasize technical assistance and capacity-building in developing countries. These efforts aim to ensure equitable access to circular economy markets and technologies, addressing potential challenges such as the creation of new trade barriers. These may include differing standards, certification requirements, or technological demands that typically require investment and involve high costs for exporters, especially in developing countries.


← **Image 3.** The 4th meeting of the G20 Initiative on Bioeconomy took place at the G20 2024 in Brazil.

© World Bioeconomy Forum, 2024.

Image 4. Black soldier fly larvae farm.



# 4.

# Advancing the circular bioeconomy through international cooperation
*Case studies*

**Various UN agencies are actively involved in scaling up circular bioeconomy solutions around the world in multiple sectors such as organic waste valorisation, agriculture, textiles, and packaging.** UNCTAD is supporting circular bioeconomy innovation through the UK-FCDO-funded Sustainable Manufacturing and Environmental Pollution (SMEP) Programme,[8] which focuses on preventing and reducing industrial waste and promoting circular approaches among SMEs. Similarly, UNIDO, with co-funding from the EU and the Finnish government, is working to strengthen cross-sectoral cooperation and foster public-private partnerships that drive circular transformation. These initiatives provide targeted support for micro, small, and medium enterprises (MSMEs), helping them adopt new technologies, improve resource efficiency, and integrate into value chains. The following case studies highlight how these collaborative efforts are beginning to reshape the industry from the ground up.

## 4.1. Organic waste valorisation in Kenya and Uganda[9]

Circularity and waste valorisation by SMEs in the food, fibre and beverage industries highlight the inherent synergies and overlaps between the circular and bioeconomy. Projects in East Africa, supported by the SMEP Programme, provide examples of scalable solutions that create value from organic waste while addressing pressing environmental and health issues. This is done through the provision of ecosystem services, which include reducing emissions from energy consumption and uncontrolled waste decomposition (e.g., methane) and preventing soil and water contamination (Table 2).

8 For more information, see https://smepprogramme.org/.

9 This section presents firm-level insights based on information and data collected during field visits. While every effort was made to ensure accuracy of the information presented, some elements could not be verified in all instances and may reflect anecdotal or self-reported evidence.

Table 2. Examples of SMEP interventions in organic waste

| Project | Partners | Country | Value-added product | Environment and health impacts |
|---|---|---|---|---|
| Piloting biochar production from food and beverage waste | Sanergy | Kenya | Biochar from crop residues<br>Organic compost<br>Animal feed (e.g., proteins from black soldier flies) | Unsustainable disposal of agricultural waste (e.g., bagasse, rice husk) |
| Assessing the feasibility of a biogas plant for a fish farm | Kenya Private Sector Alliance<br>CONSORTIUM LEAD<br>Rio Fish Ltd. | Kenya | Biogas, used for cooking and fish drying<br>Dried fish (a higher value product)<br>Fish waste briquettes | Landfilling and uncontrolled decomposition of fish waste<br>Deforestation (charcoal production)<br>Energy use (refrigeration and transportation of fresh fish) |
| Complete pineapple waste solutions | Mananasi Fibre Ltd.<br>CONSORTIUM LEAD<br>The Chequered Flag | Kenya | Textile-grade fibre extracted from pineapple leaves<br>Briquettes<br>Natural dyes<br>Insulation materials | Open air burning or uncontrolled decomposition of pineapple waste (leaves) |
| A multi-technology industrial organic waste solution | Taka Taka Solutions<br>CONSORTIUM LEAD<br>Chanzi Ltd. | Kenya | Biochar<br>Organic compost<br>Animal feed (for insect protein / black soldier fly production) | Landfill saturation and uncontrolled decomposition of municipal organic waste |
| Sustainable textiles through upcycling and commercialisation of banana fibre (Banatex-EA) | Busitema University<br>CONSORTIUM LEAD<br>Texfad Ltd., National Textiles University Pakistan | Uganda | Textile-grade fibre extracted from banana pseudostems | Open air burning or uncontrolled decomposition of banana waste (pseudostems) |

↑ *Source:* UN Trade and Development based on interviews with SMEP Programme grantees.

*Note:* Some value-added products listed may be produced independently by grantees, outside SMEP support. The Banatex-EA consortium includes Moi University, Technical University of Kenya, Uganda's Presidential Initiative on Banana Industrial Development, Uganda National Bureau of Standards, and Freakin Future.

Due to the low intrinsic value of waste, as well as the presence of underdeveloped markets and limited industrial capacity for upcycling, businesses report difficulty in creating viable business models. They operate on low margins and see the provision of and payment for these services as critical to making their models scalable and economically viable. However, only in some instances the value of these services adequately reflected on prices due to, inter-alia, weak governance and market failures. In fact, in the contexts of Kenya and Uganda, no company receives financial compensation from the government for services such as the diversion and conversion of organic waste. Instead, some companies, particularly biochar and organic fertilizers producers, are relying on market forces alone and pursuing carbon credits to recover the costs associated with waste separation (Box 1).

Bio-based value-added products, which are environmentally superior to their standard counterparts, are sold in an unregulated market and are largely influenced by supply and demand factors. Despite relatively good conversion rates of feedstocks and market appetite, these

### Box 1. Carbon credits from waste valorisation in Kenya

Producers of insect-based animal feed and organic fertilizers are exploring carbon credits as a crucial revenue stream to offset the intrinsically low margins of their businesses. These producers divert organic waste from landfills, significantly reducing methane emissions. For instance, by using Black Soldier Fly (BSF) larvae to convert 1000 kg of organic waste into 25 kg of dried larvae and 110 kg of compost, one company reported avoiding approximately 350 kg of $CO_2$ equivalent emissions. The resulting compost also sequesters carbon in soil. Beyond compost, these producers are also exploring carbon credits for biochar production from multiple crop residues. A stable form of carbon, biochar offers even greater carbon sequestration potential compared to standard compost, as it persists in soil for centuries.

The carbon savings from both compost and biochar (and blends of both) are rigorously calculated and verified by third-party certifiers, who often also provide carbon trading platform services. However, despite the environmental advantages and the potential for revenue generation, obtaining carbon credit certification is a complex and costly process. The power dynamic with the certifiers and the trading platforms is a factor, as is the length of time and significant costs to get certified. For example, Chanzi reported spending USD 135,000 and three years to achieve certification, highlighting the significant investment required.

↑ *Source:* Interviews with SMEP Programme grantees Chanzi Ltd., Sanergy and Taka Taka Solutions.

products are typically sold at high prices due to low volumes, high unit costs and inefficient supply chains – a situation that characterizes most infant industries. For instance, long distance between the points of production and consumption raises the costs of feedstocks, such as rice husk for biochar, which are transported for long distances with a moisture content of above 50%. Low volumes and losses in decortication, drying (if any), loading and transport, undermine profitability of novel fibres, such as textile grade pineapple fibre. This can be up to three times more expensive than cotton in its raw form and up to seven times more expensive when processed ("cottonised").

Consumer behaviour and enabling infrastructure also play a role. For example, in Kenya, replacing firewood with biogas from vegetable market waste failed due to consumer resistance or failures in distribution networks. Low awareness and reluctance to adopt green alternatives is also an issue for organic fertilisers, which farmers expect to perform as well as chemical fertilisers and are not willing to pay a premium for.

These issues are exacerbated by certain policy gaps, ranging from weak policy frameworks, lack of program to increase acceptance, to a lack of financial and technical support. Most notable, waste management is often informally handled and lacks a system of incentives that enforces good consumer behaviour. Companies that valorise waste such as organic fertilizer producers struggle to achieve profitability due to the difficulty of sourcing high-quality inputs from unsorted waste streams, requiring extensive manual sorting (Box 2). While there are regulations covering waste management and collection, they are only inconsitently enforced, especially on organic waste which the market perceives as having low or no value. [10]

Companies also report the lack of a clear vision from the government to create an enabling environment for the bioeconomy, with changes in other policy areas such as plastic waste management affecting operations.. In fact, while both Kenya and Uganda do not have national circular or bioeconomy strategies, they have taken steps in the transition to a circular economy in specific areas. For example, Kenya adhered to the East African Community ban on single use plastic bags in 2017, developed an Extended Producer responsibility regulation in 2021 and a Sustainable Waste Management Act in 2022 (KIPPRA, 2022).

10 Depending on the grade, waste collectors in Kenya sell organic waste to animal feed and organic fertilizer producers for a low price (e.g., 2 KES per kg, approximately USD 0.01, for food market waste). In other cases, such as with household waste (e.g., crop residues), they may give it away at no cost in exchange for disposal.

**Box 2.** Securing high-quality waste inputs: Challenges for Kenya's bioeconomy

Waste management in Kenya presents significant hurdles for bioeconomy businesses. Unlike most developed countries, where waste handling fees generate tax revenue for local government, Kenya's model relies on individual contracts with private waste collectors who collect waste from households and transport it to open dumpsites. In Nairobi, this results in an unsorted waste stream dominated by organic matter (over 50% of the total), with "cherry-picking" of high-value items such as PET by informal waste collectors (NEMA 2023, Kasozi and von Blottnitz 2010).

The fragmentation of the waste collection system further compounds the problem. While there is evidence of private companies attempting to fill the service gap left by the municipality, these companies face high transaction costs due to the lack of intermediaries and the high cost of contracting with individual buildings. The systems also lack financial incentives that encourage good consumer behaviour. For instance, the extremely low landfill disposal cost, i.e. gate fees, which are approximately USD 1 per ton (EREF, 2024), provides no incentive for proper waste separation or infrastructure development.

This results in bioeconomy businesses receiving a challenging mix of low-value, poorly sorted waste, with certain streams such as mixed household waste even provided to them for free. Extensive manual sorting is required due to the lack of separation at source, resulting in high production costs and low economies of scale. In addition, the varied composition of waste, influenced by factors like seasonality, necessitates flexible blending recipes, adding complexity to production and increasing operational risks. As a result, conversion rates and margins decrease, putting the profitability of bioeconomy businesses at risk.

↑ *Source:* Interviews with SMEP Programme grantees Chanzi Ltd., Sanergy and Taka Taka Solutions.

For project details, see https://smepprogramme.org/projects-1/.

Unit economics—the cost of producing a unit of product compared to its selling price—are particularly important for business viability as there are no policy interventions to support infant, bio-based industries. In Kenya, government support is limited to in-kind contributions, as SMEP Programme grantees dealing with waste conversion such as biogas reported receiving free land and assistance in start-up (e.g., licensing). No companies reported benefitting from financial incentive schemes. These could include price subsidies to encourage the adoption of sustainable (and more expensive) alternatives and performance-based funding schemes for innovation and development of biotechnologies that would help cut production costs. In some instances, the adoption of bio-based alternatives is further discouraged by subsidies for established products. This is the case for chemical fertilizers, which are available at a subsidized price of around 50% under Kenya's National Fertilizer Subsidy Program (Ricker-Gilbert et al.,, 2024).

In this context, some companies advocate for "assisted compliance" – a policy approach where support of virtuous companies by the government would yield better resource and energy efficiency value addition and regulatory compliance, at the same time.

Cross-border trade is also a driver for the development of the circular bioeconomy as it facilitates access to capital equipment that is not immediately available locally. In fact, companies report relying on foreign expertise for system design and importing technologically advanced equipment, such as pumps, compressors and water blowers. These goods can be purchased at competitive prices and are imported either directly or through local intermediaries from countries such as China and India. At the same time, there is also evidence of good local capabilities for basic metal structures fabrication (e.g., tanks, convoyers, etc.), with required skills available at local workshops including instances of 3D printing. However, some entrepreneurs do face intellectual property protection hurdles.

Trade-related challenges reported by grantees include import duties and fees that can reach up to 40% of the value of the imported goods. These include but are not limited to a Railway Development Levy (2%), an Import Declaration Fee (2.5%) and VAT (16%), as well as import duties under the East African Community's Common External Tariff (CET), which can be as high as 25%.[11] However, if certain end use requirements are met, such as for recycling, equipment can be imported duty free. Grantees also report that it is easier to import integrated solutions that would qualify for duty exemptions under certain tariff lines (e.g., biodigester), while facing high tariffs when importing single parts or components (e.g., biodigester fabric).

In addition to import duties, there are also non-tariff barriers, mostly related to compliance with stringent standards such as the European Union's Regulation on Fertilizing Products.[12] This includes limits on contaminants (e.g., heavy metals), and requirements on labelling and production practices, covering both organic fertilizers and biochar-based blends. Even when aiming for markets outside the EU, companies face product specification constraints, one grantee reported the rejection of pineapple-fibre-based textile fibre in Vietnam due to excessive manganese levels . Exporting in the region, such as from Kenya to Uganda, also necessitates acquiring permits and licenses, despite the AFCFTA, adding to the regulatory burden.

## 4.2. Cotton 'jhut' recycling in Bangladesh

In Bangladesh's garment industry, the recycling of cotton textile waste, locally known as jhut, offers a compelling example of a circular bioeconomy in practice. Jhut consists of post-production cotton scraps and offcuts generated during the cutting and sewing stages of ready-made garment (RMG) manufacturing. Rather than being discarded or incinerated, this plant-based, biodegradable material is increasingly being collected, sorted, and processed for reuse and recycling, transforming industrial waste into a valuable secondary resource. By upcycling jhut into new yarns, textiles, or higher-value products, the industry is closing material loops within the biocycle of the circular economy. This process not only reduces reliance on virgin cotton, thereby lowering associated water and chemical use, but also significantly cuts down on textile waste.

The SWITCH to Circular Value Chains[13] project, co-funded by the European Union and Finland and implemented by UNIDO, plays a key role in advancing jhut recycling specifically the blended cotton waste as part of a broader shift toward a circular bioeconomy in Bangladesh. The project supports industry stakeholders and government actors in adopting technical innovations, building capacity, improving traceability of materials, and enhancing working conditions—particularly for women and youth who make up much of the informal workforce involved in jhut sorting. Through training programmes for SMEs (EU suppliers), the initiative helps scale circular practices, making them safer and more efficient. By identifying investment opportunities, capacity building of local financial intermediaries towards promoting innovation, SWITCH to Circular Value Chains aims to align Bangladesh's textile sector with global circular economy trends, while unlocking new and inclusive green jobs, income streams, and sustainable growth across the value chain.

Despite compliance challenges, new EU policies and eco-design requirements for textiles—such as those introduced under the Ecodesign for Sustainable Products Regulation (ESPR)—have the potential to drive a global shift towards circular textiles, including in Bangladesh. These regulations, which emphasize durability, recyclability, traceability, and minimum recycled content, could create strong market incentives for jhut recycling, where cotton waste (including cotton-polyester blends) from garment factories is sorted, collected, and reprocessed into new fibres or products. Based on the experiences of the SWITCH to Circular Value Chains project, targeted technical assistance will be essential to ensure these measures do not become trade barriers for key supplier countries.

The initiative also involves close collaboration with local policy research organizations to support the government in developing a national strategy and nationally accredited training programs. A collaborative approach, linking EU buyers, Bangladeshi suppliers, investors, and international development actors, will be critical to realizing the promise of a more inclusive and circular global textile economy.

11 More information can be found in the text of the Republic of Kenya's Finance Bill 2024 (https://www.kenyalaw.org/kl/fileadmin/pdfdownloads/bills/2024/TheFinanceBill_2024.pdf) and the East African Community's Common External Tariff 2022 (https://www.eac.int/documents/category/eac-common-external-tariff).

12 Trade barriers are both monetary (e.g., border taxes) and technical (e.g., compliance with product standards).

13 For more information, see https://www.switchtocircular.eu/.

# 5.

# Conclusions and recommendations

**The circular economy and the bioeconomy are inherently complementary, offering distinct yet interconnected pathways to achieving sustainable use of natural resources.** Their integration into a circular bioeconomy offers significant potential for promoting resource efficiency, reducing waste and regenerating natural systems. To realize this potential, policy efforts will need to focus on putting in place national circular bioeconomy strategies where none exist, and harmonizing national circular and bioeconomy strategies, where they have been developed independently to ensure aligned goals and coherent regulatory frameworks.

The four case studies from Africa and one from Bangladesh suggest several additional interventions are needed to support bio-based innovation and driving this transition, alongside leveraging international cooperation to share knowledge and best practices:

**Governments** can provide comprehensive support and develop policies to mitigate the unfavorable economics that often hamper the growth of nascent bio-based industries while promoting consumer awareness:

- Demand-side interventions can promote the adoption of bio-based products by increasing their affordability and availability. These interventions range from price subsidies to reduce the retail price of bio-based alternatives (e.g., organic fertilizers) to quotas for bio-based products in public procurement schemes.

- Supply-side interventions can help reduce unit costs and increase economies of scale. These include financial support for innovation and investment in biotechnologies (e.g., grants, tax rebates, retrofit schemes), technology transfer mechanisms (e.g., university-industry collaborations), and buyer-supplier matchmaking (e.g., between alternative fiber producers and fashion designers). These interventions would be particularly effective in regions with abundant excess biomass, where local technological readiness would enable on-site processing of feedstock thus limiting supply chains inefficiencies (e.g., transportation of water-rich biomass). Where technologies are not readily available in the market, governments could establish fair tariff schedules and taxes that do not excessively increase the cost of imported goods, especially capital equipment.

- Enabling policy frameworks that facilitate the development of bio-based industries, such as waste management systems for improved collection and sorting of organic waste, are essential. Delivered through sound cross-agency coordination and institutional reform, these frameworks should be designed with the circular economy and bioeconomy intersections identified in this paper in mind. They should include guiding policies and enforceable regulations, critical services (e.g., waste separation), and incentive schemes (e.g., disposal taxes and fees) to promote good post-consumer behavior and high-quality waste streams.

- In highly tradeable sectors, governments should also provide technical support to suppliers to markets with stringent access requirements, such as the EU, particularly to informal collectors and recyclers, as well as local manufacturers and processors to comply with new traceability and documentation requirements, adopt cleaner technologies, improve working conditions, and certify the recycled content of their materials.

Private companies play a key role in unlocking the circular bioeconomy, not only by conducting R&D, investing to bring to market and producing innovative bio-based alternatives, but also by helping create an enabling environment. This may be the case when weak institutional capacity and limited budgets prevent public bodies from optimally providing the infrastructure and services that are critical to unlocking the circular bioeconomy. These range from industrial composting facilities to the separation of waste streams and recovery of materials. Where these gaps exist, appropriate financial compensation (at best) or incentives (at least) should be provided for private companies to invest in this infrastructure and deliver these services. At a minimum, governments should promote market-based mechanisms that allow the market to accurately price in and pay for these services, ideally based on performance. The registration, verification, and sale of carbon credits reflecting the monetary value of emission reductions and carbon sequestration from bio-based alternatives such as biochar fertilizers is a case in point. The costs of accessing these markets could be reduced through finance schemes and technical assistance for suppliers, including small and medium-sized enterprises, further enabling the market to recognize and reward the environmental benefits of bio-based alternatives.

Consumers and their behavior at both the purchase and disposal stages are key enablers of the circular bioeconomy, in that they determine the availability (and quality) of inputs for bioproducts and the ultimate uptake of bio-based alternatives. However, intention-action gaps remain. Since the production, transformation and trade of bio-based products also have negative social and environmental impacts, governments should conduct sensitization campaigns and provide incentives to promote responsible consumption practices. This can be achieved by partnering with community organizations (e.g., cooperatives and associations) that have a good knowledge of the local context and can help raise awareness and create opportunities for supply chain actors such as farmers. As the case of organic fertilizers in Kenya shows, these actors play a key role in the development of bio-based industries but may lack sufficient knowledge of the latest technological and product developments. Sensitization efforts should be based on the latest scientific evidence to ensure that supply chain actors develop realistic expectations about the benefits and performance of bio-based products. This, coupled with incentives that reduce the shifting costs, such as price subsidies, determines their willingness to pay for them and their ultimate adoption. Scale-up activities can also be stimulated through public procurement.

Finally, international cooperation including South-South, South-North, and triangular cooperation will be crucial to enable technology transfer, policy development and best practice sharing. Groups of countries with complementary roles across circular economy and bioeconomy strategies need to take the lead and help to advance circular bioeconomy solutions internationally, promoting coherent policy frameworks that leverage consumer awareness and producer readiness. As the SMEP cases show, public-private partnerships (PPPs) involving private companies, producer associations, academia and government agencies can help build consensus and deploy solutions on the ground. At the same time, multilateral institutions including the G20, BRICS, and international financial institutions (IFIs) such as development banks also have a key role to play by providing the technical and financial assistance needed to develop markets for bio-based innovations and products internationally. A synergistic and collaborative approach will be essential to unlock the full benefits of a circular bioeconomy.

At the multilateral level, the United Nations can actively contribute to strengthening the consideration of bioeconomy and bioenergy products among member states. Furthermore, supporting bodies such as the UN Council of Engineers for the Energy Transition (CET) can assist Member States in developing operational strategies to scale circular bioeconomy solutions, while existing technical assistance platforms such as the SMEP Programme can be leveraged to deliver technical assistance and promote national and regional experience sharing.

# References


Barrie, J. and Kettunen, M. (2023) Improving policy coherence: bioeconomy, circular economy and sustainable trade. Chatham House. Available at: https://circulareconomy.earth/publications/improving-policy-coherence-bioeconomy-circular-economy-and-sustainable-trade.

Bio-based and Biodegradable Industries Association (BBIA) (n.d.) What is the bioeconomy? Available at: https://bbia.org.uk/bioeconomy/.

Carus, M. and Dammer, L. (2018) The "Circular Bioeconomy" – Concepts, Opportunities and Limitations. Nova-Institute. Available at: https://renewable-carbon.eu/publications/product/nova-paper-9-the-circular-bioeconomy-concepts-opportunities-and-limitations-%E2%88%92-full-version/.

Chatham House (2025) Circular Economy policy tracker. https://circulareconomy.earth/about

Ellen MacArthur Foundation (2021), 'What is a circular economy?', Available at: https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview.

Ellen MacArthur Foundation (2019). Circular economy systems diagram. Drawing based on Braungart & McDonough, Cradle to Crade (C2C). Available at: https://www.ellenmacarthurfoundation.org/circular-economy-diagram.

Environmental Research & Education Foundation (EREF) (2024). Analysis of MSW Landfill Tipping Fees 2023. Available at: https://erefdn.org/product/analysis-of-msw-landfill-tipping-fees-2023/.

IUCN (2023). Measuring Nature-Positive: Setting and implementing verified, robust targets for species and ecosystems. Available at: https://iucn.org/sites/default/files/2023-11/iucn-nature-positive-contribution-v1.0.pdf.

Kasozi, A. and von Blottnitz. H. (2010). Solid Waste Management in Nairobi: A Situation Analysis. Technical Document accompanying the Integrated Solid Waste Management Plan. University of Cape Town. Available at: https://www.ecopost.co.ke/assets/pdf/nairobi_solid_waste.pdf.

Kenya Institute for Public Policy Research and Analysis (KIPPRA) (2022). Accelerating the Circular Economy in Plastic Waste Management for Kenya. Discussion Paper Series. Available at: https://repository.kippra.or.ke/server/api/core/bitstreams/e6d6067d-93b7-46fe-8b46-3e8c6521e83d/content#:_:text=Kenya%20has%20made%20some%20strides,Sustainable%20Waste%20Management%20Act%202022.

Khanna, M., Zilberman, D., Hochman, G. et al., (2024) An economic perspective of the circular bioeconomy in the food and agricultural sector. Commun Earth Environ 5, 507. Available at: https://doi.org/10.1038/s43247-024-01663-6.

National Environment Management Authority of Kenya (NEMA) (2023). Environmental best practices in waste management. Nairobi, Kenya. Available at: https://www.nema.go.ke/images/ACS_2023/Environmental%20Best%20Practices%20in%20Waste%20Management%20FINAL%20(10).pdf.

Nazar et al., (2025) Sustainable Bioplastics Production From Fish Waste: Their Extraction and Applications. Available at: https://doi.org/10.1002/pat.70095.

Ricker-Gilbert J., Mather D., Maredia M., Olwande J., and Khaled N.B. (2024). Evaluating Kenya's National Fertilizer Subsidy Program: Implementation, Crowding-out, and Benefit-Cost Assessment. SARA-KEA Stakeholder Conference, 29 Oct 2024. Available at: https://tegemeo.egerton.ac.ke/images/Evaluating_Kenyas_National_Fertilizer_Subsidy_Program_ImplementationJ_Crowding-outJ_and_Benefit-Cost_Assessment.pdf.

SMEP (2025) Assessing the feasibility of a biogas plant for a fish farm. Available at: https://smepprogramme.org/project/assessing-the-feasibility-of-a-biogas-and-wastewater-plant-for-a-fish-farm/.

SMEP (2025, forthcoming). From waste to value: Upcycling agricultural residues for sustainable textiles. Case studies from Kenya and Uganda.

Strapasson, A.; Ouma, C.; Domeniconi, B. (2021). Livestock Production. In: Life Cycle Assessment: A Metric for the Circular Economy. 1st Ed. Royal Society of Chemistry, UK. Available at: https://doi.org/10.1039/9781788016209-00290

Tsapekos, P., Benyamin Khoshnevisan, Merlin Alvarado-Morales, Xinyu Zhu, Junting Pan, Hailin Tian, Irini Angelidaki (2021) Upcycling the anaerobic digestion streams in a bioeconomy approach: A review. Renewable and Sustainable Energy Reviews, Volume 151. Available at: https://doi.org/10.1016/j.rser.2021.111635.

UN Trade and Development (2020). UNCTAD BioTrade Initiative: BioTrade Principles and Criteria for terrestrial, marine and other aquatic biodiversity-based products and services. United Nations: New York/Geneva. Available at: https://unctad.org/system/files/official-document/ditcted2020d2_en.pdf.

UN Trade and Development (2023) Plastic Pollution: The pressing case for natural and environmentally friendly substitutes to plastics. Available at: https://unctad.org/publication/plastic-pollution-pressing-case-natural-and-environmentally-friendly-substitutes.

UN Trade and Development (2025) Leaving the shore: Marine-based substitutes and alternatives to plastics. United Nations: New York/Geneva. Available at: https://unctad.org/publication/biotrade-principles-and-criteria-terrestrial-marine-and-other-aquatic-biodiversity.

UN Environment Programme (2024) Global Bioeconomy Assessment. Coordinated Efforts of Policy, Innovation, and Sustainability for a Greener Future. Nairobi. Available at: https://doi.org/10.59117/20.500.11822/45332.

World Bank (2014). Results-Based Financing for Municipal Solid Waste. Urban Development Series Knowledge Papers. Available at: https://documents1.worldbank.org/curated/en/237191468330923040/pdf/918610v20WP0FM0BE0CATALOGED0BY0WED0.pdf.

Yang, A., Throp, H. and Sherman, S. (2024) How strategic collaboration on the bioeconomy can boost climate and nature action. Chatham House Research Paper. London. Available at: https://www.chathamhouse.org/2024/10/how-strategic-collaboration-bioeconomy-can-boost-climate-and-nature-action.

Sustainable Manufacturing and Environmental Pollution Programme

UK International Development
Partnership | Progress | Prosperity

CHATHAM HOUSE

switch to Circular Economy Value Chains

Funded by the European Union

Ministry for Foreign Affairs of Finland