CIRCULAR BY NATURE

RESEARCH METHOD

A POLICY AGENDA FOR BIO-BASED MATERIALS IN A CIRCULAR ECONOMY

ELLEN MACARTHUR FOUNDATION

COALICIÓN DE ECONOMÍA CIRCULAR
América Latina y el Caribe

APPENDIX I - RESEARCH METHODOLOGY

This technical appendix provides a detailed account of the research design, scope, and analytical methods that underpin the conclusions and recommendations of *Circular by nature. A policy agenda for bio-based materials in a circular economy.* Section One outlines the rationale and lists the policies analysed. Section Two presents the research questions and analytical procedures. The appendix concludes with a summary of findings and their implications.

Starting from the observation that circular economy policies tend to prioritise commitments towards finite materials, we conducted research to assess the extent to which bio-based materials are considered in national circular economy strategies worldwide. To address this question, the study examines the policy coherence between national circular economy strategies and the policies regulating the production and use of bio-based materials in a set of countries with relevant instruments in both areas.

For the purpose of this analysis, bio-based materials are considered as those entirely derived from renewable biological resources — such as plants, animals, algae, or microorganisms — that enter extended cycles of use. Their total constituent mass contains no fossil-based carbon, and their molecules are not consumed in short cycles such as food, cosmetics, biofertilisers, or biofuels.

While bio-based materials may originate from diverse sources (e.g. seaweed, fisheries), this study prioritises those produced through agriculture and forestry, including wood, pulp and paper, cotton and other natural fibres, natural rubber, and leather.

The assessment was structured around the Universal Circular Economy Policy Goals developed by the Ellen MacArthur Foundation in 2021, which provided a consistent benchmark for evaluating policy ambition and scope. Each policy was reviewed in terms of its degree of alignment with these goals, with particular attention to whether and how bio-based materials were explicitly referenced. This approach allowed us to assess not only the presence of bio-based materials within policy frameworks, but also the extent to which their treatment reflects the potential of bio-based materials in a circular economy.

The evaluation applied a structured framework comprising **9** verification items for each — circular economy policies and policies regulating bio-based materials — which were expanded into 88 research questions.. An AI-assisted screening process was employed to extract responses and key evidence from the selected documents. A comparative analysis was then undertaken to identify areas of convergence and divergence between circular economy strategies and complementary policies.[1]

APPENDIX I - RESEARCH METHODOLOGY

1. Analytical scope

This study focuses on a sample of countries that have already developed regulations on circular economy-related topics, alongside policies addressing the production and use of bio-based materials.

The circular economy has gained substantial prominence in policy agendas, with a sharp rise in the number of national strategies and roadmaps over recent years. By April 2026, over 100 countries had adopted a national circular economy strategy or action plan.

Although policies regulating bio-based materials are not entirely new, innovation in this domain is accelerating. Over the past decade, several countries have developed dedicated bioeconomy strategies (24 out of 143), complemented by "green/new industry," agriculture, forestry, and biodiversity policies incorporating environmental objectives.

In this research, we assessed **31 policy instruments.** These included circular economy strategies and complementary policies regulating bio-based materials across different countries.

Countries were selected according to two primary criteria:

- **Policy momentum in the circular economy –** demonstrated through the adoption of national strategies, roadmaps, or regulatory frameworks advancing circular economy principles.
- **Innovations in regulating bio-based materials –** countries that introduced bioeconomy policy instruments were our entry point for this criterion, but subsequently we also explored policies that address sustainable agriculture and forestry, "new/green" industrial development and biotechnology to capture a wider range of mechanisms that regulate production, transformation, or use of bio-based materials.

To ensure that the final sample provides a balanced and comprehensive perspective, the selection was designed to reflect both the Global North and the Global South, with particular attention to leading exporters of bio-based materials. A deliberate prioritisation process was applied to secure:

- **Geographic diversity,** ensuring representation of different regions and policy contexts.
- **Value chain coverage,** including countries that occupy different positions in the bio-based materials system (from primary producers to processors and retailers).

This inclusive approach allows the analysis to capture a wide range of policy strategies, highlight regional specificities, and assess coherence across the value chain. It also strengthens the robustness of the comparative analysis by situating bio-based material policies within a global perspective.

The following table presents the list of policies and countries included in the analysis, organised by type of strategy and geographical scope.

Table 1: Policy documents selected for analysis

	Circular Economy (13 policy strategies)	Production and use of biobased materials/products (18 policy strategies)
Brazil	• Plano Nacional de Economia Circular (2025)[2]	• Plano Setorial para Adaptação à Mudança do Clima e Baixa Emissão de Carbono na Agropecuária (ABC+) (2021)[3] Nova Indústria Brasileira (NIB) (2025)[4] • Plano Nacional de Desenvolvimento da Sociobioeconomia (2025)[5]
Chile	• Roadmap for a Circular Chile by 2040 (2021)[6]	• National Biodiversity Strategy (2003)[7]
Colombia	• Estrategia Nacional de Economía Circular (2019)[8]	• Estrategia Nacional de Bioeconomía (2020)[9] • Política Nacional para el Control de la Deforestación y la Gestión Sostenible de los Bosques (2020)[10] • Política Nacional de Reindustrialización (2023)[11] – link
Costa Rica	• Estrategia Nacional de Economía Circular (2023)[12]	• Estrategia Nacional de Bioeconomía (2020)[13]
Rwanda	• Rwanda National Circular Economy Action Plan and Roadmap (2022)[14]	• The East African Regional Bioeconomy Strategy (2022)[15]
Finland	• Leading the cycle: Finnish road map to a circular economy (2016)[16] • Government resolution on the strategic programme for circular economy (2021)[17]	• National Bioeconomy Strategy (2021)[18] • National Forest Strategy 2023[19]
France	• Circular Economy roadmap of France: 50 measures for a 100% circular economy (2018)[20]	• National Strategy for Bioeconomy (2018)[21]
India	• N/A	• National Biotechnology Development Strategy (2020)[22]
South Africa	• National waste management strategy (2020)[23]	• National biodiversity economy strategy (2016)[24]
Vietnam	• National Action Plan on Circular Economy (Decision No. 687/QD-TTg, 2022)[25]	• National Action Plan on Sustainable Consumption and Production (2020)[26]
Canada	• A Healthy Environment and a Healthy Economy (2020)[27]	• Canada's Bioeconomy Strategy (2022)[28] • Canada's 2030 nature strategy (2024)[29]
Netherlands	• Circular Economy Implementation Programme (2023)[30] • Biomass, Food and Circular Economy Transition Agenda (2018)[31]	• The Position of the Bioeconomy in the Netherlands (2018)[32]

2. Analytical methodology

2.1 Analytical framework

The investigation was guided by two overarching hypotheses that framed the scope and direction of the analysis: first, that **bio-based material sectors are under-represented in circular economy policy strategies;** Second, existing **policy incentives for the production and use of bio-based materials often reinforce linear, extractive models rather than enabling circular and regenerative approaches.**

These hypotheses reflect a fundamental concern: that policy frameworks advancing circular economy and those targeting bio-based materials are evolving in parallel, but without sufficient integration.

To test this assumption, the team conducted a series of iterative discussions with external experts, which informed the development of structured evaluation criteria. Ultimately, this process resulted in the definition of **9 verification items** for each policy category:

CIRCULAR ECONOMY POLICY INSTRUMENTS

1. Regeneration principle

This criterion evaluates the extent to which policies establish regeneration as a guiding principle in their treatment of bio-based materials. It goes beyond generic references — such as mentions of sustainable sourcing — to assess whether regenerative production is explicitly embedded in the policy's approach. Scoring ranges from absence (no reference at all) or low alignment, where regeneration is cited but only in vague, isolated, or secondary terms, to high alignment, where regeneration is clearly positioned as a core principle, explicitly linked to design guidelines, and supported by commitments to retain material value.

2. Upstream vs. Downstream Bias

This item evaluates whether policies privilege downstream measures, such as waste management, over upstream opportunities like design for circularity or regeneration. The scoring ranged from absent (purely downstream) to high (integrated coverage of upstream and downstream with specificity for bio-based sectors). Assessment followed the main question on whether circular economy policies disproportionately emphasise end-of-life strategies rather than upstream interventions. Sub-questions directed attention to mentions of design principles (e.g. durability, repairability), regenerative sourcing, and incentives for reuse or remanufacture. The analysis operationalised this balance by coding each reference and weighing the relative focus given to upstream and downstream stages.

3. Transparency and Traceability

This criterion examines whether policies enable the tracking of bio-based materials through labelling, certification, or digital tools, thereby supporting informed decision-making. The scoring table distinguished between no mention, generic references, partial material coverage, and comprehensive systems with verification mechanisms. Sub-questions helped assess references to transparency guidelines that reveal the inclusion of bio-based materials (e.g. origin, regenerative production, compostability, etc.) or any explicit mention/differentiation between bio-based and fossil-based materials in this context.

4. Substitution Opportunity

This item assesses whether substitution of finite materials (e.g. fossil-based) with bio-based alternatives is mentioned. Also, it assesses if this opportunity is framed within circular systems or merely as a pollution-reduction measure. Sub-questions explored whether substitution is promoted in isolation, whether enabling infrastructure or business models are mentioned, and whether cascading use is considered. The operationalisation thus captured both the presence of substitution and the extent to which it was connected to systemic circularity.

5. Short-cycle vs. Long-life Design

This criterion evaluates whether policies promote life extension, reusable, and modular approaches to bio-based materials or reinforce single-use, short-cycle solutions. Scoring ranged from emphasis on disposables, through partial recognition of long-life models, to comprehensive discouragement of short-cycle products. Sub-questions guided the analysis of explicit mentions of disposables versus durable goods, incentives for repairability and modularity, recognition of risks in “green” disposable solutions, and support for repair or remanufacture strategies.

6. Clarity and visibility of bio-based materials

This item assesses whether bio-based materials are clearly defined and systematically tracked within policy frameworks, ensuring their visibility in national strategies. The alignment scale ranges from absent or vague mentions, to the presence of detailed definitions and dedicated monitoring systems. Sub-questions guided the analysis from identifying broad or non-specific references, through to the existence of definitions and sector-specific mechanisms addressing biomass or bio-based materials and products. At the highest level of alignment, national monitoring systems are in place to manage the use and efficiency of these biological resources across the economy.

7. Making the economics work

This criterion assesses whether economic incentives and regulatory measures are in place to enable bio-based circular solutions. Scoring ranged from no mention, through vague commitments, to clear targets across the full value chain. The main question asked whether policies include incentives for regenerative production along with commitments in high-demand sectors such as fashion and packaging. Sub-questions examined targets for demand-side uptake, over-reliance on production-side measures, instruments to increase durability and regeneration, and coverage of the full value chain.

8. Innovation, skills, and infrastructure

This item evaluates whether policies invest in the innovation ecosystem required to scale bio-based circularity, including R&D, skills, and infrastructure. The scoring scale ranged from no mention, through generic support, to targeted investments for bio-based applications. Sub-questions covered funding and investment for circular solutions beyond energy or food, regional strategies fostering value-added industries, support for cascading and high-value applications, and mechanisms to scale circular business models.

9. Collaboration

This criterion evaluates the extent to which policies promote collaboration across the bio-based materials value chain, both nationally and internationally. The alignment scale spans from no references, through aspirational mentions, to comprehensive mechanisms that engage multiple lifecycle stages. Sub-questions guided the analysis of platforms and networks connecting producers with end-users, public–private partnerships, collaborative monitoring and alignment efforts, and the inclusion of actors across sourcing, design, manufacturing, use, and recirculation. Evidence of cross-ministerial collaboration and commitments to pursue cross-border alignment were also considered.are in place to manage the use and efficiency of these biological resources across the economy.

POLICIES REGULATING THE PRODUCTION AND USE OF BIO-BASED MATERIALS

1. Regeneration Opportunity

This criterion assesses the extent to which policies embed nature regeneration as a guiding principle, going beyond harm reduction or basic conservation. The analysis examined whether policies merely acknowledged minimisation strategies, or whether they explicitly incorporated regenerative production practices such as ecosystem restoration on already-converted and degraded lands. Scoring ranged from absent (where policies followed a linear growth model with no regenerative lens) through partial (soft mentions of regeneration) to high alignment (clear operational guidance for regenerative practices).

2. Upstream vs. Downstream Bias

This item evaluates whether policies strike a balance between upstream and downstream strategies in managing bio-based materials. It specifically examines whether policies go beyond end-of-pipe solutions to also support upstream approaches, including product durability, cascading uses, reuse, repair, and remanufacturing. Scoring ranged from absent — where policies remain silent on resource circulation or overemphasise downstream actions — to high alignment, where upstream strategies and value retention are explicitly supported and integrated into policy tools. Intermediate scores were assigned when policies either framed end-of-pipe solutions under a linear model or acknowledged circulation concepts without embedding actionable measures tailored to bio-based sectors.

3. Traceability and Transparency

This item examines whether policies mention traceability and transparency (T&T) tools — such as DPP and label schemes — supported by economic incentives like green public procurement or tax reductions. The scoring assessed whether such instruments were absent, generic, or aspirational, or whether they were explicitly designed to facilitate high-value circulation of bio-based materials. Policies received higher alignment scores when they combined multiple T&T mechanisms with clear links to circular flows.

4. Circulation and Multiple Uses

This verification item measures the degree to which policies address the circular use of bio-based materials beyond primary production. The analysis looked at whether policies simply focused on biomass supply, or whether they articulated pathways for bio-based materials to circulate across off-taker sectors through business models and incentives. Scores ranged from absent (exclusive focus on production) to high alignment, where policies recognised multiple offtaker sectors and supported mechanisms enabling cascading uses and recirculation.

5. Substitution and Trade-off Management

This criterion investigates whether policies acknowledge and manage potential ecological trade-offs when promoting the substitution of finite materials with bio-based alternatives. It assessed whether risks such as land-use competition, biodiversity loss, or food system pressures were overlooked or explicitly addressed with safeguards. Scoring ranged from absent (bioeconomy framed as inherently positive) to high alignment, where policies recognised risks and embedded integrated planning or monitoring to mitigate trade-offs.

6. Tracking and Tools for Biomass Management

This item assesses whether policies define and differentiate types of bio-based materials and establish tools to track their flow in the economy. Such mechanisms enable identification of inefficiencies, risks of scarcity, and opportunities for circular use, while also informing cross-sectoral planning. Scoring began at absent (biomass treated as a homogenous category with no tracking) and progressed to high alignment, where policies included clear definitions, monitoring systems, and sectoral tools with moderate implementation in practice.

7. Making the Economics Work

This criterion evaluates whether policies deploy economic instruments to make circular bio-based materials more viable than linear or extractive options. Instruments considered include subsidies, procurement mechanisms, taxation, or targeted market-creation measures. The scoring framework ranged from absent (no economic measures) through aspirational (generic support with no clear link to circularity) to high alignment, where several instruments were actively applied to support bio-based materials within circular value chains.

8. Innovation, Skills, and Infrastructure

This item examines whether policies foster innovation, skill development, pilot projects, or infrastructure that enable systemic circularity in bio-based material flows. The assessment paid particular attention to whether such measures targeted early-stage or high-potential areas such as degraded lands or emerging value chains. Scoring ranged from absent (no mention of innovation or infrastructure) to high alignment, where structured programmes supported systemic transitions across selected value chains.

9. Collaboration

This criterion assesses whether policies promote systemic collaboration and equitable participation in bio-based value chains. The evaluation looked for mechanisms that reduce entry barriers, share risk, and enable cross-sectoral or institutional coordination at national and international levels. Scoring moved from absent (no reference to collaboration or equity) through limited initiatives, to high alignment where concrete mechanisms for systemic collaboration — including cross-ministerial coordination and cross-border alignment — were embedded in policy design.

2.2 Analytical process

To operationalise data gathering and ensure consistency across a large corpus of policy documents, the research employed an AI-assisted data gathering complemented by systematic human validation. The process unfolded in three stages:

- **Question development**
  For each verification item, researchers formulated 6–8 guiding questions designed to probe how specific principles were addressed in the policy text. These guiding questions ensured that the AI queries were precise, replicable, and aligned with the broader research framework.
- **AI screening**
  Using these guiding questions, the AI reviewed each policy instrument and produced structured outputs, including:
  - Overall assessment – a preliminary interpretation of the degree of alignment between the policy and the verification items.
  - Key evidence points – concise summaries highlighting the most relevant provisions.
  - Direct text extracts – verbatim passages from the policy documents, allowing for traceability of findings and transparent validation.
- **Researcher validation**
  Human researchers systematically examined the AI outputs, verifying the accuracy of the extracted evidence and refining the assessments where necessary.
- **Score definition**
  Based on this review, an alignment score was assigned to each verification item by researchers, ensuring both methodological rigour and contextual interpretation.
  - High (H): Explicit reference with concrete implementation mechanisms (e.g. design requirements, traceability, regenerative practices).
  - Medium (M): Partial or indirect alignment through general sustainability criteria or sectoral measures.
  - Low (L): Minimal overlap or weak conceptual connections with CE principles.
  - Absent (A): No discernible reference or alignment.

This blended approach enabled the team to process a large volume of material efficiently while maintaining analytical depth and quality control, combining the scalability of AI with the judgement of expert reviewers.

AI-ASSISTED POLICY ANALYSIS WORKFLOW

An AI workflow was developed to accelerate the review of the circular economy and bioeconomy policy documents. This process synthesised these documents in response to hypothesis (2), verification items (18), and derived research questions (88) posed by the research team. A roll up Retrieval Augmented Generation (RAG) design was implemented; the system answered the most granular questions (research questions) first and passed those responses upwards to inform broader questions (Verification items). This design emphasised transparency, allowing information to be traced from high-level "hypothesis" down through "sub-questions" and back to the original sources.

The workflow included the following steps: data collection, translation, text extraction, embedding, prompt engineering, and the leveraging of RAG and a Large Language Model (LLM), as well as iterative validation steps.

1. Data collection & translation

Policy documents were collected in multiple formats and languages. Where necessary, documents were converted into PDFs and auto-translated into English, with additional human verification by team analysts fluent in the relevant languages.

2. Text extraction

The PDFs were processed using GROBID, an open-source tool that extracts, structures, and parses text and metadata from PDF documents into TEI (Text Encoding Initiative) files. GROBID automatically segmented the text into paragraph-sized units using Machine Learning (ML) models trained on scholarly documents.

3. Embedding

Paragraph chunks were then embedded into 14,418 dense vector representations using all-MiniLM-L6-v2, a lightweight sentence-transformer model. Embeddings were stored and indexed in FAISS to enable efficient similarity search during retrieval. Each research question was wrapped in a structured prompt and passed to an LLM (Claude Opus 4, via API). The research question itself was also embedded and used to query the vector database. The 20 most semantically similar embeddings were retrieved and provided as contextual input for the model's response.

4. LLM prompts & context

A series of prompts was designed to define the LLM's role and store a basic set of principles and output requirements (system prompt), and to mirror the nested question structure of the research framework: hypothesis, verification items, research questions. These prompts would instruct the model to:

- Identify explicit references to bio-based materials.
- Identify explicit references to circular strategies (regeneration, circulation and substitution).
- Extract relevant quotes and reference information.
- Evaluate the presence and strength of policy provisions against predefined criteria.

Special care was taken to test various formulations of prompts to improve consistency. In addition to the prompts and retrieved text chunks, the model was provided with a key definitions document. This supplementary "Context" file included the Ellen MacArthur Foundation's framing of terms such as circular economy, bio-based materials, and the Universal Circular Economy Policy Goals. The definitions were passed to the LLM as a plain-text file for reference during all runs.

5. Hierarchical roll-up design

The RAG framework used a hierarchical "roll-up" structure. At the research question level, the LLM returned an answer alongside the 20 text chunks it had drawn upon. For the next tier of questions, the model was given both the relevant chunks and the synthesised outputs from the level below. This iterative process continued up the hierarchy, culminating in responses to the hypotheses / verification items.

6. Consolidation of information

The above process was repeated for all 'questions' across all policy documents. Once a document's questions had been processed, the outputs were compiled into a single synthesis PDF. Each synthesis included the model's answers as well as an appendix containing the source text chunks referenced in those answers. This provided researchers with both a structured synthesis and the underlying evidence for a given country's policy set.

7. Execution and iteration

Once all components of the research framework were in place, a structured report was generated for researcher review. The automation was executed across the dataset, with usually two policy documents analysed per country: one circular economy policy and one on policy regulating the production and use of bio-based materials.

During the initial runs, analysts manually cross-checked the automated outputs against the original source materials to evaluate accuracy and identify errors. These iterative runs were used to refine prompt logic, correct implementation issues, and optimise the workflow, with a focus on improving output consistency and accuracy.

3. Results

The comparative analysis of circular economy strategies and complementary policies regulating bio-based materials reveals both convergence and significant gaps.

First, findings suggest bio-based materials-related sectors are underrepresented in circular economy strategies and policy instruments. The prevailing focus on substitution, coupled with weak integration of regeneration and upstream design, risks underutilising the full potential of bio-based materials in delivering systemic outcomes. Countries with more sector-specific approaches illustrate promising practices, but these remain the exception rather than the norm.

The following tables provide a detailed breakdown of the evaluation results:

Each column represents a **single country** as the unit of analysis, scored across circular economy dimensions from High (H) to Absent (A). Columns marked with an asterisk reflect the aggregated analysis of two policy instruments from the same country.

	1	2*	3	4	5*	6	7	8	9	10	11
Design for circularity											
Regeneration principle	H	M	M	M	M	A	L	H	L	L	L
Upstream vs. Downstream bias	H	M	L	L	M	A	L	M	L	L	A
Traceability and Transparency	L	M	L	M	M	L	L	L	L	L	L
Manage value											
Substitution opportunity	M	H	M	M	H	L	M	H	M	M	L
Short-cycle vs. Long-life Design	M	M	M	L	M	L	L	M	L	L	A
Tracking and biomass management	M	H	L	M	M	L	A	L	A	L	A
Making the Economic Works	L	H	A	M	L	A	A	M	L	L	L
Innovation, skills and infrastructure	M	H	L	L	M	A	L	L	L	L	A
Collaboration	M	M	M	M	M	L	L	M	L	M	A

* This column reflects the aggregated analysis of two policy instruments of the same country.

Substitution as the dominant entry point

All policies address substitution (9 out of 11 have a medium/high coverage of this opportunity). This is not surprising, as substitution is a recurring theme in plastics discussions and has become a dominant focus in circular economy strategies. Some policies stop there (half of the policies analysed have just a low coverage or absent when it comes to other verification items that assess commitments on managing value of biobased materials or its design for circularity.

Limited integration of regeneration principles

Another missing point is that most fail to treat regeneration as a guiding principle (just 2 out of 11 policies have a high coverage of this item). As a result, design guidelines overlook the nature-positive outcomes that could be generated by rethinking products and life extension strategies (leaving room for nature and biodiversity to thrive). In addition, end of life resource management fails to create pathways for safe return of biomass to the ecosystem (when it is no longer suitable for higher-value applications).

Gaps in traceability and transparency

All this affects the ability to put in place effective traceability and transparency tools tailored for bio-based materials (8 out of 11 have low coverage on this). Without adequate traceability, it is difficult to monitor sustainability claims, manage cascading uses, or prevent premature diversion of biomass into low-value applications (e.g. energy recovery). This gap limits both accountability and the ability to integrate bio-based materials into international markets where traceability is increasingly a regulatory requirement.

Circulation strategies biased towards downstream measures

When it comes to circulation, policies analysed tend to prioritise downstream strategies, such as waste minimisation and eventually cascading use. When it comes to upstream measures, it is usually connected to innovation in product design for substitution of finite materials or biochemical development to maximise the use of (usually wasted) biomass. Upstream product design guidelines for durability or promotion circular business models (CBM) specifically for bio-based materials remain mostly generic – this is not entirely unexpected, as circular economy strategies tend to propose commitments that are material- and product-agnostic, advancing into these specificities in further policy developments. As a result, measures remain aspirational and dependent on future sector-specific regulations.

Sector-specific maturity in a subset of countries

In this context, some countries go further and demonstrate greater maturity in terms of material coverage, usually through **sector-driven regulation that offers more specific provisions** that acknowledge the particularities of both materials and products. Consequently, these policies present a broader range of measures and strategies (4 out of 11 demonstrate high/medium maturity on tracking and biomass management) — fundamental to setting up guidelines for multiple uses with sector-specific considerations (preventing premature conversion to energy), promoting industrial symbiosis, and developing end-of-life strategies.

Secondly, the analysis indicates that many existing policy incentives for the production and use of bio-based materials continue to reinforce linear practices. Even where these policies reference regenerative objectives, they often prioritise applications that lock materials into short-use cycles (such as single-use products or low-value applications). This limits the potential of bio-based materials to circulate through multiple, higher-value loops before returning safely to the biosphere.

Instruments analysed (regulating the production and use of bio-based materials) were grouped under four categories: bioeconomy, "green/new" industry, agriculture/forestry, and biodiversity. Expected impacts vary by policy strategy type (e.g. reuse and product design are more relevant for industrial policies, while regeneration aligns more with agriculture and forestry-related frameworks).

Each column represents a single policy instrument as the unit of analysis, scored across circular economy dimensions from High (H) to Absent (A). The column marked with an asterisk presented insufficient evidence for quantitative analysis; excluded at this stage of the research.

	Bioeconomy								Industry				Agro/Forestry			Biodiversity		
	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	16	17	18
Design for circularity																		
Regeneration opportunity	M	M	H	H	L	M		L	A	M	L	L	M	H	L	M	L	M
Upstream vs. Downstream bias	M	H	A	A	L	M		A	L	M	A	M	A	L	A	A	A	L
Traceability and Transparency	M	M	L	L	M	M		L	A	M	L	H	L	L	A	A	A	M
Manage value																		
Circulation / multiples uses	L	M	A	A	A	M		L	A	M	M	L	L	A	A	A	A	A
Substitution / Trade-off Management	A	M	L	L	A	L		A	A	L	L	A	L	L	L	L	A	L
Tracking / tools for biomass management	L	M	L	L	M	M		A	A	M	A	L	A	L	A	A	A	L
Making the Economic Works	L	M	M	L	H	L		M	L	H	M	M	L	M	M	L	L	L
Innovation, skills and infrastructure	M	M	L	L	M	M		M	M	M	L	L	L	M	L	L	L	L
Collaboration	M	H	M	M	M	M		M	M	H	L	M	A	A	M	A	L	L

* Insufficient evidence for quantitative analysis; excluded at this stage of the research

Limited Integration Across 17 Policies

Considering a matrix of 17 policies evaluated against 9 verification items (totalling 153 evaluation points), only 6% of the scores were rated as having a high level of alignment (H). In contrast, 61% were rated as either low (L) or absent (A) in alignment.

Limited Policy Alignment on Regeneration

When it comes to the recognition of the regenerative outcomes of the production of bio-based materials, only 3 - out of 17 - policies demonstrate a high coverage. It is interesting to note that two of those coincide with a country that demonstrated high coverage of the regeneration principle in the circular economy strategy, suggesting that such a principle could resonate across a broad set of policy instruments, thereby increasing policy alignment.

Neglected Enablers for Resource Circulation and Safeguards

The weakest alignment is found in the criteria that evaluate enablers to manage resources and keep materials in use for longer (88% of evaluation points were rated as either low (L) or absent (A) in alignment).

- Here, most policies tend to neglect opportunities to circulate materials in higher value loops - 13 out of 17 scoring absent or low in this item. This means the policies tend to focus only on biomass production with no reference to circular use in off-taker sectors; occasionally, when they go beyond production, they mention end-of-pipe solutions, but do so under a linear production model with minimal articulation of how these materials could flow through circular systems.
- Still in this subset, most policies analysed fail to anticipate or mitigate ecological trade-offs such as land-use competition, biodiversity loss, or food system pressures — particularly by overlooking circular safeguards (circulation and regeneration) for the substitution of finite materials for bio-based ones — 16 out of 17 scoring absent or low in this item.. This means that policies tend to frame bioeconomy and other instruments analysed as inherently positive or only consider economic aspects. Policies occasionally focus on scaling production to generate more value in the economy rather than ensuring materials circulate through the economy. The emphasis on “import substitution” suggests a linear approach rather than circular thinking.

Additional box - Investigation on international trade related instruments

Given the transnational nature of the value chains studied, this research began with a desk review to characterise the general dynamics of the materials and products under analysis.

A particular emphasis was placed on the Global South, with a deep dive designed to clarify the region's role in bio-based value chains, its degree of inclusion in global standards, and the maturity of policy frameworks shaping this international trade.

This research was organised into two interrelated strands:

The first strand assessed how existing voluntary sustainability standards (VSS) incorporate and reflect circular economy principles within bio-based value chains. The analysis drew on a curated sample from the ITC Standards Map, a database of over 360 sustainability standards. A selective, criteria-driven approach was applied, prioritising standards that directly cover key bio-based materials.

The sample included GOTS, FSC-STD-01-001, FSC-STD-40-004, FSC-STD-40-005, ASTM D6400, EN 13432, and a suite of OEKO-TEX® standards (STANDARD 100, ECO PASSPORT, LEATHER STANDARD, MADE IN GREEN, ORGANIC COTTON, RESPONSIBLE BUSINESS).

Each standard was evaluated against three reference frameworks: the Ellen MacArthur Foundation's circular economy principles, The Universal Circular Economy Policy Goals, and coverage across the product value chain, from input sourcing and production to end-of-life and return cycles.

Key guiding questions included identifying which materials and sectors are covered, assessing how far upstream or downstream the standards apply, and examining whether the criteria incorporate circularity elements such as durability, repairability, recyclability, renewable content, or non-toxicity.

The second strand examined HS Codes and Environmental Goods and Services (EGS) lists to assess how existing and emerging EGS lists integrate durable bio-based materials and how these proposals align with circular economy principles. The analysis focused on three EGS-related initiatives:

- The Agreement on Climate Change, Trade and Sustainability (ACCTS).
- The Asia-Pacific Economic Cooperation (APEC).
- The WTO's Trade and Environmental Sustainability Structured Discussions (TESSD).

Key guiding questions included whether durable bio-based materials such as wood, fibres, and paper are explicitly included, the type of sustainability criteria applied, and the extent to which the proposals recognise circular or regenerative practices or risk reinforcing linear models and misalignment with circular economy goals.

Additional box - business case studies

Alongside the core policy research, a complementary investigation examined business cases already putting the report's vision into practice. The aim was to illustrate how circular economy principles are being applied to the production and use of bio-based materials, and to highlight the environmental, economic, and social benefits emerging from these approaches. While not a comprehensive dataset, these cases offer tangible evidence of the outcomes that circular bio-based strategies can unlock, helping build momentum for wider adoption.

Identification of Pioneering Companies

The process began with an extensive desk-based scan to identify companies operating at the forefront of regenerative and circular practices for bio-based materials. This initial mapping surfaced **97 cases** across sectors such as textiles, packaging, agriculture, retail, and forestry. These cases covered a wide spectrum of business models, including regenerative sourcing, product redesign for extended lifecycles, cascading use of materials, and innovations in biological recycling.

The mapped cases were then evaluated using two analytical filters:

1. **Admissibility** – to confirm each case genuinely applied circular economy principles to bio-based materials and provided enough public data for analysis.
2. **Circularity Classification** – to assess how extensively circular opportunities were captured, considering the range and depth of strategies (e.g. regenerative production, reuse, remanufacturing, recycling).

This two-step process produced a refined shortlist of companies that best exemplified the vision of a circular bio-based economy.

Industry Outreach and Interviews

Following the analytical screening, the team conducted targeted outreach to representatives of the shortlisted companies. The objective was to complement publicly available information with direct insights into business motivations, operational challenges, economic rationales, and observed impacts. In total, **ten interviews** were completed with organisations operating in different regions and value chains.

Synthesis and Integration into the Report

The insights generated through this process were consolidated into a structured evidence table and reviewed alongside the policy findings. The most representative outcomes — such as improvements in soil health, cost savings from material recirculation, risk reduction through supply diversification, job creation in local processing, and enhanced product differentiation — were then woven into the main chapters as illustrative examples.

These business cases serve two complementary functions within the report:

- **Demonstrating feasibility:** They show that regenerative and circular practices for bio-based materials are already being implemented competitively across multiple sectors.
- **Supporting recommendations:** They help illustrate how the proposed policy measures could enable these pioneering initiatives to scale, evolve into broader market standards, and generate systemic benefits.

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THE ELLEN MACARTHUR FOUNDATION

CORE PROJECT TEAM:

Guilherme Suertegaray
Senior Manager Business Engagement – Latin America

Milena Lumini
Communications Manager – Latin America

Lenaïc Gravis
Editorial Development Manager

Caroline Coutinho
Content Coordinator – Latin America

Victoria Almeida
Network Manager – Latin America

Marianne Kettunen
Biodiversity Lead

Leo Nutter
Technology Lead

Hannah Stewart
Senior AI Researcher

Ian Banks
Independent Editorial Consultant

WIDER TEAM:

Jocelyn Blériot
Executive Lead Policy and Institutions

Luisa Santiago
Latin America Lead

Pedro Prata
Senior Manager Policy and Institutions – Latin America

Gustavo Alves
Policy and Business Engagement Manager – Latin America

Sarah O'Carroll
Institutions Lead – Policy

Miranda Schnitger
Climate Lead – Policy

Oriol Izquierdo
Project Manager – Policy

Sophie Moggs
Policy Analyst – Policy

Laura Smith
Programme Manager – Plastics

LATIN AMERICA AND CARIBBEAN CIRCULAR ECONOMY COALITION SECRETARIAT AT UNITED NATIONS ENVIRONMENT PROGRAMME:

Beatriz Martins Carneiro
Regional Coordinator of the Subprogram – Finance and Economic Transformations

Hindara Guetsanee Pacheco Bandres
Consultant – Finance and Economic Transformations

FURTHER CONTRIBUTORS

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Alessandro Sanches
Executive Director - Instituto i17

Alysia Garmulewicz
Co-CEO and Founder - Materiom

Ana Velloso - IKEA
Sustainability Leader – External Engagement & Partnership - Inter IKEA Group

Catalina Posada Salazar
Líder de Innovación y Sostenibilidad
Crystal Group

Chantal Line Carpenter
Head, Trade, Environment & Climate Change - International Trade and Commodities Division - UNCTAD

Devparna Acharya
Head communications - Zero Circle

Dionne Ewen
Manager Sustainability & ESG - Ahrend

Ebenezer Laryea
Project Director - FreshPPacts

Edson Pacheco Junior
Responsabilidade Ambiental - Klabin Group

Eduardo Moller Ferlauto
Diretor de Sustentabilidade - Lojas Renner S.A

Henrique Pacini
Economic Affairs Officer - Trade and Environment Branch - DITC - UNCTAD

Jack Barrie
Independent Researcher Consultant

João Tiago Camargo
Independent Graphic Designer

Joel Alves
Independent Graphic Designer and Illustrator

Juliana M Seidel
Sustainability Director - Amcor

Lorenzo Formenti
Independent Advisor - UNCTAD SMEP

Mahadev Chikkanna
Founder - Mynusco

Mariano Pineyrua
CEO TraceSurfer - TraceSurfer

Nevio Benvenuto
Head of Sustainability & Circularity - Gucci

Sidse Jensen
Senior Specialist - FSC Circularity Hub

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About the Ellen MacArthur Foundation

The Ellen MacArthur Foundation is an international charity that develops and promotes the circular economy in order to tackle some of the biggest challenges of our time, such as climate change, biodiversity loss, waste, and pollution. We work with our network of private- and public-sector decision makers, as well as academia, to build capacity, explore collaborative opportunities, and design and develop circular economy initiatives and solutions. Increasingly based on renewable energy, a circular economy is driven by design to eliminate waste, circulate products and materials, and regenerate nature, to create resilience and prosperity for business, the environment, and society.

Further information: ellenmacarthurfoundation.org

About the Latin America and the Caribbean Circular Economy Coalition

The Circular Economy Coalition for Latin America and the Caribbean was launched in 2021, in the framework of the XXII Meeting of the Forum of Ministers and High-Level Authorities of Environment of the region, to serve as a regional platform to enhance inter-ministerial, multi-sectoral and multi-stakeholder cooperation, increase knowledge and understanding on circular economy, and provide capacity-building and technical assistance for the development of public policies for circular economy and sustainable consumption and production. It currently comprises 18 governments, coordinated by the United Nations Environment Programme (UNEP) and led by a steering committee composed of five high-level government representatives on a rotating basis. Its current steering committee members include Brazil, Argentina, Chile, Ecuador and Paraguay, together with six strategic partners: the Climate Technology Centre & Network (CTCN), the Ellen MacArthur Foundation, the Inter-American Development Bank (IDB), the World Economic Forum (WEF), the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), and UNEP.

Further information: coalicioneconomiacircular.org

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ENDNOTES

1 Ellen MacArthur Foundation, Universal Circular Economy Policy Goals, 2021BRASIL, Plano Nacional de Economia Circular 2025-2034. 2025.

2 Ministério da Agricultura e Pecuária. Plano ABC e ABC+. Governo Federal Do Brasil, n.d.

3 BRASIL. Plano de Ação para a Neoindustrialização 2024-2026. Brasília: Ministério do Desenvolvimento, Indústria, Comércio e Serviços, Conselho Nacional de Desenvolvimento Industrial (CNDI); n.d.

4 BRASIL. Consulta Pública do Plano Nacional de Desenvolvimento da Bioeconomia - Sociobioeconomia. 2025.

5 CHILE. Roadmap for a circular Chile by 2040. 2022.

6 CHILE. National Biodiversity Strategy of the Republic of Chile. 2003.

7 COLOMBIA. Estrategia nacional de economía circular : Cierre de ciclos de materiales, innovación tecnológica, colaboración y nuevos modelos de negocio. Bogotá D.C: 2019.

8 COLOMBIA. Bioeconomía para una Colombia Potencia viva y diversa: Hacia una sociedad impulsada por el Conocimiento. Bogotá D.C: 2020.

9 COLOMBIA. Política Nacional para el Control de la Deforestación y la Gestión Sostenible de los Bosques 2020.

10 COLOMBIA. Política Nacional de Reindustrialización 2023

11 COSTA RICA. Estrategia Nacional de Economía Circular. San José: Ministerio de Ciencia, Tecnología y Telecomunicaciones (MICITT); 2023.

12 COSTA RICA. Estrategia Nacional de Bioeconomía. San José: Ministerio de Ciencia, Tecnología y Telecomunicaciones (MICITT); 2020.

13 RWANDA. Rwanda National Circular Economy - Action Plan and Roadmap. 2022.

14 EAC. The East African Regional Bioeconomy Strategy. 2022.

15 Pantsar M, Herlevi K, Jarvinen L, Laita S. Leading the cycle - Finnish road map to a circular economy 2016–2025. Sitra Studies 121. SITRA; 2016.

16 FINLAND. Government Resolution on the Strategic Programme for Circular Economy. 2021.

17 FINLAND. The Finnish Bioeconomy Strategy. Bioeconomy 2025.

18 FINLAND. The National Forest Strategy 2035. Ministry of Agriculture and Forestry; 2023.

19 FRANCE. 50 Measures for a 100% circular economy. 2019.

20 FRANCE. A Bioeconomy Strategy for France - 2018-2020 Action Plan. 2018.

21 INDIA. National Biotechnology Development Strategy 2021-2025. 2023.

22 SOUTH AFRICA. National Waste Management Strategy 2020. 2020.

23 SOUTH AFRICA. The Bio-economy Strategy. n.d.

24 VIETNAM. Approving the Scheme for Circular Economy Development in Vietnam 2022.

25 VIETNAM. National Action Plan on Sustainable Consumption and Production (2021-2030). 2020.

26 CANADA. A Healthy Environment and a Healthy Economy. 2020.

27 CANADA. Bioindustrial Innovation Canada. Canada's Bioeconomy Strategy - Leveraging our Strengths for a Sustainable Future. 2022.

28 CANADA. Canada's 2030 nature strategy: halting and reversing biodiversity loss in Canada. Environment and Climate Change Canada; 2024.

29 NETHERLANDS. National Circular Economy Programme 2023-2030. 2023.

30 NETHERLANDS. Transition Agenda Biomass and Food. 2018.

31 NETHERLANDS. The Position of the Bioeconomy in the Netherlands. 2018.

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