

Harnessing the Bioeconomy-Climate Nexus for Sustainable Development

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About

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Acronyms

ACB	ASEAN Centre for Biodiversity
AFOLU	Agriculture, Forestry and Other Land Uses
BIP	Brazil's Climate & Ecological Investment Platform
CAPEX	Capital expenditures
COP	Conference of the Parties
CRDC	Climate Resilient Debt Clauses
CRU	Carbon Removal Units
DFI	Development Finance Institutions
DMO	Debt Management Offices
DSI	Digital Sequence Information
EC	European Commission
FAO	Food and Agriculture Organization
FIMA	Financial Materiality Assessment
GBF	Global Biodiversity Framework
GCF	Green Climate Fund
GDP	Gross domestic product
GHG	Greenhouse gases
G20	Group of Twenty - international forum which includes many of the world's largest economies
HLP	High-level principles
IDB	Inter-American Development Bank
IDEFLOR-Bio	Institute for Forest Development and Biodiversity of Pará
IFI	International financial institutions
ILO	International Labour Organization
IMF	International Monetary Fund
JETPs	Just Energy Transition Partnerships
KPI	Key Performance Indicators
LFI	Large financial institutions
LMIC	Low and middle-income countries
MDBs	Multilateral development banks
MSME	Micro, small and medium enterprises
NbS	Nature-based Solutions
NBSAPS	National Biodiversity Strategies and Action Plans
NDBs	National development banks
NDC	Nationally Determined Contributions
NGO	Non-Governmental Organization
OPEX	Operating expenses
PPBio	The Priority Program for Bioeconomy - investment mechanism for the bioeconomy
R&D	Research and development
ROI	Return on investment
SDG	Sustainable Development Goals
SLB	Sustainability-linked bond
SME	Small and medium-sized enterprises
TFFF	Tropical Forest Forever Facility
TNFD	Taskforce on Nature-Related Financial Disclosure
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URs	Recovery Units
URTX	Triunfo do Xingu Recovery Unit

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Introduction

The bioeconomy is a socio-economic model for the sustainable production, use and transformation of renewable biological resources across economic sectors. It offers immense potential to address the connected challenges of climate change, food security, economic development, poverty reduction and sustainable growth. Bioeconomy activities aim to create economic value, as well as social and ecological benefits, particularly for local communities. Large and growing rapidly, its estimated current value is US\$4-5 trillion globally, with growth potential to US\$30 trillion if enabled by targeted government commitments, public-private partnerships, international cooperation, governance and finance (NatureFinance & World Bioeconomy Forum, 2024).

Since 2024, the agenda of bioeconomy has gained increasing relevance following the launch of the G20 Initiative on Bioeconomy. The final declaration of the G20 leaders in 2024 (G20, 2024) acknowledged the High-Level Principles on Bioeconomy (G20 Initiative on Bioeconomy, 2024) and highlighted its global importance in advancing the financing of nature-based solutions. This marked the first time the bioeconomy became a focus in a multilateral decision document and acquired such significant traction among the world's largest economies. The momentum has been sustained into 2025, continuing under South Africa's presidency of the G20.

The bioeconomy is a hugely under-valued potential contributor to climate mitigation, adaptation and increasing resilience. It can provide bio-based sustainable alternatives to carbon-intensive products, drive regenerative agricultural practices and create circular forest and agricultural economies that help extend soil health and productivity, and prevent deforestation and land conversion. It can also support scientific developments and products such as synthetic biology, genomics and bioinformatics, as well as encompass service-based activities such as tourism and gastronomy. The larger and more sustainably it develops, the more the bioeconomy benefits nature, climate, and inclusive and resilient socio-economic development.

Framing and Defining the Bioeconomy

The bioeconomy, while lacking a universally accepted definition, is broadly understood to mean using renewable biological resources to generate sustainable products, services, employment and income. The OECD, for instance, labels it as "leveraging renewable biological resources, efficient bioprocesses, and eco-industrial clusters to generate sustainable bioproducts, employment, and income" (OECD, 2004). The term bioeconomy is broad and interpreted differently across countries and territories. To structure the concept for analysis, we frame the bioeconomy as a spectrum of three interdependent segments: the Nature Intensive Bioeconomy, the Advanced Bioeconomy and the High-Tech Bioeconomy (NatureFinance & World Bioeconomy Forum, 2024).



Nature Intensive Bioeconomy

The **Nature Intensive Bioeconomy** refers to an economic system that utilizes biological resources, processes, and principles to produce goods and services. It encompasses various sectors including **agriculture, forestry, fisheries, food and bioenergy**. The goal of the bioeconomy is to create sustainable economic growth, while reducing environmental impact and dependency on fossil fuels.



Advanced Bioeconomy

The **Advanced Bioeconomy** represents an evolution from traditional bioeconomic practices, focusing on the use of **innovative technologies and advanced biological processes to create value-added products**. It aims to address environmental and economic challenges by providing sustainable alternatives to fossil-based products and enhancing the efficiency and sustainability of production processes.



Hi-Tech Bioeconomy

The **High-Tech Bioeconomy** refers to the segment of the bioeconomy focused on producing **high-value, specialized, and often technologically sophisticated bioproducts**. These products are characterized by their advanced functionalities, innovation, and higher market value compared to traditional bio-based or commodity goods.

The **Global Bioeconomy Stocktake** (NatureFinance & FGV, 2024) identified over 60 countries and regions having bioeconomy or bioscience-related strategies. The above segmentation does not suggest a hierarchy but rather emphasizes the diversity of the bioeconomy as a continuum. These segments should be understood as part of a broader spectrum rather than rigid categories, as there are overlaps and gradual transitions between them. In the context of the bioeconomy-climate nexus, the nature-intensive segment of the bioeconomy is most obviously and immediately vulnerable to climate impacts; for example, disrupted agricultural production and fisheries due to temperature increases and extreme climate events. It also has the most dramatic impacts in terms of addressing climate mitigation, adaptation and resilience increase by, for example, preventing deforestation, land-conversion and agriculture with high greenhouse gases (GHG) emissions. The advanced bioeconomy is gradually but meaningfully affected by climate change as warming temperatures begin to affect and degrade the sustainability benefits of key products such as bioplastics. The high-tech bioeconomy offers the most potential to "rescue" the nature-intensive sectors of the bioeconomy, through science and innovation-based approaches such as controlled environment agriculture and aquaculture. However, this requires longer term and capital-intensive strategies to deliver results at scale.

Integrating Bioeconomy Solutions into 2025 Nationally Determined Contributions (NDCs)

The 2025 NDC process represents a significant opportunity for countries to integrate bioeconomy solutions as a key driver of ambitious mitigation, adaptation and resilience increase outcomes. The [third round of NDC development](#) has several unique aspects that lend itself to bioeconomy solutions (World Resources Institute, 2024), namely: an increased focus on sectoral approaches; a growing emphasis on nature-based solutions; the opportunity to align with other global commitments like the Global Biodiversity Framework (GBF); a focus on comprehensive investment planning and specific investment-ready projects; an emphasis on adaptation and resilience increase in areas like food security and sustainable agriculture and forestry; and an emphasis on catalyzing investment in innovation and research. Particularly for nature-rich low- and middle-income countries, the 2025 NDC process provides a holistic platform to help accelerate the transition towards a sustainable bioeconomy while addressing climate change and promoting sustainable development.

Through a whole-of-government approach to mainstreaming bioeconomy-based climate action across sectors, countries can maximize synergies between climate mitigation, nature conservation, and sustainable natural resources utilization. Specifically, this helps to link NDCs and [National Biodiversity Strategies and Action Plans \(NBSAPS\)](#) (Convention on Biological Diversity, 2025) in ways that are designed to reduce transaction costs for countries and enhance policy coherence and strategic alignment of green economic transition strategies. By prioritizing just and equitable approaches to bioeconomy initiatives, countries can ensure inclusive participation and widespread benefits, particularly for Indigenous Peoples, Afro-Descendant and Traditional Communities, as well as for small-scale farmers. Also by clearly communicating the means of implementation and support needed for effective bioeconomy target achievement within the NDCs, countries can provide signposts for country platforms and other sources of international/bilateral/multilateral and private sector financing to integrate nature as both a climate solution and sustainable development paradigm.



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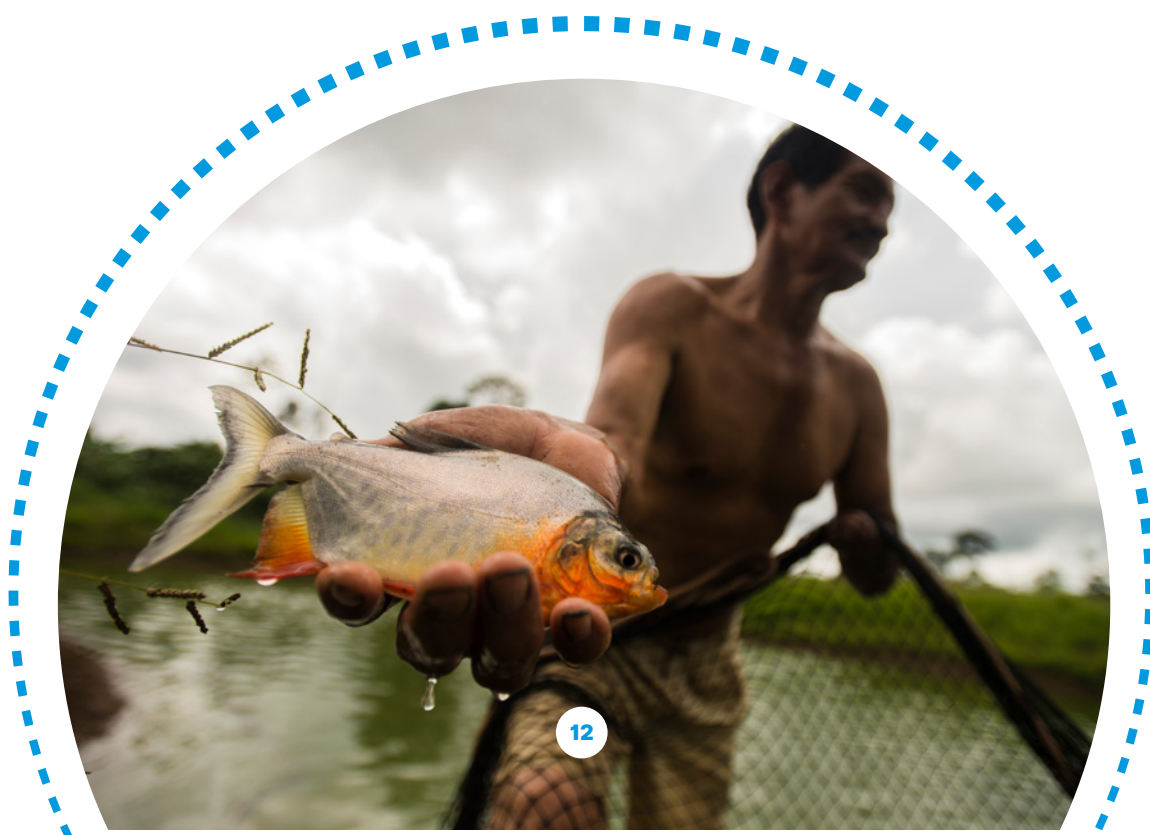
CHAPTER 1

Key Challenges at the Bioeconomy- Climate Nexus

The bioeconomy's potential to support climate change mitigation and adaptation has been widely studied, yet there is much less evidence on how climate change directly impacts the various bioeconomy sectors, particularly as the world moves beyond the 1.5°C warming threshold. According to the latest estimates in the [Emissions Gap Report 2024](#) by the United Nations Environment Programme (UNEP), **if current climate policies and mitigation efforts remain unchanged, global warming is projected to reach 3.1°C by the end of the century**. This is more than double the 1.5°C target agreed in the Paris Agreement, which represents the safer threshold to minimize severe climate impacts (UNEP, 2024). Extreme floods, droughts, wildfires and heat are already a fact of life for many countries, with their impact being felt across bioeconomy sectors in Latin America and beyond.

Specifically, climate change impacts on nature intensive sectors such as agricultural productivity, has been extensively documented. Other less studied sectors include the climate change effects on the depletion of riparian ecosystems, and the protection service that nature can confer to hydro-climate extremes in these ecosystems. But there are also more nuanced threats to more advanced bioeconomy sectors in a beyond 1.5°C warmed world. For example, at higher temperatures, more advanced bio-based products and solutions to the climate crisis lose the qualities that make them more sustainable (e.g. altered bioplastic decomposition and lowered biofuel quality). This means that some bioeconomy solutions to the climate crisis may have time limits and scientific thresholds that demand immediate, scaled investment and action to capture their benefits. Conversely, increasing temperatures may offer new solutions through some palm species of local economic importance, such as 'Macaúba' in the Brazilian Amazonia, Cerrado and other biomes, which can adapt to poorer soils and higher temperatures, thus supporting to bridge the impacts of climate change on production for local livelihoods and markets.

Besides speedy deployment, to effectively respond to the climate crisis, bioeconomy solutions must also secure broad participation and sustained support from critical stakeholders, thus ensuring an inclusive and fair distribution of the benefits and financial rewards. We identify **seven key overall challenges at the nexus of the climate crisis and the bioeconomy** that require proactive policy and finance interventions in the short to medium term.



Key Challenges

- 1

Climate Vulnerability

The climate crisis undermines the sustainability of bio-based solutions, particularly in very sensitive sectors and ecosystems, such as those for food production, coastal and riparian ecosystems for extremes protection, and other more specific provisioning sectors such as the materials sectors. Delayed substitution of carbon-intensive approaches for sustainable bioeconomy approaches exacerbates these risks, particularly for nature-rich countries.
- 2

Systemic Risks

Bioeconomy sectors face interconnected risks, such as extreme climate events, biodiversity loss, and market volatility that threaten the long-term viability of bio-based products and services. From drought conditions affecting river navigability and therefore local trade and logistics, to production seasonality limiting raw materials steady supply for secondary transformation; risks to the bioeconomy need to be understood with systemic lenses.
- 3

Uneven Access to Technology and Finance

Developed countries leverage financial and technological advantages to advance innovative bioeconomy solutions (e.g. high value bioproducts, traceability of product origin through isotopes, artificial intelligence, and geospatial modelling tools). Gaps in financing mechanisms and capacity building hinder equitable development in less developed countries.
- 4

Equity and Development Challenges

Resource-rich but technology-limited countries remain dependent on nature-intensive segments that generate lower economic value and face greater climate risks. A reliance on standardized commodity exports exacerbates vulnerability to global market fluctuations and biodiversity exploitation. New international trade regulations may also need to factor in the fluctuations in production and supply of key agroforestry commodities as a result of climate change impacts.
- 5

Shifting Sustainability Dynamics

Climate change alters not only the availability and access, but also the sustainability of bioeconomy products and services, such as bioplastics, which are vulnerable to warming trends and ecosystem disruptions.
- 6

Governance and Institutional Fragmentation

Bioeconomy initiatives in developing countries face several challenges: institutional fragmentation (e.g. misaligned priorities across ministries and government levels), limited capacity to design and enforce integrated policies, political pressure and lobbying by extractive industries favoring short-term extraction over long term sustainability. Also, investors often hesitate to support bioeconomy projects because governments fail to provide regulatory frameworks and guarantees for their investments. Financial risk mitigation measures provided by international financial institutions (IFIs) could help to reduce the perceived risks for private investment in the bioeconomy.
- 7

Inclusive Benefit Sharing

A critical challenge is ensuring bioeconomy initiatives deliver tangible benefits to Indigenous Peoples, Afro-descendants and Traditional Communities and small-scale producers—key custodians of biodiversity. Without intentional mechanisms for inclusive decision-making, capacity-building and fair revenue-sharing, bioeconomy projects risk perpetuating inequality or displacing traditional livelihoods.

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CHAPTER 2

High-Level Policy Recommendations

This document considers opportunities for countries, the private sector, multilateral development banks (MDBs), national development banks (NDBs) and other international/large financial institutions (IFIs/LFI) to leverage the bioeconomy as a central pathway for climate and nature action, mindful of the climate crisis' growing threats to the bioeconomy. It advocates continued support for the successful development of a sustainable and resilient bioeconomy at scale to combat a context of growing climate disruption that exacerbates intrinsic vulnerabilities, by removing barriers, fostering innovation, and creating an enabling environment for bioeconomic growth.

We provide five high level policy recommendations and identify three strategic recommendations. The recommendations were selected through a dual approach, leveraging expertise and experience in this domain, as well as based on previous assessment conducted by NatureFinance and partners. First, a comprehensive literature review mapped climate-related challenges and opportunities across the bioeconomy spectrum, yielding five high-level policy recommendations aligned with urgent, consensus-backed priorities. Second, three strategic framework recommendations were prioritized to address gaps in existing discourse considered critical for enabling a sustainable and investable bioeconomy, particularly in the Global South.

Final prioritization was guided by five criteria: (i) climate impact (alignment with mitigation and adaptation goals); (ii) equity (e.g. inclusive benefit-sharing mechanisms); (iii) feasibility (potential to mobilize public or blended finance in the short to medium term); (iv) future-proofing (resilience in warming scenarios); and (v) policy synergy (consistency with global agendas such as NDCs, COP30, and G20 priorities).

These strategic recommendations are: the importance of financing and scaling the bioeconomy in a manner that is (1) equitable, (2) quick, and (3) adaptive to dramatic shifts in the operating environment. Designing for equity, speed, and adaptability is essential to avoid losing momentum in the pursuit of NDC targets, either because climate change renders bioeconomy solutions obsolete or political support is lost due to inequity in development. This discussion paper pays special attention to these three strategic recommendations, offering new thinking and concrete examples under each for countries, MDBs, NDBs, other IFIs/LFIs and the private sector to consider incorporating directly into its operations and/or to promote more widely.



High-Level Policy Recommendations



Integrate the Bioeconomy into Green Economic Transition

Provide Fiscal Incentives: Governments should offer tax breaks, subsidies, preferential procurement and concessional loans to encourage sustainable production practices in promising bioeconomy sectors. Embedding the bioeconomy in national green taxonomies is an important mechanism to accomplish this.

Support Small and Medium-sized Enterprise (SMEs) and Micro, Small and Medium Enterprises (MSMEs): Strengthen government policies and financial mechanisms—particularly through national development banks and LFI—to connect SMEs and MSMEs with global markets and scale strategic, bioeconomy sectors. Creating regional networks of NDBs to share their institutional strengthening trajectory has also resulted in positive outcomes, particularly by increasing financial flows to key bioeconomy sectors.

Establish a Bioeconomy MDB Facility: This facility could translate into a whole-of-sectors approach to address the systemic risks driving bioeconomic potential loss. A multilateral facility could inform strategies and provide and channel financial resources for bio-based products value chains, while responding to countries' needs, and provide links to broader strategies on green economic transition and green industrial policy. A G20/COP30 platform could galvanize support.



Enhance Natural Resource Management for Resilience

Nature as Infrastructure: Support bioeconomy-dependent infrastructure such as waterways in forest-based economies, promote urban biodiversity credits for climate change adaptation and integrate nature-based solutions into national climate strategies, focusing on territorial approaches for collective action. For example, urban-based biodiversity credits anchored in restoring key ecosystem services such as heat resistance can offer dual fiscal-environmental benefits.

Nature as a Shock Absorber: Develop targeted financing schemes to help transition vulnerable, nature-intensive, bioeconomy sectors towards more sustainable practices. For example, through adaptive social protection and insurance mechanisms that address short-term risk and up-front costs.

URTX: Brazil's First Forest Restoration Concession

The Triunfo do Xingu Recovery Unit (URTX), located in Pará, Brazil, is pioneering a novel, 40-year forest concession dedicated to ecological restoration. This groundbreaking initiative is the first of its kind in Brazil and reflects the country's growing commitment to scaling up restoration through legal innovation and public-private collaboration.

Forest concessions in Brazil began in 2006 with the enactment of the Public Forest Management Law nº 11.284/2006, which aimed to promote sustainable timber production and reduce illegal logging. In Pará, a pioneer in this sector, 11 forest concession contracts are currently managed by the Institute for Forest Development and Biodiversity of Pará (IDEFLOR-Bio). At the Federal level, 23 such agreements in National Forests are active.

A critical milestone came in 2023, when Federal Law 11.284/2006 was amended by Law 14.590/2023, eliminating a restriction that previously prohibited concessionaires from generating and selling carbon credits. This amendment created a new class of forest concessions, focused on environmental restoration and carbon sequestration.

The State of Pará enacted Law 10.259/2023 the same year, establishing a new protected area category known as Recovery Units (URs). These areas are explicitly designated for regenerating degraded or deforested public lands, with the State assuming long-term stewardship responsibilities. This new legal framework enabled the development of the URTX project, which was designed to attract private investment while generating measurable environmental and social benefits.

The URTX concession—Pará's first restoration-focused concession—covers 10,370 hectares of degraded public land. Under the 40-year contract, the selected concessionaire will implement forest restoration and conservation actions that meet clearly defined ecological and social performance indicators. In return, the private operator may generate revenue through the sale of carbon credits and the sustainable management of native species, timber, and non-timber forest products. An annual grant payment to the State of Pará is also required.

IDEFLOR-Bio, as the State's Granting Authority, is responsible for delegating, managing, and monitoring all forest concession agreements, including URTX. The public tender for URTX was launched in late 2024, and the auction took place on March 28, 2025, at the B3 Stock Exchange in São Paulo.

The selected concessionaire is expected to invest approximately R\$258 million (around US\$45.3 million), including both capital expenditures (CAPEX) and operational costs (OPEX) throughout the concession term. Projected gross revenues are R\$869 million. The project is estimated to sequester 3.7 million metric tons of CO₂ equivalent over the years of concession.

In summary, the URTX project marks a transformative shift in Brazil's forest policy, leveraging recent legal reforms, innovative financing mechanisms, and public-private partnerships to promote large-scale restoration in Amazonia. It aligns with national and global climate objectives and creates a replicable forest recovery model that integrates economic opportunity, environmental integrity and social inclusion.



Develop Lifeboat Strategies for High-Risk Sectors

Sectoral/Landscape Adaptation Plans contributing to safe and stable economies: For NDCs and development plans, prioritize sectors critical for livelihoods, peace, security, fragile territories, and economic resilience. Specific territorial plans would also allow actions to address risks anchored in insecurity, illicit economies, integrity, which would also prevent private investments in the bioeconomy.

Beyond 1.5°C Scenarios: Model vulnerabilities to identify adaptive interventions that extend the viability of bioeconomy sectors. Assess trends and dynamics in shifting ecological and site suitability for production.

Bioeconomy-Climate Observatory: Consider establishing a bioeconomy-climate observatory to gather, share and analyze data in partnership with external stakeholders about the interdependencies between the bioeconomy and climate crisis, drawing in real time observations and cutting-edge science particularly for key value chains.

Indoor/Regional Shifts: As the temperature increases, explore shifting production of key agricultural products to controlled environments or new ecologically suitable sites, recognizing that the long lead time and capital-intensive nature of investments requires urgent near-term action.



Foster Global Collaboration, Collective Intelligence and Innovation

Leverage emerging technologies and invest in Research and Development (R&D): Governments should fund scalable, climate-resilient bioeconomy research, emphasizing collaboration between governments, academia, and the private sector, both across South-South and North-South dimensions.

Enhance Technical Assistance: A growing number of countries and financial institutions have accumulated substantial bioeconomy knowledge and could provide training on sustainable practices, resource management and climate change adaptation.

Global, Regional and South-South Cooperation: MDBs and international partners can help facilitate cross-border collaboration on bioeconomy best practices and technologies. They can help leverage successful bioeconomy models between Pan-Amazonian countries, Latin America, the Caribbean, and emerging economies, as well as between Global North and Global South stakeholders. This includes building trust and strengthening stakeholder collaboration.



Facilitate Trade Integration and Access to International Markets

Promote Trade Incentives: Countries and regional trade bodies should make bioeconomy goods eligible for the same subsidies that unsustainable products currently enjoy.

Promote Trade Harmonization: Embed bioeconomy, high-level principles (HLPs) into trade agreements, align them with NDCs and NBSAPs, and develop comprehensive frameworks to ensure bioeconomy scalability and sustainability across sectors like food and biopharma.

Develop Regional Bio-Hubs: Establish logistics centers to integrate bioeconomy supply chains and reduce transport-related emissions.

Standardize Bio-Based Products: Align goods with international standards to access global markets.

Monetize Ecosystem Services: Incorporate carbon credits and ecosystem services into market mechanisms to capitalize on climate-positive solutions.

Three Strategic Recommendations



Deploy innovative solution design processes to accelerate the adoption of bioeconomy solutions considering a territorial approach.



Pursue innovative finance solutions to link equitable and resilient bioeconomy development to climate and nature Outcomes, in alignment with existing policy and institutional architecture and tailored to specific territories.



Future-proof bioeconomy solutions for warming beyond 1.5°C, understood as central to the creation of wealth and social wellbeing in the territories and countries.

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CHAPTER 3

Unpacking the High-Level Policy Recommendations

Integrate the Bioeconomy into Green Economic Transition

To date, many countries' green transition strategies and associated financing and donor support, such as [Just Energy Transition Partnerships](#) and [Country Platforms](#), have focused primarily on transition from fossil fuels to renewable energy, with less attention on the potential of nature-based solutions and the bioeconomy more broadly as drivers of sustainable, economic transformation.



Case Study

Integrating Bioeconomy into Country Platforms:

Case Study from Brazil

Country platforms, such as Just Energy Transition Partnerships (JETPs), are increasingly recognized as tools to align climate finance with national development agendas. While early platforms prioritized fossil fuel phaseouts and renewable energy expansion (Jain & Bustami, 2025), Brazil and Colombia exemplify a transformative shift toward integrating bioeconomy into climate strategies, linking decarbonization with biodiversity conservation and equitable growth.

Brazil's Ecological Investment Platform

In 2024, Brazil launched its Climate & Ecological Investment Platform (BIP), a government-led mechanism designed to channel domestic and international finance into projects that bridge energy transition, industrial decarbonization, and ecosystem restoration. Unlike earlier energy-centric models, BIP explicitly prioritizes nature-based solutions and other bioeconomy innovation. For instance, its US\$10.8 billion of potential investments include reforestation initiatives like the “Corridors for Life” project, which restores fragmented Atlantic Forest areas, and a US\$ 1.15 billion agricultural bio inputs and green fertilizer production, which reduces emissions while supporting sustainable food systems (Bloomberg Philanthropies, 2024). This mix illustrates how BIP is attracting projects across the spectrum – from clean tech to ecosystem restoration – under one platform. These projects align with Brazil's economy-wide target of reducing its net greenhouse gas emissions by 59% to 67% below 2005 levels by 2035 and its Ecological Transformation Plan, which positions forests and sustainable agriculture as economic assets (Federative Republic of Brazil, 2023).

Traditional Just Energy Transition Partnerships (JETPs), like those in South Africa and Indonesia, have largely focused on coal phaseouts and grid decarbonization, with limited attention to broader development strategies. In contrast, Brazil is positioning the bioeconomy as a core pillar of economic transformation. Through innovative platforms, it is attracting blended finance to support bio industrial innovations such as biopharmaceuticals derived from rainforest biodiversity and regenerative agriculture.

This country's experience offers key lessons for global platform design. Aligning investments with national climate strategies boosts coherence and investor confidence. Leveraging rich natural capital can unlock financing for nature-based solutions that jointly address climate and development goals. This case presents a compelling model for integrating bioeconomy and nature into climate finance an approach especially relevant for biodiversity-rich nations ahead of COP30.

The bioeconomy has largely been treated as a siloed, largely science and technology focused area in developed countries, and as nature-intensive and/or social focus (socio-bioeconomy) in nature-rich countries, rather than a broad menu of industries and approaches that can sustainably harness nature to support mitigation, adaptation, resilience and sustainable development. Existing country strategies and NDB and MDB efforts that touch on parts of the bioeconomy – such as supporting mangrove forest conservation and restoration, blue economy aquaculture and seaweed mariculture, circular production of urban waste, nature credits, biotechnology applications including gene editing to eradicate pests, and regenerative agriculture interventions – would benefit from being integrated under a larger, bioeconomy strategic umbrella. By leveraging South Africa's interest during its G20 Presidency around creating a standing bioeconomy support mechanism for Global South countries, international donors could consider supporting the consolidation and establishment of an MDB bioeconomy fund to more effectively collectivize resources, knowledge and innovation across a range of bioeconomy sectors globally.

Nature-based solutions (NbS) such as ecosystem restoration and sustainable agroforestry are labor-intensive and can significantly outpace fossil fuel industries in job creation. This job creation potential complements the energy transition, which increasingly relies on renewable energy sources like bioenergy and sustainable land management practices. By integrating NbS into energy transition strategies, these roles can simultaneously support decarbonization goals and provide critical employment opportunities, particularly in regions where fossil fuel industries are being phased out. A 2024 report by the International Labour Organization (ILO), the United Nations Environment Programme (UNEP), and the International Union for Conservation of Nature (IUCN) estimates that scaling up nature-based solutions could generate up to 32 million jobs globally by 2030, primarily benefiting regions like Africa, Latin America and Arab States, where ecosystem restoration and sustainable land use can directly support both livelihoods and climate adaptation.

The bioeconomy's capacity for job creation can be illustrated through concrete national strategies. For instance, Colombia's National Bioeconomy Strategy, initiated in 2020, aims to expand the bioeconomy to contribute 10% of the country's GDP by 2030, creating approximately 2.5 million new jobs (Ministry of Science, Technology and Innovation [Ministerio de Ciencia, Tecnología e Innovación – MinCiencias], 2020). Already, bioeconomy-related sectors, including agriculture, forestry and bio-industries, employ around 4 million people, approximately 18% of national employment (Alviar et al., 2021).

To integrate the bioeconomy effectively within a green economic transition, explicit attention must be given to mechanisms that attract private sector investment. Private capital can be mobilized through innovative financial instruments such as sustainability-linked bonds, which incentivize sustainability goals through financial rewards or lower capital costs. Similarly, nature credits—encompassing carbon and biodiversity credits—provide tangible financial incentives that support long-term sustainability commitments. Successful cases from current bioeconomy practices illustrate the transformative potential of these instruments, encouraging further private sector participation and investment.

A compelling example from Brazil is the **Priority Program for Bioeconomy (PPBio)**, established to attract private sector investments into biodiversity-based projects in Amazonia. The Manaus Duty-Free Zone Tax Incentive Law sets aside a percentage of the funds collected for investment in R&D. PPBio tries to direct this money towards local bioeconomy ventures. As of May 2023, R\$86 million were raised. It demonstrates how targeted policy tools can effectively de-risk and incentivize private capital participation, aligning corporate innovation with biodiversity conservation and sustainable regional development (Partnerships for Forests, 2024).

The Amazon Bioeconomy Fund

The Amazon Bioeconomy Fund is a regional Program from the Green Climate Fund (GCF) and implemented by the Inter-American Development Bank (IDB), which aims at unlocking private finance by valuing bioeconomy products and services with climate mitigation and adaptation results in Amazonia. The Fund combines target grant funding for incubation and acceleration with tailored financial instruments positioned along the concessionality maturity gradient. The US\$598 million Fund aims to catalyze private sector investment through bio-businesses in prioritized value chains. This includes a diversity of sectors including incipient value chains of agricultural produce, non-timber forest products, ecotourism and forestry, but also more innovative businesses such as fintech, remote sensing-tech and climate services.

Beneficiaries in the participating countries (Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru and Suriname) have different risk profiles and access to international capital markets, whilst local capital and financial markets vary significantly from one country to another. The Fund applies a range of effective and flexible instruments to tackle this heterogeneity: a grant window aims to benefit small and indigenous business through direct investments and technical assistance; equity investment is made available for early-stage innovative companies; sovereign investment loans to bioeconomy businesses through national development banks. Finally, thematic bond issuances will be supported through specialized advisory services to effectively include bio-businesses in bond structuring, and through a guaranteed credit enhancement where IDB will provide guarantees in lieu of GCF, which will support the cost of the guarantee through grants.

Among the main socio-economic benefits of the Fund are the creation and strengthening of markets, stimulation of local economic growth, and the increased value of primary production and related value chains. The Fund also contributes to job creation, the diversification and improvement of countries' production and export base and the enhancement of rural livelihoods – both agricultural and non-agricultural. Additionally, it empowers women-led and indigenous bio-enterprises, expands access to finance for micro-small and medium bio-enterprises and small producers, and improves financial institutions' ability to identify, evaluate and manage the financial risks and opportunities associated with the bioeconomy.

From its implementation in September 2022, the Fund is delivering important contributions to kick-start a change of entrenched behaviors, helping create the foundation for markets that value the fundamental role of natural capital. Using a diverse and complementary financial instrument, it enables the development of profitable, scalable and climate-resilient production models in which private entities will be more willing to participate. Jumpstarting private participation in bio-businesses is producing demonstration effects in Amazonia, highlighting biodiversity as an intrinsic element of economic success beyond the initial climate finance support.

Enhance Natural Resource Management for Resilience

Enhanced natural resource management is another key imperative for countries to foster resilient and adaptive bioeconomy strategies that can continue to provide solutions at scale to the climate crisis. Enhancing natural resource management through ecosystem-based approaches and regional cooperation is vital for ensuring long-term climate resilience. A key element is to deploy a “nature as infrastructure” approach ([Asian Infrastructure Investment Bank, 2023](#)), which makes strategic use of partial or entirely natural solutions to address infrastructure needs that would otherwise be addressed using conventionally engineered “grey” infrastructure. MDBs and NDBs can be the bridge between public and private financing and help overcome barriers to adopting nature-based solutions. Specifically, they can help to crowd-in private financing for critical “nature as infrastructure” resilience and adaptation projects like forest waterway preservation and urban bio-credits, particularly for climate vulnerable sectors of the bioeconomy.

For the nature-intensive bioeconomy, the most climate-vulnerable of them all—MDBs and NDBs can support the adoption of sustainable agricultural practices such as agroforestry, organic and regenerative farming and conservation tillage. These practices enhance carbon sequestration, improve soil health and increase agricultural resilience to climate change. Governments could partner with MDBs, NDBs and large multinationals to develop medium-term, transition plans for vulnerable bio-based supply chains –for example, around regenerative agriculture practices - and deploy creative innovative financing mechanisms that provide local farmers with the upfront capital and insurance required to kickstart and survive the five-year transition period.

Recommendations to enhance natural resource management at the bioeconomy-climate nexus include:

- **Nature as Infrastructure:** Support
 - bioeconomy-dependent infrastructure like
 - waterways in forest-based economies,
 - promote urban biodiversity credits for
 - climate change adaptation and integrate
 - nature-based solutions into national
 - climate strategies by focusing on territorial
 - approaches for collective action.
- **Targeted transition support for sustainable practices:** Develop targeted
 - financing schemes to help transition
 - vulnerable nature-intensive bioeconomy
 - sectors to more sustainable approaches,
 - for example through regenerative
 - agriculture loan and insurance
 - mechanisms that address short-term
 - risk and up-front costs.

Develop Lifeboat Strategies for High-Risk Sectors

As climate conditions become more unpredictable, industries are increasingly turning to sustainable practices, climate-smart agriculture, and technological innovations to adapt and safeguard the bioeconomy for future generations. The success of these strategies will depend on concerted efforts from governments, MDBs, the private sector and local communities. In certain instances, for example a shift to controlled environment agriculture solutions, these strategies will require immediate, capital-intensive interventions with long lead-times.

For high-risk sectors, particularly nature-intensive industries with deep connections to livelihoods, essential needs and security such as agriculture, forest economies and fisheries/aquaculture, governments should work with MDBs and NDBs/LFIs to develop sectoral adaptation plans that prioritize minimal disruption and the prolonging of productive resources in a warming world. This could include medium-term investments in new climate-resilient approaches like controlled environment agriculture or aquaculture, and/or creating parametric insurance mechanisms for heat or extreme weather event-induced productivity losses. The silvopastoral **Macaúba project** that the IDB Lab is supporting in Brazil is an excellent example of integrating bioeconomy resilience, adaptation and livelihood priorities into an approach that also targets climate mitigation outcomes around deforestation in the Cerrado region. Projects like Macaúba highlight the active participation of Indigenous Peoples and Traditional Communities, as well as the recognition and valorization of their traditional knowledge. They are central actors in a climate-resilient and adaptive bioeconomy, and core to the success of sectoral and landscape adaptation plans specifically, (Climate Investment Funds, 2020) that could ultimately contribute to safe and stable economies.



Countries would benefit from more proactively modeling vulnerabilities in these sectors to sharpen their view of physical and transition risks and likely related outcomes. They can draw on the latest climate-nature integrated research from central banks (e.g. the European Central Bank and Network for Greening the Financial System) and scientists, as well as the IMF, to ensure that they are integrating the most accurate, up-to-date scientific data and expectations in their planning and adaptation strategies. Such knowledge also leads to new opportunities for prevention through increased up-front investment in critical landscapes. For example, biotech companies relying on medicinal plants and microbial cultures that disappear at a certain level of warming or ecosystem destruction can be targeted for insetting. In addition, the exploration of controlled environment approaches can ensure viability as temperatures rise. Countries and international partners might consider establishing a bioeconomy-climate observatory, to gather, share and analyze data in partnership with external stakeholders about the interdependencies between the bioeconomy and climate crisis, drawing in real time observations and the latest in scenario modeling and risk assessment to benefit a wider range of stakeholders globally.

Recommendations for developing “lifeboat” strategies for high-risk bioeconomy sectors include:

- **Sectoral/Landscape Adaptation Plans contributing to safe and stable economies:** For NDCs and development plans, prioritize sectors critical for livelihoods, peace, security, and economic resilience. Examples include approaches that would contemplate uncertain land tenure systems, difficulties in verifying sustainable supply chains, and significant reputational exposure in riskier territories.
- **Beyond 1.5°C Scenarios:** Model vulnerabilities to identify adaptive interventions that extend the viability of bioeconomy sectors. For instance, policies that would avert a tipping point in Amazonia, including by avoiding deforestation, adopting climate-smart agriculture, and improving fire management, would generate US\$339 billion in additional wealth (Banerjee et al. 2022).
- **Bioeconomy-Climate Observatory:** Consider establishing a bioeconomy-climate observatory to gather, share and analyze data in partnership with external stakeholders about the interdependencies between the bioeconomy and climate crisis, drawing in real time observations and cutting-edge science particularly for key value chains.
- **Indoor/Regional Shifts:** Explore shifting production of key agricultural products to controlled environments or new ecologically suitable sites as the climate warms, recognizing that the long-lead times and capital-intensive nature of investments requires urgent near-term action.

Foster Global Collaboration, Collective Intelligence and Innovation

Regional and South-South cooperation on R&D for the bioeconomy presents significant opportunities to advance sustainable solutions and promote innovation across various sectors, from agriculture and forestry to biotechnology and renewable energy. By collaborating, regions can pool resources, share knowledge and align their R&D efforts to tackle global challenges like climate change, food security, and renewable energy needs. There are a wide range of existing efforts that bring together research institutions, NGOs and private companies to support regional cooperation on R&D, for example: the Red Bioamazonia, a regional network that connects research institutes in Amazonia, the African Network for Bioeconomy Policy, the Sustainable Bioeconomy for Africa, the ASEAN Centre for Biodiversity (ACB) and the ASEAN Bioeconomy 2025 initiative, to name a few. Helping these institutions strengthen international connections and learning, especially around technology transfer and enabling policy frameworks, can help accelerate South-South cooperation on innovation and implementation in areas including agricultural productivity, deforestation and regional bioeconomy clusters focused on bio-based chemicals, materials and fuels.

By collectively investing in research facilities such as bio-refining plants or biotechnology laboratories, such pooled efforts can foster collective intelligence. This is similar to what was accomplished through the mRNA technology transfer hub for COVID 19 vaccines; multiple countries and regions shared expensive infrastructure and achieved economies of scale in R&D more quickly than if they had worked alone. This is particularly true for more advanced bioeconomy sectors, such as capital-intensive, climate-resilient food technologies that will become more essential to bio-based industries across the tropics in the coming years. Collaborative efforts could also prioritize the intersection of the bioeconomy-climate nexus, such as in bio-based carbon capture technologies, drought-resistant crops and alternative energy sources.

- **Leverage emerging technologies and invest in R&D:** Governments should fund scalable, climate-resilient bioeconomy research, emphasizing collaboration between governments, academia, and the private sector, both across South-South and North-South dimensions.

- **Enhance Technical Assistance:** A growing number of countries and MDBs have accumulated substantial bioeconomy knowledge and could provide training on sustainable practices, resource management and climate change adaptation.

- **Global, Regional and South-South Cooperation:** MDBs and international partners can help facilitate cross-border collaboration on bioeconomy best practices and technologies. They can help leverage successful bioeconomy models between Pan-Amazonian countries, Latin America, the Caribbean, and emerging economies, as well as between Global North and Global South stakeholders. This includes building trust and strengthening stakeholder collaboration.

Facilitate Trade Integration and Access to International Markets

Trade interventions are pivotal to catalyze a coherent bioeconomy framework that integrates with broader green economic transition strategies and prioritizes Global South countries. This includes everything from establishing harmonized standards and reducing regulatory barriers to creating investment mechanisms that support bio-based industries in agriculture, healthcare, construction, aviation and pharmaceuticals. It also involves linking emergent industries to regional and global supply chains. Crucially, a climate resilient, bioeconomy, trade strategy must prioritize shifting from extractive economic models to regenerative approaches that value biological resources as strategic assets for sustained development as well as planetary and human well-being.

At its best, trade can play a vital role in creating a conducive environment for sustainable, resilient bioeconomy innovation, market access and investment. A cohesive bioeconomy trade framework could facilitate a just transition by addressing inconsistent standards and regulations across regions and international markets that hinder the development of bio-based products. The agreement on a new Digital Sequence Information (DSI) framework at COP16 for sharing the benefits from genetic information sequenced from nature provides an important foothold to begin integrating intellectual property (IP) rights as an important asset and financing mechanism. There is potential for the MDBs, NDBs and regional institutions to help smooth the trade of bioplastics, and organic food products across the region by harmonizing environmental and health standards and sustainability criteria. Countries can also collectively agree to support the reduction of tariff-related trade barriers for climate resilient bio-based trade, for example high tariffs on biotechnology-related products such as genetically modified seeds, fertilizers, and advanced biotech tools.

Recommendations to facilitate trade integration and access to international markets for bioeconomy goods include:

- **Promote Trade Incentives:** Countries and regional trade bodies should make bioeconomy goods eligible for the same subsidies that unsustainable products currently enjoy.
- **Develop Regional Bio-Hubs:** Establish logistics centers to integrate bioeconomy supply chains and reduce transport-related emissions.
- **Standardize Bio-Based Products:** Align goods with international standards to access global markets.
- **Promote Trade Harmonization:** Embed bioeconomy high-level principles (HLPs) into trade agreements and align them with NDCs and NBSAPs and develop comprehensive frameworks to ensure bioeconomy scalability and sustainability across sectors like food, bioenergy, and biopharma. For example, the new Deforestation Regulation approved by the European Union in June 2023 (European Parliament & Council of the European Union, 2023), gives exporters 18 months to prove that commodities (cattle, cocoa, coffee, oil palm, soy, and wood), destined for the European market are 100 percent clean from deforestation.
- **Value Ecosystem Services:** Incorporate carbon credits and ecosystem services into market mechanisms to capitalize on climate-positive solutions. Although the track record of ecosystems services valuation programs is mixed, in general, meta-analyses suggest that, like protected areas, they have positive but modest impacts (Busch & Ferretti-Gallon 2023; Wunder et al. 2020; Snilsveit et al. 2019; Börner et al. 2017).

The background features a dark brown wood-grain pattern. Overlaid on this are several overlapping circles in different shades of brown. A prominent circle in the center contains the chapter title. A dashed white line forms a circular path around this central circle. The left edge of the image is a solid white vertical bar.

CHAPTER 4

**Strategic
Recommendations**

Deploy Innovative Solution Design Processes to Accelerate the Adoption of Bioeconomy Solutions Considering a Territorial Approach

To avoid the bioeconomy development process being overtaken by worsening climate disruption and rendering solutions obsolete, more deliberate and creative action is needed to accelerate adoption across a wide range of actors and stakeholders. The challenge is that many bioeconomy solutions are still relatively niche or early stage. Solutions such as performance-based and blended finance are not yet being deployed at scale or getting sufficient policy support to realize their potential.

Technical capability and technological capacity gaps, institutional inertia and fragmentation, and policy uncertainty will greatly complicate and delay the development of critical bioeconomy instruments, operating systems and frameworks. Catalyzing the transition to a future-proofed bioeconomy will require an equal dose of process and product innovation. For that reason, NatureFinance launched an Accelerator Program for sovereigns and sub-sovereigns to speed up the operationalization of key performance indicators (KPIs) for sustainability-linked performance-based financing and budgeting. This draws on tools and techniques developed to help organizations navigate complex design and coordination challenges under conditions of radical uncertainty and urgency. It includes scenario planning, design sprints, rapid prototyping, and other “design-thinking” methodologies widely employed in software development and business process innovation. The Sustainability Sovereign Debt Hub (SSDH) has adapted these for the sovereign financing context, and it is an “open source” and well-studied approach that countries, MDBs and NDBs could take up and integrate in their own country engagement.



Human-centered design is essential to developing adaptive and resilient bioeconomy solutions. Drawing on the lessons of other innovation ecosystems, especially the digital economy, uptake and rapid deployment are higher if solutions are designed around the lived experiences, needs and preferences of target “users.” For instance, NatureFinance is conducting a series of design sprints with the city of Rio de Janeiro based on its territorial features to craft a financing strategy for their urban biodiversity credit pilot project. The sprint will help to expose use cases for the credits and the related ecosystem services data in the city’s public, financial management. It will also optimize distribution strategies for the biodiversity credits among prospective buyers. Ensuring that instruments meet the needs and demands of both beneficiaries and investors (in the case of urban biocredit retail instruments, the two groups may overlap), is key to their take-up and success by markets and communities. A similar initiative is expected to be conducted for an Amazonian city in 2025.

The transition to an equitable and climate resilient bioeconomy will also need to be properly sequenced and paced. Adopting one innovation (e.g. a sustainability-linked bond) without another (e.g. the transparency and accountability systems to ensure performance) will likely deliver suboptimal results, or worse, lead to a misallocation of resources. That entails a programmatic approach that packages solutions into a coherent bioeconomy strategy. In the sovereign financing domain, for instance, it means transcending the false dichotomy between use-of-proceed and sustainability-linked debt. Instead, these should be seen as complementary and distinct functions. In NatureFinance’s Accelerator, this is accomplished by using KPIs that tie together a range of instruments: conventional, sustainability-linked, thematic debt, credit enhancement, etc.

Furthermore, accelerating bioeconomy adoption depends fundamentally on effective governance and strong political will. Countries can strengthen this by establishing national bioeconomy councils or multi-stakeholder platforms that involve governments, representatives of Indigenous, Afro-descendent, Traditional, and Local communities, private sector, and civil society, aligning diverse interests toward common objectives. Integrating transparency and accountability frameworks into financing mechanisms is equally relevant. Finally, enabling more direct climate finance flows to subnational actors can help overcome bureaucratic barriers, ensuring faster and more targeted implementation of bioeconomy solutions.

Pursue Innovative Finance Solutions to Link Equitable and Resilient Bioeconomy Development to Climate Outcomes and Attract Private Finance

There are several key opportunities for countries, NDBs, MDBs and private sector stakeholders to leverage and adapt innovative financing solutions for critical, climate-positive bioeconomy sectors and to shape development patterns in an inclusive, equitable, and sustainable manner. Concretely, equity – in the sense of fair distribution of benefits – can be encoded in financial instruments via the performance indicators, the interest rates on debt and the investment incomes related to the bioeconomy. Ensuring that the downstream distributional effects on actors and stakeholders of financing the bioeconomy are fair will help to sustain buy-in and mitigate the risk of misallocation and misappropriation of resources.

In particular, as MDBs and public and private-sector stakeholders expand their work on innovative finance for climate, nature, people and the planet, they can draw on these “four I’s” (Instruments, Indicators, Interest and Investors) plus an expanding [suite of policy and financing instruments](#) to craft their strategies (NatureFinance & World Bioeconomy Forum, 2024). Indeed, the “four I’s” framework could be integrated into country, NDB and MDB strategies with a mainstreamed focus on bioeconomy (and NBSAP) support alongside its existing focus on climate NDC targets. Below is an overview of the “four I’s” and how they could be deployed in practice. This includes exploring opportunities related to sustainability-linked debt instruments, nature credits, retail bonds and new insurance mechanisms which are particularly catalytic to private capital.

Instruments

EQUITABLE ALLOCATION OF FUNDING

Instruments can be programmed to allocate funds to different sectors of the bioeconomy in ways that pursue sustainability objectives inclusively and equitably. This can be achieved through “use-of-proceeds provisions” embedded into the instruments themselves, which stipulate how the funds will be used. Alternatively, it can be done via the mandates that channel investments into targeted bioeconomy activities. Green, social, sustainability, and sustainability-linked (GSSS+) are examples of the former; sustainability bonds channel proceeds into investments that achieve both social and environmental objectives. For instance, Brazil’s inaugural Sovereign Sustainability Bond issued in 2023 (World Bank, 2024) allocated funds to a combination of deforestation control, biodiversity conservation, the National Climate Change Fund, programs to combat poverty (e.g. Bolsa Família - Ministry of Social Development and Assistance, Family and Fight Against Hunger [Ministério do Desenvolvimento e Assistência Social, Família e Combate à Fome - MDS], n.d.) and the fight against hunger (e.g. Food Acquisition Program - Biodiversity for Food and Nutrition Initiative, n.d.).

Amazonia Bonds are an innovative capital markets instrument focused on addressing the urgent need for sustainable development in Amazonia. The bonds issued under frameworks aligned with the Amazonia Bonds Investment Guidelines (Inter-American Development Bank, n.d.). The bonds are expected to connect public and private issuers with sustainability-focused investors looking to integrate Amazonian investments into their portfolios responsibly. Amazonia Bonds are needed to address the financing gap in Amazonia and allow more funds to flow from investors into projects that have positive environmental and social benefits in the region. Amazonia Bonds seek to support the transformation of the Amazonia region's economy from an extractive, frontier economy towards a sustainable economy that: (i) generates employment and improves quality of life for Amazonian residents, particularly Indigenous Peoples, Afro-descendants and Traditional Communities, (ii) reduces deforestation and values nature restoration, by supporting governance and innovative solutions, (iii) strengthens economic growth and scales socio-bioeconomy value chains based on the region's social and natural capital. Examples of eligible investments are agroforestry, nature-based solutions and biodiversity restoration. The impact of Amazonia Bonds that follow the guidelines will be measured by KPIs specific to Amazonia.

An added design feature is for the instruments to include incentive mechanisms. These may be aimed at inducing bioeconomy actors to adopt more equitable practices by rewarding them with more favorable financing terms such as longer loan tenors or subsidized interest rates. Alternatively, the instruments can be designed as “pay for performance” or “pay for outcome” structures, where the interest rate decreases (“steps down”) if certain equity milestones are achieved or increases if they are not. The [sustainability-linked loan \(SLL\) for Barbados announced in December 2024](#) (Inter-American Development Bank, 2024) contains targets aimed at reducing marine and groundwater pollution. This helps to protect both marine ecosystems and nearshore reefs as well as groundwater quality and safeguard public health.

Other instruments can be hard coded to pay out a portion of their proceeds to different stakeholders, including Indigenous Peoples, Afro-descendent, and Traditional Communities. For instance, the [Amazon Reforestation Outcome Bond](#) issued by the World Bank on August 13th, 2024 (World Bank, 2024a), has a built-in mechanism to share the proceeds from the sale of Carbon Removal Units (CRUs) with small family farmers and native cocoa producers. Similar outcome bonds were issued in Vietnam (World Bank, 2024b), [Ghana and Indonesia](#) (World Bank, 2023).

Such innovations at the downstream transaction level are necessary but insufficient to achieve equitable impact at scale. Other financial flows that do not contain use-of-proceeds provisions or built-in incentives will need to be channeled using different mechanisms to ensure nature and equity alignment. Frameworks such as the Taskforce on Nature-Related Financial Disclosures (TNFD) for corporates and “Green Budgeting” for sovereigns can help to chart out these flows. The proliferation of tools such as NatureFinance's NatureAlign can lead to actionable insights on how to achieve budgetary and asset allocation targets. However, for this to work, the instruments and mechanisms need to incorporate well-crafted indicators that accurately track environmental and distributional impacts. The emerging [Tropical Forest Forever Facility](#) (TFFF) (Government of Brazil, 2024), is one compelling option linking upstream and downstream innovation on integrating equity into bioeconomy resilience and climate mitigation.

The TFFF is an innovative initiative to raise significant additional funding for the conservation of tropical forests

on a permanent basis from public and private sources. The TFFF aims to allocate this funding to tropical forest countries based on performance measured against forest cover through remote sensing technologies. The funds that are allocated are expected to benefit those that effectively conserve the forests on the ground, such as local communities and Indigenous People. Although the TFFF's financial mechanism is still under development and scrutiny by economists and stakeholders, it has gained significant momentum and may present a great opportunity for nature-rich countries and international climate and nature targets. The initiative was formally endorsed in the 2024 G20 Leaders' Declaration and recognized as a pioneering approach for compensating ecosystem services. It highlights the need for innovative financial instruments to support countries in meeting their NDCs and NBSAPs targets.

Additional policy interventions such as premium subsidies for crop insurance and enabling regulation (e.g. risk-based solvency capital requirements) can help deepen insurance penetration and be linked to KPI-bond structures for bioeconomy development and resilience in innovative ways.

Indicators

TRACKING EQUITABLE OUTCOMES

Fortunately, financial market participants can choose from a cornucopia of KPIs. Many combine both bioeconomy and social objectives at the project, portfolio and economy-wide levels. For example, the indicators can track the share of output and employment by sectors of the bioeconomy that offer more inclusive growth potential. Or, they can target increasing the share of beneficiaries from vulnerable population segments in a given bioeconomy finance portfolio, similar to the KPIs used by the Development Bank of Rwanda (BRD) in their [sustainability-linked bond](#) (SLB) issued in 2023. That bond aimed to increase the share of female-owned small and medium-sized enterprises (SMEs) in their direct lending book from 15% to 30% by 2028 (Development Bank of Rwanda, 2024). To be effective, KPIs that optimize for equity need to map the economic and social dynamics that link financing to impacts. This is no easy feat, especially at the macroeconomic level. The transmission channels linking performance on headline indicators to variables such as economic growth and employment are challenging to map out ex-ante. However, a growing suite of frameworks and tools can help in this regard. NatureFinance's [Sustainability-linked Sovereign Debt Hub](#) (SSDH) has developed an analytical approach, the Financial Materiality Assessment (FIMA) framework, to model the macro-fiscal uplift from achieving sustainability targets. It is currently being piloted in several countries to test how to connect bioeconomy targets to drivers of creditworthiness for risk-averse private investors.

More work is needed to fully understand the causal relationships between finance, equity and the bioeconomy. But this is essential if we are to create buy-in from critical stakeholders such as Indigenous Peoples, Afro-descendent and Traditional Communities and other vulnerable social segments who may be justifiably skeptical of arcane financial products. It is also needed to bolster the value proposition of innovative bioeconomy finance to risk-averse governments and investors who are rightly concerned about the reputational costs of missing targets or of accusations of greenwashing. The FIMA framework and other models that sketch out economic and distributional impacts can give them a degree of confidence that they are moving in the right direction. It also improves the risk-reward calculus for borrowers on whether to undertake such sustainability-linked financing or not. Finally, these efforts may also have growing resonance with credit ratings agencies and the IMF's Debt Sustainability Analysis framework, which will continue to be pushed to reckon with the valuation of natural capital and the prophylactic benefits of country investments in adaptation and resilience in the coming years.

Interest

SHARING THE COSTS OF BORROWING

Another way to convince borrowers of the merits of bioeconomy instruments and indicators is by offering them lower interest rates on debt to fund bioeconomy investments. Equity, in this regard, means sharing the cost of borrowing, which has become prohibitive for low- and middle-income countries (LMICs) facing historic debt burdens and acute fiscal stress. Since the return on investment (ROI) for many nascent bioeconomy activities will be low at the early stage of the product life cycle, the high cost of finance acts as a major distinctive to invest. The cost of capital, in turn, reflects economy-wide factors, especially sovereign reference rates. In Brazil, the risk-free Selic rate currently stands above 10%, whereas the ROI on activities such as regenerative agriculture is in the low single digits. These return rates will likely rise as we move down the bioeconomy, marginal cost curves decline, and new investment opportunities open up. However, containing the cost of finance will also be necessary.

The high sovereign borrowing costs across LMICs are a function of multiple, country-specific variables and global forces. However, it is safe to assume that climate change will intensify pressure on country risk premia as the economic and fiscal costs of physical and nature loss crystallize. Rising **sovereign debt distress and defaults across LMICs** are already symptoms of this trend (World Bank, 2024b). They foreshadow worse to come if adaptation and resilience measures are not scaled up quickly.

By contrast, borrowing costs in the high-income economies of the Global North are likely to remain relatively lower in a beyond 1.5°C warming scenario, partly due to the “flight to safety” effect of investors fleeing the Global South. Advanced economies also benefit from a century of carbon-intensive development and capital accumulation, which has translated into abundant savings for investment in their green transitions.

LMICs instead need to develop under much harsher constraints on greenhouse gas emissions and natural resource exploitation. At the same time, the prodigious transfers of capital from the Global North to the South that are needed to fulfil international climate and nature finance goals are failing to materialize at the requisite speed and scale. Even if they did in the form of loans (versus a TFFF mechanism, or **Global Solidarity Levies** - (Global Solidarity Levies Task Force, n.d.)), at prevailing interest rates, servicing the debts from these flows could easily aggravate the acute fiscal stress and crushing debt burdens that many LMICs are shouldering. The topic of equity is, therefore, historical, transnational and structural. It requires the Global North to share the burden of financing the transition towards a sustainable and equitable bioeconomy in the Global South.

Blended finance is one way of doing that. Financial guarantees, first loss capital, insurance and other credit enhancements can reduce the cost of capital on projects, portfolios, and public debt. At the sovereign level, it has been effectively deployed in debt-for-nature swaps in **Belize, Gabon, Ecuador, Barbados, and El Salvador** (The Nature Conservancy, 2021; The Nature Conservancy, 2023; Inter-American Development Bank, 2023; The Nature Conservancy, 2022; CAF - Development Bank of Latin America, 2024). The SLB by the Development Bank of Rwanda, mentioned above, benefited from a collateral loan that lowered the coupon interest rate.

Despite these pioneering transactions, much more is needed to scale up credit enhancement for sustainability-linked sovereign finance. The supply from multilateral development banks (MDBs) and development finance institutions (DFIs) is woefully insufficient to cover a meaningful part of the public financing needs for the bioeconomy transition. The MDBs and DFIs are working on solutions, including through the **Taskforce on Credit Enhancement** for Sustainability-linked Sovereign Financing of Climate and Nature, for which the SSDH acts as the secretariat. The Task Force recently published Voluntary Principles for the Deployment of Credit Enhancements, which call for inclusive and equitable governance of credit-enhanced structures, among other criteria (Task Force on Sustainability-Linked Sovereign Financing for Nature and Climate, 2024).

Investors

SHARING THE RETURNS ON INVESTMENT

Blended finance will be necessary to attract large volumes of risk-averse, catalytic capital to the Global South, but external financing will not be sufficient. Countries also need to mobilize domestic capital to reinforce and sustain the structural transformation of their economies and to ensure that the returns on investment in the bioeconomy are distributed equitably. That means bringing more people into the financial system, especially the marginalized, underbanked and unbanked. In other words, it means aligning the bioeconomy and financial inclusion agendas.

Another route is through retail sovereign bonds: small-denomination instruments targeted at average citizens who benefit from a “risk-free” return on their small savings without incurring the costs of financial intermediation in the banking sector. By integrating digital financial innovations such as mobile money, electronic know-your-customer utilities and digital bonds on the blockchain, retail sovereign finance has significant potential to scale and become a meaningful source of local funding for governments and the bioeconomy. The opportunities to embed sustainability features such as bioeconomy targets are equally promising. A forthcoming report by NatureFinance surveys the landscape of existing thematic and sustainability-linked retail bonds, such as the UK’s [National Savings and Investments \(NS&I\) Green Savings Bonds](#) (National Savings and Investments, n.d.) or [Indonesia’s green sukuk](#) (Ministry of Finance, Republic of Indonesia, 2018). The BRD SLB mentioned above included a large retail participation, as the minimum subscription was as low as US\$70.

Once again, more work is needed on this front. Retail sovereign finance is as old as the debt itself, and it offers distinct advantages over other forms of financing from a debt management standpoint: they are denominated in local currency, provide diversification benefits, support other objectives such as capital market development and financial inclusion, and so on. In the case of urban biodiversity credits, for example, sub-sovereign retail instruments have the ability to demonstrate real time returns and tangible outcomes to individual investors, businesses and communities. Yet, retail instruments’ role in solving the intertwined sovereign debt, nature and climate finance challenges has been mostly overlooked and understated. We think it should be more prominent in global policy discussions, but especially regarding how to develop a sustainable and equitable bioeconomy.

Future Proof Bioeconomy Solutions for a World Warming Beyond 1.5°C

Bioeconomy solutions will not only need to be deployed rapidly, but also to be more agile and adaptable to adjust quickly to changes in an operating environment marked by volatility, uncertainty, complexity, and ambiguity. That means building contingency mechanisms and safety valves to account for shocks and tail risks. It also means being more deliberate and creative about scenario planning to anticipate possible development pathways for the bioeconomy in a beyond 1.5°C warming world.

Strategies that assume stable operating conditions and that rely on conventional planning and risk management techniques are already losing credibility and utility in a more volatile environment. The agility to pivot strategies quickly in the face of sudden shifts based on leveraging real-time and alternative data, enhanced computing and analytics, and decision-making frameworks such as scenario planning, will be crucial.

Bioeconomy actors and policy practitioners will need to guard against “baseline bias”. This means anchoring on a “business-as-usual”, base-case scenario, with alternative scenarios largely presented as after-thoughts based on linear extrapolations of past performance, with some stochastic noise to convey “realism.” By contrast, a scenario planning approach attempts to challenge the conventional wisdom and mental models of key actors in the bioeconomy community. For example, when NatureFinance supports sovereigns in the selection of KPIs for performance-based financing through its Accelerator Program, it begins with a scenario planning exercise that charts out possible bioeconomy development pathways with the aim of future-proofing related KPIs. Put differently, the KPIs in a sustainability-linked bond or loan need to last for the life of the instrument, which may be over a decade, during which time the bioeconomy may evolve in very different directions. Anticipating possible migration scenarios is critical to selecting durable KPIs. Similar scenario planning should underpin solution design in other contexts and applications, in keeping with the human-centered design approach outlined above.



Adaptability by design means incorporating contingency mechanisms into solutions. Long-term, fixed and rigid debt service schedules (i.e., as in vanilla fixed income instrument) may no longer be viable in a beyond 1.5°C warming context where borrowers are buffeted by escalating shocks. Safety valves such as climate resilient debt clauses (CRDCs) will be crucial to create breathing room for borrowers to prioritize disaster relief and recovery. IDB has been a pioneer among MDBs by incorporating **CRDCs in its Flexible Financing Facility (FFF) since 2021** (Inter-American Development Bank, 2024). It has been an active participant in SSDH's Multistakeholder Working Group on CRDCs, which convenes G7 Treasuries, MDBs, borrower Debt Management Offices (DMOs), and technical experts with the aim of optimizing and scaling up these instruments.

Parametric solutions such as CRDCs should also be scaled up in other areas of the bioeconomy, especially via parametric insurance and inclusive insurance technology (Insurtech) that protect those individuals and communities most affected by climate-related impacts in the near term. A new program in India, run by **Climate Resilience for All and SEWA** offers a climate insurance package for US\$1-US\$3 per year to street vendors, waste recyclers, ship breakers, farmers, salt miners and other self-employed, heat-exposed women in Gujarat, Maharashtra and Rajasthan states (Desai, 2023). Similar schemes could be developed for bioeconomy producers of heat and drought sensitive products across Latin America and the Caribbean as a climate shock, bioeconomy, safety-net strategy.

In August 2021, the Brazilian National Institute of Meteorology (Inmet) introduced the first parametric index insurance policy for cocoa producers in southern Bahia. It covers 140 hectares across three farms in Ilhéus against excess or insufficient rainfall between August 1st and September 30th. Using meteorological data from Inmet stations as risk indicators, the policy provides farmers with a financial safety net against climate variability, ensuring more predictable income. Integrating sustainability, it finances premiums through carbon credits, promoting forest preservation and sustainable agricultural practices. This initiative, a collaboration between NEWE Seguros S.A., Wiz Corporate Partners, Dengo Chocolates, ZCO2/BlockC, and Instituto Arapyáú, combines financial resilience with environmental stewardship, offering an innovative model for mitigating climate risks in agriculture (Brazilian National Institute of Meteorology [Instituto Nacional de Meteorologia], 2021).

Sustainability-linked insurance to promote regenerative agriculture is another example of a pioneering initiative that integrates technology, sustainability, and agriculture to create more efficient and environmentally friendly farming practices as an inssetting strategy. One example is the **Precision Conservation Management program**, where PepsiCo funded a sustainability-linked crop insurance subsidy in partnership with The Nature Conservancy, drawing on the latest real time observation and data technologies and approaches (Precision Conservation, n.d.). MDBs could build on these kinds of approaches through, for example, developing a swap insurance mechanism to support farmers in the transition process to more sustainable and climate resilient agricultural practices over a five-year period. This would involve farmers drawing down from the fund in the early stages of transition when they are operating at a loss and feeding back into the mechanism during the final stages where they are hopefully beginning to generate a higher return.



CONCLUSION

**The Way
Forward-Integrating
Bioeconomy
Solutions into
2025 NDCs**

Harnessing the bioeconomy in ways that support equity and climate-nature action is pivotal to achieving inclusive development and environmental sustainability. Comprehensive policies, targeted investments, and global collaboration can unlock its full potential, driving economic growth, resilience, and environmental sustainability in the face of an evolving climate crisis. **The 2025 NDC process provides a critical opportunity to proactively advance bioeconomy solutions** that can integrate nature into green economic transition strategies and maximize resilience and longevity in the face of the climate crisis. Global fora like the G20 and COP30 provide opportunities for international collaboration and commitment to advancing bioeconomy solutions globally, with NDCs providing the nexus between finance and the real economy to help countries develop, finance and deliver strategies at scale.

Building speed, agility, and adaptability into the design of bioeconomy solutions will be critical to anticipate and mitigate the impacts of a deteriorating operating environment in a world beyond 1.5°C warming. The use of design-thinking, scenario-planning, contingency mechanisms and safety valves can help MDBs and NDBs catalyze and future-proof the bioeconomy. Stakeholders such as the Nature4 Climate coalition, UNFCCC, International Union for Conservation of Nature (IUCN) and World Resources Institute (WRI) have already done excellent work **providing recommendations** on how countries can enhance the inclusion of nature overall in their NDCs. Building on those insights, there are five specific areas where countries can leverage bioeconomy strategies as core mechanisms to deliver their NDC goals: (1) mitigation, (2) sectoral targets, (3) nature-based solutions, (4) adaptation strategies, (5) measurement.





Mitigation

A key priority for this NDC round is to elevate **ambitious economy-wide GHG goals**, and there are clear opportunities to link these goals to bioeconomy-based solutions (United Nations Framework Convention on Climate Change, 2024). Specifically, increasing the share of sustainable bio-based products in the economy can be linked to GHG reduction targets in a variety of ways, including:

Prioritizing sustainable forestry and agricultural practices that enhance carbon sequestration.

Promoting bio-based products instead of fossil fuel-based products (e.g. bioplastics, biocement and biosteel) through a combination of policy measures, economic incentives and support for research and development, such as:

- Establishing new market incentives that favor bio-based products such as public procurement requirements or tax incentives for companies using bio-based materials.
- Establishing regulatory frameworks that support the growth of bio-based industries while protecting the environment.
- Gather data on bioeconomy potential, prioritizing scientific research on sustainable biomass production and conversion technologies.



Sectoral targets

Countries can develop or strengthen GHG emission reduction and non-GHG emission reduction targets in the Agriculture, Forestry and Other Land Uses (AFOLU) sector as a key bioeconomy contribution to NDCs (Frank et al 2024). This includes enhancing soil carbon sequestration, such as through silvopastoral practices. The bioeconomy in some countries can also support renewable energy targets through advanced bioenergy production from agricultural waste and biofuels to reduce bioeconomy products transportation emissions. It can help decarbonize industries using bio-based alternatives to fossil fuel derived products, support waste reduction and circular economy goals through reuse of wastewater and biomass as organic fertilizers, and it can enhance resilience in public health through the development of bio-based pharmaceuticals through R&D based bioprospection. By integrating these bioeconomy approaches into sectoral NDC targets, countries can enhance their climate ambition while promoting sustainable development and innovative economic growth.



Nature-Based Solutions

Countries can incorporate bioeconomy-focused nature-based solutions across various ecosystems by implementing strategies related to forest ecosystems (e.g. sustainable management, sustainable agroforestry, restoration and conservation), dryland ecosystems (e.g. drought resistant crops, regenerative agriculture), coastal areas (sustainable aquaculture and marine biomass, mangrove forest restoration) and wetlands (wet agriculture for sustainable biomass production, peatland restoration). There is robust evidence on the role of nature-based solutions to mitigate and to adapt to climate change (Griscom et al., 2017). The broader emerging category of “Nature as Infrastructure” offers a wide range of opportunities to collaborate with MDBs and NDBs in developing “green” and “grey” approaches to infrastructure needs, from mangrove, reef and salt marsh restoration to urban greening and biocredit efforts, to forest, wetland and river restoration, to agroforestry techniques. There are a broad range of examples demonstrating how green infrastructure can be deployed as solutions to carbon sequestration, flood management, air quality and many other mitigation, adaptation and resilience increase efforts, often at a lower cost than **traditional grey infrastructure** (International Finance Corporation, 2023).



Adaptation strategies

Countries can integrate bioeconomy-based adaptation targets that utilize ecosystem-based approaches to enhance resilience across sectors and ecosystems. For example, **Costa Rica has developed a holistic bioeconomy agenda that prioritizes rural development** (Castillo Monagas, 2023) while fostering primary industries such as agriculture, fisheries and forestry. This approach balances advanced tech-driven bioeconomy goals with the concept of bio-principled cities, enhancing resilience across urban and rural ecosystems. In **Malaysia, the country has implemented a comprehensive bioeconomy program** emphasizing a biomass-driven approach, that focuses on developing high-value bio inputs for various economic sectors, including agriculture, horticulture, chemicals, materials, and healthcare, thereby enhancing cross-sectoral resilience (Nadzrin, 2023). In Brazil, the country has developed a “**socio-biodiversity bioeconomy**” concept, which emphasizes the protection of Amazonia while providing economic and social support to local communities, enhancing both ecosystem and social resilience (Costa et al., 2021). More broadly, countries can set adaptation targets that maximize the potential of nature-based solutions in the bioeconomy, such as climate-resilient crop varieties and agroforestry systems.



Measurement

Measuring the contributions of bioeconomy-based climate action requires a comprehensive approach that includes:

- | Quantifying the amount of CO₂ and other greenhouse gases sequestered or avoided through bioeconomy initiatives, such as sustainable forestry practices, bioenergy production, and use of bio-based materials.
- | Monitoring key biodiversity indicators such as trends in species populations, ecosystem health, and habitat restoration to assess the impact of bioeconomy practices on biodiversity conservation.
- | Undertaking ecosystem services assessments that measure improvements in water quality, soil health, and other ecosystem services provided by nature-based solutions in the bioeconomy sector.
- | Economic indicators that track the economic value of biodiversity and ecosystems services, and generated by bioeconomy activities, including job creation, rural development, and the market share of bio-based products, as well as the catalytic effect of investment policies (e.g. private investment mobilized).
- | Social impact metrics that examine the inclusiveness of bioeconomy initiatives, considering factors such as stakeholder engagement, gender equality and benefits to local communities.

Many of these areas already link in concrete ways to the Sustainable Development Goals (SDG) implementation and monitoring, and/or NBSAP implementation and monitoring, but will undoubtedly require additional assistance from international donors, MDBs and research institutions. The **extraordinary uptick in biodata** resources using AI and remote sensing technology is an option for governments to track key biodiversity indicators as well as ecosystem service assessments (Taskforce on Nature-related Financial Disclosures, n.d.). For other areas such as social impact metrics and the bioeconomy, we have seen growing investment by institutions like the **IDB**, the **FAO** and the **EC's Joint Research Centre** in developing indicators, frameworks and methodologies that can be adopted and deployed by others (Inter-American Development Bank, 2023, Bracco et al., 2019, (European Commission, n.d.). Broader emphasis on natural capital accounting can also play an important role generating relevant data. As of 2025, over 90 countries have begun compiling natural capital accounts, with the **World Bank's Wealth Accounting and Valuation of Ecosystem Services (WAVES)** Partnership as one example of an effort to help support national statistical agencies in developing natural capital accounting expertise (Wealth Accounting and the Valuation of Ecosystem Services, n.d.). Overall, by implementing robust measurement approaches, countries can effectively track the progress of nature-based climate action in the bioeconomy, make ambitious progress on their NDCs, and support more evidence-based decision-making at the bioeconomy-climate nexus.

ANNEXES

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Glossary

Bio-based products: Bio-based products are wholly or partly derived from biological resources (urban bio-waste, organic residues or wastes from primary production and industrial processes, dedicated industrial crops, biogenic CO₂, etc.) Source: European Commission, International Organization for Standardization

Bioeconomy: The bioeconomy is a socio-economic model for the sustainable production, use and transformation of renewable biological resources across economic sectors. Source: NatureFinance and World Bioeconomy Forum, 2024

Biodiversity: The variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species, and of ecosystems. Source: Convention on Biological Diversity

Circular Economy: The circular economy is a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. Source: Ellen MacArthur Foundation

Climate Resilience: The capacity of social, economic, and environmental systems to cope with hazardous climate events and trends, responding or adapting in ways that maintain their essential function, identity, and structure. Source: Intergovernmental Panel On Climate Change (2022)

Controlled Environment Agriculture: Controlled Environment Agriculture (CEA) encompasses a range of farming methods and technologies that allow crops to be cultivated outside their natural or preferred environments. Examples include growing leafy greens indoors or cultivating temperate fruit varieties in tropical regions. By controlling and adjusting environmental factors, CEA optimizes crop growth and development. Source: United Nations Development Programme (2025)

Ecosystem services: Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits. Source: Millennium Ecosystem Assessment

Nature: The living parts of the biosphere, including their diversity and abundance and functional interactions with one another and with the abiotic parts of the earth system. Source: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

Nature-based Solutions: Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. Source: United Nations Environment Assembly (UNEA 5.2 Resolution, 2022)

Natural Capital: Natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people. Source: United Nations System of Environmental Economic Accounting

Nationally Determined Contributions (NDCs): Climate action plans submitted by countries under the Paris Agreement, outlining efforts to reduce emissions and adapt to climate impacts and ensure sufficient finance to support these efforts. Source: United Nations Framework Convention on Climate Change

Parametric Insurance: Parametric insurance is a type of insurance that provides cover based on the occurrence of a pre-agreed set of adverse conditions, rather than on the amount of actual losses or damage incurred. Source: United Nations Development Programme Insurance and Risk Finance Facility

Regenerative Agriculture: Farming practices that restore soil health, biodiversity, and water cycles while sequestering carbon. Source: FAO