DEVELOPMENT BANK OF LATIN AMERICA AND THE CARIBBEAN

Latin America and the Caribbean

Biodiversity and Productive Development: Extractivist traps and symbiotic innovation ecosystems in Latin America & the Caribbean

Amir Lebdioui

BIODIVERSITY AND PRODUCTIVE DEVELOPMENT: EXTRACTIVIST TRAPS AND SYMBIOTIC INNOVATION ECOSYSTEMS IN LATIN AMERICA & THE CARIBBEAN

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Key messages

- The region's trajectory in terms of biodiversity-development *dilemma* or synergy largely depends on the type of finance mobilised: short-term extractive capital locks in degradation, while long-term, patient capital aligned with natural-capital accounting underpins sustainable, inclusive prosperity through nature-centred knowledge economy.
- Low R&D investment rates and limited innovation capabilities leave most LAC economies stuck in the middle-income trap. The volume of R&D spending needed to close the gap in LAC needs to increase from about USD35 billion a year currently to at least USD130 billion annually. But an increase of R&D investment, a new direction for innovation is also needed for the region to leap to the innovation frontier. In LAC, biodiversity provides as entry door to leapfrogging into disruptive innovation activities in order to break the middle income trap.
- Nature-inspired innovation must be prioritised over nature-based solutions: Not all "bioeconomy" models are developmental. Without capability building, fair governance, and local value-sharing, bioeconomy often translated into a biologicalization of extractivism. Amongst different types of biodiversity-based development models, bio-inspired innovation offers the most scalable and least ecologically constrained path for long-term biodiversity-based productive development.
- Territorial inequality in terms of science and innovation capabilities have generated cognitive extractivism. LAC's biodiverse areas in LAC are often the poorest in terms scientific and innovation capacity. Spatially rebalancing R&D with investment in the innovation capacity and local value creation is both a fairness and efficiency imperative.
- We need new biodiversity finance taxonomic classifications that do not just answer how much is spent and on what habitat, but also how it builds capabilities, who benefits, where value is captured, and whether the result is durable without endless subsidies. This can be done by introducing a new label of biodiversity-oriented productive investment, along with outcomes reporting.
- Development banks have can play a catalytic investment role as they can mobilise patient capital, absorb first-mover risks, and align financial in-

strument towards key pressure points in regional biodiversity-based innovation ecosystems. Beyond financing, development banks can support regional science cooperation, fund shared scientific infrastructure, embed R&D components in loans, and bridge the finance–science divide.

- Development finance institutions such as CAF can fulfil a key role as architects of the scientific commons that underpin a regional biodiversity-based innovation ecosystems but only with stronger science-policy integration. The voice of scientific institutions in LAC is critical, gathering decades of experience and understanding of specific challenges and opportunities in local innovation and natural ecosystems. The Chicó-Bogotá Declaration for Positive Biodiversity in Latin America and the Caribbean, launched in 2024, provides a historic step forwards towards institutionalising scientific knowledge into policy and financial decision making in the region.

About CAF

CAF is a multilateral financial institution whose mission is to support the sustainable development of its shareholder countries and the integration of Latin America and the Caribbean. It serves the public and private sectors, supplying multiple products and services to a wide portfolio of clients formed by the shareholder States, private companies and financial institutions. In its management policies, it integrates social and environmental variables and includes eco-efficiency and sustainability criteria in all its operations. The Strategy for the 2022-2026 period aims to transform CAF into the green bank and the sustainable and inclusive growth of Latin America and the Caribbean, and position it as a region of solutions to global challenges. Its formulation was a comprehensive exercise that involved all areas of the organization and development experts, and is framed in the mission of "supporting shareholder countries to achieve sustainable development and regional integration through the offering of financial instruments and knowledge services".

About the University of Oxford's TIDE centre

The Technology and Industrialisation for Development (TIDE) centre is a research centre based within the University of Oxford. Since its formal creation in 2008, the centre has served as a global nerve centre for cutting-edge, interdisciplinary research into the development of technology and industrialisation in the developing world. For almost two decades, the centre's research projects have focused on enhancing our collective understanding of how technological capabilities can enhance development, thereby helping policymakers access informed counsel and insights that can serve as the basis for useful policy lessons.

With increasing disparities in technological capabilities and the challenge to achieve ecological sustainability, the centre's mission is to push the knowledge frontiers for economic and innovation policies that deliver local prosperity and true sustainability for all.

Table of content

List of Figures

List of Tables

Foreword

Latin America and the Caribbean hold more than half of the planet's biodiversity. This wealth is not only a global environmental responsibility but also one of the region's most powerful engines for development. Yet, for too long, biodiversity has been treated as something to preserve, not as something to learn from. At CAF, we believe that sustainability and development must go hand in hand. The dual crises of climate change and biodiversity loss have revealed the limits of extractive growth models, but they have also opened new opportunities for innovation.

This report developed in collaboration between CAF and Amir Lebdioui, from the University of Oxford, comes at a decisive moment. It invites us to see biodiversity in a new light: as the foundation of a more inclusive, resilient, and knowledge-based economy. Latin America and the Caribbean can no longer afford to remain suppliers of raw materials or biodiversity samples. We must become creators of value and innovation, transforming our biological richness into ideas, products, and solutions that serve both people and the planet. That is the central message and intention of this work,

The findings here reinforce CAF's own vision: that development finance must evolve. For too long, biodiversity finance has focused primarily on conservation but not on livelihoods. While these efforts remain essential, they are not enough. Development banks such as CAF have a unique role to play in bridging these agendas: providing patient capital, fostering innovation, and catalysing partnerships among governments, scientific institutions, and the private sector.

CAF is advancing this vision through initiatives such as the Chicó Declaration, which calls for integrating science into public policy and finance, and through efforts to strengthen regional networks of research, data, and innovation infrastructure.

This publication also reflects CAF's growing commitment to a Positive Biodiversity agenda: one that recognises that nature and development are not opposing forces but inseparable partners. The task ahead is to scale up this approach, embedding biodiversity in industrial strategies, education systems, and financial instruments across the region. The opportunities are immense, but so are the responsibilities.

At CAF, we see this report not as an end but as a starting point and a valuable contribution to a regional dialogue about how Latin America and the Caribbean can lead the world in the age of biodiversity-based innovation. The time has come to move from protecting biodiversity to learning, innovating, and prospering with it.

Alicia Montalvo
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Executive Summary

From a biodiversity-development *dilemma* to a biodiversity-development *nexus*

Latin America and the Caribbean (LAC) is a global biodiversity hotspot, making it a critical player for our planet's health and in the sustainability agenda. Home to a vast share of the world's mammals, reptiles, birds, and amphibians, the region provides ecosystem services from which the whole world benefits and has pioneered legal recognition of nature's rights. Yet in the face of pressing needs for economic development and job creation, biodiversity remains pressured by extractivist models that prioritise short-term gains. This report argues that biodiversity is not only a natural asset to preserve but a productive frontier to cultivate, capable of anchoring structural transformation, quality employment, and environmental resilience. The economic and ecological risks of the integration of LAC economies as raw materials providers in global value chains are reinforced in the context of the transition to a low carbon economy, given the region's endowment in the critical minerals that are necessary as inputs for low carbon technologies. **However, the most critical material that the region disposes of is not a mined metal, but it is its rich biodiversity.**

Many questions arise: What are the main tensions between biodiversity and productive development? How is biodiversity linked to the challenge of the middle-income trap? What are the shortcoming of existing bioeconomy strategies? How can biodiversity be truly leveraged to nurture a new age of technological innovation in LAC? And what is the role of development banks in supporting that process?

The need to rethink the relationship between biodiversity and economic development is urgent. Moving forward, LAC countries have a unique opportunity to harness their biodiversity in way that breaks free of an unhelpful dichotomy between nature and productive development. To that end, this report provides a review of different models through which the region's biodiversity drives productive development and emphasizes the importance of integrating biodiversity into economic, innovation and industrial development strategies across the LAC region, before discussing the binding constraints and policy pathways to achieve a virtuous biodiversity-development *nexus*.

Beyond bio-extractivist models

In that perspective, LAC has witnessed a range of pioneering efforts to leverage the economic value of biodiversity, since the 1990s, within varying outcomes and degrees of success. The region's experimentations with various types of biodiversity-based activities, ranging from payments for ecosystem services, ecotourism, bioprospecting, provides critical lessons.

Many LAC governments have increasingly turned towards the so-called 'bioeconomy', which can be defined as the production, utilization and conservation of biological resources to provide information, products, processes and services in various economic sectors. In recent years, many governments such as in Argentina, Brazil, Colombia, and Costa Rica have published bio-economy strategies to promote sustainable development. However, the bio-economy encompasses a wide range of activities that exhibit varying degrees of extractivism and impact on nature. For instance, many agro-based activities (such as Açaí-based bio-utilisation) lead to deforestation and biodiversity loss when they are scaled up.

This report therefore clarifies that not all "bioeconomy" is developmental. Left unchecked, parts of the bioeconomy can simply biologise old extractivism, by replacing fossil feedstocks with biological ones while preserving unequal value capture, weak learning, and ecological pressure. The report distinguish among different varieties of biodiversity-based economic models, from Payment for Ecosystem Services/ biodiversity credits, ecotourism, bio-utilisation, and bio-inspiration. Each of those models present benefits and limitations, and their development must be carefully assessed to avoid negative economic and environmental consequences. **However, the region's potential has been limited by a narrow focus on bio-utilisation, with far less attention provided to other types of biodiversity-centred innovation fields with high potential for technological disruption.** Bio-utilisation (or bioprospecting) involves the use of biological materials (e.g. organic acids and phenolic compounds from fruits such as Açaí) for economic purposes (and solutions development through that process are often oriented towards the agriculture, pharmaceuticals and cosmetics industries). Meanwhile, bio-inspiration implies learning from innovative solutions found in nature to solve human challenges, especially in manufacturing, construction, and energy. **Bio-inspired innovation remains the least explored biodiversity-based economic model across LAC, yet it offers the most scalable and least ecologically constrained path for long-term productive and technological development** because it draws on nature's design principles rather than continuous biomass extraction. As this innovation method does not rely on extracting any physical material from nature, it not present the same ecological limits to scalability as bio-utilisation. A virtuous biodiversity-development *nexus* indeed requires a shift away from the exploitation of biodiversity towards leveraging the potential of biodiversity to drive innovations that can help push the technology frontier in various fields such as biotechnology, renewable energy, mobility and digital tech. Yet, the development of more bio-inspired could also face a similar risk of becoming concentrated in large private companies that often engage in biopiracy practices. Ensuring that the economic benefits of bio-inspired innovation reach marginalized populations in rural areas of countries therefore requires strong capacity-building at the local level and targeted safeguards for intellectual property rights for bio-inspiration as it falls between the cracks of the Nagoya protocol on the use of genetic resources and associated traditional knowledge.

Biodiversity as a vector for science and innovation in Latin America and the Caribbean

Innovation is not an outcome of development, but a means to achieve economic development, which is why innovation capabilities are a key binding constraint for the middle-income trap. In Latin America and the Caribbean, low rates of investment in R&D have considerably contributed to economic stagnation and the persistence of the middle income trap in many nations. The region's average R&D expenditure (as a share of GDP) is amongst the lowest in the world (<0.6%), and more than half of the little existing R&D expenditure is financed through public funds, providing fiscal constraints on increasing the rate of investment. **The volume of R&D spending needed to close the gap in LAC needs to increase from about USD35 billion a year currently to *at least* USD130 billion annually** to reach the global average of R&D spending as a share of GDP. Catalytic investments by national and regional development banks, such as CAF, will be critical in reaching this target, notably by crowding in more private investments into R&D.

But besides the volume R&D investment, the direction of R&D efforts also matters to leap to the innovation frontier. In that regards, while biodiversity-centred innovation presents tremendous opportunities as a bank of ideas for innovation, a variety of financing hurdles, policy inconsistencies, and institutional factors have led to the persistence of important coordination failures that hinder the expansion and diffusion of biodiversity-based R&D. Creating and strengthening technological capabilities has often not been easy in LAC economies, due to the presence of not only market failures but also system and learning failures. More specifically, identified obstacles that are preventing biodiversity-based innovation to reach its full potential in LAC include limited access to physical and digital infrastructure related to biodiversity research, including a lack of coordination and harmonisation amongst existing taxonomic systems to facilitate the mapping and study of existing genetic material; a lack a critical mass of human capital with the right type of multidisciplinary training across the entire lifecycle of biodiversity-centred innovation; biopiracy; as well as inadequate financial support for science and innovation, high laboratory operating costs and weak mechanisms to secure non-repayable or long term funding to develop spinoffs, scale up and commercialise nature-based innovative solutions, leading innovators in LAC to over-rely on small grants.

The paradox of LAC's bio-innovation landscape is that **the richest areas in biodiversity are often the poorest in terms of value generation from scientifica and technological capacity endowment and technological capacity endowment.** The Amazonian, Caribbean, and Pacific provinces concentrate biological wealth but have the lowest density of laboratories, research universities, and innovation funding. This spatial inequality mirrors broader centre-periphery dynamics within countries, resulting in a pattern of cognitive extractivism: biological samples and traditional knowledge flow from peripheral regions to central laboratories, while value-added activities and patents remain concentrated elsewhere. Addressing these disparities is not only a matter of fairness but of efficiency: innovation systems that exclude the territories of greatest biological potential are by definition inefficiency and do not fulfil their full potential.

When biodiversity finance meets development finance: from a rentier model to a productive one led by development banks

Latin America and the Caribbean stands at the brink of a formidable opportunity to redefine the relation of its economic systems with nature, with a positive vision of biodiversity that holds great potential to shape our technological and planetary futures. But to fully realize this potential, a radical transformation is needed for domestic actors to move from being strictly technological consumers to technology providers; and from being markets follower to becoming market-shapers. Doing so require a reorientation of economic, industrial, innovation and environmental policies, but also requires financing instruments that value long-term transformation over short-term gains. This implies both a drastic increase in biodiversity finance, but also its *strategic integration* with development finance.

Historically, biodiversity finance has received much less attention and resources than those directed toward climate change, despite being of equal (and perhaps even higher) importance for ecological sustainability in LAC. There is however a clear upward trend in biodiversity spending. The biodiversity finance targets agreed in international fora have increased (notably at COP15, to mobilise at least USD 200 billion annually from all sources of funding for biodiversity finance, see UN 2025), and in Latin America, biodiversity spending has by far outpaced that of the other regions (increasing six-fold from around 500million to over 3billion by 2017), clearly reflecting the region's interest and leadership in this agenda. Nevertheless, **LAC notably lags behind when it comes to biodiversity-specific and biodiversity-related development finance.** With an average of USD3.2 billion per year over the past decade, LAC falls behind Africa and Asia in terms of the amount of biodiversity-related development finance.

Nevertheless, one of the core challenges lies in the current metrics used to assess biodiversity finance, which often measure funding sources (e.g., funding from development finance institutions) with codes and classifications that are donor-driven

rather than reflecting developmental outcomes and priorities. While current biodiversity finance taxonomies are built to measure funding and labelling conservation categories (whether protected areas, species programs, restoration), they do not to explain what that money does for livelihoods, productive capabilities, or long-term economic resilience. As a result, current taxonomies are weak where policy needs the most clarity: which biodiversity finance is truly development finance, and how it affects jobs creations, skills provision, firms upgrading over time. The result of the If we want policy to shift, the taxonomy must shift first. **We need a classification that doesn't just answer how *much is spent* and on *what habitat*, but also *how* it builds capabilities, *who* benefits, *where* value is captured, and *whether* the result is durable without endless subsidies.**

Addressing these gaps requires a paradigm shift in how biodiversity finance is defined, measured, and tracked. As such, a revised taxonomy of biodiversity finance that clearly identifies activities that target productive development can be achieved by introducing a new label/code family for biodiversity-oriented productive development finance. Adopting this approach, which would a separates conservation/public goods from productive biodiversity investments while requires to report development outcomes, would not only clarify biodiversity finance flows but also help decision-makers be better equipped to understand the interplay between biodiversity finance and sustainable development and address funding gaps.

There is also a key role of play for **development finance institutions in stepping up to fill the gap in long-term transformative funding required for transformative biodiversity-based innovations.** Public financing for biodiversity-based R&D in LAC has been sub-optimal and is expected to be heavily constrained due to fiscal pressures in many LAC nations, while the domestic banking sector and private capital has tended to be risk-averse and often fails to provide the conditions that enable long-term, and patient capital for the early-stage development of technologies, especially when profits from innovation can only be expected far into the future.

In that perspective, along with their catalytic investment role and long term horizon, development finance banks, especially ones with a regional mandate such as CAF, can mobilise patient capital, absorbing first-mover risks, and aligning financial instruments towards key pressure points in regional biodiversity-based innovation ecosystems. They can embed R&D components into loans, co-finance biodiversity-based ventures, support scientific infrastructure in biodiverse territories, and promote regional mechanisms for shared learning and scientific exchange. In doing so, they can shift the region's development trajectory from one based on natural resource rents to one grounded in knowledge, capabilities, and value creation.

However, development finance institutions such as CAF cannot fulfil their role from passive funders into architects of the scientific commons that underpin a regional biodiversity-based innovation ecosystems without stronger science-policy integration and feedback loops with local, national and regional scientific communities. The voice of scientific institutions in LAC is critical, gathering decades of experience and understanding of specific challenges and opportunities in local innovation ecosystems. This is well exemplified by the Chicó-Bogotá Declaration for Positive Biodiversity in Latin America and the Caribbean, launched in 2024 under CAF's leadership, which represents a landmark commitment to bridge the long-standing divide between science, policy, and finance around biodiversity issues in Latin America and the Caribbean. The Declaration emphasizes a model in which scientific institutions—universities, biodiversity institutes, and knowledge networks—become recognized partners in the governance of natural capital and the design of biodiversity positive investment policies. CAF's adoption of this declaration marks the first time a regional development bank in the Global South explicitly positions science as a driver of its biodiversity investment strategy. In pushing its implementation, CAF can help build the missing connective tissue of the region's innovation ecosystem.

In conclusion, while biodiversity represents an immense opportunity to drive sustainable development in Latin America and the Caribbean, this report details why and how seizing such an opportunity requires moving beyond traditional conservation models and embracing transformational agendas to both protect the ecological value of biodiversity while leveraging their innovation value. Achieving this developmental vision of biodiversity will require an increase and reorientation of investment and biodiversity finance, as well as greater coordination between a range of stakeholders, including public and private sectors, scientific communities, local communities, and finance institutions. Such coordination has historically not been an easy task in LAC, but the region's ability to leap to the development frontier and shape the 21st century largely depends on it. **The need to adopt an ecosystemic thinking that recognises the interconnectedness of all stakeholders is perhaps the greatest lesson that can be drawn from the region's rich natural ecosystems.**

1.

Biodiversity in Latin America & the Caribbean: from a developmental *dilemma* to a developmental *nexus*

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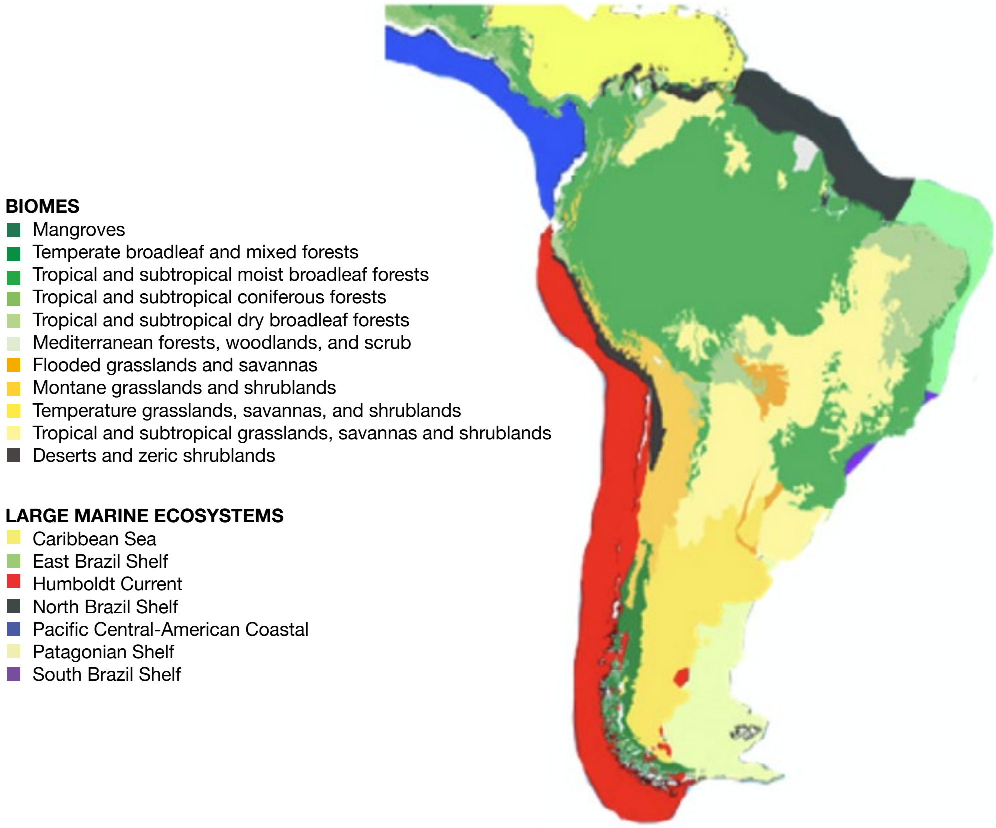
Biodiversity in Latin America and its vital economic functions

Latin America and the Caribbean (LAC) is characterised by a singular geography and natural ecosystems, home to global biodiversity hotspots, making it a critical region for our planet's health. The region is home to 33% of mammals, 35% of reptiles, 41% of birds, and 50% of amphibians in the world (UNEP, 2010). More than half of the 13 most biodiverse nations in the world are in Latin America (see Fig. 1.)

The governments in the region have seen pioneering initiatives for recognising nature's rights, and many governments across LAC have made significant efforts to protect and valorise their rich biological heritage. For instance, currently, there are more than 9000 Protected Areas in Latin America and the Caribbean, which cover 22% of their land surface and marine area (CAF, 2023). Meanwhile, countries such as Ecuador and Bolivia have explicitly enshrined the rights of nature within their national constitutions, and remain the only two countries in the world to have done so.

Fig. 1 | Distribution of Large Marine Ecosystems and terrestrial biomes in Latin America and the Caribbean.

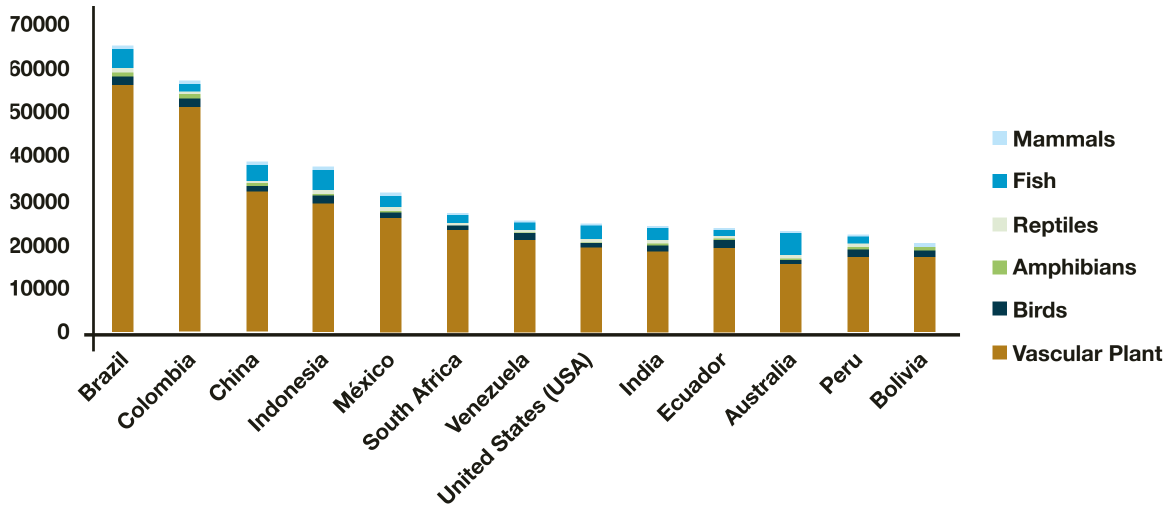


Source: Elaboration based on figures supplied by CAF (2023) and Sherman & Hempel (2009).

The natural ecosystems of the region provide vital services that benefit a range of industries. These benefits, known as ecosystem services, encompass the provision of food, freshwater, medicine, and materials, and are indispensable for human and economic development (Millennium Ecosystem Assessment, 2005; PBES, 2019). For instance, the Amazon rainforest alone holds a carbon stock equivalent to nine years of global fossil fuel emissions, which contributes to the global effort against climate change (Baccini et al., 2012). Biodiversity protection also have great recreational value. Ecotourism generating over 26% of the total GDP in the Caribbean as of 2020 and over 10% in Latin America (CEPAL, 2020). Environmental protection is also critical to food production, which heavily relies on the natural regulation of the water cycle, for instance. Thanks to their environmental impact, those ecosystem services are therefore also a driver of economic development and planetary health.

As such, the region provides critical ecosystem services from which the whole world benefits. But to what extent has the region fully leverage the value of biodiversity for its own development? In many ways, we cannot dissociate the conversation on biodiversity from the conversation on economic and industrial development strategies. Indeed, the development policies of Latin America and the Caribbean focused on harnessing their natural resources, prioritizing short-term economic needs, at the expense of the sustainability of economic activity and the preservation of ecosystems. In light of the need for economic development and job creation, LAC's biodiversity faces threats from economic models prioritizing extraction and short-term economic gains, as explained below.

Fig. 2 | Biodiversity Index based on the total number of amphibian, bird, fish, mammal, reptile, and vascular plant species, by country.



Source: Data compiled in Mongabay, usingdata from the World Conservation Monitoring Centre of the United Nations Environment Programme,2004; Fishbase; Birdlife International; AmphibiaWeb; IUCN; and the Reptile Database

Threats to Biodiversity in Latin America

Latin America and the Caribbean is facing significant threats that jeopardize its unique ecosystems. One of the main reason behind forest loss in the region is deforestation for agriculture and livestock, particularly in the Amazon rainforest. Between August 2023 and July 2024, approximately 6,288 square km of forest were destroyed (Meyerfeld, 2024) Though there is progress (with a reduction of deforestation rates in recent years), the cumulative loss remains substantial, driven primarily by agricultural expansion, illegal logging, and infrastructure development.

Additionally, overexploitation of natural resources poses a significant threat to biodiversity. Unsustainable fishing practices have led to declining fish stocks, especially in coastal areas of Peru and Chile. Similarly, the illegal wildlife trade is a persistent issue, with many species hunted or captured for international markets. Mining and oil extraction further degrade ecosystems by polluting waterways, destroying habitats, and displacing local communities. Together, these activities reflect a broader challenge of balancing economic development with environmental stewardship, highlighting the urgent need for sustainable practices and stronger conservation policies in the region.

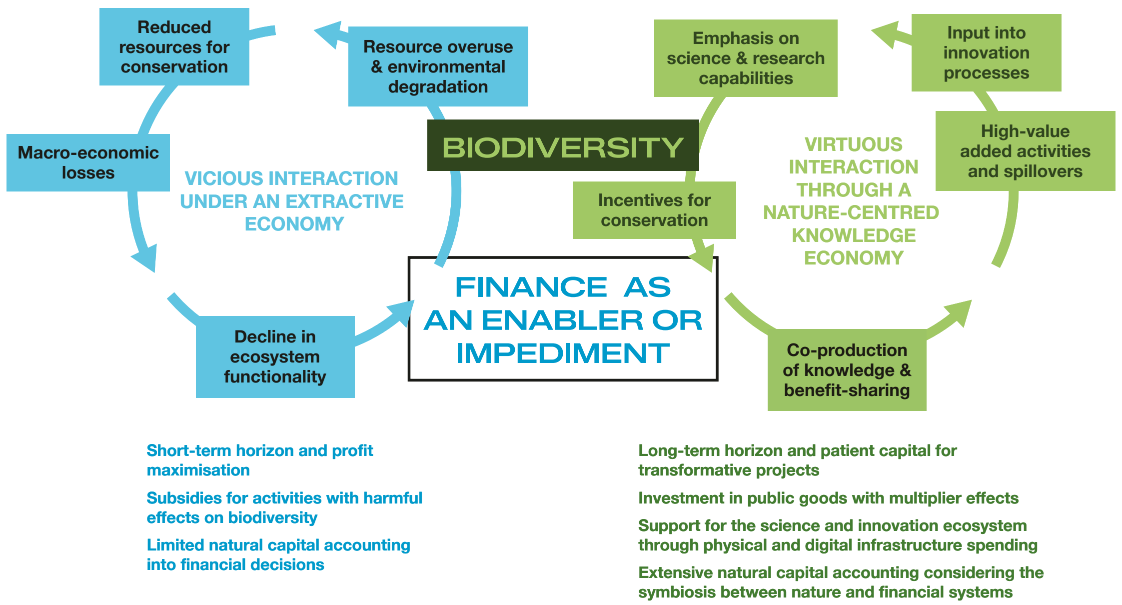
Climate change further exacerbates biodiversity loss in the region. Altered precipitation patterns and increased temperatures have led to more frequent and severe droughts, impacting ecosystems like the Pantanal wetlands which experience over 2,500 fires in 2024, marking a 1,776% increase compared to the same period in the previous year, devastating approximately 372,000 hectares (Meyerfeld, 2024). These climatic shifts threaten species adapted to specific environmental conditions, leading to population declines and, in some cases, extinction.

In sum, the historic dependence of many LAC economies on extractivist models of development with acute reliance on commodity exports has come at the expense of both economic and environmental sustainability. The economic and ecological risks are paradoxically exacerbated by the global transition to a low carbon economy, given to the integration of LAC economies as raw materials and critical minerals providers in global value chains. This further reflects the tensions that can arise for a global fight against climate change that does not include biodiversity considerations. Indeed, while LAC's critical mineral endowment has often been at the core of green economy plans, the most critical material that the region disposes of is not a mined metal, but it is its rich biodiversity, which has yet to be fully integrated into the productive development agenda.

From a biodiversity-development *dilemma* to a biodiversity-development *nexus*

The need to rethink the relationship between biodiversity and economic development is urgent. In many ways, biodiversity is not just a natural asset to be preserved but also a potential engine for sustainable economic development. Far from being a constraint on development, biodiversity can be harnessed for long-term economic prosperity, innovation and sustainability. Echoing Carlos Nobre's call for a "Third Way for the Amazon," biodiversity must become a driver of bioindustrialisation and climate resilience rather than deforestation and extraction. Nobre's vision of an Amazonian bioeconomy of standing forests resonates with an innovation-led use of biodiversity as the foundation for a new development model in the region (Nobre, 2018, 2019).

Fig. 3 | The role of finance in vicious or virtuous biodiversity-economic interactions.



Moving forward, LAC countries therefore have a unique opportunity to harness their biodiversity in way that breaks free of an unhelpful dichotomy between nature and productive development. To that end, this report provides a review of different models through which the region's biodiversity drives productive development and emphasizes the importance of integrating biodiversity into economic, innovation and industrial development strategies across the LAC region, before discussing the binding constraints and policy pathways to achieve a virtuous biodiversity-development *nexus*.

Under an Extractive Economy, there is a viscous interaction between biodiversity and economic development. Such an interaction is marked by resource overuse and environmental degradation, which leads to a decline in ecosystem functionality, which in turns results in macroeconomic losses and reduced resources for conservation efforts. As ecosystems become degraded, their ability to provide essential services—such as water filtration, carbon sequestration, and soil fertility—diminishes, further exacerbating economic challenges. This cycle perpetuates environmental harm and weakens the financial sustainability of both ecosystems and economies reliant on natural resources.

However, under Nature-Centred Knowledge Economy, biodiversity is integrated at the core of economic activity, in which science and innovation, enables the sustainable use of biodiversity for economic upgrading. Under this approach, bio-inspired innovation is complementary to having strong environmental safeguards and promoting conservation efforts, as inputs from biodiversity feed into high-value-added activities and innovation processes, such as bio-inspiration, biomimicry, and sustainable product development (see section 4). These activities incentivize conservation efforts by demonstrating that ecosystems can provide long-term economic value without being degraded.

As shown in figure 3, finance has a pivotal role in determining the trajectory of the interactions between biodiversity and economy systems, whether towards a vicious or virtuous path. Under the extractive model, financial systems priorities short-term gains and activities that harm biodiversity through subsidies for activities such as industrial agriculture or fossil fuel extraction. To this day, globally, subsidies harmful to the environment are quite a bit larger than the volumes of development and biodiversity finance combined. But rather than being an impediment to positive biodiversity, finance can also be an enabler. In a nature-centred knowledge economy, priority is given to investments with a long-term horizon and patient capital for transformative projects, that create the foundation for sustainable development. A systematic integration of nature through natural capital accounting helps aligning economic goals with ecological preservation.

As such, a different biodiversity-based economy in Latin America and the Caribbean is possible. But this requires a transformative reorientation of financial systems to prioritize conservation, innovation, and equity as further explained in section 5. By aligning economic activities with ecological realities, the virtuous cycle can become a blueprint for resilience and sustainability.

2.

The productive development agenda and its urgency in Latin America and the Caribbean

2. The productive development agenda and its urgency in Latin America and the Caribbean

Many economies in Latin America and the Caribbean (LAC) are at a critical juncture, facing structural challenges that have persisted for decades. The region's economic model, characterized by a heavy reliance on commodity exports, limited industrial diversification, and insufficient investment in innovation, is increasingly under strain. External shocks, including volatile global markets and climate-induced risks, exacerbate these vulnerabilities, underscoring the need for a robust productive development agenda. This agenda is not merely an economic imperative but a pathway to ensure social, environmental, and economic resilience amid profound transformations. In that perspective, biodiversity can be a great asset to redefine new pathways to productive development. As Raúl Prebisch (1950) and the Latin American structuralists argued, development challenges in the region are not simply about growth rates but about structural asymmetries in production, trade, and technological learning. These insights remain critical in the biodiversity era: natural-resource abundance must be channelled through learning, innovation, and diversification rather than reinforcing dependency.

Latin America's structural characteristics and exposure to climate and transition risks

Many LAC countries are heavily dependent on exporting raw materials and low-value-added products, such as agricultural goods, oil, and minerals. In 2022, commodities accounted for approximately 60% of the region's total exports (World Bank, 2024) While these commodities have historically driven economic growth, they leave the region vulnerable to price fluctuations in global markets.

Fig. 4 | Commodity dependent nations in LAC by dominant export product group, 2019–2021

Source: UNCTAD

In terms of trade, the region faces mounting pressure to adapt to shifts in global demand and new megatrends. More specifically, the current trade specialisation across LAC makes the region particularly vulnerable to the effects of technological disruption (such as automation of assembling activities) but also climate change -as well as its decarbonisation - in the medium and long term.

It is estimated that by 2050, climate change damages could cost USD 100 billion annually to the region (Vergara et al. 2013). The increasing frequency of extreme meteorological events has led to dramatic effects on production, tourism, and infrastructure, while long-term fluctuations in precipitations and temperature also threaten the long-term productivity of several agricultural goods that countries in the region depend on as a source of revenue, exports and food security. To note just a few obvious examples, climate change poses a serious risk to salmon farming in Chile, coffee in Colombia, and cacao in Ecuador (Soto et al. 2019; Macias Barberan et al. 2019).

Meanwhile, the global mitigation of climate change and the decarbonisation agenda also has important implications for the region's trade prospects. On the one hand, several oil producers in Latin America are facing the headwinds of the global energy transition, as the demand for fossil fuels is expected to drop in the medium to long term. Venezuela, Mexico, and Brazil depend on oil exports to finance public spending, making them vulnerable to declining global demand for hydrocarbons. Without a strategy to diversify their economies, these nations face fiscal pressures that could undermine social investments and exacerbate inequalities. The global transition to a decarbonised economy will have considerable effects on the fossil fuels sector and cause the loss of over 360,000 jobs in fossil fuel extraction and fossil fuel-based electricity generation in the region (Saget et al. 2020). It is further estimated that as the world draws closer to net-zero emissions, most jobs in petroleum and coal power plants (93% to 94%) would disappear by 2030, while 80% of jobs in gas power plants and 70% of fossil fuel extraction jobs would disappear by 2050 (ibid.).

Although the use of petroleum in our societies will not completely disappear given the use of petroleum products for a wide range of non-energy products such as pharmaceuticals, cosmetics, and plastic goods, it can nonetheless be expected that the oil-producing countries with high costs of extraction will be driven out of the market. The cost of production of an oil barrel in Latin America tends to be higher than in other regions. For instance, the total costs for producing an oil barrel in recent years have been relatively high in countries such as Brazil (USD 35); Venezuela (USD 28)compared to competitors such as Iran and Saudi Arabia (USD9 both); Iraq (USD 11), Russia (USD19) or even Norway (USD 21), while the cost of production in Colombia fluctuated from USD16.3 in 2017 to USD45 in 2020 (Wall Street Journal, 2016; ACP, 2017). As oil prices go down, it is therefore expected that Latin American countries with higher production costs will be driven out of the market first.

Other Latin American countries are poised to benefit from the increasing demand in minerals that are essential inputs of low carbon technologies needed to mitigate climate change. Critical minerals will play an increasingly important role in Latin American trade. Latin American countries present a large -and spread out- endowment in critical minerals, as well as the existence – and potential for developing downstream industries that utilise those minerals as inputs, especially in Brazil and Costa Rica. For instance, Latin America dominates the production -and holds very large reserves- of a range of critical minerals, such as lithium, copper, silver, as well as Bauxite, Zinc, Manganese, Nickel, and Graphene to a lesser extent (IEA, 2021). With appropriate policy tools, the region is geared to considerably benefit from the growing market for critical minerals and low carbon technologies required to meet climate goals, especially if the industrial capacity to refine and process those minerals is further developed.

However, even for countries that are dependent on the so-called minerals of the future, for which demand is expected to increase with the deployment of low carbon technologies, the long-term outlook is still dominated by high levels of uncertainty and risks of technological disruption. In the early 20th century, the discovery in Germany of a new way of producing ammonia had a dramatic economic impact on Chile, which had largely dependent on the extraction of natural deposits of sodium nitrate. Such a scenario is not unthinkable nowadays for Latin American countries such as Chile or Bolivia that are currently banking on the so-called minerals of the future (such as lithium) given the large amounts of resources invested in R&D to develop alternative electric battery technologies (such as solid-state batteries, or hydrogen-based batteries) that relies on substitute minerals and raw materials (Lebdioui, 2022). Decisions to invest in downstream value addition capacity or electric batteries production in lithium-producing countries must therefore consider the potential risks of technological disruptions, which can be considerable given the narrowness of the forward linkages that exist from commodities such as lithium (mostly used for electric batteries), in contrast to minerals such as copper or silver, which enjoy a wide range of possible applications.

The relevance of productive diversification

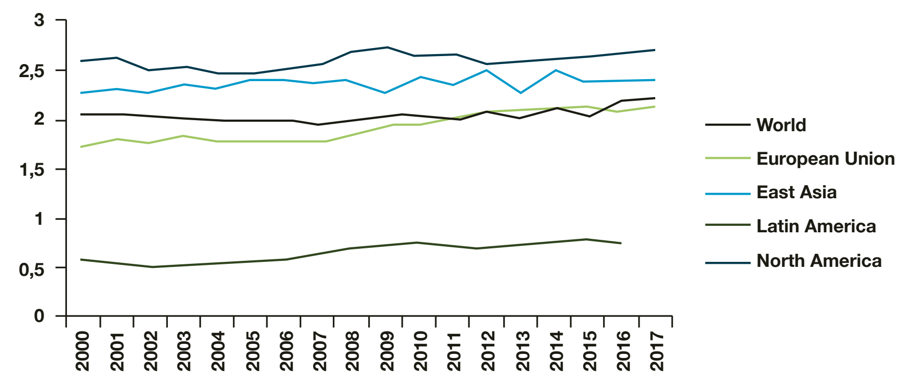
Given these challenges, the urgency of the productive development agenda cannot be overstated in LAC. Diversifying economic activities can reduce the region's vulnerability to external shocks, enhance its competitiveness, and generate higher-quality jobs. However, achieving this requires deliberate policy interventions to address structural constraints and catalyze innovation, and going beyond market forces, as evidence from successful experiences of economic diversification shows that following market forces do not suffice in the acquisition of new comparative advantages (Chang, 1994, Lebdioui, 2019; Cherif and Hasanov, 2021, Mazzucato, 2013).

As LAC navigates the intersecting challenges of economic volatility, climate risks, and social inequalities, productive diversification offers a pathway to sustainable and inclusive growth. However, this requires coordinated efforts from governments, private sector actors, and international partners. Policymakers must not adopt a long-term vision, prioritizing investments in innovation, but also a vision of productive development that places biodiversity protection at the core of economic systems, as further explain in section 3.

Innovation, R&D spending, and the binding constraints of the middle-income trap

Latin America and the Caribbean feature extremely low R&D shares. The region's average R&D expenditure (as a share of GDP) is amongst the lowest in the world (<0.6%), falling well below the world average (>2%). It is undeniable that more and better-oriented public R&D efforts and their coordination with the private sector of the economy need to take place in Latin America (Perez, 2008). In addition, in almost every Latin American country, more than half of the little existing R&D expenditure is financed through public funds, where the share in Europe and North American countries (excluding Mexico) tends to be lower than 35%. In Argentina, Ecuador, Cuba, and Costa Rica, the share of public funding in R&D even exceeds 70%. Moving forward, finding ways to encourage further complementary private financing for R&D will be essential in making the most of the economic and trade opportunities that arise from energy transitions (see section 5).

Fig. 5 | Expenditure on Research and Development by World Region (% GDP) for the most recently available years



Source: Author's based on data from the World Development Indicators

LAC's low rates of R&D spending are quite problematic, and contribute to explaining the different between simple growth and productive development, and the persistence of a middle-income trap in various LAC economies. A vast body of literature has evidenced the key role of innovation in economic catch-up (Schumpeter 1939; Aghion and Howitt, 1990; Perez, 2008). More recently, several studies (such as World Bank, 2010). Eichengreen et al., 2012, 2013; and Lee, 2013; Lebdioui, Lee and Pietrobelli, 2021) have also evidenced that innovation capabilities are the key binding constraint for escaping the middle-income trap.

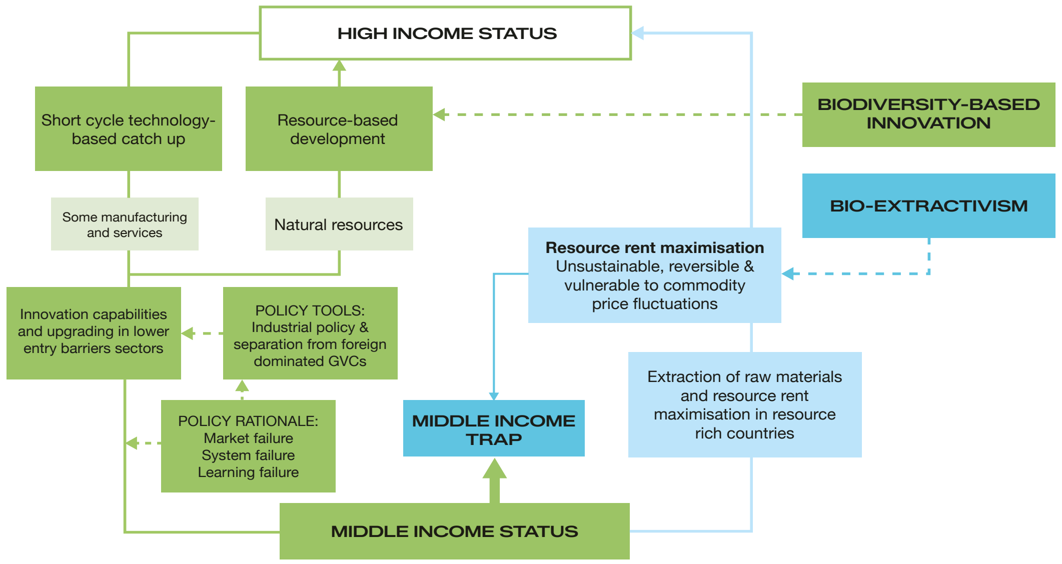
The role of innovation for structural transformation remains relevant in the context of sustainability, which is increasingly considered the next innovation frontier (Nidumolu et al., 2009; Lema et al. 2020). As Carlota Perez (2010) has argued, every technological revolution brings with it an opportunity for new forms of development and inclusion. The green techno-economic paradigm represents such a turning point, where countries that align their innovation strategies with sustainability goals can leapfrog to the new frontier. For Latin America, biodiversity and renewable resources can form the material base of this new paradigm. In that sense, a key question in the LAC region is how to leverage existing biodiversity to support innovation efforts and leapfrogging to the technology frontier, not only as a way to develop innovation capabilities, but also to reach higher living standards. Jorge Katz (2000) has evidenced that catching up requires building domestic technological capabilities, not merely adopting imported technologies, which is a lesson directly relevant to biodiversity-based innovation strategies that rely on local knowledge and R&D institutions.

Fig. 6 | Mapping of selected R&D centres in Latin America and the Caribbean

Source: Author's elaboration

Figure 1 illustrates this argument. The existence of a middle-income trap amongst many LAC nations stems largely from weak innovation capabilities and an inability to move beyond resource dependence or low-value manufacturing. Escaping the trap requires targeted industrial policy interventions that address market, coordination, and learning failures. Historically, successful transitions to high-income status occurred when countries used industrial policy to promote domestic firms' upgrading in sectors with manageable entry barriers, such as technology-based manufacturing or resource-linked industries. However, in LAC, industrial policy has often reinforced dependence on resource rent maximisation, leading to unsustainable and volatile growth paths tied to commodity cycles.

Fig. 7 | Middle income trap: three types of strategies and the role of biodiversity



Source: Adaptation of the framework in Lebdioui, Lee and Pietrobelli, 2019

The diagram suggests two distinct trajectories stemming from resource-based development. The red path, labelled bio-extractivism, represents the traditional model—focused on raw material extraction and rent capture, which is unsustainable, reversible, and vulnerable to global price fluctuations. The green path, by contrast, represents a new development strategy: biodiversity-based innovation. This approach treats natural wealth not as a stock to be depleted, but as a source of ideas, bio-inspiration, and biotechnological potential. By investing in research, innovation ecosystems, and scientific cooperation, countries can transform biodiversity into a driver of learning, productivity, and diversification, rather than a trap of dependency.

The idea of leveraging biodiversity as the new form of technological catch-up aligns with the early insights by Carlota Perez and other Latin American scholars that Latin America nations should utilize their natural resources to leap forward with the next technological revolution (Perez, 2010; Marin et al. 2015). Just as earlier industrial revolutions were powered by coal, oil, or digital networks, the next wave—centred on

bio- and eco-innovation—will reward those who can align natural capital with knowledge production. In this sense, biodiversity becomes the region's comparative advantage in the emerging "green techno-economic paradigm" (Perez & Marin, 2015).

More recent work further argues that LAC countries can leverage their biotechnology capabilities to build more inclusive and sustainability-oriented bioeconomies (Robert and Marin, 2022). Rather than focusing only on agricultural bio-inputs, they argue for bio-innovation platforms that connect biodiversity research with industrial policy and export diversification. This perspective strengthens the argument that biodiversity-based innovation can serve as a bridge between industrial upgrading and environmental goals, rather than treating these domains separately.

The strategic challenge is thus to design policies and institutions that channel biodiversity use away from extractive rent-seeking and towards learning, value addition, and capability building.

3.

Varieties of biodiversity-based economic models and their differentiated impact on productive development

3. Varieties of biodiversity-based economic models and their differentiated impact on productive development

Given LAC's vast endemic biodiversity and unique natural ecosystems, biodiversity-based trade and innovation services can be a transformative force for boosting economic development and trade in the region. Traditional conservation approaches have often provided limited tools to understand how biodiversity could be leveraged as a lever for sustainable development and can in fact perpetuate structural inequities, adversely affecting Indigenous peoples and local communities (Gill et al. 2023). Meanwhile, biodiversity generates direct benefits to humankind in the form of new genetic material for drugs, agriculture, and increasingly ecotourism (Pearce and Pearce, 2001; Swanson, 1996) but also have value as sources of information that can feed into research, innovation, and industrial processes (see Benyus, 1997; Simpson et al., 1996; Swanson, 1996).

There are indeed several ways in which the region's biodiversity influences trade opportunities, not only in terms of market-based instruments such as payments for ecosystem services and biodiversity permits, but also in terms of eco-tourism, and bio-utilisation, forming part of a broader bioeconomy, which has become increasing popular in the formulation of policy strategies in Latin America and the Caribbean.

This section explores these different models, assess their viability, and highlight examples from Latin America and the Caribbean, as summarised in Table 1.

The rise of the concept of bioeconomy, its promises and its shortcomings

The concept of the bioeconomy has risen to prominence as a policy paradigm, especially in Latin America and the Caribbean, amid global crises of sustainability, productivity stagnation, and biodiversity loss. At its core, the bioeconomy promises a transition from fossil-based and unsustainable development pathways toward economic models founded on the intensive and innovative use of biological resources, supported by advances in science and technology (FAO, 2019). Yet, as the experience in Latin America and the Caribbean starkly reveals, the bioeconomy concept embodies both significant opportunities and deep contradictions, as its transformative promise often thwarted by extractivist inertia, "biologicalization" of old paradigms, and the marginal inclusion of bio-inspired innovation ecosystems (Allain et al., 2022; Trigo et al. 2013, Lebdioui, 2022).

This section critically examines the rise and limitation of the bioeconomy concept globally and in LAC, focusing squarely on the region's unparalleled biodiversity and the imperative of harnessing it for structural transformation. It calls for a shift from traditional resource extraction towards a development model rooted in innovation, ecosystem-building, and the valorisation of local knowledge, which in many ways goes beyond the traditional understanding of the concept of bioeconomy.

Table | List of national bioeconomy strategies in Latin America and the Caribbean.

Country	Policy Document (Year)	Sectoral Priorities
Argentina	"Argentine Bioeconomy Strategy" (2016),	Agriculture, forestry, food, bioenergy, biotechnology
Brazil	National Bioeconomy Strategy (2024)	Biofuels, forestry, biodiversity, Amazon, bioproducts
Colombia	"National Bioeconomy Strategy" (2020)	Biodiversity, bioprospecting, health, agri-tech, bioenergy
Costa Rica	"National Bioeconomy Strategy" (2020)	Agriculture, forestry, biobusiness, eco-innovation, tourism
Ecuador	"National Bioeconomy Policy" (2021)	Agriculture, food, biorefining, bioproducts, energy, waste
Mexico	"Bioeconomy Strategy" (2022)	Bioenergy, agro-industry, food, green chemistry, biodiversity
Uruguay	"Plan Sectorial de Biotecnología" (2011/Rev.2020)	Agriculture, forestry, bioenergy, biotechnology, aquaculture
Chile	No explicit bioeconomy programme, but several relevant policies	Forestry, fisheries, food, chemistry, eco-industry
Bolivia	No single, centralized bioeconomy program, but multiple relevant policies	Agroindustry, biodiversity, local bioproducts, forestry

In theory, the bioeconomy offers considerable developmental promises, particularly relevant to LAC's conditions. It provides a pathway for diversifying economies long reliant on commodity exports, by enabling the development of value-added industries such as biopharmaceuticals, bio-based chemicals, advanced materials, and bioenergy (FAO, 2019; UNDP, 2025). By embedding bioprocessing and bio-manufacturing at the rural and territorial level, the bioeconomy has the potential to promote green jobs in a diffuse manner that favours rural and marginalised areas, support indigenous and rural livelihoods, and ensure environmental resilience (ECLAC, FAO, and IICA, 2019). It also promises an avenue for innovation because LAC's biological wealth, combined with traditional and scientific knowledge, can serve as a springboard for technological solutions that generate high-tech, high-value goods and services (e.g. in Brazil, biofuels have been a tremedous source of technological upgrading, knowledge spillovers and value addition).. However, in reality, despite its rhetoric of transformation, the mainstreaming of bioeconomy policies in LAC and globally has often reproduced or even deepened existing development shortcomings. Key limitations identified in the literature include:

- Renewed extractivism through Biologicalization
- Limited impact on productive transformation
- Uneven value chains, and persistent Inequality
- Excacerbation of environmental risks

Critics argue that much of the applied bioeconomy in LAC simply rebrands resource extraction, extending the region's traditional "commodity trap" into the bio-based domain (Allain et al., 2022). Rather than restructuring economies to foster local value addition and endogenous innovation, bioeconomy rhetoric often rationalizes continued large-scale monoculture production (e.g., *Açaí* in Brazil, industrial forestry in Chile, although both sectors have generated knowledge spillovers) with technologies, and intellectual property that are still dominated by external actors outside of communities in biodiverse regions (Birch et al., 2010; Levidow, 2015). In order words, the risks is that the bioeconomy amounts to the mere "biologicalization" of the productive system: replacing fossil feedstocks with biological ones but without changing the economic structures governing resource use and distribution (Bèfort et al. 2020; Allain et al., 2022). This critique is particularly salient for LAC, where power asymmetries in land, finance, and technology persist (Bertola and Ocampo, 2012). The implications of an extractivist bioeconomy model are important: instead of supporting high-value, diversified local production, the region remains locked into its historic role as a raw materials exporter, missing opportunities for technological upgrading and economic diversification.

There are also considerable distribiutional effects to consider. Despite their transformative rhetoric, many bioeconomy strategies in LAC do not fundamentally alter existing patterns of land, market, and technological power. They often prioritize large-scale biomass that favour multinational corporations, leaving smallholder farmers and indigenous peoples locked into peripheral roles as suppliers of low-value raw materials (Birch et al., 2010; IICA, 2024). Governance issues often compound distributive problems. For instance, policy roadmaps tend to focus on scaling up bioprocessing and high-yield crops, with insufficient attention to issues of land reform, equitable access to innovation finance, and participatory governance of genetic resources (ECLAC, FAO, and IICA, 2019). This oversight is particularly problematic in LAC, where agrarian structures are highly unequal and innovation ecosystems are often fragmented and the "one dominant agricultural transition model" threatens to crowd out

alternative agroecological practices and truly disruptive approaches rooted in local knowledge and agro-biodiversity (Magrini et al. 2019; Vanloqueren and Baret, 2009).

There are also concerns that, without strong safeguards, bioeconomy expansion may intensify pressure on land and biodiversity, as large-scale monoculture and bioenergy production compete with food crops and drive habitat loss (FAO, 2019). As further discussed later in this section, the production of bioplastics and other bio-based materials is not inherently sustainable in absence of appropriate environmental safeguards, and may lead to significant resource use, emissions, and waste if not governed by holistic circular economy principles (Schröder et al., 2020; ECLAC, FAO and IICA, 2019).

In sum, we must go beyond the 'bioeconomy' as an all-ecompassing policy paradigm. The bioeconomy concept undoubtedly signals a crucial evolution in development thinking, particularly for regions such as Latin America and the Caribbean, where biodiversity is not only an ecological endowment but a strategic asset for productive transformation. Yet, as this review has shown, the bioeconomy's mainstream expressions have too often fallen short, trapped by extractivist inertia, institutional inertia, and a failure to build inclusive, innovation-driven ecosystems. When concepts or policy paradigm are too broad, they often stop being useful.

Moving beyond "biologicalization" of extractive paradigms requires not just new technologies but profound institutional and policy innovation, the integration of indigenous knowledge, and an ecosystem-building approach (see section 7 of this report). Only through these changes can LAC truly turning biological wealth into real innovation and development opportunities. To do so, we must also really to distinguish among very different varieties of bioeconomy strategies, understanding their strengths and limitations, and the factors that affect their viability in different contexts across Latin America and the Caribbean. The rest of this section review four different types of bioeconomy strategies, and assess their strengths and limitations. Those are: Payments for Ecosystem Services (PES), Biodiversity credits, eco-tourism, bio-utilisation, and bio-inspired innovation.

Table 2 | Tradable services based on biodiversity: summary of strengths and limitations

Type of service	Consists of:	Examples from LAC	Benefits	Limitations	Conditions for success
Payments for Ecosystem Services	Financial incentives provided to landowners or communities for maintaining or restoring ecosystems	Carbon sequestration programs in Costa Rica, such as those paying farmers to conserve forests and adopt sustainable practices; mangrove restoration in Colombia	Reduces deforestation, promotes conservation, enhances carbon capture, and provides income for communities	Requires monitoring, funding continuity, and clear land ownership In the absence of external or private financing, PES become a conditional cash transfer that can constrain public finance.	Strong governance frameworks, transparent payment systems and schedule, mechanisms for monitoring compliance
Biodiversity credits	instrument used to finance activities that deliver net positive biodiversity gains	Biodiversity credit to conserve 340 hectares of the Bosque de Niebla in 2020, with each credit serving to pay local landowners to conserve or restore an area of 10 sqm for 30 years.	allow companies to support nature-positive action rather than simply offsetting damaging impacts on location-specific ecosystems	Limited demand Lacking a and arguably lacking a "common currency" that can be consistently measured across biodiverse areas	more standardized metrics for biodiversity
Ecotourism	Sustainable tourism focused on natural areas	Costa Rica's ecotourism sector contributes to a large share of GDP and job creation, attracting visitors to cloud forests, volcanoes, and protected marine areas	Generates revenue in a diffused manner, supports conservation, and provides jobs to millions of people with positive distributional effects	Risk of over-tourism, dependency on external markets, and potential degradation of ecosystems	Adequate regulation, strong local benefits-sharing mechanisms, and environmental impact assessments
Bio-utilisation (bio-economy / Biotrade)	Harvesting natural resources for commercial purposes	Harvesting of Amazonian plants for pharmaceuticals and cosmetics; sustainable fisheries in Chile	Generates revenue, supports traditional knowledge, and encourages sustainable practices	Overexploitation risks, lack of equitable sharing of benefits, and biodiversity impacts	Enforcing sustainable quotas, integrating traditional knowledge, and ensuring benefit-sharing agreements
Bio-inspiration (bio-economy)	Using nature's designs as models for innovation	Biomimicry-based products, such as Strong by Form's timber composites mimicking tree structures in Chile; renewable energy solutions inspired by natural designs	Encourages innovation, promotes sustainable technologies, and leverages local biodiversity expertise	Requires significant R&D investment, limited awareness, and challenges in scaling innovations	Partnerships between research institutions and industries, access to funding, and policies encouraging sustainable innovation

Payments for Ecosystem Services (PES) and Biodiversity credits

Communities across LAC are currently providing a range of ecosystem services (such as carbon storage, watershed protection, conservation of fauna and flora) from which the whole world benefits and should compensate. Fortunately, mechanisms exist to marketize and compensate for the protection of such valuable assets. Such mechanisms include Payments for Environmental Services Program (PES) is a financial mechanism whereby landowners receive direct payments for the ecological services that their lands produce when they adopt environmentally friendly land uses and forest management techniques (Malavasi and Kellenberg 2002).

LAC countries have been at the forefront of global PES adoption, implementing over 250 programs of this kind since the 1990s, succeeding pioneering programmes in Costa Rica and Mexico (Alpízar, Madrigal et al., 2020). Nevertheless, these programs need to be carefully designed to ensure a positive effect on the environment (CAF, 2023; Alpízar, Madrigal et al., 2020).

Some studies have found that PES programs may have minor or no effects on deforestation reduction (Robalino & Pfaff, 2013; Ruggiero et al., 2019; Sánchez-Azofeifa et al., 2007). One notable effect is leakage, which refers to the displacement of deforestation from participating areas to non-participating areas, as evidence in Bolivia, Mexico and Peru (Sohngen and Brown (2004) Izquierdo-Tort et al. (2019) and Alix-Garcia et al. (2012); Giudice et al. (2019). This is why, to be effective, PES programs must adhere to the principle of additionality, which means they should result in a greater flow of ecosystem services or conservation actions than would prevail in the absence of the scheme (CAF, 2023). However, even in the context of additionality (in high deforestation risks), there is an inherent trade-off between the anti-poverty and conservation goals of PES when PES simply compensate the foregone income from avoided deforestation rather than improving the well-being of the targerted communities (Jayachandran, 2023). Another issue also had to do with the distributional effects of PES programmes, with issues of land-grabbing and food inflation reported after their implementation, especially if they lead to a decrease of production of locally consumed crops.

Furthermore, PES mechanisms have often been limited to national boundaries and local communities often struggle to receive remuneration from the international community for this 'tradable' service. The case of Ecuador's Yasuní-ITT Initiative is a case in point, as it directly confronted the issue of international ecosystem services by leaving oil in the ground in the Yasuní National Park, one of the most biodiverse hotspots in the world. The initial proposal by the Government of Ecuador involved keeping almost a billion barrels of petroleum underground if the international community contributed with at least half of the opportunity cost of exploiting the petroleum (Larrea and Warnars 2009). The initial support from international institutions, European governments, and NGOs worldwide did not translate into concrete action and the 2008/9 financial crisis also added pressure on Ecuador's international sources of financing, which led President Correa to pursue his back-up plan to drill for oil if contributions were not received (ibid.) However, despite its failure, several lessons can be learned for the future success of similar programmes, especially regarding the need for international coordination and clearer legal frameworks to compensate for biodiversity protection from which the whole world benefits. Even though many ecosystem services are not readily transacted and valued by the market, they are still economically valuable and there is increasing research and policy discussion aiming to determine the value of (both market and non-market) derived from the management and protection of ecosystems.

The issue of international compensation brings the attention to the potential relevance of biodiversity credits, which have gained significant attention in recent years. Biodiversity credits are an economic instrument used to finance activities that deliver net positive biodiversity gains (Gray and Khatri, 2022) Unlike carbon or biodiversity offsets, which are payments made by a business to compensate for its damaging impacts on location-specific ecosystems, biodiversity credits allow companies to support nature-positive action, funding long-term conservation and restoration of nature (ibid.).

Biodiversity credits offer benefits and limitations. On the one hand, they are perceived as a promising way to scale up private finance for nature (Gray and Khatri, 2022). On the other hand, a common criticism has been that those mechanisms can be risky and can have high opportunity costs, potentially distracting actors from other more effective forms to mobilise biodiversity finance, especially given limited demand for these credits to date (Campaign for Nature, 2024; Rao et al. 2024). Furthermore, unless while a tonne of carbon is the same everywhere, biodiversity is, by its nature, diverse, and arguably lacking a "common currency" that can be consistently measured, tracked and traded and appropriately prices (Rao et al. 2024). This is why it remains unclear if biodiversity credits can play a sufficiently effective role in aligning local development with sustainability goals.

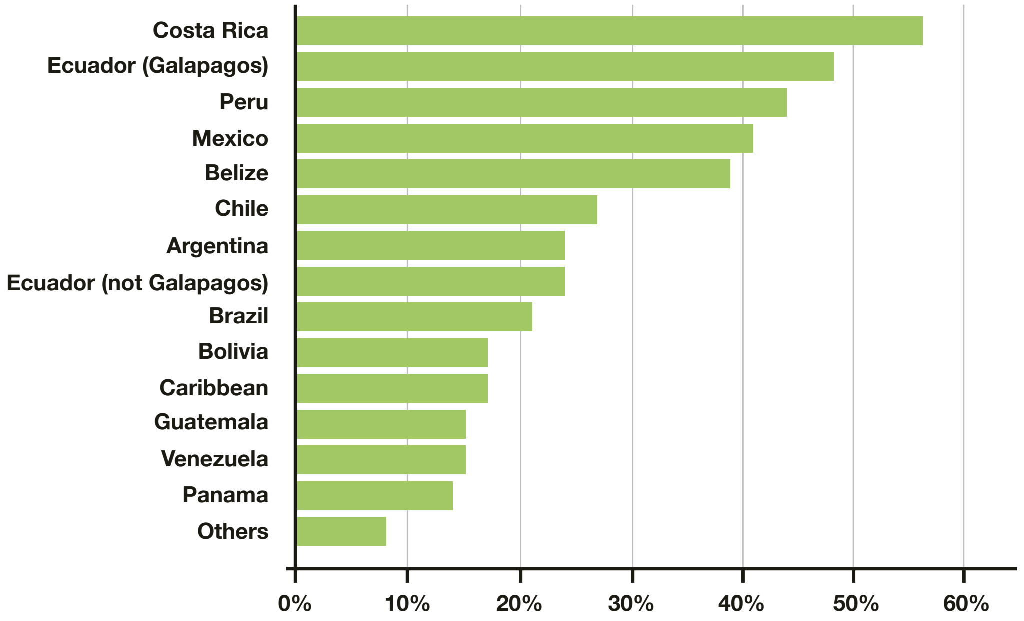
Eco-tourism

Ecotourism provide another avenue with a potential to provide local economic benefits while maintaining ecological resource integrity (Stem et al. 2023). It has become increasingly popular across Latin America as a way to promote environmentally friendly growth. Ecotourism, which aims to reduce the environmental footprint of tourism activities, is defined as the promotion of responsible travel to natural areas, and conservation of the environment, while improving the well-being of local people (TIES, 2015). Trade in ecotourism services is considered a promising way to support the dual challenge of sustainability as well as economic diversification (Hubler 2019). LAC countries are among the major ecotourism destinations in the world (see figure 5). Ecotourism generates around 3.5 million jobs in Latin America and the Caribbean, while tourism, in general, generates around 19 million jobs in 2018, or 8% of total employment (Saget et al. 2020). Nature-based tourism can accelerate poverty alleviation, especially in remote areas where alternative sources of job creation are scarce while providing foreign exchange across several economic sectors (IDB, 2017).

Nevertheless, overreliance on ecotourism has often posed important environmental and developmental risks, while presenting a model that is highly vulnerable to external shocks such as pandemics, climate change and natural disasters (Purkey, 2022). Nature-based tourism activities, which represent a key source of revenues and employment in Latin America (accounting for as much as 40% of export earnings in countries such as the Dominican Republic), are highly affected by climate change (Gouvea 2004). For example, the 2017 hurricane season resulted in an estimated loss of more than 800,000 visitors to the Caribbean, which would have generated USD740 million for the region and supported about 11,000 jobs (Saget et al. 2020). The risks associated with dependence on ecotourism are also well demonstrated by the experience of the emblematic Galapagos Islands, which have become overdependent on tourism as a source of funding for biodiversity protection, and where public revenues dropped. During the COVID crisis, the number of tourists visiting the islands dropped by 75%

between 2019 & 2020 (Personal communication with the Governor of the Galapagos, April 2021. While nature has gained some relief, the revenue drop jeopardised the local livelihoods, as well as the public budget to maintain local natural ecosystems.

Fig. 8 | Percentage of US-based ecotourism operators offering products by country.



Source: Purkey, 2021

Ecotourism cannot be viewed as a benign, non-consumptive use of natural resources in biodiverse nations because scale influences tourism's negative impacts, and where ecotourism dominates local economies, towns may become economically vulnerable (Jacobson and Lopez, 1994). Furthermore, Ecotourism does not automatically generate benefits for conservation and its effectiveness is contingent on multiple factors, including equitable distribution of benefits and secure land tenure (Stronza et al. 2019). In Costa Rica, where eco-tourism has gained appeal as a strategy to align both conservation and development, assessments of its impact on the country have been mixed. The development of ecotourism in Costa Rica resulted from the Biodiversity Law (No. 7788, 1998) and complementary entrepreneurship training programs (including business development with a focus on environmental and social responsibility) tailored to the needs of each community). On the one hand, some existing assessments reveal that the tourism industry in Costa Ric tends to hire more local people than other sectors within the region, while providing jobs with higher salaries, including for young people and women with children (thanks to a more flexible working schedule) (Hunt et al., 2015). On the other hand, some negative impacts of the eco-tourism industry in Costa Rica have also been raised, and include solid waste generation, air pollution, habitat destruction, and sociocultural ills (see Jacobson and. Lopez. 1994; Stem et al. 2003; Koens et al. 2009 for instance).

Bio-utilisation and the principles of biotrade

The bioeconomy is a relatively new concept with many definitions, making it difficult to define. Broadly speaking, it can be defined as "the production, utilization and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services in all economic sectors aiming toward a sustainable economy" (International Advisory Council of the Global Bioeconomy Summit, 2018). One key pillar of the development of a bioeconomy in Latin America lies in the promotion of innovation processes that contribute to the diversification of economies and generate new value chains (Rodriguez et al. 2019).

Within the bioeconomy, bio-utilisation has been particularly widespread in Latin America as an economic model. This refers to the extraction and use of biological materials or living organisms as part of a design or technology, also refered to as "bio-ingredients". Bioingredients can be obtained from marine and terrestrial sources to be added in the manufacture or preparation of product in modified form with biological activity (such as food, pharmaceutical products or cosmetics, for instance) (Premkumar et al. 2018). In fact, the reliance on biodiversity as an input into the R&D process in various industries (e.g. pharmaceutical and agricultural industries) is so substantial that the elimination of biodiversity could be disastrous for these important industries (Swanson, 1996). Between 25-50% of pharmaceutical products are derived from genetic resources and around 70% of drugs used for cancer are natural or are synthetic products inspired by nature (IPBES Global Assessment on Biodiversity and Ecosystem Services, 2019).

In Latin America and the Caribbean, high value bio-economy initiatives include the extraction of bio-ingredients for the pharmaceutical and cosmetics industry, such as Papain from papaya (used in skincare), collagen from fish (used in cosmetics), or anthocyanins from açaí berries (used in health supplements) (see Fig. 9). For instance, the Brazilian cosmetics company Natura sources 45 natural ingredients such as Brazil nuts and andiroba in collaboration with 44 Amazon communities (Clancy, 2024).

Fig. 9 | Selected examples of bio-ingredients, their origins and industry applications in Latin America and the Caribbean

Source: Purkey, 2021

While those industries can provide high rents, quality jobs and innovation potential, they can also present significant environmental trade-offs, including deforestation and species loss, especially if bio-utilisation activities are scaled up to increase production volumes. Furthermore, especially when it comes to marine resources, there is a heavy concentration of intellectual property leading to intellectual monopolies. In fact, one corporation owns 47% of patents for marine genetic sequences, exceeding the combined share of 220 other companies (Blasiak et al. 2018).

This is why it is essential for bio-industries to follow Biotrade principles, as developed by UNCTAD (2020). The BioTrade principles and criteria for terrestrial, marine and other aquatic biodiversity-based products and services, have been developed and implemented since 2007, include seven principles:

- Conservation of biodiversity
- Sustainable use of biodiversity
- Fair and equitable sharing of benefits
- Socioeconomic sustainability
- Legal compliance
- Respect for actors' rights
- Right to use and access natural resources

While trade and bio-utilisation can be an indirect driver of biodiversity loss through excessive extraction and degradation, applying the BioTrade P&C means respecting biodiversity and support livelihoods and contribute to the conservation and sustainable use of biodiversity. In LAC, CAF has pushed for the application of those principles notably through the Andean Biotrade project (Biocomercio Andino).

Alongside respecting sustainability principles in biotrade and bio-utilisation, complementing bio-extraction (which involves the physical removal of biological materials, such as plants, microorganisms, or genetic resources, from their natural environment) toward eco-friendly biodiversity-based innovation can mitigate negative environmental impacts while retaining economic benefits. For instance, biomimicry, which implies emulating biology, is different from harvesting organisms to accomplish a desired function, and therefore marks a divergence from the Industrial Revolution, which was “an era based on what we can extract from nature” (Benyus 1997) . Rather than “using an organism to ‘do what it does’, biomimicry aims to instead leverage the design principles embodied by the organism (Kennedy et al. 2013). This is the equivalent of the difference between using fireflies themselves to produce light, and understanding and applying the complex chemistry involved in bioluminescence (Helms et al. 2009; Kennedy et al. 2013). Recent studies by United Nations Economic Commission for Latin America and the Caribbean (CEPAL) have identified biomimicry amongst the possible bioeconomy development routes in the region (Rodriguez, 2019; Gramkow, 2020). Nevertheless, despite its considerable potential, the biodiversity-inspired innovation sector has so far been in rather nascent stages across Latin America and the Caribbean, as further explained in the next section.

4.

Leveraging biodiversity as LAC's entry door for science and innovation leapfrogging

4. Leveraging biodiversity as LAC's entry door for science and innovation leapfrogging

Biodiversity as a critical input for three types of innovations

As explained in section 2, Latin America and the Caribbean feature extremely low R&D spending, with the region's average R&D expenditure (as a share of GDP) being amongst the lowest in the world. This section explores the extent to which biodiversity opens avenues for innovation. This is particularly relevant as solutions found in nature often provide superior results in terms of sustainability, which in turns is considered the next innovation frontier (Nidumolu et al., 2009; Lema et al. 2020; Lebdioui 2024). In that sense, a key challenge in the LAC region is how to leverage existing biodiversity to support innovation efforts and leapfrogging to the technology frontier, not only as a way to develop innovation capabilities, but also to reach higher living standards.

Beyond their essential ecological value, natural ecosystems can hold considerable value as a source of information that can feed into innovation processes. Several economists have described the R&D process as one of information utilization, application and diffusion (e.g. Arrow, 1962) and dependent upon a stock of "information" for its generation of useful innovations (Stoneman, 1983). In that perspective, biodiversity is one of the primary sources of a stock of information that may be accessed for possible solution concepts to socio-biological problems (Swanson, 1993). As previously explained, biodiversity generates direct benefits to humankind, but biodiversity also have value as sources of information that can feed into research, innovation, and industrial processes (see Benyus, 1997; Simpson et al., 1996; Swanson, 1996).

In that sense, LAC's biodiversity represent a great opportunity for innovation. Latin America's unique biodiversity provides opportunities for the region to leapfrog in science and innovation, with potential vast applications and demand across the world given that global challenges such as climate change, resource depletion, environmental conservation and food insecurity can be addressed through biodiversity-based innovations.

Some LAC countries have already shown laudable efforts to capitalise on the innovation value of biodiversity through bioprospecting. The most well-known initiative took place in the 1990s in Costa Rica, with the creation of the National Biodiversity Institute (INBio), which worked under the premise that a country will be able to conserve a major portion of its wild biodiversity if this biodiversity generates enough intellectual and economic benefits to make up for its maintenance (Mateo et al. 2001). However, across the region, only a few government policies exist, and entrepreneurship has so far been rather minimal compared to its envisioned potential (Lebdioui, 2022).

In that sense, it is useful to distinguish three types of biodiversity-centred innovation strategies in Latin America and the Caribbean: conversation technology, bio-utilisation, and bio-inspiration (Lebdioui, Puga Duran and Santos, forthcoming), as further explained in table 2.

Amongst these three types of types of innovation ecosystems, the third one is the most promising as part of a virtuous nature-based knowledge economy (see section 1) and yet, the most under-developed in Latin America. Indeed, the field of biomimicry has been booming over the past 20 years. There has been a twelvefold increase in biomimicry patents, scholarly articles, and research grants between 2000 and 2019, as shown in figure 10. Between 1985 and 2005, there were proportionally more biomimicry patents filed than other patents (Bonser, 2006). The rate at which patents related to biomimicry were filed also increased rapidly following the 1990s and into the early 2000s (Pawlyn, 2016).

The rapid development of biomimicry as a field is also evidenced by a growing demand for training in biomimicry theory and practice (Lepora et al., 2013).

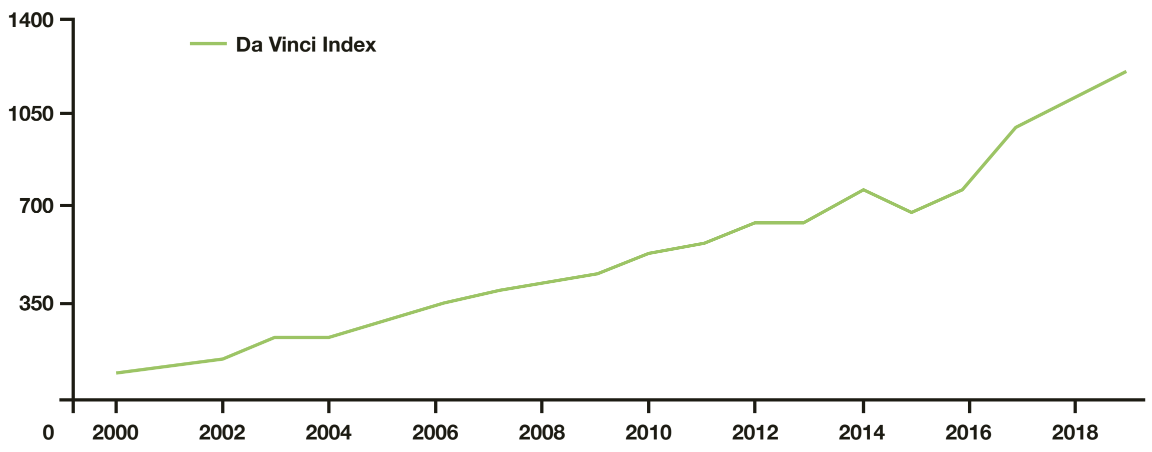
Table 3 | Three types of biodiversity-based innovation strategies

	**Conservation technology** refers to the use of advanced tools, data, and technologies to monitor, manage, and protect natural ecosystems. Those technologies enhancing the ability to monitor and manage protected areas, and help the detection of threats to natural ecosystems, thereby improving conservation efforts. For instance, in Brazil, the increasing use of drones can help monitor deforestation in the Amazon by capturing high-resolution images, enabling authorities and environmentalists to detect illegal logging activities and monitor the health of forests. In the Caribbean, remote sensing technologies such as satellite imagery and underwater sensors have been used to monitor the health of coral reefs, supporting the work of the Caribbean Coastal Marine Productivity Program, which has been collect data to study land-sea interaction processes since 1992.
	**Bio-utilisation and bioprospecting** involves the use of biological resources for economic purposes, aiming to ensure sustainability while deriving value from biodiversity. It can include everything from harvesting natural products to searching for commercially valuable compounds in nature. Costa Rica has been a global leader in bioprospecting, particularly through initiatives like INBio, which collaborated with pharmaceutical and cosmetic companies to identify plants and organisms with potential medicinal or commercial uses, while ensuring sustainable harvesting practices. In the Amazon, several research centres are involved in the extraction of organic acids and phenolic compounds from local fruits such as Açaí and Cupuaçu as inputs for the pharmaceuticals and cosmetics industry.
	**Bio-inspiration, or biomimicry**, involves learning and drawing inspiration from natural systems, structures, and organisms to develop innovative solutions in engineering, design, and technology. Biomimicry enables to leverage nature's value as a source of information that can feed into innovation processes, by producing more resource-efficient designs and solutions, which has particular relevance in architecture, materials science, and energy. Despite remaining at a nascent stage in Latin America and the Caribbean, several initiatives exist to leverage biomimicry for innovation. For instance, in Brazil, engineers have studied termite mounds, which naturally regulate temperature, to design energy-efficient buildings. In Ecuador, biologists developed university spinoffs that took advantage of the capacities of endemic volcanic microalgae of Ecuador to manufacture bio-filters to capture CO_2 in urban environments and convert it into oxygen.

Source: Lebdioui, Puga Duran and Santos (forthcoming)

Fig. 10 | Evolution of biomimicry-related research and patents (Da Vinci Index)

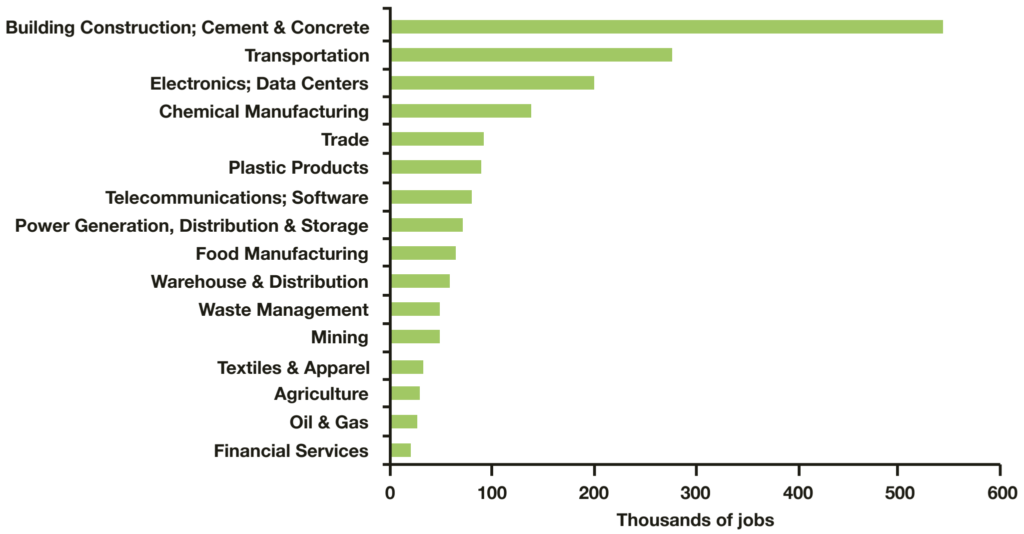
Index, 2000=100



Source: Fermanian Business & Economic Institute.
(Note: The Da Vinci Index -created by the Fermanian Business & Economic Institute and launched in 2011- measures activity in the field of bioinspiration by monitoring the number of scholarly articles, patents, grants, and dollar value of grants).

Biomimicry activities can generate large spillovers in terms in value and employment creation. Estimates from the Fermanian Business & Economic Institute (2013) suggest that biomimicry could account for as much as USD425 billion of the GDP of the United States and USD1.6 trillion of global output by 2030 (ibid). Bio-inspired products are also expected to increase employment and productivity in various sectors with the largest single-industry contributions in the construction, transportation, chemical manufacturing, and the power sectors (see Figure 11).

Fig. 11 | Bioinspired innovation's forecasted impact on employment in 2030

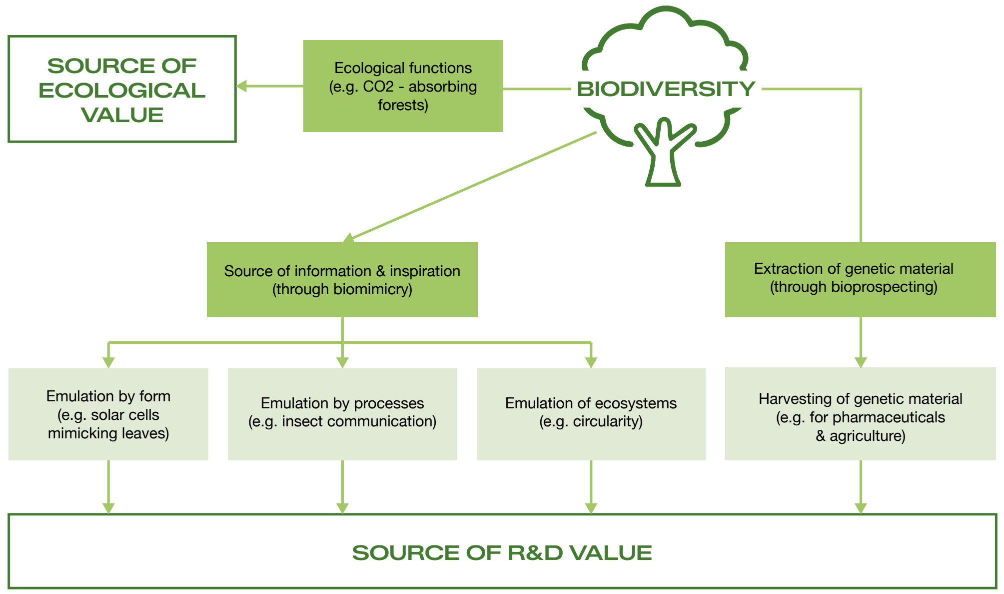


Source: FBEI (2015)

From bio-utilisation to bio-inspired innovation: from nature-based to nature-inspired

While most of LAC's bio-diversity-bassed innovation activity seems focused on bio-utilisation, another area of innovation appears much more promising, based on the scalability and sustainability dimensions it offers: bio-inspired innovation. Bio-inspired innovation, also known as biomimicry or biomimetics, relies on a perspective of biodiversity as a bank of ideas (Benyus, 1997, Lebdioui, 2022a and 2024). This method is different from harvesting organisms to accomplish a function: rather than using an organism to 'do what it does,' biomimicry aims to leveraging the design principles embodied by the organism (Figure 12).

Fig. 12 | From biodiversity to R&D value. Forms, processes, and ecosystems



Source: Lebdioui (2022a)

Biomimicry could add around $1.6 trillion to total global output by 2030, with electronics manufacturing, utilities (water and energy), and more generally engineering sectors revenues positively impacted between 5 and 15% (Fermanian Business & Economic Institute, 2013). Nature can offer models for sustainable energy, ranging from sector specific tasks (generation, transmission, storage) to global efficiencies across industries. Innovations inspired by natural processes can lead to breakthroughs in energy efficiency and renewable technologies. Acting as natural R&D, evolution has historically selected the most efficient and optimal designs and discarded the non-functional ones. Evidence suggests that energy efficient designs could transform up to 10% of the transportation equipment industry (including cars, trucks, planes, and boats), for instance. Biomimicry solutions found and developed in LAC therefore hold potential to push the innovation frontier around energy generation, CO2 capture and removal, and resource efficiency, and also open investment opportunities in those areas. This energy focus is justified by the fact that this sector offers the most synergies between existing industry challenges, solutions from nature, and regulatory incentives, and on the challenges digital sectors are facing, described in Section II.

The bio-inspired innovation panorama in LAC and vectors for expansion of capabilities

Despite its considerable potential, the field of bio-inspiration has so far been in rather nascent stages across Latin America and has received far less attention than bioprospecting/bio-utilisation. Brazil, despite being the most biodiverse country in the world, has particularly lagged behind in terms of building up a biomimicry ecosystem, which can be partially explained by the economic downturn of previous years, which led to many organisations cutting R&D capabilities. Bio-inspiration is also area of huge potential for Chile given its diverse ecosystem and number of endemic species. For example, over 62% of Chile's marine species are endemic to the country and not found elsewhere (Conicyt, 2016). Nevertheless, the sector is at an early stage in Chile, although some research, companies and state-sponsored programmes do exist, notably thanks to Start-up Chile.

There is a range of obstacles that explain the infancy stage of bio-inspired innovation in LAC, compared to other parts of the world. Previous studies (Lebdioui, 2022) complemented with recent fieldwork in the Amazon region in July 2025 and consultations with over 20 research centres in Latin America and the Caribbean shows that the major obstacles include:

- Limited access to physical and digital infrastructure related to biodiversity research
- A lack of coordination and harmonisation amongst existing taxonomic systems to facilitate the mapping and study of existing genetic material.
- A lack a critical mass of human capital with the right type of multidisciplinary training across the entire lifecycle of biodiversity-centred innovation. Across LAC, very few universities provide the interdisciplinary technical training required to translate the already existing local capabilities in biological mapping into technological innovations.
- Biopiracy - the unauthorized use of genetic resources or indigenous knowledge for profit without fair compensation.
- Inadequate financial support for science and innovation, high laboratory operating costs and weak mechanisms to secure non-repayable or long term funding to develop spinoffs, scale up and commercialise nature-based innovative solutions, leading innovators in LAC to over-rely on small grants.

Table 4 | Selected start-ups/firms based on bio-inspired innovation in Latin America and the Caribbean

Start up	Year of foundation	Country	Description
Nucleário	2015	Brazil	Develops a reforestation device inspired by bromeliads and winged seeds, designed to protect tree seedlings, conserve water, and prevent invasive grasses.
Strong by Form	2019	Chile	Utilizes a fabrication technology called Woodflow, which mimics the structural efficiency of trees to create high-performance, ultralight timber-based composites for construction and mobility industries.
Copper3d	2017	Chile	Develops antibacterial nanocomposites for additive manufacturing applications in 3D printing prosthetics, surgical separator, pill dispenser for the medical industry.
SAS Chile		Chile	analysis of bees and other insects in order to understand neural decision making and trying to apply this to their analytics and software products
Cells for Cells	2010	Chile	Biotechnological spin-off of Universidad de los Andes dedicated to the research, development and commercialization of innovative cellular therapies
Eutrolife	n/a	Colombia	Mimicking the filtering functions of salps and devil rays, Eutrolife is a modular system, designed to treat eutrophic water bodies by filtering surface water and redistributing excess nutrients
Anuka	2017	Ecuador	Designs, build, and implement urban biofilters in order to capture the atmospheric CO2 and transform it into oxygen
ALIS Biotecnologia	2018	Mexico	Develops living systems for wastewater treatment.

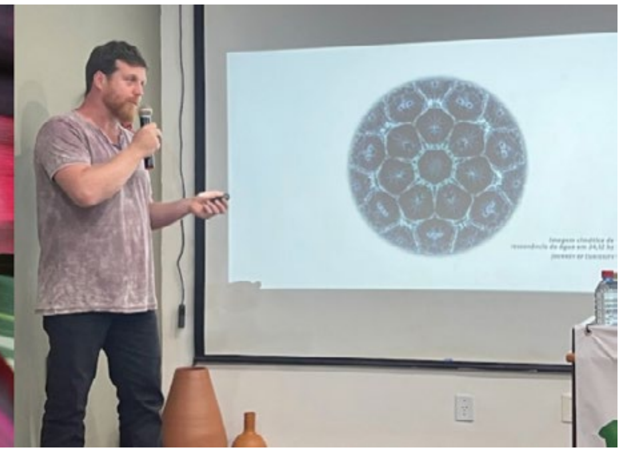
Start up	Year of foundation	Country	Description
Bio Thermosmart	2017	Mexico	Applies lessons from animals' circulatory systems to develop a heating, ventilation, and cooling system for buildings that harvests waste heat and cycles it back into the system, reducing costs, fossil fuel emissions, and energy.

Source: elaboration based on desk-based research

Box 1. Nucleário (Brazil): Bromeliad-inspired seedling protector for scalable reforestation

Nucleário is a biodegradable ring that surrounds seedlings, collects and stores rainwater, shades the soil, blocks invasive grasses, and deters leaf-cutter ants. Its technology is inspired by bromeliads' water-catching rosettes and winged seed aerodynamics. The design mimics natural strategies to protect young plants in degraded forest areas. The goal is to cut post-planting maintenance costs and improve survival rates in hard-to-access restoration sites.

Why it matters? By reducing labour and chemical inputs while improving seedling survival, Nucleário lowers the per-tree cost curve for large-scale forest restoration, turning fragile projects into viable, scalable restoration ventures. It exemplifies bio-inspiration delivering operational efficiency for climate resilience and biodiversity recovery.

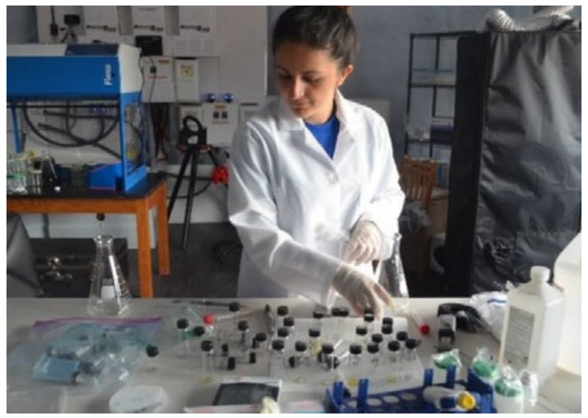


CEO Bruno Rutman speaking at the UFPA-Oxford workshop on bio-innovation in Belen, July 2024

Box 2. Costa Rica: Velvet-worm-inspired hydrogel for medical applications

Research led by Yendry R. Corrales-Ureña at LANOTECH-CENAT explores the velvet worm (Onychophora) and its unique slime: a protein-based shear-responsive hydrogel that rapidly hardens into fibers. This natural mechanism has inspired the design of biocompatible, triggerable medical adhesives and hydrogels that could transform wound care and tissue engineering. The worm's slime, which can liquefy and re-solidify reversibly, provides a model for recyclable, sustainable polymer systems.

Why it matters? A bio-inspired hydrogel that sets on demand has major implications for surgery, regenerative medicine, and sustainable materials science. Corrales-Ureña's research bridges Costa Rica's biodiversity with advanced materials innovation, demonstrating how local science ecosystems can translate biodiversity into high-value global technologies.



Box 3. Anuka (Ecuador): Urban microalgae biofilters for CO_2 capture and air quality

Founded in 2017 by Queenny López and Gabriela Samaniego, Anuka develops cylindrical microalgae biofilters that pull in ambient air, filter particulates, and use photosynthesis to convert CO_2 into O_2, improving air quality in dense urban areas. The project name “Anuka” means algae in Kichwa, reflecting both local culture and biotechnology innovation.

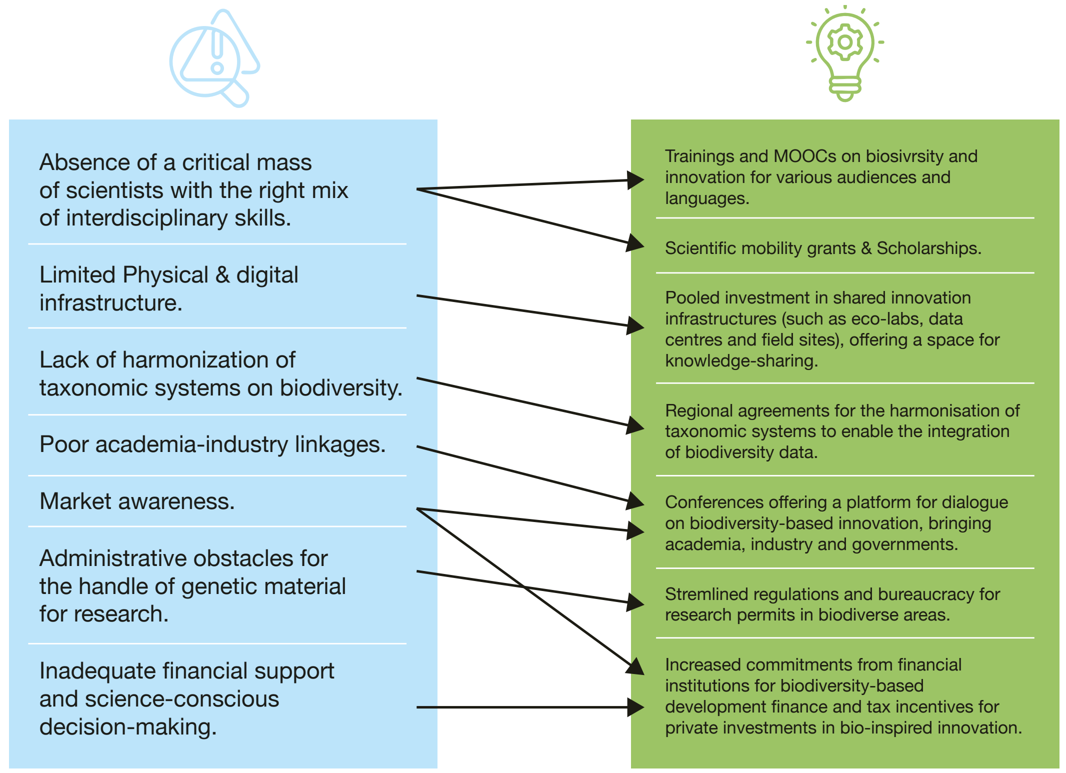
Why it matters? Cities produce around 70% of CO_2 emissions, yet few deploy biological infrastructure. Anuka’s photobioreactor reframes urban design as living climate technology with measurable co-benefits for public health. The team has won early innovation awards (including GIST Tech) and seeks to scale deployment in Quito and other Andean cities. It showcases how bio-inspired design and Indigenous language can co-exist in practical, entrepreneurial innovation.

Fortunately, solutions exist. For instance, currently, thanks to consultations with stakeholders, notably through the scientific symposium organised by CAF in August 2024 bringing over a variety of scientific institutions and biodiversity institutes, various solutions can be identified for biodiversity-based innovation. Solutions include interdisciplinary trainings in various biodiversity-based innovation methods (including biomimicry), which can be designed in a format (such as Massive Open Online Courses - MOOCs) to attract a maximal volume of beneficiaries in LAC; scientific mobility grants for LAC scientists to spend research visits abroad in institutions that complement their expertise; pooled investment in shared innovation infrastructures (such as eco-labs, data centres and field sites), offering a space for knowledge-sharing, especially in cross-border biodiverse areas (e.g. the Amazon or shared marine ecosystems in the Caribbean); Regional agreements for the harmonisation of taxonomic systems to enable the integration of biodiversity data; Conferences offering a platform for dialogue on biodiversity-based innovation, bringing academia, industry and governments; and Streamlined regulations and bureaucracy for research permits in biodiverse areas.

The above-mentioned measures can be considered as “enablers”, but realising LAC’s potential to become a global leader in bio-inspired technological innovation may requires a strategic intervention to promote both foundational capabilities and advanced capabilities. The region already possesses key foundational capabilities in biology science (especially with scientific expertise in areas such as

ecology, natural product chemistry, and conservation biology), which serve as the bedrock for bio-inspired innovation. Moving forward, more efforts are required to promote engineering capabilities, as well as the interdisciplinarity required for acquire a strategic mix of foundational skills required for bio-inspired innovation.

Fig. 13 | Matching of hurdles for biodiversity-based innovation with potential solutionsin 2030



Source: Author’s elaboration based on stakeholder consultations and a scientific symposium organised in August 2024 in Bogota, Colombia.

However, foundational capabilities alone are not sufficient to transition from research to market-ready innovations. This is why a second vector involves fostering advanced capabilities, which remain underdeveloped in much of the region. Cross-pollination between foundational sciences and advanced technologies, such as biotechnology and artificial intelligence (AI), is critical to unlocking the full value of biodiversity (Lebdioui, Melguizo, & Munoz, 2025). Modern biotechnology offers the unique opportunity to transform biodiversity into a key driver of economic growth through its valuation, sustainable use, and conservation. For example, genetic engineering and synthetic biology can develop high-value bio-based products, while the computational power of Artificial Intelligence can optimize the discovery and application of biodiversity-inspired solutions, as discussed in the next section.

5.

Bio-Intelligence: The Greening of Artificial intelligence as a window of opportunity in LAC

5. Bio-Intelligence: The Greening of Artificial intelligence as a window of opportunity in LAC

Overview of the opportunities of AI and constraints posed by resource-intensity

Artificial Intelligence (AI) is a defining technological innovation of our time, offering immense potential for economic transformation, particularly in Latin America and the Caribbean (LAC). Yet the surging energy and material demands of AI are increasingly misaligned with the region's imperatives for sustainability and biodiversity. Left unchecked, this revolution could deepen biodiversity loss and intensify climate risks, with LAC's ecological wealth on the line.

AI-driven solutions can bridge infrastructure gaps, industrialize new sectors, and spark digital entrepreneurship. The region's productive potential is immense: AI could contribute up to 5.4% of LAC's GDP by 2030—an estimate likely conservative, given pre-generative AI baselines (McKinsey, 2018). More recent projections suggest that GenAI could amplify this impact by as much as 40% (McKinsey, 2023), although other voices note the transformative effects might take years to materialize or may be concentrated in task automation rather than broad economic renewal (Acemoglu, 2024).

LAC's good connectivity, natural resource endowments, and relatively clean energy matrix position it as a prime candidate for sustainable, AI-enabled development. However, AI development in LAC also poses great risks. First, deficits in digital skills constrain the region's capacity to fully harness AI, creating the risk that much of society, especially marginalized groups such as women, rural communities, indigenous groups and low income groups, will be bypassed by these technological gains. The persistence of human capital and technology gaps and lack of a regional governance of AI mean AI could reproduce and even amplify LAC development traps, namely low productivity, high inequality, weak institutions, and environmental risks (Muschett and Opp, 2024, Aguilar et al., 2023, ECLAC, 2022).

Secondly. AI's voracious resource appetite threatens local ecosystems, with mounting scientific concern over accelerating environmental footprints (UNESCO, 2024; Gmyrek et al., 2024). Deforestation, unsound mining, competition for minerals and water, and, critically, data center pressures in drought-prone regions such as Chile, Mexico, and Uruguay pose difficult *dilemmas*. The lack of transparency around the resource intensity of data centers compounds these risks (Lebdioui et al., 2025). Still, policy innovation is possible: Chile's recently launched Plan Nacional de Datacenters (2024–2030) offers a regional model, with the aim of mobilizing $4 billion, expanding sector training, and integrating environmental accountability.

AI's accelerating energy and resource consumption, with corporate environmental footprints rising annually in double digits, now precipitates a direct conflict. Does the region prioritize rapid AI and data sector expansion, risking further biodiversity loss? Or, alternatively, does it constrain energy growth to protect ecosystems, curtailing AI's momentum?

Confronting this means facing the extraordinary demands AI innovations impose, from rare earth and mineral extraction for semiconductors to the massive water and power requirements for training large language models and operating data centers. In LAC, where natural capital is both engine and constraint, the surge in AI's energy requirements risks serious economic and environmental costs. Compounding these issues is a troubling lack of environmental transparency: leading AI firms often fail to disclose emissions or resource data from model training (Stanford Institute for Human-Centered AI, 2024; ITU, 2024). Global AI could account for 4.2–6.6 billion cubic meters of water withdrawal by 2027, which represents half of the UK's annual demand (Kenny, 2025)

Environmental disclosures confirm sharply rising energy and resource use in tech, with AI a principal driver. Clean electricity supply is emerging as a critical constraint—and lever—for the sector's future. According to IEA (2024a), data center electricity consumption could top 1,000 TWh by 2026, equivalent to the current combined usage of Brazil, Chile, Mexico, and Uruguay. This pressure places LAC's clean energy matrix at the center of both the risks and the opportunities.

The greening of AI: a window of opportunity for LAC?

The greening of AI, especially in relation to biodiversity issues, is highly relevant for Latin America and the Caribbean because it represents not only risks, but an unprecedented "green window of opportunity" for the region. The green transition open many doors for technological and industrial development (Lema et al. 2020), in way that amounts to the advent of a new 'techno-economic paradigm', as posited by Christopher Freeman (1992, 1996) and Carlota Perez (2016).

LAC's installed renewable energy capacity and cleaner energy matrix on average compared to the rest of the world (with over 400 watts per capita of installed renewables capacity, twice the world average, see Lebdioui 2022) gives it an advantage to seize that green window of opportunity for AI. Furthermore, the Renewable Energy for Latin America and the Caribbean (RELAC) initiative aims to further increase the share of renewable energy in the electricity mix of Latin American and Caribbean countries to at least 70% by 2030, promoting regional cooperation in renewable energy adoption and grid integration.

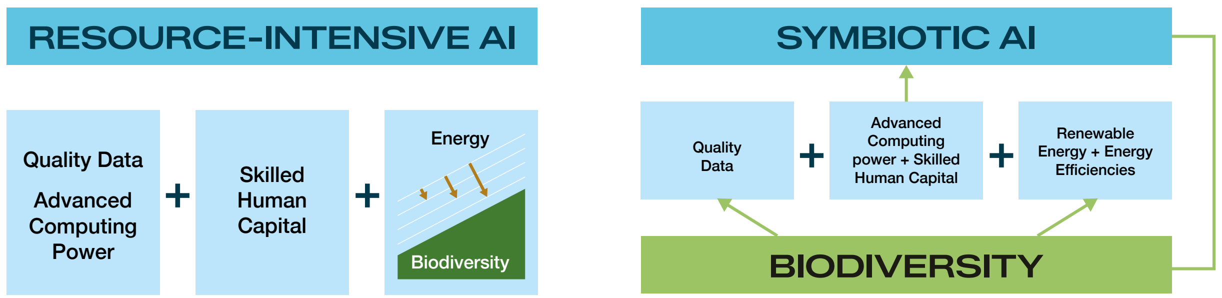
However, it is not just LAC's clean energy that gives it an upper hand to seize the green window of opportunity, but also its biodiversity. Thanks to its 3.4 billion years of natural R&D, LAC's biodiversity can provide a bank of ideas of innovation (Benyus, 1994, and Lebdioui, 2022a), which matters because global AI start-ups derive value primarily from technological ingenuity (OxValue.AI, 2024). Biodiversity, through bio-inspiration, must therefore be fully integrated at the centre of the region's innovation and AI agendas. Far from being a constraint on development, biodiversity can be harnessed for long-term economic prosperity, AI innovation, and sustainability, and this report explains how biodiversity, if placed at the heart of AI policy and ecosystem design, can propel sustainable productive development.

Can AI learn from nature? From a Resource intensive AI to a symbiotic AI

Is a *virtuous relation AI-energy-biodiversity* possible? There is growing evidence of remarkable AI-driven innovations on energy issues which set a good basis for the path transition (ITU, 2024, Chen et al, 2023; ECLAC, 2022).

Across sectors, AI enables new sustainable practices: precision farming reduces energy consumption while enhancing productivity by employing sensors and advanced analytics to monitor soil, water, and climate; IoT and 5G applications in industry enhance real-time resource efficiency and optimization through predictive analysis, optimizing real-time energy consumption and adjusting demand based on environmental and operational data (Rojek et al., 2023; Tace et al., 2023).

Fig. 14 | From a from a *resource-intensive* to a symbiotic AI



Source: Lebdioui et al. 2025

Perhaps most critically for LAC, AI is a frontline tool for conservation and mitigation. Powerful machine learning models can now process satellite and sensor data to detect illegal deforestation, wildlife trafficking, and pollution in near real time, providing early warning and targeted interventions, especially in vast areas like the Amazon, which is critical for the region's fragile biodiversity and climate-critical forests. AI also improves disaster response, with predictive analytics for hurricanes, floods, and droughts now being operationalized (Silvestro et al., 2022).

Interestingly, AI does not have to just be a tool for preservation, but can also become a student of nature. By drawing design inspiration from biological models, AI research can unlock new efficiencies in hardware and architectures, pushing beyond the linear "resource-intensive" growth of the past. At the very core of a future "nature-conscious" AI ecosystem lies the ambitious concept of bio-inspired innovation, discussed below. Nature can indeed inspire energy solutions that allow keeping AI momentum while also fostering resilient sustainable growth and contributing to biodiversity preservation (Lebdioui et al. 2025).

Bio-inspiration as the innovation frontier for an AI-Biodiversity symbiosis

Biodiversity has, in many ways, its place at the core of this potential virtuous *nature-conscious AI ecosystem*. AI offers powerful tools for conserving biodiversity. AI can monitor endangered species, optimize agricultural practices to reduce deforestation, and predict climate change impacts, in order to mitigate biodiversity loss. A far less explored strategy lies in the use of knowledge from nature to develop AI systems that not only measure and mitigate environmental impact but unlock new areas of knowledge to leap to the sustainable innovation frontier. Indeed, why not design AI models that seek inspiration and learn from strategies found in nature to solve human design challenges to create a healthier, greener, and more sustainable future?

A particularly promising area is that of the so-called bio-inspired innovation, which relies on a perspective of biodiversity as a bank of ideas (Benyus, 1997, Lebdioui, 2022a and 2024). Bio-inspired innovation is different from harvesting organisms to accomplish a function: rather than using an organism to 'do what it does,' biomimicry aims to leveraging the design principles embodied by the organism.

Nature's evolutionary "R&D" offers millions of efficient, resilient solutions: from whale fin-inspired wind turbines and termite mound-cooling for buildings, to biomaterials stronger than steel and natural DNA data storage (Fermanian, 2013). Bio-inspiration holds the potential to transform energy capture, storage, distribution, and efficiency, by reducing the footprint of everything from data centers to electric vehicles and sensor networks.

AI is especially well positioned for this: with new data harmonization and taxonomic interoperability, AI can mine vast biological datasets, identifying and refining strategies evolved in nature, from optimized neural and microbial networks for edge computing, to leaf and beetle-inspired cooling mechanisms for thermal management in hardware. Yet, formidable barriers persist. Biological data is scattered in siloed, often incompatible databases; fragmented research ecosystems and regulatory bottlenecks impede collaboration. For LAC, regional harmonization of standards, new collaborative networks, and regulatory reforms for access and benefit-sharing can unlock this innovation frontier. AI-enabled tools will accelerate the translation of biological "blueprints" into hardware, infrastructure, and system innovations for productive sectors.

Table 5 | Examples of bio-inspired sustainable energy solutions

Forms	
Sustainable materials	Biomaterials, inspired by structures like spider silk or insect exoskeletons, can be both lightweight and strong. By applying these materials to AI hardware design, it is possible to reduce the energy needed for material production and device operation.
Optimization of resource distribution	Deep learning of microbial patterns and fungal networks, such as mycelium, which distribute resources with minimal energy can inspire distributed AI architectures minimizing data transfer and processing energy (e.g., edge computing where processing happens close to the source of data).
Energy efficiency through new forms	The design of whale fins (with their protrusions called tubercles) to the blades of wind turbines improve aerodynamics, allowing for kinetic energy to be converted into electricity more efficiently (WhalePower project). Use of natural ventilation principles observed in termite mounds significantly reduce air conditioning use and energy consumption (Eastgate Center, Zimbabwe). This system is used to cool buildings for improved energy efficiency.
Superior data storage structures	Synthetic DNA could be used to store digital data, optimizing energy use.
Processes	
Energy generation (including photosynthesis)	Artificial photosynthesis to improve the efficiency of solar cells (such as Daniel Nocera's Artificial Leaf). AI can be trained on the mechanics of photosynthesis to optimize solar-powered energy sources or even develop artificial photosynthesis. This could help produce on-site energy that powers AI systems sustainably. The structure of seaweed can inspire processes to generate electricity from the flow of water (BioPower Systems' BioWave). These generators are set up in coastal areas, providing clean, renewable energy. Piezoelectric batteries, which are self-charging power cells that convert mechanical energy (the energy related to an object's motion and position), into chemical energy can be a solution for EVs battery charging, improving long-distance smart mobility. Electricity generation inspired by the organic structure of the pectoral fin of electric fish (such as rays), composed of electro plaques–flattened cells stacked in vertical columns like piles of coins.
Energy-efficient sensor networks	Biological Sensor Models offer important lessons to improve AI systems, given the superiority of the various highly sensitive and efficient sensory systems found in nature (such as the olfactory senses of dogs or navigation systems of bees, birds, and bats). By studying these systems, AI developers can create sensors that are more efficient and require less energy for functions like environmental monitoring.
Thermal management and cooling	Some species (e.g., volcanic long-horned beetles) have evolved with natural ways to dissipate heat and chemical reactions to reduce their body temperature. Hardware inspired by these natural thermal regulation methods could improve the efficiency of cooling systems in data centers and AI hardware.
Ecosystems	
Circular energy and material flow models	Principles of circularity and re-use of waste into inputs for other productive systems, as natural ecosystems operate on principles of waste recycling where the byproduct of one species becomes the resource for another. By designing AI systems inspired by these circular principles, excess heat, and byproducts (like data center heat) can be redirected and used to fuel other processes, lowering the net energy consumption.
Real-time adaptation for energy consumption	Just as ecosystems dynamically adjust to environmental changes, AI systems can be designed to scale their operations based on real-time energy availability and environmental conditions

Source: Elaboration based on AskNature.org, BioMiG, and a review of the scientific literature in Lebdioui et al. 2025

In terms of the emulation of *forms*, biomimetic designs can optimize energy capture and distribution. For instance, microbial patterns and fungal networks, which enable resource distribution with minimal energy could inspire distributed AI architectures that minimize data transfer and processing energy, such as in edge computing where processing happens close to the source of data. WhalePower's wind turbines incorporate whale fin structures to improve aerodynamics, enhancing wind capture for electricity generation. Similarly, Zimbabwe's Eastgate Center is leading research on how to reduce energy consumption by mimicking termite mound ventilation, while biomaterials like spider silk inspire lightweight, durable materials in AI hardware, reducing production energy.

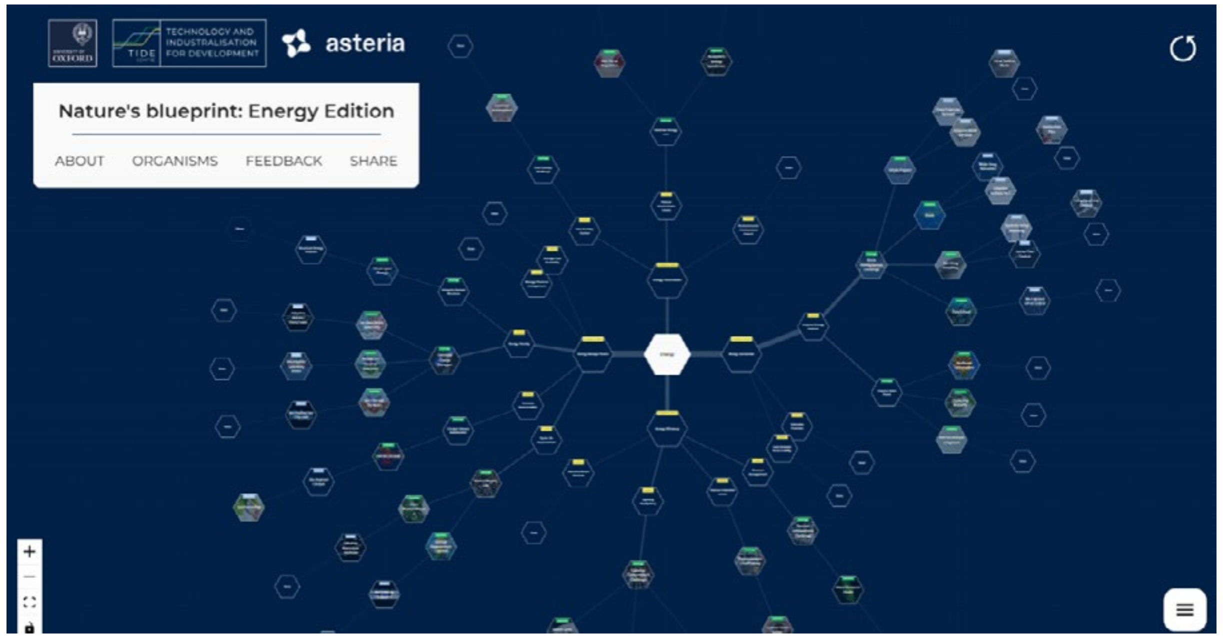
The emulation of *processes* would consist of seeking inspiration from biological mechanisms, such as photosynthesis (for instance, the artificial leaf aims to replicate photosynthesis to improve energy efficiency for industrial applications) while technologies such as BioWave generates electricity by simulating the motion of seaweed in ocean currents. For the specific context of AI hardware, energy consumption could be reducing with thermal management and cooling innovations inspired by how distinct species (such as volcanic beetles) have evolved to dissipate heat with natural regulation methods, which could hold lessons for improving the efficiency of cooling systems in data. These solutions illustrate how mimicking biological processes can enhance energy production and sustainability.

The AI industry may also benefit from *ecosystemic* innovations that draw inspiration from the interactions between various living organisms. From instances, the principle of circularity found in nature and whereby waste is turned into resources for other organisms can be applied to data centers and other AI systems to reduce net energy use. Inspired by ecosystem adaptability, AI systems can also be designed to dynamically adjust energy consumption based on availability, optimizing energy efficiency. By emulating the self-regulating and waste-reducing models found in nature, these innovations offer promising pathways to sustainable energy management.

In sum, rather than using AI merely to optimise existing industrial processes, green AI can be directed to uncover solutions already perfected by evolution, effectively turning biodiversity into a living R&D library. In this context, the Atlas of Nature's Innovations, developed by the University of Oxford and Asteria, exemplifies how AI can provide directionality to biodiversity-based innovation. The platform uses Asteria's specialised AI agents to mine open biological and taxonomic datasets, searching for organisms and living systems that have evolved to solve energy challenges (efficiency, storage, transmission and generation). By linking these biological strategies to industrial problems in energy efficiency, storage, generation, and transmission, the Atlas constructs traceable pathways from nature's designs to potential bio-inspired technologies. Each match includes an explanation of the biological mechanism, why it aligns with the engineering constraint, which species illustrate it, and how it can inspire a functional or material solution.

This approach operationalises a profound conceptual shift: the view of biodiversity as a "knowledge bank" rather than merely a reservoir of extractive inputs. Every species embodies millions of years of R&D under constraints of efficiency, resilience, and circularity—exactly the parameters now demanded by sustainable industrial systems. By indexing biological functions and aligning them with concrete industrial challenges, the Atlas moves from metaphor to mechanism: it provides an actionable bridge between ecological complexity and engineering design.

Fig. 15 | Visual Map of the Atlas of Nature's Solutions



For Latin America and the Caribbean, tools such as the Atlas demonstrate how the region's biological wealth can underpin participation in the emerging bio-digital paradigm, where data, computation, and nature intersect to shape new industries. By investing in open data infrastructures, scientific institutions, and AI capabilities that translate biodiversity into innovation pipelines, the region can reposition itself not as a passive provider of raw materials, but as an active producer of nature-positive technologies.

In many ways, this perspective aligns with the Amazonia Third Way initiative (A3W) which calls for a vibrant, socially inclusive biodiversity-driven ‘green economy’ in the Amazon by harnessing Nature’s value through the physical, digital and biological technologies of the 4th Industrial Revolution (Nobre and Nobre, 2019).

Barriers for symbiotic AI in LAC

What is missing for LAC to leverage the informational value of nature for better, symbiotic AI, to replace resource-intensive AI? Admittedly, the path towards bio-inspired innovation for AI energy improvement is paved with considerable challenges and coordination failures. One major obstacle lies in the fragmented state of biological data and taxonomic systems. Currently, nature’s vast repository of information (spanning millions of organisms) is organized inconsistently across various databases, many of which are outdated or limited in scope. This is also the case for research centers between different Latin American and Caribbean nations, which poses a great challenge for data sharing and merging (as discussed in section 7). Only through region-wide standardization in how data is categorized, described, and validated can researchers efficiently mine for functional traits, adaptive behaviors, and ecological efficiencies that might inform AI applications, especially those aimed at optimizing energy use or environmental resource management. The deeper the interoperability, the greater the prospects for translating biodiversity into actionable opportunities for technology and policy.

Such a harmonization of taxonomic systems is an essential prerequisite for the use of AI for biodiversity. With access to better and more reliance biodiversity data, along with advances in computational power, AI itself can play a vital role in identifying and analyzing patterns within ecosystems and species that excel at particular processes, such as energy efficiency, resource distribution, or thermal regulation.

However, realizing this vision also brings regulatory and resource-related challenges. Establishing frameworks that support responsible and legal access to biodiversity data, as well as providing resources for researchers to build and use advanced analytical tools, is critical. Without supportive policies and adequate funding, researchers may struggle to develop the tools necessary to ex-

tract actionable insights from nature’s patterns. Addressing these barriers would not only accelerate bio-inspired innovation but also position biodiversity as a cornerstone for sustainable technological advancements in AI and energy.

Furthermore, efforts to establish a network/ecosystem of local startups, research institutions, and global companies open to innovation in sustainability are crucial. A regulatory environment that promotes responsible innovation can also attract international partnerships and investments, accelerating the region’s development in sustainable technologies. Building a supportive ecosystem that fosters entrepreneurship in biomimicry and sustainable AI will enable LAC to better capitalize on its unique biodiversity. By integrating these initiatives into national and regional development strategies, and by ensuring smart regulatory frameworks and proactive productive development policies, the region capture an important green window of opportunity for AI.

6.

Ways forward: catalytic investments and the role of development finance

6. Ways forward: catalytic investments and the role of development finance

From a rentier to a developmental model of biodiversity finance: refining taxonomies

Latin America and the Caribbean stands at the brink of a formidable opportunity to redefine the relation of its economic systems with nature, with a positive vision of biodiversity that holds great potential to shape our technological and planetary futures. But to fully realize this potential, a radical transformation is needed for domestic actors to move from being strictly technological consumers to technology providers; and from being markets follower to becoming market-shapers. Doing so require a reorientation of economic, industrial, innovation and environmental policies, but also requires financing instruments that value long-term transformation over short-term gains. This implies both a drastic increase in biodiversity finance, but also its strategic integration with development finance.

Historically, biodiversity finance has received much less attention and resources than those directed toward climate change, despite being of equal (and perhaps even higher) importance for ecological sustainability in LAC. For several decades, the world has witnessed clear definitions, monitoring mechanisms and targets for climate finance (from the annual 100 billion target to the recently negotiated New Collective Quantified Goal - NCQG), while it is only recently that targets have been negotiated for biodiversity finance, while definitions and monitoring mechanisms still nascent. There is a clear upward trend in biodiversity spending. The biodiversity finance target agreed at COP15 is to mobilise at least USD 200 billion annually from all sources of funding for biodiversity finance, and in Latin America, biodiversity spending has by far outpaced that of the other regions (increasing six-fold from around $500million to over $3billion by 2017), clearly reflecting the region's interest and leadership in this agenda. Nevertheless, LAC notably lags behind when it comes to biodiversity-specific and biodiversity-related development finance. With an average of USD3.2 billion per year over the past decade, LAC falls behind Africa and Asia in terms of the amount of biodiversity-related development finance (including from both multilateral institutions and bilateral providers that are members of the OECD Development Assistance Committee).

The link between biodiversity finance and development finance remains insufficiently explored and emphasised. Indeed, biodiversity finance must not only ensure that environmental assets are untouched (by helping fund the maintenance of protected areas, and the management of invasive species for instance), but also help position LAC as a global leader in biodiversity-based innovation and sustainable productive development. In that sense, one of the core challenges lies in the current metrics used to assess it, which often measure funding sources (e.g., funding from development finance institutions) rather than the direction or developmental outcomes of the funds (long term finance for developmental purposes). The result of the ambiguity is that development banks still struggle to prioritize, target, and scale interventions that create both ecological and productive value.

While current biodiversity finance taxonomies are built to measure funding and labelling conservation categories (whether protected areas, species programs, restoration), they do not to explain what that money does for livelihoods, productive capabilities, or long-term economic resilience. As a result, current taxonomies are weak where policy needs the most clarity: which biodiversity finance is truly development finance, and how it affects jobs creations, skills provision, firms upgrading over time. The result of the If we want policy to shift, the taxonomy must shift first. We need a classification that doesn't just answer how much is spent and on what habitat, but also how it builds capabilities, who benefits, where value is captured, and whether the result is durable without endless subsidies.

Compounding this issue, institutions often apply inconsistent criteria for biodiversity markers, further muddying the financial picture. In principle, there are clear guidelines for biodiversity markers (see OCED 2024 for reporting directives), but those markers can be applied in way that is inconsistent across different actors, as these guidelines are not adopted by all development finance actors (especially those not members of the OECD Development Assistance Committee).

Addressing these gaps requires a paradigm shift in how biodiversity finance is defined, measured, and tracked. Increasing the volume but also the quality of biodiversity related development finance requires the provision of a standardized, transparent, and credible framework for identifying how biodiversity investments align with development goals and ensuring that finance contributes meaningfully to both ecological and socioeconomic outcomes. As such, a new taxonomy of biodiversity finance that clearly identifies activities that target productive development is much needed, or at the very least, a new label/code family for biodiversity-oriented productive development finance (BOPB) within existing taxonomies. Both options involve revising the standardized taxonomy for biodiversity finance by:

i. Categorizing funding across sectors and activities (rather than conservation objective solely), with corresponding sub-codes (e.g. bio-materials, agro-ecology, Science & capability platforms, such as biobanks, testing labs, etc.).

ii. Requiring outcome fields for each sub-code to ensure that the funding is not solely focused on conservation but involves objectives for jobs, firm dynamics, capabilities, local value generation.

Quality employment sits at the core of sustainable development not merely in terms of employment volumes, but their productivity, formality, learning content, and resilience (Salazar-Xirinachs, Nübler and Kozul-Wright, 2018). As such, employment quality must be embedded as an ex-ante design criterion for projects, not as an ex-post hope. In practical terms, the proposed biodiversity finance taxonomy should require a minimum “quality jobs” basket (e.g. wage premium, formalisation rate, apprenticeship/credential hours per FTE, women/Indigenous participation) for any operation tagged as productive biodiversity finance.

Table 6 | The flaws and areas of improvements of taxonomies for tracking Biodiversity-Based Development Finance

	Weaknesses of current metrics	Potential improvement	Relevant implementation bodies
Definition	Based on donor type rather than outcome (Biodiversity-related development finance is biodiversity finance provided by development finance institutions)	Finance mechanisms that help achieve a dual objective of conservation and productive development to sustain local livelihoods.	
Key driver	Donor-led metrics and reporting	LAC governments and Regional Development Banks to define code families alongside development priorities, in consultations with local community in biodiverse provinces.	CAF, in coordination with ministries of Finance/Economy/Environment across LAC
Objective	Measure funding and built to measure funding rather than the type of impact desired, beneficiaries and outcomes in terms of livelihoods and productive capabilities	Standardized, transparent, and credible framework for identifying how biodiversity investments align with development goals through the creation of a Productive Biodiversity code/label	International Development Finance Club (IDFC)
Code classifications	Broad markers that blur conservation with productive development, focused on labelling conservation categories (whether protected areas, species programs, restoration) rather than type of activity/industry supported.	Create a productive development family code/label within biodiversity finance taxonomies with clear criteria for eligibility; sample annex with real projects; and identification of national and regional priorities to match.	International Development Finance Club (IDFC); CAF; IDB
Outcome indicators	Outcomes focused on conservation but absent metrics for jobs, firm dynamics, capabilities, local value capture.	Each project and family code should be linked to specific intended objectives, such as jobs, SMEs finance, domestic value added, training/certifications, benefit-sharing flows, products launched.	Development Finance Institutions / Donors
Territorial tagging	National aggregates mask spatial concentration and potential capture outside of biodiverse provinces	Geocode to biome & province through GIS integration	Development Finance Institutions / Donors
Science & innovation	Scientific capabilities not tracked and barely reported/invisible in existing taxonomies.	Scientific capabilities to be highly visible in codes and outcomes reporting, alongside priorities defined by national scientific institutions.	National Science, Technology and Innovation agencies; Biodiversity institutes
Open data & accessibility	Scattered information about the distribution of biodiversity finance, reporting is not user-friendly.	Easily accessible public portal where donors are required to register financing, allowing for periodic audits.	DFIs' data teams; International Development Finance Club for platform hosting
Regional coordination	Data and definitions not comparable across borders and cross-border ecosystems (Amazon, Andes, Caribbean, Chocó) cannot be jointly monitored or financed. Taxonomic categories driven by OECD and EU sustainable finance taxonomy	Regional Biodiversity Finance Standard to harmonize purpose codes, outcome indicators based on regional priorities (quality jobs, innovation, tech uptake, forestation rates, etc.)	LAC governments (setting priorities), CAF (convening), ECLAC (analytics),

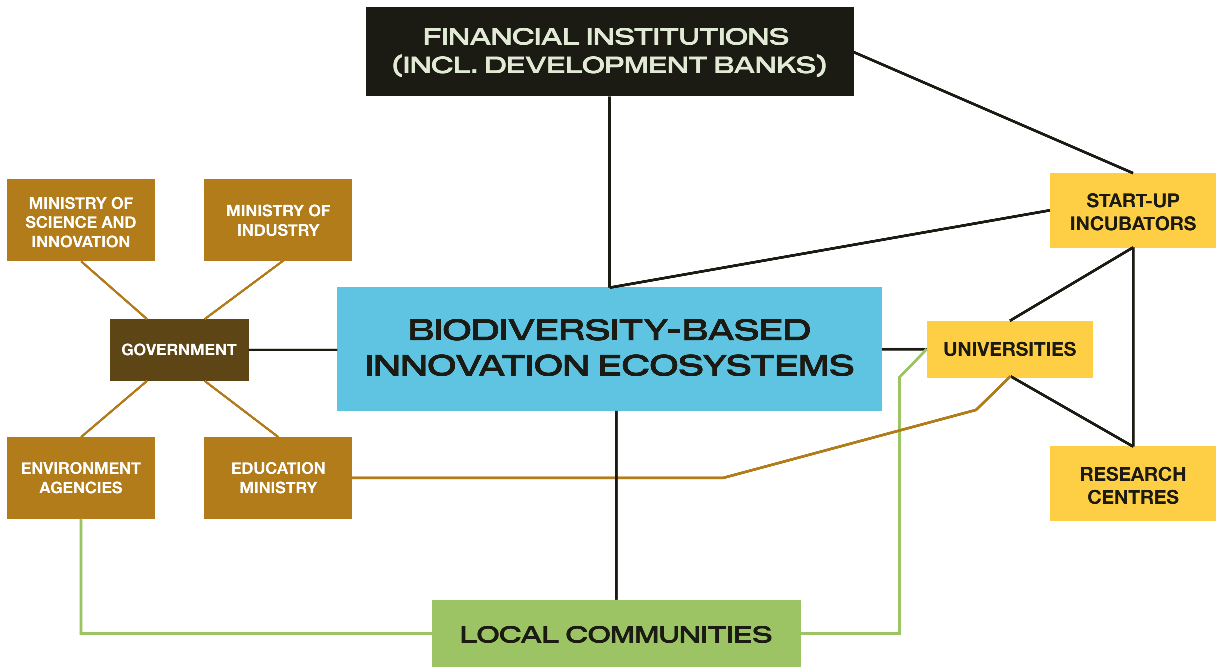
Adopting this new approach would not only clarify biodiversity finance flows but also help decision-makers be better equipped to understand the interplay between biodiversity finance and sustainable development and address funding gaps. Given its wide membership and mandate, the International Development Finance Club (IDFC) is a particularly suited institution for leading this taxonomic revision and establishing a new biodiversity-oriented productive development label. Because of the financing priorities of the LAC region, and its potential, the region would constitute an ideal region to pilot its use and deploy the mechanisms to assess if the projects are delivering results.

In sum, there is key role of play for development finance institutions in stepping up to fill the gap in long-term transformative funding required for transformative biodiversity-based innovations. This implies both a drastic increase in biodiversity finance, but also its strategic integration with development finance. Indeed, mainstreaming biodiversity finance within existing development finance mechanisms can help address the core challenging of how government can do more with less financial resources, especially in light of the growing pressures on international public finance.

The role of directional and patient finance in innovation ecosystems

Finance plays a key role in innovation ecosystems. Public funding particularly is critical in stimulating the early-stage development of new technologies, especially when profits from innovation can only be expected far into the future (Mazzucato, 2013, 2016; Semieniuk and Mazzucato, 2019). However, public financing for biodiversity-based R&D in LAC has been sub-optimal and is expected to be heavily constrained due to fiscal pressures in many LAC nations, while the domestic banking sector and private capital has tended to be risk-averse and often fails to provide the conditions that enable long-term, and patient capital for the early-stage development of technologies, especially when profits from innovation can only be expected far into the future. Indeed, because it derive from biological systems, ecological processes, and nature-based knowledge, biodiversity-based innovation typically requires long innovation cycles, often extending over a decade from research to commercialization, and a strong reliance on public research infrastructure and multi-stakeholder cooperation.

Fig. 16 | Cooperation and interactions of various stakeholders within a biodiversity-based innovation ecosystem



Source: author's elaboration

In contrast, public development banks can play a key role, for various reasons. Firstly, they are designed to provide "patient capital" (Rodrik, 2014; Mazzucato and Penna, 2016). Their financial instruments, long-term loans, concessional credit lines, or and technical assistance, can absorb the time lag between innovation investment and profitability. Moreover, their policy mandate allows them to steer finance toward socially desirable outcomes, embodying what Mazzucato (2021) calls "mission-oriented" public finance. Such directionality is essential to ensure that bio-innovation complements rather than replaces conservation, aligns with access and benefit-sharing principles, and strengthens local scientific capacity. These ideas echo José Antonio Ocampo's (2019) call for development banks to act not as passive financiers but as catalytic system builders, that is institutions capable of coordinating long-term investment, industrial upgrading, and technological transitions.

Secondly, they are institutionally well suited to address first-mover disadvantages and crowding-in followers in biodiversity-based innovation (Lebdioui, 2019, 2022). Entering a new market or technology domain, such as bio-inspired materials or biodiversity digital data platforms, carries high uncertainty, a lengthy trial and error process, and high fixed costs in R&D. Without visible success stories, private investors and firms stay on the sidelines. Development banks can resolve this coordination failure by acting as first movers themselves. Through blended finance and demonstration projects, they can create the initial proof of concept that de-risks the sector for subsequent entrants (Hausmann and Rodrik, 2003). This "catalytic sequencing" role, where public investment shapes expectations and lowers entry barriers, is one of the comparative advantages of development finance institutions (Griffith-Jones and Ocampo, 2018).

Thirdly, they are able to provide non-repayable or concessional instruments as public-good investment, thereby solving market failures. As identified in sections 4 and 6, the main constraint on the biodiversity-based innovation landscape in LAC is related to investments in research infrastructure by modernizing laboratories, data centres, and scientific stations, particularly in biodiverse hotspots such as the Amazon and the Andes; and funding for targeted training programs to equip researchers and technicians with interdisciplinary skills at the intersection of biology, engineering, design and chemistry. These initiatives not only require substantial financial resources, but are not expected to be directly profitable. Indeed, biodiversity knowledge and the infrastructure that supports it (e.g. gene banks, data systems, standards, and trainings) are quasi-public goods. The social returns exceed private returns, justifying non-repayable or highly concessional finance. National budgets in LAC rarely have the scale or stability to fund these systems sustainably. Development banks can fill this gap through technical-cooperation grants, and concessional funding that internalize the long-term public value of scientific cooperation. The CAF-financed projects in the Amazon region, for instance, already combine loans and grants to strengthen biodiversity-based scientific capacity (e.g. Museu da Amazonas). Expanding this logic, for example, to establish regional bioprospecting laboratories, biodiversity data platforms, or bio-innovation funds, would create shared assets underpinning national strategies. Such investments are very much in line with the mandate of development banks, which are tasked with addressing market failures and coordination failures, precisely the obstacles that hinder biodiversity-based innovation.

Fourthly, biodiversity systems in Latin America are inherently transboundary (e.g. the Amazon, Andes, Mesoamerica, and the Caribbean). Yet most science and innovation funding remains nationally compartmentalised, leading to duplication and inefficiency. Development banks, especially regional ones such as CAF, can correct this by financing regional public goods (Estevadeordal et al., 2004). They can pool resources from multiple countries into shared research facilities, harmonised regulatory frameworks, financing mobility grants for members of the research community and common standards for access and benefit-sharing.

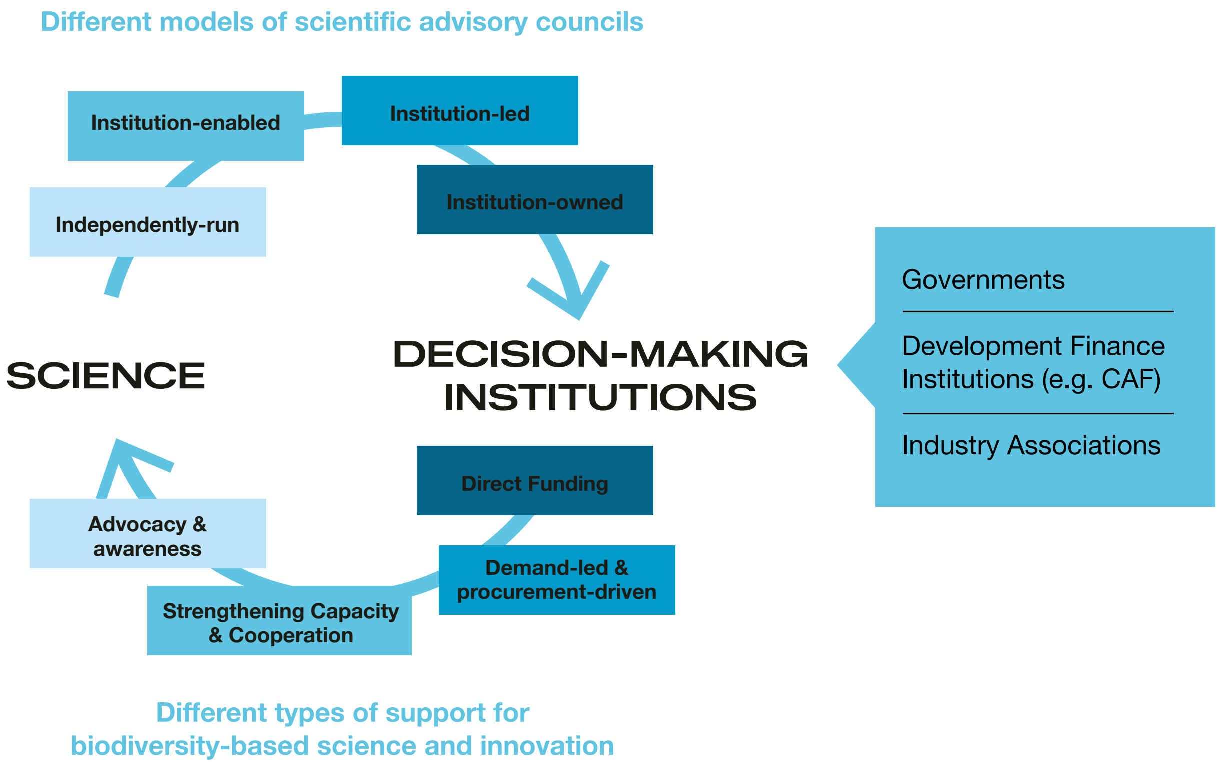
In summary, because conventional financial markets, dominated by short-term horizons and risk-averse investors, are structurally ill-equipped to support this transformation, development banks, and particularly regional development banks such as CAF, are uniquely positioned to act as catalytic investors, precisely because their mandates combine development directionality, long term horizon, cross-border reach, and a tolerance for early-stage uncertainty. Furthermore, its dual character as a regional development bank and a Latin American-owned institution gives it legitimacy and convening power. Its cross-border membership, technical capacity, and growing climate-biodiversity portfolio enable it to mobilise knowledge and finance at scales unreachable for most national governments. CAF's recent strategic framework (CAF, 2022) already positions the bioeconomy and green industrialisation as pillars of its action. Extending this to explicitly include biodiversity-based innovation ecosystems would be a natural progression. Furthermore, the reputational credibility of regional banks can attract co-investment from global partners (GEF, Green Climate Fund, EU, etc.) while ensuring regional leadership, as already witnessed with CAF's recent partnership with the Arab Coordination Group for co-investments in Latin America and the Caribbean. Development banks, and particularly CAF, are therefore the natural architects of the region's biodiversity-based innovation ecosystem.

Bringing the voice of science closer to policy and development finance through scientific advisory councils

Beyond their catalytic investment role, development banks' role in structuring scientific cooperation deserves further emphasis. Development banks can help reduce the gap between research and investment, but they cannot fulfil their role from passive funders into architects of the scientific commons that underpin a regional biodiversity-based innovation ecosystems without close interactions and feedback loops with local, national and regional scientific communities. As emphasised by Ana Stewart-Ibarra and her collaborators, regional cooperation on biodiversity and climate in Latin America requires aligning scientific diplomacy, finance, and policy instruments, which calls for stronger science-policy integration (Mastrangelo et al, 2024; Ehlers, da Silva, and Stewart-Ibarra, 2021). In that perspective, the voice of scientific institutions in LAC is critical, gathering decades of experience and understanding of specific challenges and opportunities in local innovation ecosystems.

This is well exemplified by the Chicó-Bogotá Declaration for Positive Biodiversity in Latin America and the Caribbean, launched in 2024 under CAF's leadership, which represents a landmark commitment to bridge the long-standing divide between science, policy, and finance and signals a turning point in the integration of science into policymaking across Latin America and the Caribbean. Bringing together scientists, public institutions, Indigenous representatives, and development financiers around a shared agenda to move from diagnosing biodiversity loss to integrating scientific knowledge directly into decision-making and investment processes, the Declaration emphasizes calls for regional cooperation in research and new mechanisms to embed evidence, data, and ecological indicators into the policy cycle and financial programming of development banks and governments. In doing so, it formalized a model in which scientific institutions—universities, biodiversity institutes, and knowledge networks—become recognized partners in the governance of natural capital and the design of bio-innovation policies. CAF's adoption of this framework marks the first time a regional development bank in the Global South explicitly positions science as a driver of its biodiversity investment strategy.

Fig. 17 | Models of scientific engagement in decision-making institutions



Source: author's elaboration

This opens the door to practical reforms to further institutionalise scientific advice closer to decision-making. In that sense, scientific advisory councils can offer various advantages. However, their effectiveness can vary, and such councils can take different shapes and formats. Recent evidence (see Morales 2021) shows that advisory bodies to bring the voice of science into policy-making can be independently-run, or enabled, led or owned by the decision-making body (whether it is a government, a development bank or a private organisation). Independent-run advisory councils would operate without any financial backing of the decision-making body. Alternatively, they can lean heavily on funding from the decision-making body, primarily through contracts and request for advice (enabled scientific advisory councils). Decision-making bodies can also have more control over those scientific advisory councils if they host (partly or exclusively) those councils or if they entirely fund them.

In the context of biodiversity-based innovation, the interactions between science and decision-making can be organised along any of those models, depending on the type of decision making institution and overall objective (see Fig. 17).

As decision making institutions (governments, but also development finance institutions such as CAF) consider setting up their own scientific advisory councils, it is critical to draw on existing lessons for establishing effective scientific advisory councils to promote biodiversity-based innovation in Latin America and the Caribbean (LAC). The five key lessons identified in Morales (2021) based on global experiences are:

- Flexibility and Adaptability of Scientific Advisory systems to responding to emerging challenges and opportunities. This flexibility is crucial for addressing the dynamic and complex nature of biodiversity issues in LAC.
- A dedicated role of a Principal Scientific Advisor within the decision-making institution (whether a government or a development) that acts as a point of contact with the scientific council, enhances the integration of scientific evidence into policy-making, and provides leadership in ensuring that biodiversity considerations are prioritized in innovation strategies.
- Autonomy of Advisory councils so that they operate independently from political pressures allows for unbiased, evidence-based recommendations, which is vital for the credibility and effectiveness of decisions.
- Public Trust and Transparency in advisory processes and fostering public trust in science are essential. This is particularly important in LAC, where public engagement is interlinked with biodiversity-debates.

- Balance between representativeness and expertise within advisory councils to enable a diverse range of stakeholders and comprehensive and inclusive biodiversity-based innovation strategies.

Implementing these lessons can strengthen future scientific advisory councils for biodiversity-based innovation in LAC and are especially critical considering that scientific institutions have more knowledge on the type of coordination failures that hinder the scale up of research and development activities, which often evolve and change over time, requiring constant monitoring, dialogue and information-sharing.

In conclusion, while biodiversity represents an immense opportunity to drive sustainable development in Latin America and the Caribbean, seizing such an opportunity requires moving beyond traditional conservation models and embracing transformational agendas to both protect the ecological value of biodiversity while leveraging their innovation value. Achieving this developmental vision of biodiversity will require an increase and reorientation of investment and biodiversity finance, but also a greater coordination between a range of stakeholders, including public and private sectors, scientific communities, local communities, and finance institutions. Such coordination has historically not been an easy task in LAC, but the region's ability to leap to the development frontier and shape the 21st century largely depends on it. The next section is further devoted to the issue of coordination for scientific co-operation in the region, at the national, provincial, regional and international level.

7.

Scientific cooperation at the subregional, regional and international levels

7. Scientific cooperation at the subregional, regional and international levels

Bringing scientific institutions at the core of biodiversity-based innovation ecosystems: from national to regional capacity-building

The strategic shift toward biodiversity-based innovation in Latin America and the Caribbean cannot be achieved by financial capital alone. Development banks may act as catalytic investors, but their impact will remain limited unless it is matched by a corresponding investment in knowledge, cooperation, and scientific cooperation across LAC. Scientific cooperation, both within and beyond national borders, is not an accessory to the biodiversity-based innovation agenda, but is its central infrastructure.

The idea of innovation ecosystems in Latin America and the Caribbean has been explored extensively by Gabriela Dutrénit (2014) and Jeffrey Orozco (2020), who both emphasize the need for localized networks of collaboration between universities, firms, and government agencies to sustain learning and innovation.

Building biodiversity-based innovation will depend on strengthening these territorial innovation systems, particularly in biodiverse provinces where institutional density and scientific infrastructure remain weak (see section 7.2). Their work underscores that effective ecosystems are not spontaneous, and instead require deliberate policies for coordination, trust-building, and knowledge diffusion.

Fortunately, the LAC region counts on an extensive list of renowned public biodiversity institutes, with various mandates and uneven funding and capacity across countries. Overall, they tend to aim to generate, steward, and mobilise biodiversity knowledge, via collections, monitoring, and applied research, to inform policy, conserve ecosystems, and increasingly catalyse bio-based innovation and local livelihoods). Their roles span marine and Amazon research, national data systems, and botanic gardens that bridge science and society. The oldest one is Brazil's Rio de Janeiro Botanical Garden Research Institute (JBRJ), founded in 1808, followed by the Natural History Museum of Jamaica (1879) and Argentina's Instituto de Botánica Darwinion (1911).

However, in most LAC countries, biodiversity institutes were designed as conservation and research entities, and not all of them have been capacitated as innovation actors. Their mandates of cataloguing species, managing collections, conducting ecological assessments, are indispensable but insufficient for large-scale impact innovation. To become engines of a biodiversity-based economy, they must evolve into innovation intermediaries: connectors between science, entrepreneurship, and territorial development. To main question is therefore how can they be empowered as active actors of a national innovation ecosystem rather than purely sticking to a conservation mandate?

The region features several examples of successful partnerships that have provided opportunity for experimentations and joint innovation relying by the biological material those institutes hold, in order to provide a demonstration effect. For instance, the Iwokrama Centre in Guyana shows how protected areas can serve as platforms for experimentation in sustainable forestry, ecotourism, and community bio-enterprises (Iwokrama centre, 2022). Similarly, while many institutes already manage biodiversity observatories and data systems (e.g., Costa Rica's INbio and more recent DNA mapping initiative, Mexico's Conabio, or Ecuador's INABIO), these datasets can become the backbone of bio-digital innovation if connected with AI tools (see section 5 on bio-intelligent AI).

Table 7 | List of major national biodiversity institutes in Latin America and the Caribbean

Name		Creation	
Instituto de Botánica Darwinion	Argentina	2010	Research and taxonomy of South American flora; maintain one of the continent's largest herbaria; coordinate national plant databases and the Flora del Cono Sur project.
UB-ERI – Environmental Research Institute, University of Belize	Belize	2010	Applied research, education and capacity-building for sustainable management of Belize's natural resources; align with national policies.
Instituto Nacional de Pesquisas da Amazônia (INPA)	Brazil	1952	Tropical biology and Amazon research; provide science for public policy; priorities include biodiversity, environmental dynamics, socio-environment & health, innovation.
Instituto de Pesquisas Jardim Botânico do Rio de Janeiro	Brazil	1808	Promote/do/disseminate science on flora for conservation and valuation; integrate science, education, culture and nature; manage collections and public engagement.
Instituto Chico Mendes de Conservação da Biodiversidade	Brazil	2007	Manage federal protected areas; protect natural heritage with people; support traditional communities, research/knowledge management, environmental education.
Instituto de Ecología y Biodiversidad	Chile	2006	Frontier research on biodiversity & ecosystem functioning; train new scientists; evidence for conservation and sustainable management; science-policy interface.
Instituto de Investigación de Recursos Biológicos Alexander von Humboldt	Colombia	1993	National biodiversity arm under MinAmbiente: generate and broker data/knowledge to inform policy and decisions on Colombia's biodiversity (monitoring, assessments, collections, decision support).
Instituto de Investigaciones Marinas y Costeras (INVEMAR)	Colombia	1994	Basic/applied research on marine & coastal ecosystems to support policy, sustainable management, restoration, and decision-making; technical support to SINA.
Instituto Amazónico de Investigaciones Científicas SINCHI	Colombia	1993–95	High-level scientific studies on Amazonia's biological, social and ecological reality; knowledge dissemination for sustainable regional development.
Instituto de Investigaciones Ambientales del Pacífico	Colombia	1991	Research and information for decisions/policies on the Chocó Biogeográfico; community-based knowledge co-production; cultural identity and territorial peace.
Instituto Nacional de Biodiversidad (INBio)	Costa Rica	1989 (until 2021)	Conduct biodiversity inventories and research; pioneer in bioprospecting and digital biodiversity data; since 2015 its collections are hosted by the National Museum of Costa Rica, continuing as a knowledge reference for the region.
Instituto de Ecología y Sistemática (IES)	Cuba	1986	R&D and scientific-technical services in ecology & systematics; biodiversity data/assessments to support sustainable use and monitoring; post-grad training (CITMA).
Jardín Botánico Nacional	Dominican Rep.	1976	Study, conserve and manage Dominican flora; national botanic garden created by Law 456/1976; collections, education, public services.

Name		Creation	
Instituto Nacional de Biodiversidad (INABIO)	Ecuador	2014	Plan, coordinate and execute biodiversity R&D and innovation to strengthen conservation and sustainable use; manage collections/knowledge services.
Iwokrama International Centre	Guyana	1996	Promote conservation and the sustainable, equitable use of tropical rainforest for ecological, economic and social benefits via research, training and technology.
Natural History Museum of Jamaica (Institute of Jamaica)	Jamaica	1879	Preserve, study and showcase Jamaica's biodiversity; maintain national collections; research, education, and public engagement for conservation.
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO)	Mexico	1992	"Bridge" institution to promote/coordinate knowledge of biodiversity and its conservation & sustainable use; decision-support for society and policymakers.
Instituto de Ecología (INECOL)	Mexico	1975	Generate, transfer and socialize frontier knowledge on ecology and biological diversity for conservation, restoration, sustainable management and productive alternatives.
Smithsonian Tropical Research Institute	Panama	1966	Advance knowledge of the past, present and future of tropical biodiversity; operate long-term research platforms (e.g., BCI), training and outreach.
Instituto de Investigaciones de la Amazonía Peruana	Peru	1979–81	Generate and provide knowledge on Amazonian biological and socio-cultural diversity; integrate science, technology and ancestral knowledge for sustainable development.
Instituto de Investigaciones Biológicas Clemente Estable	Uruguay	1927	Public life-sciences institute creating original knowledge across biology (neuro, micro, genetics, environmental sciences) with national problem-solving focus.

However, for those initiative to empower public biodiversity institutes as not only scientific but also innovation powerhouses, it is useful to explore collaboration mechanisms beyond the national scale. Over the past two decades, most Latin American and Caribbean (LAC) countries have built national innovation systems and dedicated STI agencies. Yet much of this architecture remains sectoral, metropolitan-centred, and only loosely connected to the biodiversity assets that constitute the region's true strategic capital (Katz, 2000; Dutrénit, 2014). Funding still gravitates toward conventional industries or imported paradigms, while the ecosystems that matter for a biodiversity-based economy may remain peripheral to national innovation strategies.

A biodiversity-based innovation strategy must therefore be territorial and networked, not merely national, for three main reasons. First, the meaningful scale is biogeographic rather than administrative because biodiversity and ecological processes ignore borders: the Amazon is a single ecological system fragmented into nine jurisdictions; the Caribbean's coral reefs are interconnected ecological and economic commons; and the Andean páramos regulate water systems across multiple countries, which is why fragmented national research efforts cannot capture or manage these dynamics effectively.

Second, regional scientific cooperation is needed to achieve critical mass and specialisation. Although some have extensive experience and pioneering capabilities, many of LAC's national institutes are small with constrained funding, and by pooling biorepositories, genomic platforms and training, the region can overcome the small-scale trap that limits bio-innovation (Estevadeordal, Frantz & Nguyen, 2004).

Regional scientific cooperation is not new in the region, as LAC countries have a long tradition of bilateral, regional, and global scientific cooperation as an essential tool to strengthen and complement national capacities for research, technological development, and innovation. However, despite numerous multilateral initiatives, the region has not fully leveraged the opportunities and additional benefits that scientific collaboration offers to achieve common development goals (Soler, 2014). The multiplicity of forums at the political level, budgetary problems, political instability, and the gap between science and policy have limited the effectiveness and relevance of multilateral scientific initiatives on broader political and societal decisions (ibid).

Several initiatives are of particularly relevance in that perspective, as they underpin the type of cooperation needed for biodiversity-based innovation ecosystems: the Inter-American Institute for Global Change Research (IAI), the Ibero-American Programme for Science, Technology and Development (CYTED), and the Amazon Cooperation Treaty Organization (ACTO). Interestingly, both the Ibero-American Programme for Science, Technology and Development (CYTED) and the Inter-American Institute for Global Change Research (IAI), operated initially as North-to-South initiatives driven institutionally and financially by Northern countries but evolved into more horizontal, South-to-South cooperation networks (Soler, 2014), while ACTO begun as a regional cooperation initiative to harmonise indicators, data and policy dialogues across Amazonian states, a prerequisite for shared monitoring, restoration and innovation agendas.

CYTED, which has established long-running thematic networks and consortia in biotechnology, bio-inputs and bioeconomy that illustrate pooled training and joint problem, solving, was established by a group of researchers and administrators from Spain and Latin America who, in the early 1980s, discussed the possibility of creating a formal structure for fostering scientific cooperation among Spain, Portugal, and Latin America (ibid.). Yet, it also create a new model for South-to-South cooperation among Latin American countries with little experience in scientific exchange among themselves (Sebastian, 1992). In its first 30 years, over 441 thematic research networks and 680 innovation projects had been funded with the participation of more than 8,400 research groups from all Ibero-American countries, with the direct involvement of more than 28,800 scientists (Corbi, 2012).

Meanwhile, at its creation in 1992, the Inter-American Institute for Global Change Research (IAI) was also envisaged as an instrument by the US administration to promote scientific cooperation as a way to maintain U.S. leadership on issues associated with the economic and social impact brought by environmental change, which is why the National Science Foundation (NSF) promoted the creation of a series of regional institutes in the Americas, Europe, Africa, and Asia-Pacific (NSF, 1994; Soler, 2014). Nevertheless, as IAI matured, and as the political, economic, and scientific environments changed in the Northern and Southern member countries of the organizations, one feature that has emerged is the strengthening of South-to-South cooperation (Soler, 2014). Over time, principal investigators from the South grew in number, in step with the enhancement of regional research capacity of Latin America, and the majority of proposals submitted and funded by IAI shifted from the United States and Canada (twenty-one of twenty-six initial grants) to Argentina, Brazil, Mexico, and other southern countries (ibid.)

These existing regional platforms therefore provide building blocks but despite their mandates, their influence could be even larger with more resources and coordination. For LAC's biodiversity-based innovation agenda, the implication is therefore to continue building regional scientific instruments that are aligned with production systems priorities, by strengthening the institutions that already exist and that can be scaled. For instance, the IAI's treaty-based network shows how to institutionalise science–policy linkages across countries; while ALCUE-NET/BiodivERsA mappings and GBIF-anchored nodes (e.g., CONABIO, SiB Colombia) demonstrate how shared data standards unlock collaboration. Moving forwards, expanding regional research funding calls targeting biodiversity-based innovation, scaling up investments in shared infrastructure programmes (such as regional biobanks, gene sequencing facilities) and continuing efforts to harmonize biodiversity data alongside join taxonomies and data standards appear as critical priorities. Crucially, regional cooperation should avoid duplication: rather than each country building a full suite of capabilities, specialization and complementarity should be encouraged. While one country could lead in genomics, and other ones in bioprospecting ethics or marine biotechnology, each contributing to a shared regional innovation web.

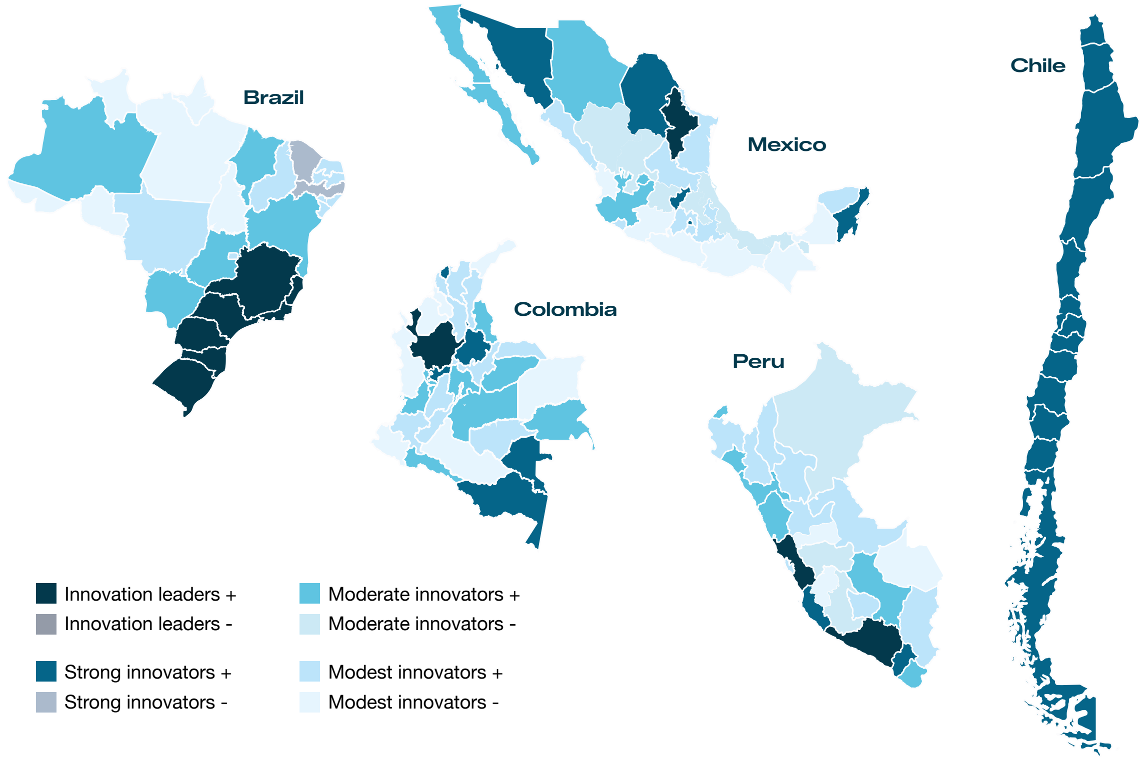
Lastly, at the regional scale, despite exsiting impactful initiative, LAC lacks the equivalent of programmes such as Horizon Europe or the European Research Council Funding, which enables to devote resources around regional issues at scale. Drawing inspiration for the EU's research ecosystem, some of those priorities can be organised within a LAC's version of the EU's horizon programme or an Erasmus/Marie Curie–style mobility scheme for biodiversity-based innovation that would circulate researchers and engineers across institutes (such as INABIO, SINCHI, INPA, CONABIO, etc.). Delivering this shift requires a clear political signal: biodiversity institutes are not only custodians of nature but protagonists of development. Naturally, those initiative require financial resources, which is why regional Development banks, yet again, appear as prime actors to endow those collaborative networks, as part of their technical cooperation programme, given that science and innovation may not be profitable on their own but have large socio-economic spillovers.

Sub-Regional Disparities and the Territorial Challenge for LAC's biodiverse areas

The paradox of LAC's bio-innovation landscape is that the richest areas in biodiversity are often the poorest in terms of scientific and technological capacity endowment. The Amazonian, Caribbean, and Pacific provinces concentrate biological wealth but have the lowest density of laboratories, research universities, and innovation funding (see Fig. 18). This spatial inequality mirrors broader centre-periphery dynamics within countries, which has been a core concerns of Latin American structuralist economists since the 1950s.

On the one hand, such situation is to be expected as national science policies are typically driven by metropolitan centres (e.g. São Paulo, Bogotá, Mexico City, Santiago) where research infrastructure and talent are concentrated. Meanwhile, biodiverse areas, especially those that are benefiting from strong conservation efforts, tend to exhibit less infrastructure, limited urban centres, and smaller population sizes.

Fig. 18 | Sub-regional innovation competitiveness index in LAC's major economies



Source: Latin American Subnational Innovation Competitiveness Index (2023)

However, there are two reasons for concern. The first one is that economic activity, often environmentally damaging, is taking place, and the limited access to innovation capacity locks in local populations towards ways of sustaining their livelihoods that can often come at the cost of biodiversity preservation (logging, monoculture, as seen by alarming rates of deforestation in the Amazon region). In those context, expanding biodiversity based innovation services with opportunities for local job creation provide a valuable alternative economic model.

Secondly, the result of the concentration of scientific and innovation capacity outside of biodiverse provinces is a pattern of "cognitive extractivism" (see in Klein 2013): biological samples and traditional knowledge flow from peripheral regions to central laboratories, while value-added activities and patents remain concentrated elsewhere. Unless this geography changes, a biodiversity-based economy risks replicating the same colonial division of labour it claims to overcome. In Brazil, bioprospecting and natural-products chemistry consolidated in Rio and São Paulo, even as upstream sampling occurs in Amazonian states (Silva, 2022). Patent mapping confirms dense innovation clusters in the Southeast (Pamplona, 2025; WIPO, 2023). Similar core-centric patent capacity appears in Mexico (Briones, 2025) and capability thinness in Colombia's Amazon vs. Bogotá (Rao et al., 2023). Addressing these disparities is not only a matter of fairness but of efficiency: innovation systems that exclude the territories of greatest biological potential are by definition inefficiency and do not fulfil their full potential.

Bridging this gap requires territorial decentralization of scientific capacity. As emphasised in the CAF Economic and Development Report 2025, bringing decision-making closer to citizens through decentralization holds the promise of improving the quality of government and public services, as proximity facilitate the identification of local needs and more direct social control (CAF, 2025).

Several priority areas stand out, such as funding gaps and infrastructure for innovation. For instance, dedicated regional science grants earmarked for biodiverse provinces could support research centres, incubators, and training programmes in biodiversity-rich territories and ensuring that they are not excluded from funding opportunities. For instance, this has been a systematic complaint of Brazil Amazonian universities in comparison to the University of Sao Paulo, which are perceived to have superior funding for Amazonian studies (personal communication with researchers based in Amazonian universities in Brazil, July 2024). These grants for technological innovation and incubation could be co-financed by national science agencies and regional development banks, with performance indicators and grants conditionalities linked to local employment, local start-ups support, and conservation outcomes.

Meanwhile, many biodiverse regions lack broadband and laboratory facilities and other types of facilities needed to prototype and patent technologies, and which are critical to science and innovation. For instance, without digital access, even the best training cannot translate into innovation at scale. Investments in ecologically-conscious research infrastructure, such as labs, specimen digitization, remote sensors, should be prioritized in development-bank loan portfolios. Otherwise, "scientific cooperation" risks remaining an elite conversation disconnected from the territories where biodiversity actually resides, and where livelihoods needs to be incentivised from an extractive realm to a biodiversity-positive one.

Lastly, the integration of local communities in science and innovation processes cannot be overstated. Scientific cooperation and innovation is not only a technical process; it is first and foremost also a **cultural and political negotiation.** The most social inclusive models of innovation and scientific cooperation are not based modes of knowledge production that are not extractive but relational. Indigenous peoples often hold intricate knowledge of genetic resources, ecological processes, and sustainable use practices. LAC's scientific institutions have experience with a range of initiative displaying relational –rather than extractive- modes of knowledge production, although the empirical evidence on the process and impact of those initiatives are limited. Yet, some cases can be highlighted. For instance, in Colombia, the Instituto Humboldt has experience integrating Indigenous knowledge into data collection and research. The institutre's field expeditions and biodiversity publications include "diálogos de saberes y encuentros comunitarios," where scientists and Indigenous, Afro-descendant, and rural communities exchange insights on flora, fauna, uses, and local taxonomies (Cuastumal and Miguel, 2016). They commit to socializing results back to the communities, training them in use of platforms to register biodiversity findings, and making the research legible and useful to local actors while viewing community practices, traditions, and ecological understandings as necessary to better understand territories (ibid). This experience and practice underscores the integration of local knowledge not as a gesture, but as part of participatory science approaches. Although it is not a LAC institution, another interesting initiative is Arizona State University's "Amazon Indigenous Peoples / Language for Sustainability" project, housed in the Center for Biodiversity Outcomes, emphasizes co-production of knowledge, blending Indigenous biocultural wisdom with science-based conservation and monitoring. The project explicitly seeks to engage local Indigenous communities not only as implementers, but as knowledge holders whose observations, language, and relationships with species shape the design of research and conservation outcomes.

International Scientific Cooperation and the matter of Knowledge Sovereignty

Besides national and regional-level policies, international cooperation plays a pivotal role in fostering biodiversity-based innovation in Latin America. Latin America's biodiversity has long attracted international scientific attention, but often in ways that reproduce asymmetrical power relations. Foreign universities and corporations have historically extracted biological samples and knowledge without adequate compensation or recognition, a pattern now termed biopiracy. Biopiracy often benefits firms located in high-income economies. For instance, a recent report from the Ecuadorian government identified the United States, Germany, the Netherlands, Australia, and South Korea as the countries that requested the most patents for products derived from Ecuador's endemic resources (Senescyt, 2016).

The policies of foreign countries and restrictions to technology transfer and diffusion also often exhibit biases that limit the LAC's potential to fully leverage its biological resources. Addressing these biases requires both a rethinking of cooperation frameworks and a commitment to equitable, context-sensitive collaboration.

One major challenges lies in the focus of international cooperation on biodiversity conservation (and a broader bias towards carbon emissions reduction which is a responsibility of the international community and high historic emitters) rather than its sustainable use for technological and economic development, where more benefits accrue locally. This emphasis is not simply the result of LAC's lack of investment in research and development (R&D) but is in many ways also shaped by cooperation policies and the associated resources (or lack thereof), which are often predetermined by donor countries and institutions. These policies prioritize certain types of collaboration, such as conservation-oriented initiatives, that Latin American countries often accept without much opportunity to influence or adapt them to their specific needs. For example, research highlights that the relationship between the Global North and South in science and technology has been historically asymmetrical. As pointed out by Venezuelan sociologist Edgardo Lander (1992), science and technology are inherently political and shaped by power relations. They often perpetuate inequalities when the transfer of knowledge and resources does not account for the priorities or contexts of the recipient nations. This imbalance reinforces dependency rather than fostering local capabilities in biodiversity-linked innovation (Lander, 1992). Consequently, this approach limits the region's ability to transform its biodiversity into an engine of socio-economic development through innovation.

For instance, recent reviews of EU–LAC science cooperation underline a clear picture of unbalance. Mapping two decades of bi-regional initiatives, Belli and Morín Nenoff (2022) show that the shift from the EU–LAC "Common Knowledge Area" to the Common Research Area (CRA) narrowed cooperation to three operational pillars (researcher mobility, access to research infrastructures, and joint work on shared challenges), yet it flags a persistent asymmetry as an EU-led agenda pull that is not always co-designed with LAC needs, with under-resourced technical secretariats and weak visibility that hamper continuity and stakeholder inclusion (especially firms and entrepreneurs). In short, when cooperation delivers common assets (databases, infrastructures, mobility channels) under clear governance, it works; when it stops at dialogue without instruments, it stalls (ibid.).

Another recent study by Colombia's Javeriana University notes that cooperation often follows a linear model in which resources flow from the North to the South without sufficient integration of the South's scientific and technological priorities. Reframing this dynamic requires promoting horizontal collaborations that recognize the expertise and agency of LAC institutions (Corradine, 2023) Indeed, Cooperation programs must be co-designed with local stakeholders, ensuring they address specific regional needs, such as valuing biodiversity through sustainable bioprospecting, ecosystem restoration technologies, or bio-inspired innovations. A shift in the approach to international cooperation is urgently needed. By adopting a more inclusive and adaptable approach to international cooperation, donor countries and LAC countries can jointly address the region's unique challenges and opportunities. This collaborative effort would enable the region to transform its biodiversity into a cornerstone of sustainable economic growth and global technological leadership.

A new paradigm of biodiversity-oriented knowledge diplomacy should rest on three principles. Those are:

i. *Capacity-building and local value creation* with international partnerships that must embed capacity building in every project, through joint laboratories, training programmes, and co-authorship are minimal standards. Contracts should require that a significant share of research spending occurs in the host country, and that intellectual property generated is shared with local institutions. The recently announced Nature's Intelligence Studio by the University of Oxford, based in Belem (Brazil) and in partnership with the National Institute of Amazonian Research offers a good example.

ii. *Respect for indigenous and local knowledge* with scientific cooperation that adhere to the principle of Free, Prior, and Informed Consent (FPIC). Indigenous communities and their knowledge should be recognised as co-researchers rather than subjects. Protocols for data sovereignty, especially for genetic and digital sequence information, are essential to prevent the digital extension of biopiracy. Regional guidelines, inspired by the Cusco Declaration on Traditional Knowledge (2018), could standardize these practices.

iii. *Open science with safeguards*. While open access to biodiversity data can accelerate innovation, but unregulated openness may expose sensitive information on rare species or traditional uses to foreign capture. Regional data governance mechanisms, possibly under a Latin American "bio-data commons", could balance transparency with sovereignty concerns.

In this context, development banks have an important convening role. They can finance multi-country research programmes that explicitly link biodiversity conservation with economic diversification, while embedding ethical standards and community participation. As the region and its development banks are increasing engaging with a range of international partners (China, Gulf states, EU's Global Gateway strategy), it is as clear as ever that strong regionally-set safeguards are needed for fair, just and equitable scientific collaborations.

8.

Concluding remarks: building the Next Innovation Frontier in Latin America and the Caribbean

8. Concluding remarks: building the Next Innovation Frontier in Latin America and the Caribbean

Latin America and the Caribbean stand at a crossroads. The region's extraordinary biodiversity with one fifth of the planet's species, spanning Amazonian forests, Andean ecosystems, and Caribbean marine corridors, is more than a natural inheritance; it is an underused source of knowledge, innovation, and sustainable prosperity. The central argument of this report is that biodiversity can and must be repositioned as the region's next productive frontier, anchoring a model of development that generates quality jobs, new industries, and environmental resilience. Achieving this transformation requires deliberate policy design, sustained investment in innovation capabilities, and the strategic leadership of development banks.

Throughout, we have shown that innovation remains the missing link in LAC's structural transformation. The region's persistent productivity gap and vulnerability to commodity cycles stem from the same underlying weakness: limited capacity to create, adapt, and diffuse new technologies. Escaping the middle-income trap depends on breaking this cycle of technological dependency and building domestic ecosystems that connect science, industry, and nature. The sustainability revolution provides a unique opening, what Carlota Perez (2010) calls a new "techno-economic paradigm”, in which green, circular, and bio-inspired technologies will define global competitiveness. For LAC, this is not a niche opportunity but a historic one: the chance to turn biological abundance into intellectual and industrial capability.

If the region is to lead globally in biodiversity-based innovation, it must move beyond the extractive paradigms that still dominate its development narrative. Carlos Nobre has long argued that to save the Amazon, we must invest in its science. This could not be truer today. The great opportunity for a nature-centred knowledge economy requires investing in science and technology systems that transform biological knowledge into usable innovation, from bio-inputs and biomaterials to bio-inspired design and digital biointelligence. In that perspective, scientific cooperation provides the architecture for a new paradigm: a web of institutions, researchers, communities, and firms co-creating value from nature while regenerating it. Scientific cooperation transforms biodiversity from a stock of resources into a flow of knowledge, which is a renewable form of capital that grows the more it is shared. LAC’s challenge is to institutionalise this flow: to build a regional innovation ecosystem rooted in its ecological and cultural uniqueness, and powered by science.

Development banks emerge as pivotal actors in that transformation. Their mandate, financial depth, and convening power make them uniquely suited to bridge the divide between conservation, innovation, and productive development. By taking on catalytic and directional roles, by mobilising patient capital, absorbing first-mover risks, and aligning financial instruments with long-term technological missions, development banks such as CAF can help build the missing connective tissue of the region’s innovation ecosystem. They can embed R&D components into loans, co-finance biodiversity-based ventures, support scientific infrastructure in biodiverse territories, and promote regional mechanisms for shared learning and scientific exchange. In doing so, they can shift the region’s development trajectory from one based on natural resource rents to one grounded in knowledge, capabilities, and value creation.

In conclusion, while biodiversity represents an immense opportunity to drive sustainable development in Latin America and the Caribbean, this report has detailed why and how seizing that opportunity requires moving beyond traditional conservation models and embracing transformational agendas that both protect biodiversity’s ecological value and leverage its innovation value. Achieving this developmental vision will require an increase and reorientation of investment and biodiversity finance, as well as far greater coordination among public and private sectors, scientific communities, local communities, and financial institutions. Such coordination has historically been difficult in LAC, but the region’s ability to leap to the development frontier and shape the twenty-first century largely depends on it. Adopt an ecosystemic policy and finance thinking that recognises the interconnectedness of all stakeholders is perhaps the greatest lesson that can be drawn from the region’s rich natural ecosystems.

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