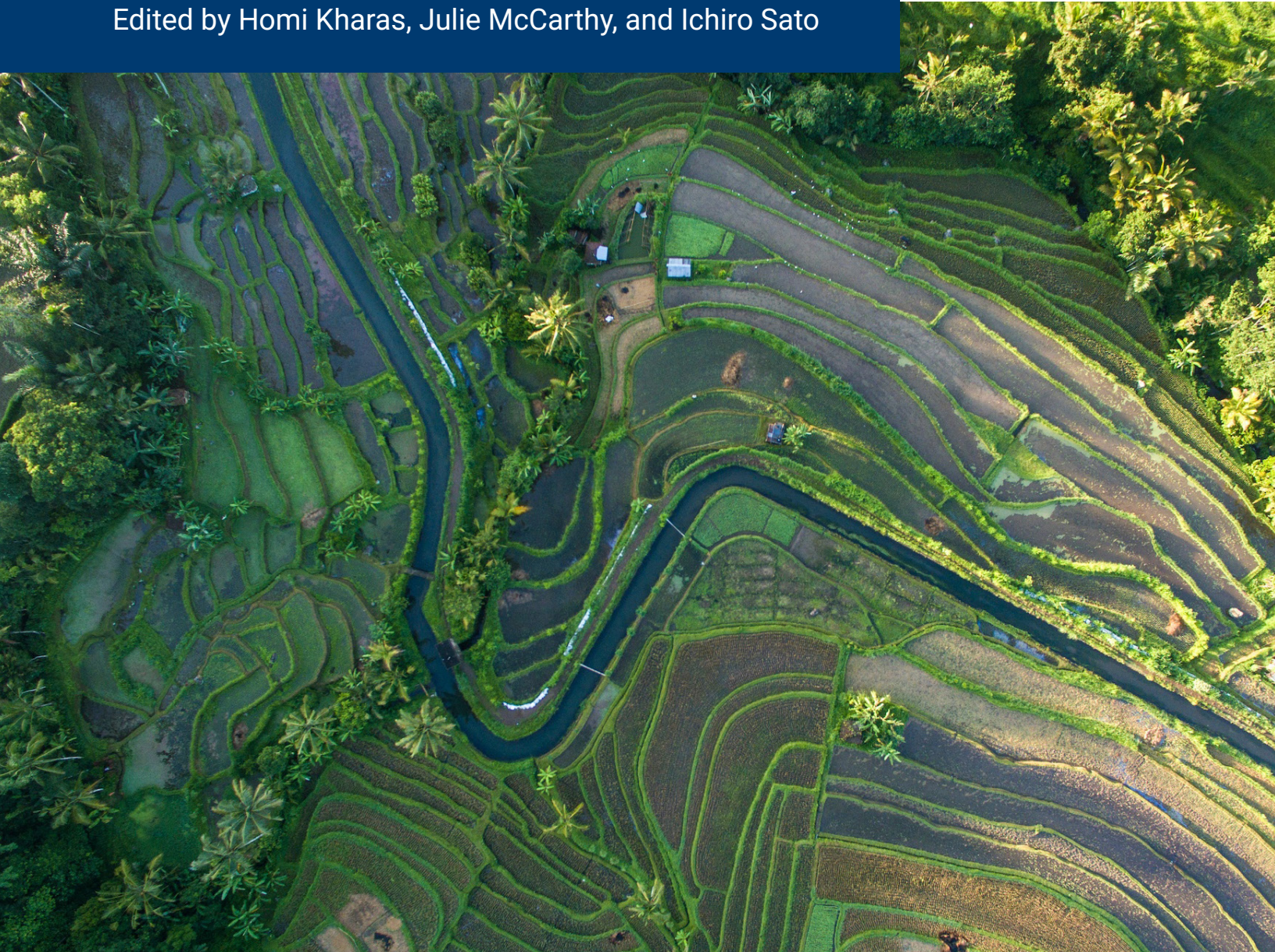


# NATURE, PEOPLE, AND SUSTAINABLE DEVELOPMENT

Edited by Homi Kharas, Julie McCarthy, and Ichiro Sato





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ONE

# **NATURE, PEOPLE, AND SUSTAINABLE DEVELOPMENT: WHY THE NEXT DECADE MUST BE DIFFERENT**

Homi Kharas, Julie McCarthy, and Ichiro Sato

This volume is about the relationship between nature, people, and prosperity—and why the way the world currently accounts for that relationship is failing all three. Its central claim is easy to state and harder to act upon: The living systems that our economies and societies treat as a backdrop are in fact the foundation on which development rests. To see why that matters, and what is at stake in getting it wrong, it helps to begin not with a definition but with a place.

Imagine a country that has vast forests that have been feeding timber, palm oil, and soy into global supply chains for decades. It has rivers that once flooded predictably, seasonally, in a way that farmers had learned over generations to plant around. It has coastlines rich with fish and mangroves that once held the shore in place.

It also has peoples who have lived inside these ecosystems for longer than the state has existed—who have their own names for every river bend and seasonal shift, who carry in their practices and their knowledge systems a relationship with place that is, among other things, a form of ecological management. Forests that look wild to outsiders are actively tended. Fisheries and estuaries that seem natural are carefully governed and protected.

Now imagine that a newly elected leader is told that the immediate future will look very different. Most of the original forests are gone now, and the rest are being actively degraded. The rivers no longer flood on schedule—they alternate between catastrophic inundation and drought, because all the vegetation and the deep soil that once regulated the water cycle has been stripped away. Rain now runs straight off degraded hillsides and into towns that were not built for floods like these. On top of that, climate patterns are shifting. Last year's harvest was the worst in a generation. The fishing communities along the coast are in crisis: The mangroves that previously nursed young fish have been cleared for commercial shrimp farms, the coral bleached by warming waters, and the daily catch is a fraction of what it once was. And the Indigenous communities who understood these systems most intimately—who in many cases actively resisted their destruction, sometimes at enormous personal cost—have watched not only their livelihoods but their worlds disappear. Landscapes that languages were built around no longer exist. Species that played central roles in ceremonies have collapsed. A relationship with the living world, accumulated over centuries, for which there is no market price and no line in any accounting or development ledger, is rapidly disappearing. And once it is gone, it is simply gone.

The leader is told that people are on the move—from coasts to cities, from rural areas to urban peripheries that are themselves flood-prone and underserved. The government is trying to oversee all this. It is borrowing to rebuild roads washed out by floods that now arrive every year instead of every few decades, to support farmers after failed harvests that are increasingly common, to manage the constant displacement. It is also trying to stay economically afloat in a geopolitical context where spikes in the cost of essential imported inputs like energy and fertilizer have become the norm. But its credit rating has been sliding because the international financial system can see the volatility in its agricultural export revenues, can see the climate exposure of its infrastructure, and prices the risk accordingly. The country pays more to borrow but has less to invest in resilience to adapt to the threats that are undermining its credit in the first place. The government feels compelled to continue to sell the timber from its forests and expand agriculture into sensitive ecosystems to generate the revenue that servicing its mounting debt requires.

It is a vicious cycle. Ecological collapse feeds economic fragility. Economic fragility forecloses the choices that might slow that collapse. And the warming planet accelerates both.

This is not a hypothetical tale. It is Indonesia—and it is also Zambia, Ecuador, the Philippines, and Mozambique. It is most of the world's lower- and middle-income countries that sit on significant natural wealth: The places that did the least to destabilize the climate are paying the highest price for it, while simultaneously being pushed by debt and development pressure to liquidate the natural systems that are their only real buffer against what is coming. None of this, it should be said, is the exclusive predicament of poorer countries. The same climatic and ecological shocks now strike wealthy countries—drought and heat crippling harvests in Spain, floods overwhelming towns across Italy and the United Kingdom, stranded assets accumulating in California. What differs is not exposure to the underlying disruption, which is universal, but the financial and geopolitical buffers available to absorb it: preferential lending, more diversified economies, and the accumulated advantages that let some societies rebuild while others fall further behind. The predicament is global; it is the capacity to withstand it that is unequally distributed, along lines that remain, in many places, distinctly colonial.

Why is this happening, and what can be done? These are the questions that this volume tries to address. Three propositions run through the chapters that follow. The first is that nature and ecological integrity are not one sector of development among many, but a precondition for all of it. The second is that our prevailing economic and financial system rewards the liquidation of nature and penalizes its protection. The third is that a credible post-2030 agenda will therefore have to change institutions and incentives themselves, not simply bolt stronger conservation targets onto a framework that still treats nature as external to the economy. A theme that recurs across the chapters that follow is that none of this can be achieved through markets alone. Capturing nature's value by pricing or commod-

ifying it can just as easily accelerate its destruction as arrest it; whether it conserves and regenerates depends on strong regulation, well-designed incentives, and credible accountability and sanctions working in concert—an alignment hardest to achieve precisely where it matters most, in states already strained by debt and weak institutions.

In the first part of the volume, we ask what we should protect. After all, the current reality is that nature largely has recognizable “value” in our economic system only when it has been destroyed—for example, once it has been transformed into commodities or real estate. This destruction is no longer a slow-moving background threat to societies and economic development—it is arriving, now, as economic crisis, food system failure, fragility, and climate breakdown. It is affecting all countries, but the costs are especially onerous for the poorest countries in the world, where natural capital accounts for over half the wealth. The World Economic Forum suggests that over half of global GDP is “moderately or highly dependent on nature and its services.”<sup>1</sup> The scale of exposure is vast.

The second part of the volume asks how we can incentivize change to restore and protect nature using market innovations. Some of these innovations lead to more efficient and equitable outcomes by capturing the value provided by nature and distributing this value to customary land and nature owners. But other innovations have to do with enforcement of regulations and addressing the political economy of environmental crime.

The volume then looks forward. Having asked what to protect and how to incentivize its protection, it turns to where these efforts could lead: the possibility that countries rich in biodiversity might leapfrog toward green industrialization, making healthy ecosystems the basis of a new, more resilient and equitable development model. The question this raises—and the one on which the post-2030 agenda will ultimately be judged—is not whether to build a more regenerative and resilient economic system, but how to shape it, so that the communities and countries that steward the world’s natural wealth share in the value it creates. Threaded through that question is a hard economic reality this overview returns to later but is worth naming at the outset: Building a regenerative economy demands significant upfront investment, and the countries that most need it face the tightest fiscal space and the highest costs of capital—so the sequencing of reform, and who bears its early costs, matters as much as its direction.

## The Sustainable Development Goals and the world that wrote them

Nature and economic development have long been considered deeply intertwined. But most theories of economic growth that evolved in the 20th century focused on human and physical capital accumulation, on technologies, and on good governance and institutions. Despite ad hoc efforts, measures of natural capital, or trends in its use, have not been systematically included in the economic models used by central bankers or finance ministers. Meanwhile, ecological science seemed largely concerned with describing slow processes of little relevance to the here-and-now priorities of reductions in poverty, infant and maternal mortality, hunger, and illiteracy. The longer time frames of ecological processes meant they got short shrift—\$100 in benefits in 20 years is only worth \$15 today at a 10% discount rate, so many of the concerns about natural capital depletion and overstep of planetary boundaries could be safely ignored by economists and political leaders with far shorter time horizons.

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1 World Economic Forum (2020), 8.

The disconnect between the environmental and economic development camps began to change in earnest with the universal approval of the Sustainable Development Goals (SDGs) in 2015.<sup>2</sup> Pope Francis' *"Laudato Si',"* issued three months before the summit, gave moral language to delegations wanting stronger nature and climate commitments—and almost certainly contributed to the atmosphere of ambition that made 2015 unique: a single calendar year that produced the Addis Ababa Action Agenda, the SDGs, and the Paris Agreement in quick succession.

The Paris Agreement and the parallel advance of the Convention on Biological Diversity—which would eventually produce the Kunming-Montreal Global Biodiversity Framework in 2022—reflected a growing recognition that climate and nature were not environmental sideshows but central to economic stability and human welfare. That recognition, however, had yet to fully penetrate the SDG architecture itself. Nor did it influence the Addis Ababa Action Agenda, where nature and climate were treated as tangential to discussions around reforming the global financial and economic architecture. The result was a 2015 SDG settlement that was historic in its ambition and structurally compromised in the same breath—nature was acknowledged everywhere and meaningfully embedded nowhere.

## Where nature landed in the SDGs—and why

The 2015 negotiations marked the first time that linkages between climate and development were formally enshrined in both the development and the climate agreements.<sup>3</sup> That was genuinely new. But how nature and climate showed up in the goals reflects the fault lines of the negotiation as much as any integrated vision.

Climate got its own goal—SDG 13—but it was conspicuously thin. This was deliberate at the time, as climate goals were to be set by a United Nations Framework Convention on Climate Change (UNFCCC) process taking place in Paris in December 2015, and so SDG 13 was essentially a placeholder that deferred to whatever the Paris Agreement would produce. It acknowledged urgency without specifying quantitative goals for limiting warming, without binding emissions commitments, and without the finance architecture that developing countries were demanding.<sup>4</sup> It was more of a political agreement to keep two processes from colliding, rather than a substantive integration of climate into development thinking.

Nature got two goals: SDG 14 (Life Below Water) and SDG 15 (Life on Land). Both were framed in the language of conservation and sustainable use—to protect, restore, and sustainably manage. They did not, however, treat nature as fundamental for economic and human development. SDG 15 in particular has been criticized for ignoring vital connections between human and nonhuman nature, and for failing to center the rights and knowledge of Indigenous Peoples and local communities—the very communities that most depend on, are often most knowledgeable about, and remain the historical custodians and stewards of, the ecosystems that this goal was meant to protect.<sup>5</sup>

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2 The intellectual and diplomatic roots of this integration have a deep history. The 1987 Brundtland Commission report, *Our Common Future*, brought “sustainable development” into mainstream policy language, and the 1992 Rio Earth Summit (the United Nations Conference on Environment and Development) produced Agenda 21 and the Rio Declaration and opened both the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change for signature—an explicit attempt to bind the environment and development agendas together. The SDGs emerged in 2015 as a merger of the Rio+20 mandate for an open working group to propose a set of sustainable development goals with the time-bound target methodology of the Millennium Development Goals.

3 United Nations (2015a; 2015b).

4 Kanie and Biermann (2017).

5 Krauss (2022).

Frameworks treating communities as rights-holders rather than beneficiaries already existed—the Convention on Biological Diversity’s 2010 Nagoya Protocol on access and benefit-sharing among them—but sat outside the SDG process and were never meaningfully integrated into it. Ultimately, by treating Indigenous Peoples as beneficiaries to be considered rather than as rights-holders and knowledge-custodians, the SDGs reproduced the same extractive logic they were ostensibly designed to address.

The result was a structural problem baked into the SDGs from day one: Nature and climate sat in their designated goals while the goals for food, water, cities, health, poverty, and growth proceeded in parallel lanes, as though ecological systems were external context rather than the base everything else rests on. This was not an accidental oversight—it mirrored precisely how the broader economy had long treated nature: as an externality to be managed at the margins, rather than the system within which all economic activity takes place. The consequences were predictable and have since been confirmed: Negative trends in nature will substantially undermine progress toward 80% of all assessed SDG targets.<sup>6</sup> The framework was designed to address a crisis that it has been simultaneously reproducing through its very structure.

## A mirror held up to the economy

The treatment of nature was a problem that the SDGs inherited from the world that wrote them—a reflection of sorts.

For most of the 20th century, mainstream economics treated nature as a backdrop—a supplier of raw materials, a sink for waste when needed, and otherwise irrelevant to the models that governed investment decisions, credit assessments, growth projections, and development planning. GDP growth was the only important signal; what happened to soils, fisheries, watersheds, and forests in the process of generating it was, in the technical sense, an externality.<sup>7</sup> A country could liquidate its forests, deplete its fisheries, destroy its grasslands, and degrade its soils to exhaustion—and every transaction would register as positive economic activity up until the moment the system collapsed.

The SDGs reproduced this blind spot. The logic—that a society and economic system built on destroying natural systems could not continue to grow indefinitely without catastrophic consequences—had not landed yet in the mainstream political imagination. Nor was it reflected in the corporate accounting, sovereign credit-ratings methodology, development finance plans, and national income statistics carried forward into the world’s most ambitious development framework.

The scale of what this gap means in practice has since been quantified. According to the most recent “State of Finance for Nature” report by the United Nations Environment Programme (UNEP), close to \$7.3 trillion flowed in 2023 into activities that directly harm nature—from fossil fuel subsidies to investments in high-impact sectors like utilities, construction, and food—equivalent to roughly 7% of global GDP.<sup>8</sup> In 2022, investments in nature-based solutions totaled approximately \$200 billion, just 2.5% of all nature-related finance flows.<sup>9</sup> The global economy is not merely failing to invest adequately in nature—it is actively financing its destruction, at colossal scale, year after year. The Earth itself is keeping score: The most recent estimate is that we will reach roughly 2.7-2.9°C warming by

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<sup>6</sup> IPBES (2019), 15.

<sup>7</sup> Dasgupta (2021).

<sup>8</sup> UNEP (2023b, 2026); The 2026 edition updates the figure to \$7.3 trillion.

<sup>9</sup> UNEP (2023b), 26.

the end of the century without dramatic shifts in current policy.<sup>10</sup> Scientists have now confirmed that seven of the nine planetary boundaries—the biophysical limits within which humanity can safely operate—have been breached, a finding that puts a harder, more urgent frame around what it means for the SDGs to be off track.<sup>11</sup>

Naming and quantifying the scale of the problem is not defeatism. It is the precondition for getting serious about solving it.

## What is changing

Ten years on, the debate has moved forward—and so, more importantly, have the real economy, geopolitics, and the financial system.

The most consequential shift may be the one happening in low- and middle-income economies. For countries endowed with biological abundance—the vast forest systems of the Amazon, Congo Basin, and Indonesia, the marine ecosystems of coastal West Africa, the extraordinary biodiversity of Latin America’s Cerrado and wetlands—nature has historically been valued primarily as something to extract and export in raw form. The bioeconomy offers a different proposition: that thriving ecosystems can be the source of a new generation of fertilizers, fuels, materials, pharmaceuticals, and food products, generating far more local economic value per hectare than the commodity extraction models they replace, while keeping ecological systems intact. This is a win-win proposition—for nature, for climate, and for the people who depend on both. That promise, however, is not automatic, and the term itself conceals a fault line. As Monique Atouguia and Dorothy Maseke argue in their chapter below, a regenerative, circular, and rights-respecting bioeconomy—one that keeps ecosystems intact and returns value to the communities that hold them—is a fundamentally different proposition from a biomass-intensive model that reproduces the old extractive structures using biological inputs rather than fossil ones. Which of these the coming decade builds is not settled by the technology; it is a matter of design, rights, and rules. These issues are taken up by Robert Muggah and Ilona Szabó de Carvalho in their discussion of why the inability to crack down on illegal activities is such an important structural constraint on any nature-positive market.

The momentum is real. Under Brazil’s 2024 G20 presidency, the G20 Initiative on Bioeconomy produced the first plurilateral framework for bioeconomy development, defining it as an innovative productive paradigm—not a supplement to the fossil-fuel-based economy, but a potential successor.<sup>12</sup> South Africa continued the momentum under its subsequent G20 presidency, and at COP30 in Belém, the Bioeconomy Challenge was launched as a formal workstream under the COP Action Agenda—the first time bioeconomy had been positioned as a central strategic objective in the conference’s history.<sup>13</sup> NatureFinance and the World Bioeconomy Forum estimate the global bioeconomy could reach \$30 trillion in value by 2050, up from \$4 trillion in 2025.<sup>14</sup>

For lower- and middle-income countries, this represents more than an economic opportunity. It is a potential re-framing of the development bargain itself: moving from a model that requires liquidating natural capital to service

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10 UNEP (2021), xvi; UNEP (2023a), xv. The 2023 edition updates the figure to 2.9°C (range is 2-3.7°C).

11 PBScience (2025).

12 G20 (2024); OECD (2026).

13 NatureFinance (2025).

14 World Bioeconomy Forum (2022). The \$30 trillion by 2050 projection is cited in NatureFinance and Getúlio Vargas Foundation (2024).

debt, to one in which healthy, diverse ecosystems are the basis of sustained and locally distributed prosperity, innovation, and growth. The transition is not automatic—it requires finance, infrastructure, governance, and market access—but the direction is becoming clearer. China’s 14th Five-Year Plan made ecological civilization one of its six overarching national development goals—embedding ecological health not as an environmental annex to growth policy, but as a constitutive dimension of what development means for the world’s second-largest economy.<sup>15</sup> That is a signal of a different order than a voluntary pledge. The reframing has deepened: China’s planning has begun to treat the bioeconomy itself as a strategic industrial pivot—a bid to reduce dependence on imported fossil inputs, secure supply chains, and position biotechnology as a future engine of growth and a matter of national security.<sup>16</sup>

In the financial system, the Network for Greening the Financial System (NGFS)—the body representing central banks and supervisors from more than 95 countries—released its final framework on nature-related financial risks in 2024, concluding that biodiversity loss is as serious a risk as climate change.<sup>17</sup> The Taskforce on Nature-related Financial Disclosures has developed a voluntary reporting framework now being adopted by financial institutions globally.<sup>18</sup> The gap between acknowledgment and widespread implementation is real, but the direction of travel in financial regulation is nonetheless meaningful.

On sovereign debt—historically the most nature-blind corner of global finance—economists have produced the world’s first biodiversity-adjusted sovereign credit ratings, demonstrating that if nature loss were factored into existing rating methodologies, 26 countries would face downgrades increasing their annual debt service costs by up to \$53 billion.<sup>19</sup> Existing analysis does not yet fully integrate soils, watersheds, coastal protection, and climate regulation, where the sovereign debt implications of nature loss become far larger.

The Kunming-Montreal Global Biodiversity Framework—the 2022 agreement sometimes called the Paris Agreement for nature—established a global target of protecting 30% of land and ocean by 2030 and mobilizing \$200 billion for biodiversity annually, providing an agreed reference framework that had been entirely absent from the SDGs.<sup>20</sup>

And in the spaces where the SDG framework was weakest—the treatment of Indigenous Peoples and local communities—there is a slow but real power shift occurring. Across Latin America, Africa, and the Pacific, Indigenous-led governance models are advancing legal frameworks that recognize rights of nature, the standing of ecosystems, and the authority of communities whose prosperity has always been understood as inseparable from the health of the land and water they inhabit. Bolivia and Ecuador have enshrined rights of nature in their constitutions. New Zealand granted the Whanganui River legal personhood at the insistence of Māori communities.<sup>21</sup> The new Tropical Forest Forever Facility launched by Brazil aims to reward Indigenous stewards for keeping tropical forests standing. These are not simply cultural achievements. They are alternative economic architectures, tested over generations, built on a premise the dominant paradigm is only beginning to grasp: that human flourishing and ecological health are not in tension but expressions of the same thing. As David Cotacachi, Fany Kuiru, Tatiana Schor, and Verónica Tejerina show in their chapter in this volume, Indigenous territories—particularly across Amazonia—consistently sustain higher ecosystem integrity than lands under other forms of management, which makes recognizing Indig-

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15 China (2021); Liu, Liu, and You (2021).

16 Zhu, Cingiz, and Wesseler (2026).

17 NGFS (2024).

18 TNFD (2025).

19 Agarwala et al. (2026); Lewsey (2022); Uganda, Ministry of Finance (2026).

20 CBD (2022).

21 For more on the rights of nature jurisprudence see Cullinan (2011). On the Whanganui River, see Te Awa Tupua (Whanganui River Claims Settlement) Act 2017.

enous Peoples as rights-holders and decisionmakers not a concession to be granted but one of the most effective ecological strategies available. Momentum is building, too, behind formal recognition of “ecocide” as a prosecutable crime under the Rome Statute—an effort that, whatever its near-term odds in a strained international system, signals how much the standing of nature is shifting in legal imagination.<sup>22</sup>

## What has not changed

Clear-eyed diagnosis requires acknowledging how far the emerging consensus is from becoming the actual governing logic of our economies and societies.

The current economic system continues to price sovereign debt without accounting for deforestation, to extend commodity finance without accounting for soil loss, and to measure economic growth in ways that record the liquidation of an ancient forest as a positive contribution to GDP. The G20 High-Level Principles on Bioeconomy are voluntary and nonbinding. The financial disclosure frameworks that do exist are largely voluntary. The major credit rating agencies—the gatekeepers of more than \$66 trillion in sovereign debt—still largely ignore the economic consequences of ecological degradation, even as geopolitical events with far less quantifiable impacts are routinely factored into their assessments.<sup>23</sup> The Financing for Development process has not produced the structural reforms to debt architecture, concessional finance, and capital market access that would make ecological investment economically rational for the governments most under pressure to liquidate those resources. Concrete reforms are not hard to name: embedding adaptation investments, natural-capital depletion, and climate exposure directly into the debt sustainability analyses that govern International Monetary Fund and World Bank lending; standardizing climate-resilient debt clauses that pause repayments when a climate shock hits; and scaling debt-for-nature and debt-for-climate conversions from bespoke, one-off deals into a standardized instrument. The Fourth International Conference on Financing for Development in Seville in 2025 pointed toward several of these, but its commitments remain largely voluntary and unmatched by changes in practice that would give them force.

It is worth being clear that financial markets not only suffer from a problem of mispricing, but of political economy. Nature is destroyed not merely because markets fail to capture its value but because powerful actors profit from its destruction—through land concentration, corporate influence, unequal terms of trade, weak tenure, and entrenched illegal economies. Correcting prices is necessary but insufficient wherever the status quo has beneficiaries with every incentive to defend it.

And the politics have gotten even harder in many respects. The multilateral ambition that produced the Addis Ababa Action Agenda, the SDGs, and the Paris Agreement in a single year is not the political environment of 2026. Geopolitical fracture, the return of great-power competition, and the domestic political pressures bearing on international commitments in wealthy countries make coordinated, ambitious action harder to sustain. The countries that most need long-horizon investment in ecological resilience are precisely those facing the most acute short-term borrowing pressures—a structural trap that the current international financial architecture not only fails to resolve but actively deepens.

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<sup>22</sup> ICC OTP (2025).

<sup>23</sup> Cox (2019).

And beneath the politics lies a harder economic challenge: Shifting production systems away from extractive, nature-destroying models and toward bio-based, circular, and regenerative alternatives almost always requires significant upfront investment—at precisely the moment when inflation, price shocks, and tightening fiscal space have made that kind of long-horizon spending politically toxic in rich and poor countries alike. The transition is necessary, and the costs of not making it are far higher—but the timing could hardly be worse. Compounding all of this, largely unaddressed by the institutions nominally responsible for governing it, is the brute force of environmental crime—illegal deforestation, unregulated and illegal gold mining, wildlife trafficking—which in regions like the Amazon operates at industrial scale, backed by organized crime, untouched by voluntary disclosure frameworks or G20 principles, and entirely indifferent to diplomatic negotiations. It is also increasingly interwoven with other illicit economies—money laundering, arms, and human trafficking—that share its routes, its enablers, and its impunity.

Another force reshaping the development landscape that the SDGs did not anticipate and that the post-2030 agenda cannot afford to ignore is the explosive and largely ungoverned growth of artificial intelligence. AI carries genuine promise for sustainable development—not least for precision agriculture, ecosystem monitoring, early-warning systems, and accelerating the bioeconomy itself. But its physical infrastructure has become one of the fastest-growing sources of environmental pressure on the planet, and this is only set to intensify over the coming years. The impact on electricity demand, water, and e-waste will be significant, and in lower- and middle-income countries, where governance frameworks to assess or constrain environmental impacts are almost entirely absent, the rush to build data centers could disadvantage communities living near these sites, while gains are captured elsewhere.<sup>24</sup> At the same time, the concentration of AI's economic gains is compounding exactly the inequalities that the SDGs were designed to address. The AI boom is concentrating economic and political power in a small number of technology companies and states. The post-2030 agenda cannot be credible without directly addressing AI: the concentration of wealth and power it is generating, the land, water, and energy it is consuming at scale, and the question of who governs it, for whose benefit, and under what rules.

There is a further risk worth naming. As nature moves up the agenda of financial institutions and multilateral bodies, it risks being absorbed into the existing paradigm rather than transforming it—becoming another asset class to be priced and traded, rather than recognition that the economy is a subsystem of the biosphere, not the other way around. Carbon markets have shown how this can happen: A good-faith attempt to quantify the cost of emissions becomes, in practice, a mechanism for the continued purchase of the right to emit. Nature markets could follow the same trajectory, with biodiversity credits and ecosystem service payments generating financial flows without ultimately generating ecological recovery. The risk is that, like carbon markets, we attempt to put a price on nature, and then assume the work is done. As David Obura points out in his chapter, the problem is not one of “market failure” but of “values failure.” Without clarity on what we value, the market cannot be expected to accurately assign a price to the externality. Part of that clarity is recognizing that nature holds value in more than one register at once: instrumental value, in the food, water regulation, and coastal protection it provides; relational value, in the identity, stewardship, and reciprocal obligation that bind communities to particular places; and intrinsic value, in living systems whose worth does not depend on human use at all. A price can, at best, approximate the first. It is the second and third that markets tend to erase—and that any honest reckoning with what we owe the living world must keep in view.

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24 A report by NatureFinance and NatureAlpha (2025) found that 45% of data centers globally are located in river basins with high water availability risk.

# The opportunity ahead: Nature as the foundation of the post-2030 sustainable development agenda

An estimated \$58 trillion of annual global economic output is directly dependent on nature.<sup>25</sup> But the deeper point is not economic—it is that the premise that human prosperity can be built in increasing separation from the natural world has been empirically rejected by six decades of development policy experience. Nature is not a sector. It is not a set of services to be priced and traded at the margins. It is the system within which all human activity takes place.

The SDGs started the process of integrating nature and economic development. On many fronts, although most goals are unlikely to be met, there is modest progress compared to the state of economic development in 2015: less poverty and hunger, improved health and education, and a more prosperous and more equal global economy.<sup>26</sup> Yet on nature, there is likely to be backsliding in 2030 compared to 2015: The World Wildlife Fund’s 2024 “Living Planet Report” documents a 73% fall in wildlife populations over 50 years; episodes of mass coral bleaching; and threats of tipping points leading to collapse of the Amazon rainforest and the subpolar gyre.<sup>27</sup> The World Meteorological Organization’s 2025 “State of the Global Climate” report confirms that the past 11 years have been the hottest on record and that 2025 was 1.43°C warmer than the preindustrial 1850-1900 average.<sup>28</sup> It documents the largest-ever imbalance in the Earth’s energy in 2025—the difference between incoming energy from the sun and outgoing energy released by thermal radiation.

These are the basic facts that must be confronted as the 2030 endpoint for the SDGs approaches. There is an opportunity to construct a post-2030 agenda that does not merely consider nature as one or two sectors among many but that properly positions it as the underpinning of all sustainable development.

The chapters in this volume explore how a meaningful post-2030 agenda could be constructed. The purpose is not to provide a blueprint but to start a debate on two fundamental questions that we believe the post-2030 agenda should address: What should we protect and how can we incentivize change and inspire action? The chapter topics are neither exhaustive nor a comment on priorities. Rather, they illustrate the kind of analysis and evidence that should be brought to bear in the debate.

The first part of the volume addresses what we should protect. The analytical frame provided by David Obura, drawing on the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), presents the core concept of nature as the foundation of a sustainable development system. Obura argues that it is essential to understand the key sources of what makes the current system unsustainable—not just the extractive-restorative balances often associated with conservation but also an additional loop of how societies organize the checks and values needed to keep the system in balance. He observes that balance is required at many levels—global, national, and local. At the global level, geopolitical divides complicate a balanced consensus view, but multiple mini-lateral groupings and coalitions of the willing can provide examples of what success can look like.

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25 Usher (2026).

26 Kharas, McArthur, and Onyechi (2024).

27 WWF (2024), 7.

28 WMO (2026), 6.

The underlying theme of how to align nature's temporal and spatial domains with economic and social time frames and administrative boundaries is picked up in a chapter by Masahisa Nakamura on watershed management. He argues that most attention in watersheds is given to the flow issues of flood control and water resource development, while not enough attention has been given to the retention systems of lakes, wetlands, and groundwater connections. Together, these determine how water basin systems actually behave. Without a governance and institutional system that adapts and learns, the systems cannot be brought back into balance. Japan's experience with the Law Concerning Special Measures for Conservation of Lake Water Quality to review over time plans for designated lakes of strategic importance is offered as an example of how to improve governance. In a theme that recurs in several chapters, Nakamura cautions that recognition of the issue does not automatically lead to appropriate action and good practice. He calls for strengthened governance, and science-based institutions that use dynamic learning from experience to build understanding of complex system behavior evolving over long periods of time.

Noriaki Sakaguchi uses the example of mangrove ecosystems to explore the difficulties and challenges in implementing nature-based solutions (NbS). Mangroves offer a classic example of extractive approaches to nature. They have been destroyed to establish fish and shrimp ponds that yield short-term economic benefits but at the cost of longer-term benefits. The broad array of mangrove benefits, however (as for many other NbS) cannot readily be quantified—there are no markets providing valuations for coastal protection, local wild fishery resources, carbon sequestration, and biodiversity, in addition to disaster risk resilience. Without such data, technical planning guidelines for NbS are less well-developed than, for example, guidelines for alternatives such as gray infrastructure that have technical specifications for resistance to predicted storm waves and tsunamis. Like other areas, the global conversations on mangroves have recognized the undesirable consequences of mangrove loss and issued calls for protection and conservation, to be achieved by mobilizing significant financial resources from public and private sources. New institutional structures to monitor and share information have been established at the global level (for example, the Mangrove Alliance for Climate and the Mangrove Breakthrough) and national level (Indonesia's initiative on the World Mangrove Center), but financial mobilization has fallen short: As of 2025, less than \$1 billion of the \$4 billion needed by 2030 had been raised.<sup>29</sup>

David Cotacachi, Fany Kuiru, Tatiana Schor, and Verónica Tejerina offer an alternative perspective on what to protect: the Indigenous Peoples and cultures that have long coexisted with nature. The authors argue that protecting Indigenous Peoples—their territories, governance systems, and cultural values—is essential to safeguarding high-value ecosystems. Drawing on cases from Amazonia, the world's largest tropical forest, they show that Indigenous territories maintain high levels of ecosystem integrity and generate local and global environmental benefits, including hydrological regulation, biodiversity conservation, and climate stability. However, the impact of empowering and engaging Indigenous Peoples at scale falls short of its potential due to the lack of a meaningful compensation framework for Indigenous communities. The chapter highlights the importance of integrating traditional knowledge and Indigenous governance models into global sustainable development agendas, recognizing Indigenous Peoples as strategic partners, rights-holders, and decisionmakers.

The second part of the volume shifts to the question of how to incentivize change using market forces. Arend Kulkampff and Julie McCarthy frame this in terms of addressing a “triple crisis” of debt vulnerability, climate shocks, and ecosystem breakdowns. They point to a core underlying structural problem: in their words, “governments and companies are penalized for vulnerability but not rewarded for active steps to improve resilience.” They draw on

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29 See more on the Mangrove Alliance for Climate at <https://mangrovealliance4climate.org/>; see more on the Mangrove Breakthrough at <https://www.mangrovebreakthrough.com/about>; see more on the World Mangrove Center at <https://worldmangrovecenter.org/>; Mangrove Breakthrough (2025) reported more than \$750 million in mangrove-positive investments since 2020.

examples of how countries are now looking to offset such structural disincentives by predetermining key performance indicators of how public investments can decrease risks to nature and then linking the payments on bonds and insurance products to these key performance indicators.

Beyond sovereigns, a number of models of how markets can be used to make payments for ecosystem services (PES) are evolving. Technical issues with monitoring, reporting, and verification, along with lack of standardization, mean that many of these models remain one-offs. There are lessons to be learned, however, in institutionalizing finance for nature such that nature-positive outcomes are translated into financial advantage for countries, firms, and communities.

New bioeconomy markets will struggle to scale in remote areas where state presence is limited, tenure is contested, and illicit economies are entrenched. In their chapter, Robert Muggah and Ilona Szabó de Carvalho argue that environmental crime has become a structural constraint on nature-positive development. Land grabbing, illegal logging, illicit mining, wildlife trafficking, illegal fishing, and waste crime generate direct ecological and climate harms, but their effects extend further. Criminal networks use coercion, corruption, and institutional capture to weaken the rule of law, while illicit supply chains undercut compliant producers, erode public revenues, distort commodity markets, and deter the lawful investment on which sustainable bioeconomy markets depend. The chapter also cautions against treating all illegal activity alike, distinguishing organized, enterprise-driven criminality from survival-driven illegality rooted in insecure tenure, weak public services, and the absence of viable livelihoods. Responses must therefore combine targeted deterrence and enforcement with development, financial, and market reforms—stronger public services, land and resource rights, livelihood opportunities, traceability, and financial integrity in frontier communities. As they write, “decisive leverage sits at chokepoints such as mills, ports, traders, and financiers, rather than only at the forest edge ...” Markets for nature cannot succeed unless the institutions governing territory, trade, and finance make legal stewardship more secure and economically attractive than illegal extraction.

The power of market forces—and the current limitations—is illustrated in the chapter by Felipe Faria, Morgan Gillespy, and Guido Schmidt-Traub. They argue that value chains can function as levers of transformation if they align policy, finance, and technology. Using the examples of the soy and cocoa value chains—both with concentrated supply and demand but with different structures—they show how value chains can transmit incentives through procurement, finance, and trade, but that it is public policy that sets the rules of the game.

Faria et al. recommend that financial supervisors require nature-related financial disclosures. The impact of these measures may be complemented and accelerated by trade policy frameworks aimed at reducing deforestation risks in commodity supply chains, including the European Union Deforestation Regulation, although outcomes will depend on how such rules are designed and implemented. They further recommend that systems of rural credit and intra-value chain finance of forward contracts, input prefinancing and barter arrangements, the instruments which comprise the bulk of smallholder finance, be aligned with environmental or social performance.

A common theme in all these chapters is the potential for countries to leapfrog and drive toward green industrialization. This is the theme taken up in the concluding chapter by Monique Atouguia and Dorothy Maseke. The chapter draws on examples of how Brazil integrated its bioeconomy principles into climate change commitments, how China and South Korea have moved forward with AI-enabled biomanufacturing, how Africa is approaching data sovereignty, and how India frames its bio-innovation to accelerate biofuels and biopharma. The examples suggest that technical and institutional governance must be complemented by equity considerations so that both countries with financial and human capital and innovation capacity and those that are rich in raw biodiversity assets can benefit from the bioeconomy. A structurally sound bioeconomy, on this view, must avoid replicating the extractive patterns

of the present economy—both locally, in how Indigenous knowledge is recognized, valued, and fairly remunerated, and internationally, in how the resources, biodiversity, and genetic information of the Global South are used and valued across global supply chains.

If principles of genetic resource sovereignty and benefit-sharing can be coupled with technical innovation, the bioeconomy represents a true leapfrog pathway. The authors conclude, “The choice before policymakers is therefore not whether to pursue a bioeconomy but how to shape it.” That is the challenge they present for the post-2030 discourse.

## Beyond the SDGs: Nature as the foundation

It would be easy, writing at this moment, to mistake difficulty for impossibility. The years immediately ahead may in fact be harder than the ones behind us—the politics more fractured, the fiscal space tighter, the planetary alarm bells louder and more violent.

But the argument this volume makes does not rest on optimism about the next five years, and it is worth being precise about why. The claim that nature is the foundation of development rather than a sector within it is not a hopeful proposition; it is an empirical description of how economies actually work, and every season of failed harvests, washed-out roads, and downgraded sovereign credit makes it more legible, not less. The old paradigm is actively being refuted by events, every day. That is a particularly grim way to land a policy argument—but it is also why this one will not go away.

The shifts described in these pages—the reframing underway in central banks and credit methodologies, the bioeconomy moving from the margins toward the center of national strategy in some of the world’s largest economies, the slow return of legal and economic standing to the communities who have stewarded these systems longest—do not depend on any particular multilateral summit being successful, or a handful of political leaders being sympathetic. They are an alignment of changes being made, often quietly and against the grain of the prevailing politics, by people who understand that the tools a society reaches for in a crisis are the ones already built and waiting when the crisis arrives.

The task of a post-2030 agenda is to ensure that when the failures of the current model become impossible to ignore—and they will—the alternative is not just a set of intuitions, but a working architecture ready to bear the weight of the challenge. The 2030 agenda began the work of moving nature from the margins of how we understand development toward its foundation. That work is now unavoidable, and the cost of deferring it compounds with every year we wait.

The post-2030 agenda that follows could paint a reassuring picture—one in which the public face of progress stays smooth and untroubled while, out of frame, the mounting toll of all that is being lost goes quietly untallied. Or it could show a world meeting the mounting threats to its economies, its societies, and its natural systems with seriousness equal to the gravity of the moment: a world that has moved past quibbling over how to describe its concern and begun building the institutions, the finance, and the rules to prepare for and blunt a defining challenge of our time. Which picture the post-2030 agenda holds up is not yet determined. For now—though the window is narrowing—we are still the ones holding the brush.

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## **PART I**

# What we should protect



## TWO

# NATURE AS THE FOUNDATION FOR SUSTAINABLE DEVELOPMENT: LINKING NATURE'S NEEDS TO SUSTAINABLE DEVELOPMENT ACTION

David Obura

## Linking nature to sustainable development action

Nature provides the foundations for human society and economies. This understanding underpins the sustainable development paradigm from its first formulation 50 years ago to its current formulation in the 2030 Agenda for Sustainable Development (Agenda 2030) and the Sustainable Development Goals (SDGs). However, there has been limited systemic and theoretical underpinning of the paradigm, likely a factor in the poor achievement of outcomes.<sup>1</sup> The global economic system is not only systematically but increasingly overdrawing on two accounts—what nature can provide, and what societal actors can endure in terms of inequalities—and is environmentally, socially, and financially unsound.<sup>2</sup>

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<sup>1</sup> Clark and Harley (2020); Mensah (2019); Purvis, Mao, and Robinson (2019); Biermann et al. (2022); United Nations (2024).

<sup>2</sup> Obura et al. (2026).

The core proposition in this chapter is that the construct of “nature, economy, and society” is fundamentally a systems model of human life in nature, deeper than the framing of sustainable development, which represents one scenario, or configuration of outcomes.<sup>3</sup> Historically, how we have converted what nature produces into goods and services through the economy, and our understanding of the intangible benefits from nature that support cultural identity, mental well-being, sense of place, and “gifts” of nature have been severely out of balance.<sup>4</sup> The main question, now, is: Are we at or beyond the threshold of multiple planetary boundaries and tipping points of major Earth systems, and what is the needed transformative change?<sup>5</sup> This question was posed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in its 2019 Global Assessment on Biodiversity and Ecosystem Services and is taken up in this chapter to inform considerations of the post-2030 sustainability framework and the successors to the SDGs.<sup>6</sup>

The crises we face are not just technical challenges, or “market failures” that can be reversed through tweaks to the current system. Mainstream framing by economists has been that the problems, arising from externalities—carbon emissions, ocean acidification, impacts on biodiversity and water—can be progressively priced, and markets will self-correct.<sup>7</sup> The deeper explanation, however, relates to a fundamental mismatch between what we value (therefore what markets price and do), and what is needed. If economies and markets valued balance, externalities would not arise as their impacts would not be accepted as “part of a package.” This shifts the debate toward recognizing the multiple values of nature (and social systems) alongside financial profit. What we currently face is more a values failure underpinning markets, not simple market failures amenable to technical solutions.

A systems approach helps show the full dynamics across natural, economic, and societal domains, and how they relate to finance. It reveals why the underlying trends in biodiversity and planetary boundaries have continued to worsen despite rapid advances in technical and scientific understanding of what needs to be done. More than three decades since the Earth Summit in 1992, and now a decade into Agenda 2030 and the SDGs, nature is still not fully internalized into the development agenda. This chapter argues that making nature the foundational element of social and economic development is the transformation that is needed, and that this goes beyond the classical focus on instrumental uses from nature to incorporating intrinsic and relational values, as well as the values inherent in social capital. While apparently theoretical, given its grounding in systems theory, this approach provides tangible heuristics in just about any context to help actors select more sustainable pathways.

## The Sustainable Development Goals

The SDGs illustrate the gap addressed here for sustainable development more generally, i.e., between the internal logic and coherence of the concept, and external weak application. Presented as a static rectangle of 17 goals with associated targets and indicators, the goals and targets express the dominant political economy of the time, an operational framework to facilitate action and alignment.<sup>8</sup> However, given the importance of negotiated text in intergovernmental agreements, ambition has been locked in the agreed words for the last decade, directing attention

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3 Ibid.

4 Pascual et al. (2017).

5 Lenton et al. (2019); Rockström et al. (2009).

6 IPBES (2019).

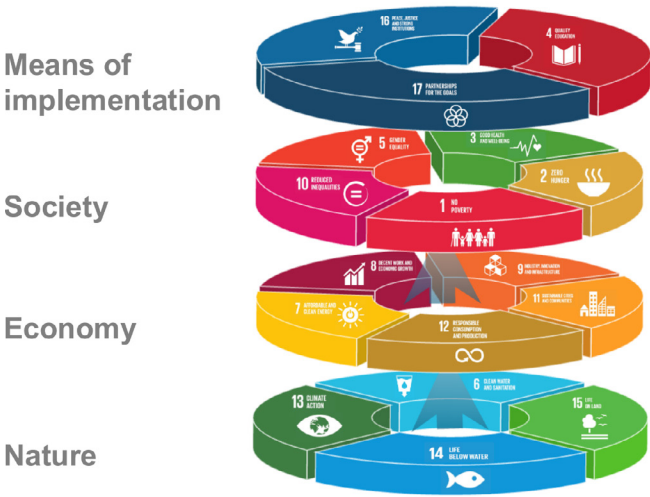
7 Maechler and Boisvert (2025); Kill (2014).

8 Kamau, Chasek, and O'Connor (2018).

away from interlinkages among the goals and change dynamics.<sup>9</sup> As a result, in spite of explicit recognition of their indivisibility, implementation of the SDGs has been characterized by siloed action and alienation, resulting in poor delivery of outcomes.<sup>10</sup>

In fact, the goals embed highly integrated narratives of people’s lives and economies in nature. The goals can be arranged in a stack with nature as the foundation (figure 2.1), moving up through goals associated with economic, societal, and means of implementation domains.<sup>11</sup> Community-based small-scale fisheries provide a case-study narrative for localization of the SDGs.<sup>12</sup> This starts with life in the ocean (Goal 14) as the source, affected by adjacent land use, freshwater flows, and climate (Goals 15, 6, 13), which provisions aquatic food caught by small-scale businesses and fishers (Goal 8). Fishers use gear and vessel technologies that have differential impacts on fish and the ocean (Goals 7, 9, 12), and are embedded within communities and settlements (Goal 11). The fishing sector supports incomes (Goal 1), food security (Goal 2), and health (Goal 3) of households, with distributional and equity aspects that vary among locations and countries (Goals 5, 10). The whole is governed (Goal 16) and supported by varied partners such as banks and other financial institutions, and technical and other organizations (Goal 17). Technical and local or Indigenous knowledge (Goal 4) influence choices and decisions that determine how fishing actors operate. The intimacy and lived reality of these narratives become harder to express at larger scales. Combined with the alienating language of the negotiated text, this has resulted in poor delivery of SDG outcomes across scales.

FIGURE 2.1



**NOTE:** Stack of the Sustainable Development Goals, starting with nature goals as the foundation, with contributions from nature leveraged through economy goals in the second layer, supporting social goals in the third layer. Goals necessary for implementation are shown as a fourth layer.<sup>13</sup>

**SOURCE:** Author’s updated design, adapted from Obura (2020, fig. 3). Original figure © 2020 Elsevier.

9 Biermann, Kanie, and Kim (2017); Singh et al. (2018).  
 10 United Nations (2024).  
 11 Obura (2021).  
 12 Bitoun et al. (2024); Obura (2021).  
 13 Obura (2021).

# A systems model of nature, economy, and society

A systems model starts with a description of the system.<sup>14</sup> Like other species, all humans inhabit an ecological niche determined by our material needs from nature—in the form of food, water, shelter, a livable environment, and myriad others.<sup>15</sup> Our niche is made more complex by sociality and the differentiation this allows among individuals, as well as our high degree of self-awareness and capacity to pass knowledge and practices to future generations.<sup>16</sup> These have profound implications for how our ecological niche is materialized, and how our needs are met, from individual to group or societal dimensions. The IPBES developed the concept of nature's contributions to people (NCP) as an inclusive framing of all material and nonmaterial needs of people from nature, grouped into three overlapping classes related broadly to intrinsic, instrumental, and relational values of nature: needs met through regulating functions of natural systems that generate conditions on which people depend (such as clean air or water, diversity of species); direct material needs met through consumption, capture, or harvest from nature, obtained through direct use (such as food, water, shelter); and nonmaterial needs from nature that are important to people's sense of well-being, culture, and learning (such as habitats or species of cultural or spiritual significance).<sup>17</sup> These relate, respectively, to intrinsic, instrumental, and relational values of nature. The exchanges of all these flows can be depicted in the space between people and nature (figure 2.2a).

For people living directly from nature, individuals, households, or small social groups may directly access the contributions from nature they depend on. But as social groups grow in size, specialization of roles occurs, necessitating sharing and trading of skills and goods extracted from nature. Mechanisms for such exchange have been found almost universally across cultures, and over time, currencies have developed to facilitate the measurement of relative value, exchange, and accumulation of value.<sup>18</sup> Now, most people operationalize their ecological niche (i.e., how they obtain food, shelter, water, and other basic necessities) through financial exchanges in markets. Fundamentally, the global economic system represents humans' globalized socio-ecological niche of the 21st century. Importantly, this economy has focused on assigning value to, pricing, and trading some goods from nature (e.g., food, materials, energy). But it has done this while failing to price many essential benefits from nature (e.g., carbon sequestration, biodiversity, regulating services, cultural values), and externalizing many costs and impacts, and thus excluding these from market decisions.

This fundamental relationship between nature, economy, and society can be represented in a system model (figure 2.2b), enabling direct exploration of the properties of each domain, the interactions between them, and how the purpose of the system directs and determines these, building on the conceptual and values frameworks developed by the IPBES.<sup>19</sup> The model comprises two inner interaction loops, with one as the base (nature-economy), the second above it (economy-society), and a third outer loop (nature-society). Nature forms the foundational layer, with

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14 Holling (2001); Meadows and Wright (2008).

15 Polechová and Storch (2019).

16 McInturff et al. (2025).

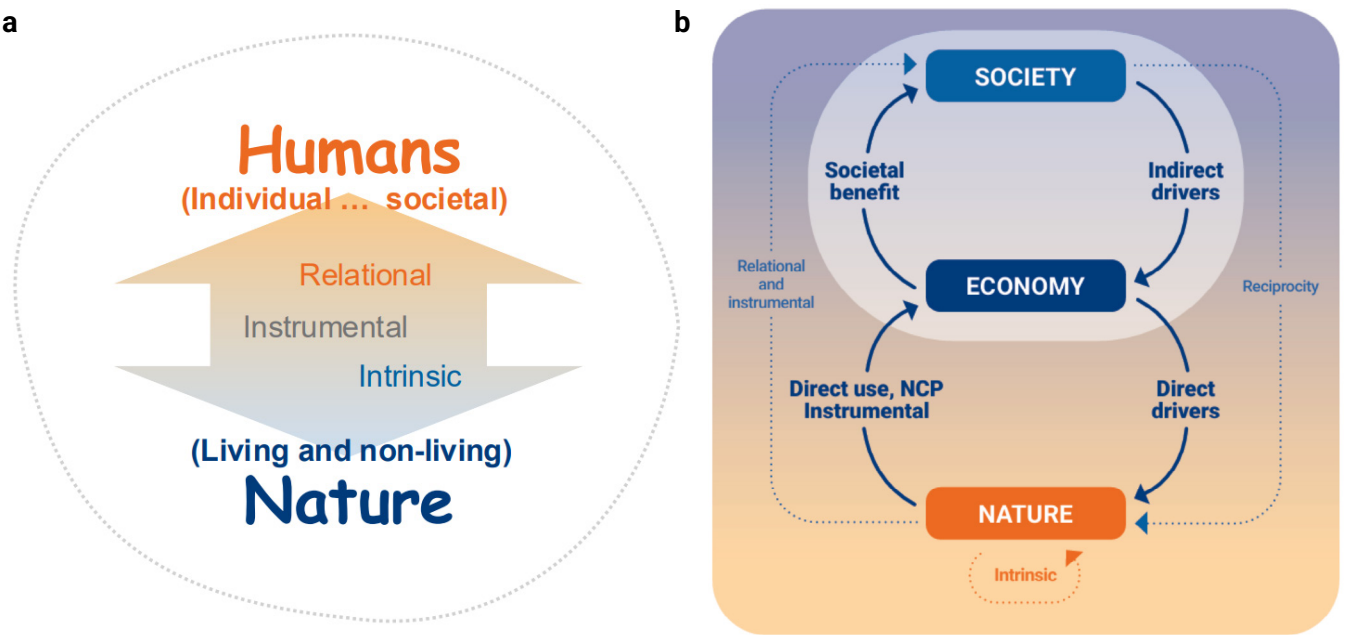
17 IPBES (2022); Pascual et al. (2017, 2023).

18 Ruddick (2025); Middelkoop (2016).

19 Meadows and Wright (2008); Obura et al. (2026); Díaz et al. (2015); IPBES (2022); Pascual et al. (2017).

material contributions flowing directly into the economy through direct use and extraction from nature, generating benefits that are distributed among actors in society. Values held by members of society influence the indirect drivers that determine how the economy operates, and thus the direct drivers impacting nature. Societal values also include relationality and reciprocity of people with nature.<sup>20</sup> The illustration depicted here emphasizes interactions in the global economic framing (see below), but other arrangements could be drawn for other value systems.

FIGURES 2.2A AND 2.2B



**NOTE:** Figure 2.2a. Distinction of humans as a species within nature, with the space in between illustrating the transfer of nature’s contributions to people, across intrinsic (closer to nature), instrumental (between the two), and relational (closer to humans) values. Examples of potential distinctions within nature (living vs. nonliving) and humans (individual vs. societal) are also illustrated. Figure 2.2b. Expresses how “economy” operationalizes the exchange of goods and services with instrumental value between nature and humans, i.e., the ecological niche of humans in societal groups. Economy is nested within society, and society within nature, but economy is placed mechanistically between them. The key linkages depicting intrinsic, instrumental, and relational values are shown.<sup>21</sup>

**SOURCES:** Figure 2.2a: Author’s own design; Figure 2.2b: Adapted from Obura et al. (2026, fig. 3), licensed under CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>). Colors and typography modified.

20 Obura et al. (2026).  
21 Obura et al. (2026).

## MULTIPLE STATES—SUSTAINABILITY VS. THE ANTHROPOCENE

Multiple states or configurations of a model may be possible, with systems approaches enabling exploration of how shifts may occur between them.<sup>22</sup> Two configurations of this model are most relevant here. First is the idealized configuration that is in balance across elements of the system and in all its interactions, such that the system is stable and sustains itself into the future. To maintain balance, negative feedbacks operate such that perturbations to any of the loops are counterbalanced by compensatory responses. For common usage, these are more directly described as stabilizing feedback loops, such that economy and nature are in balance with one another, and economy and society are in balance. The outer feedback loop of nature-society interactions would also be stabilizing. Overall, this model configuration must be guided by a system purpose, or the rules and norms of the society, that values and thus produces balance among elements and directs the stabilizing interactions. This configuration corresponds to the “sustainable development” paradigm.

The second configuration matches present-day conditions of market-based extractivism, in which the economy is dominant, with interactions that degrade the state of nature, and of society. Interactions in the two loops show positive (i.e., destabilizing) feedbacks. Over-extraction from nature and externalization of costs by economic actors produce the five direct drivers (land- and sea-use change, direct exploitation, pollution, climate change, invasive alien species) at levels that further drive nature’s decline. At the same time, the goal to grow wealth through private ownership reinforces destabilizing interactions in the nature-economy loop and magnifies unequal sharing of benefits among people and exposure to social impacts and inequalities. Destabilizing interactions in the outer nature-society loop result from inadequate care and stewardship of nature, reinforcing the mutual instability in the two inner loops. These self- and mutually reinforcing feedback loops result in the complex “polycrisis” and conditions currently experienced of the Anthropocene, which are only partially described by any singular focus.<sup>23</sup> For example, the “triple planetary crisis” focuses on decline in nature and two of the five direct drivers between the economy and nature domains (climate change and pollution, figure 2.2b).<sup>24</sup> It has been very impactful in bringing these complex challenges to a policy audience, but only partially describes the extent of challenges.

Note that neither of these configurations implicitly or explicitly requires currencies or financial exchanges to mediate interactions between the three domains (see the “Finance” section below).

## LOOP 1: THE ENGINE ROOM—NATURE AND ECONOMY

The basal feedback loop addresses our use of instrumental values from nature, which have been commodified for trade and mediated through economic actors. The IPBES’ Nexus Assessment focused on this loop, addressing interactions between two nature subdomains (biodiversity and climate change) and three economic sectors (water, food, and health sectors).<sup>25</sup> Its goal was to identify how to minimize trade-offs that result in harm to any of the focal elements and thus to actors dependent on them, and enable synergies to amplify co-benefits and cooperation among actors—essentially to establish stabilizing feedback loops among the five elements. The IPBES Business and Biodiversity Assessment focused on the specific interests and capabilities of primary actors (businesses) within the economy domain.<sup>26</sup> It framed the linkages as “impacts and dependencies” between businesses and nature, or

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22 Holling (2001); Meadows and Wright (2008).

23 Clark and Harley (2020); Estoque (2023); IPBES (2024a).

24 Andersen (2020).

25 IPBES (2024a).

26 Jones et al. (2026).

“risks and opportunities,” translating the IPBES terms “direct drivers” and “nature’s contributions” into terms more accessible to business actors.

Any aspect of nature (whether a species, habitat, ecosystem, or biome), looked at from any applicable scale (local to global), has limits to how much use or damage it can sustain while continuing to support people and life more broadly. This is also the case for altered ecosystems such as in agricultural or pastoralist landscapes, or seascapes, where ecosystem and ecological functions are altered to varying degrees around production to support people.<sup>27</sup> The nature-economy loop may be in one of three states: stable, in which exchanges between the two domains are balanced; unstable, where one (or both) of the stocks is being depleted, the other potentially expanding, eventually reaching a point of collapse (or zero function) resulting in collapse of both; or it may be possible for both stocks to grow (particularly if they have both been depleted in the past), if linkage interactions are calibrated to enable this without tipping into an unstable state. Regeneration from a degraded state of one or both domains can enable improved condition and state of both, enabled fundamentally by nature’s ability to regenerate itself through the growth and replenishment of species populations and reestablishment or strengthening of ecological interactions. This emphasizes the primary role of natural functions in supporting the entire model, and the primary benefit of maintaining and/or regenerating nature as a primary solution.<sup>28</sup>

The “engine room” feedback loop between economic actors and nature is addressed by concepts and principles around the circular economy and the bioeconomy. Circular economy concepts directly apply the logic of the feedback loop by focusing on reuse and repurposing of previously used material to minimize extraction of new material from nature, which also assists in minimizing waste and impacts on nature to as low as may be possible.<sup>29</sup> Varied economy frameworks emphasize the functioning of natural systems and variety of benefit streams that are possible, starting with varied interpretations of the term “bioeconomy” broadly focused on certain nature-based approaches to emerging challenges or opportunities, “green economy” focused initially on agriculture but more generally on land systems, “blue economy” on sustainable and inclusive use of ocean resources, “wildlife economy” on tourism and recreational hunting, and even “biodiversity economy”—though many usages may not have explicit requirements for sustainability.<sup>30</sup>

## LOOP 2: THE CONTROL ROOM—ECONOMY AND SOCIETY

The upper feedback loop expresses how exchange of services and goods distributes benefits across the range of actors in society. This is mediated by societal rules and norms, or the license and controls imposed by society on the behavior of economic actors and on economic activity. The IPBES Global Assessment on Biodiversity and Ecosystem Services highlighted the importance of indirect drivers in four broad classes (demographic and socio-cultural, economic and technological, institutions and governance, conflicts and epidemics), underpinned by deeper “values and behaviors” held by people in society.<sup>31</sup> The IPBES Methodological Assessment of the Diverse Values and Valuation of Nature showed how worldviews aligned with extractive, market-based values direct the destabilizing feedback loops of the current global condition, while other worldviews enable greater balance between and among people and with nature.<sup>32</sup> The IPBES Transformative Change Assessment identified three sets of values

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27 Leadley et al. (2022); Mohamed et al. (2024).

28 IPBES (2024a).

29 D’Amato (2021); Ghisellini, Cialani, and Ulgiati (2016); Tan and Lamers (2021).

30 Roe and Snyman (2026); Tan and Lamers (2021).

31 IPBES (2019), xxix.

32 IPBES (2022).

or “underlying causes” that lock in the destabilizing feedbacks currently active between society and economic actors, namely (a) values promoting domination over people and over nature, (b) reinforcement of unequal power and wealth among people, and (c) prioritization of short-term material and financial gains.<sup>33</sup> These incentivize and reinforce destabilizing feedbacks across both upper and lower loops, and disincentivize actions that would stabilize them over longer time periods.

A system’s behavior is set by its purpose, which here is set by the dominant values held by society.<sup>34</sup> How values are expressed by different communities and societies across the planet varies enormously; the interest here is in identifying the “operational rules” that determine how the system behaves. The three “underlying causes” of the current condition were clustered from available evidence by the IPBES Transformative Change Assessment and offer operational instructions that set the “effective purpose” of the global human-nature system as it is now.<sup>35</sup> To shift the system to a new stable state, systems framing would propose the inverse of each of these to propose “underlying causes” of a sustainable system state: promoting care and reciprocity with nature (and other people), assuring equity in power and wealth among people, and prioritizing long-term prosperity and security.<sup>36</sup> Each of these would shift multiple linkage interactions in the model to be stabilizing (negative feedbacks) rather than destabilizing (positive feedbacks). More importantly, without such foundational shifts in values, this systems framing holds that superficial solutions cannot deliver systemic change and balance (i.e., a phase shift from one state to another). Patchwork efforts will be undermined and doomed to failure by continuation of the values driving the current system.

## Transition or transformation?

The IPBES Transformative Change Assessment also identified a wide range of building blocks to transformation, identifying the need to achieve changes in “views, structures and practices” to effect a shift from transition (which may improve some conditions but overall system state remains within the same phase) to transformation (shift the state of the system).<sup>37</sup> Knowledge and practice on individual interaction links of the model, corresponding to practices and actions (nature-economy interactions) and structures or institutions (society-economy interactions), may in many cases be quite well known, such as in the evidence accumulated to identify more than 70 response options in the IPBES Nexus Assessment.<sup>38</sup> But additional to these is the need to shift deeper underlying drivers and causes, or views and values, that correspond to the purpose or vision driving the system, in this case in relation to the goals driving markets, and wealth accumulation. The point at which changes shift from being transitional to transformative is not clear, and may only emerge from aggregated and mutually reinforcing shifts across views, practices, and structures that result in a shift in whole-system behavior toward sustainability.<sup>39</sup> This aligns with emerging work on positive social tipping points, where key shifts may trigger major cascades that result in transformation in system behavior to sustainable outcomes.<sup>40</sup>

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33 IPBES (2024b).

34 IPBES (2022); Pascual et al. (2023).

35 IPBES (2024b).

36 Obura et al. (2026).

37 IPBES (2024b).

38 IPBES (2024a).

39 IPBES (2024b).

40 Milkoreit (2023).

But as noted in the prior section, systems theory posits that establishing a new system purpose is necessary for a system to persist in a different state. The question may therefore be about how much transitional change in views, practices, and structures may be needed to motivate sufficient societal will to both adopt and invest in a vision of sustainability that would enable the deeper and persistent changes needed to shift from the current Anthropocene configuration to the sustainable configuration. Agenda 2030 and the SDGs have led us to a point of seeing the potential for transformation but have not led us close enough for it to happen. This is the work that the final years of the SDGs and a post-2030 agenda will have to address.

## Discussion

### RESETTING VALUES

To date, the global system has been locked within two mutually reinforcing/destabilizing positive feedback loops driven by a value system that is explicit to market actors in terms of minimizing cost and maximizing return to shareholders. But the consequences may not be fully appreciated either by all actors in the markets, or by the public at large. While public and official ambitions are to “leave no one behind” and eliminate poverty, the rules governing economic and financial decisionmaking have become increasingly competitive and deregulated, incentivizing greater extraction from natural and social capitals.<sup>41</sup> Contributing factors include the increasing geographic scales of value chains and thus separation of cause and effect, and concentration of power through information, the media, and advertising being increasingly controlled by larger corporations and individuals that benefit from this direction of capital conversion. These factors make the causal chains of choices increasingly invisible to, and undermine the agency of, less powerful actors and consumers in the markets, even as documentation and scientific explanation have expanded.

Other configurations of the system model may be possible, determined by other worldviews or sets of values, such as Indigenous and other cultural worldviews. These may focus on balance in the interactions between economic actors pursuing livelihoods and ways of living with or as nature, in relation to the nature they consume and the society they are embedded in.<sup>42</sup> Dominant interactions within the system may also reside in the outer loop of relationality between people and nature. In many instances, these economies may function without currencies, maintaining stable and regenerative exchanges among nature, economy, and society.<sup>43</sup> In other value systems, securing the state of nature might be dominant, or securing societal values might be. The multilateral worldview within which the sustainable development framework has been negotiated embeds dominant assumptions of Global North cultures that set the “postwar” consensus of the 1950s, embedding inconsistencies and direct conflicts with Global South and Indigenous or community worldviews, whose voices have historically been suppressed, though they are now increasingly heard.<sup>44</sup> An emerging framing around the “global” or “tropical majority” is a sign of increasing balance and more inclusive values.<sup>45</sup>

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41 United Nations (2015).

42 IPBES (2022); Pascual et al. (2023).

43 Ruddick (2023; 2025).

44 Fukuda-Parr and Muchhala (2020).

45 Spalding et al. (2023).

Where a configuration of the model is localized and has minimal linkages or impacts beyond its space and to other social groups, almost any model configuration might be possible. But as human population and size of economies increase, almost all large cultures historically have reached limits and then followed varied pathways of collapse, including through ecological overshoot.<sup>46</sup> With the world now connected from local to global levels and at planetary limits, the two configurations addressed here are of critical importance—the current configuration driving toward whole-system collapse, and the alternative that seeks to bring all interactions into balance, that allows rebuilding and regeneration of degraded system components, and sustains the whole into the future.

## HOW ‘STRONG SUSTAINABILITY’?

Recent syntheses and reviews of the sustainable development paradigm and the SDGs have found limited systemic and theoretical underpinning, instead finding collections of concepts and frameworks, investigation of policy and negotiation processes, and exploration of synergies and trade-offs among goals and targets.<sup>47</sup> The top-level political texts, being negotiated and agreed across all countries, omit details of theory and principles to facilitate consensus, thus provide little mechanistic guidance on how to operationalize them.<sup>48</sup> As a result, the aptly named formulations of “weak sustainability,” but also of supposed “strong sustainability,” have not been strong enough to counter the acceleration of drivers and impacts and “underlying causes” of the current situation.<sup>49</sup>

Internal contradictions and trade-offs have undermined operationalization of sustainable development, a prime example being prioritization of economic growth (e.g., in target 8.1) that makes fulfillment of other goals or targets very challenging (e.g., target 6.3 on minimizing pollution, or target 15.5 on preventing extinction of species).<sup>50</sup> Resolving the complexity of interactions requires deeper and mechanistic framing of causes and consequences. This occurred with the concurrent development of the IPBES Conceptual Framework (focused on mechanisms and interactions) with negotiation of the SDGs (focused on political consensus). Both were developed over several years to 2015, but independence of the processes, different contexts (knowledge synthesis vs. multilateral policy, respectively), and specialized terminology have inhibited integration and alignment.<sup>51</sup> Aligning them may enable “super-strong” operationalization of sustainable development through enabling systemic and aligned responses to intensifying challenges of the Anthropocene.<sup>52</sup>

## ANTHROPOCENE LIMITS—THE FLOOR, THE CEILING, AND LOCALIZATION

That humanity is pushing key properties of our planet beyond livable limits motivated the first explorations of sustainable development, and was further developed in the planetary boundaries framework and the “safe” thresholds of key biophysical elements.<sup>53</sup> Concerns about what these mean for a dignified life and escape from poverty have

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46 Brozović (2023).

47 Clark and Harley (2020); Mensah (2019); Purvis, Mao, and Robinson (2019); Rockström and Sukhdev (2017); Vos (2007); Biermann, Kanie, and Kim (2017); Kamau, Chasek, and O’Connor (2018); Nilsson, Griggs, and Visbeck (2016); Singh et al. (2018).

48 Kamau, Chasek, and O’Connor (2018); United Nations (1992; 2012; 2015); United Nations Secretary-General (2021).

49 Godin et al. (2022); Wu (2013); Steffen et al. (2015); IPBES (2024b).

50 IPBES (2024a); Kamau, Chasek, and O’Connor (2018); United Nations (n.d.).

51 Obura (2026, forthcoming).

52 Obura et al. (2026).

53 Brundtland et al. (1987); Meadows and the Club of Rome (1972); Richardson et al. (2023); Rockström et al. (2009).

stimulated formulation of conceptions of “just” complements to the safe boundaries.<sup>54</sup> These were brought together powerfully in the ring of “doughnut economics” visualizing an inner floor of minimum social needs with the ceiling of planetary or biophysical outer limits, and applied in several urban and national contexts, where jurisdiction, a tax foundation, and geographically and socially defined boundaries enable action.<sup>55</sup> Adding further dimensions of quantification, justice, and time, the Earth Commission has extended the ring into a “safe and just corridor” into the future.<sup>56</sup> Both formulations allow for translation of the space between the floor and ceiling into a global budget (e.g., of carbon dioxide, water, components of biodiversity), which can be allocated to relevant actors, and which may be set at different scales from local (e.g., cities’ doughnut economic plans) to global.<sup>57</sup>

Rendering these concepts accessible to actors is a significant challenge. This systems model provides a mechanistic model of how actors operate in the space between the floor and ceiling. Simplistically, the nature and society domains may be thought of as analogs to the planetary ceiling and social floor, though conceptually inverted with nature as the foundation (figure 2.2b). Further theoretical and practical work can deliver more nuanced and disaggregated elaborations for specific contexts, while the common language of sustainable development and the SDGs enables linking actors and contexts, for all to adopt their fair share of the global budget relevant to their actions.<sup>58</sup> For practical purposes, operationalizing this systems model can be achieved for different geographic (city, region, country) or thematic (sector, company) contexts, through a portfolio of relevant indicators across the three layers and the linkages between them: the bottom layer with respect to nature outcomes, the upper layer with respect to social outcomes, and sandwiched between them indicators of economic activity. For the small-scale fisheries example (see “The Sustainable Development Goals” section), local indicators of ecosystem health, fishery actors and income and other social benefits, alongside measures of the linkages—fish catch, benefits provided to consumers, governance and financial support to fishers and the fishers’ boats and gear use—may be used to provide a holistic picture of the sustainability (or not) of the fishery.

Importantly, while local-to-global quantification and linkages are desirable to know each actor’s just share and contribution to the global budget, even without this, actors can determine if their actions are stabilizing or destabilizing and worsening or improving the condition of or interactions between each domain. This frees monitoring from the “perfect being the enemy of the good” so that progress can be pursued in all contexts, rather than waiting for perfect information before taking action. This speaks to the powerful metaphor of “bending the curves of biodiversity decline”; while trajectories, or feedback loops, are trending toward decline, actors don’t need detailed quantification of the final goal: They can first “bend the curves” under their control, prioritizing drivers and underlying causes because otherwise system dynamics will continue as before, so trajectories and feedback loops bend toward the desired outcomes.<sup>59</sup> Once measures are trending in the right directions, actors can spend greater effort on identifying a final target, and reaching it in the most productive and effective ways. In the above fishery example, perfect data on each of the domains or interactions are not needed for first decisions to improve sustainability, where early action can achieve early wins for sustainability and progressive improvements in the fishery, and building capacities essential to enable future change.

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54 Gupta et al. (2021).

55 Fanning and Raworth (2025); Raworth (2017); Khmara and Kronenberg (2023); Recordon et al. (2025).

56 Gupta et al. (2022; 2024).

57 Bai et al. (2022; 2024); Gupta et al. (2024).

58 Gupta et al. (2024); Kallis et al. (2025).

59 Mace et al. (2018).

# NATURE-BASED SOLUTIONS

The concept of nature-based solutions (NbS) originated in the climate change space, where the scale and complexity of emerging challenges forced a realization that purely technical and anthropogenic solutions pale in significance compared to the potential scale and scope of solutions from nature. A corollary of the IPBES’ concept of contributions from nature is that any of the contribution classes (of which there are 18; see table 2.1) could be the substrate of a “nature-based solution.” Thus, focus has broadened from carbon sequestration (NCP 4), to insect pollination (NCP 2) as a primary service for agriculture, then to how natural systems support disaster resilience (multiple NCP: 6, 7, 9). Examples of novel approaches to nature-based solutions include restoring natural river courses and flows and reclaiming wetlands, as solutions against flooding and extreme climate events in the United Kingdom; eliminating invasive species to restore native vegetation critical to watershed management in drought-stressed Cape Town, South Africa; or regenerating mangroves across tropical coastlines in Southeast Asia and East and West Africa to address sea-level rise, storm protection, carbon capture, and regeneration of fisheries.<sup>60</sup>

TABLE 2.1

## Nature’s contributions to people (NCP) as defined by the IPBES

Earlier NCP in the table tend to be more intrinsic, middle ones instrumental, and later ones relational, though these categories overlap, and measuring and valuing any NCP will tend to instrumentalize it.

|                                                                     |                                                                                                                     |
|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| 1. Habitat formation and maintenance                                | 10. Pest, disease and stress regulation                                                                             |
| 2. Pollination, seed dispersal and connectivity                     | 11. Production of biomass-based fuels                                                                               |
| 3. Regulation of air quality and atmospheric gases                  | 12. Food and feed, from wild, managed or domesticated species                                                       |
| 4. Regulation of atmospheric gases that affect climate              | 13. Production of materials derived from wild or domesticated species                                               |
| 5. Regulation of ocean acidification                                | 14. Medicinal, biochemical and genetic resources                                                                    |
| 6. Regulation of freshwater quantity, location and flows            | 15. Opportunities for learning, artistic, scientific and technological inspiration                                  |
| 7. Regulation of freshwater and coastal water quality               | 16. Opportunities for physical and experiential interactions with nature                                            |
| 8. Formation, protection and decontamination of soils and sediments | 17. Symbolic meaning, involving spiritual, religious, identity connections, social cohesion and cultural continuity |
| 9. Regulation of hazards and extreme events                         | 18. Preservation, by organisms and ecosystems, of options for the future                                            |

SOURCE: Adapted from IPBES (2019).

60 Gordon-Walker et al. (2007); Climate Adaptation Platform (2026); Tiggeloven et al. (2026); Song et al. (2023).

To resolve these challenges, the multiple-values-of-nature framing of the IPBES, and this systems framing of sustainability, focus attention on balance in the two feedback loops such that: (a) enhancing production of a focal NCP does not degrade nature or provisioning of other NCP, and (b) access to benefits from the solution is equitable among people, and not just serving dominant actors or those paying for it. Importantly, many NbS (such as in disaster resilience) provide benefits to society without mediation through markets and finance via the outer loop of nontraded instrumental benefits from nature to society (figure 2.2b) (though market mechanisms may be instrumental in enabling them through financing operations and development). And as demonstrated in the examples cited above, the richer the range of value streams provided by any system, the greater the return on investment in nature-based solutions—measured in aggregate “real” and monetary values.

The multiple options for, and benefits from, nature-based solutions in any natural system reinforce consideration of nature as critical infrastructure.<sup>61</sup> With many benefits not being directly quantifiable monetarily, or tradable through financial markets, quantifying full benefit flows is essential. Global standards are already advanced for natural capital valuation of certain value streams, though many value flows (particularly intrinsic and relational values) are not addressed by these methods, and it may be inappropriate to do so.<sup>62</sup> Establishing relevant indicators for them, in “natural” units relevant to each, is a critical first step. This can be followed by conversion to financial values where appropriate, based on existing knowledge, with due consideration for assumptions, uncertainties, and error embedded in any such methods, and provisions to update conversion factors and caveats as new knowledge emerges. Computational power to aggregate multiple types of data and indicators is no longer an obstacle, obviating the earlier need to convert all values into the same units, usually currency (notably, early systems modeling focused on energy as a common unit or currency, also with varied success).<sup>63</sup> Valuing the flows of the full breadth of values, nature’s contributions, and nature-based solutions from any ecosystem or production system should now be possible, to show the full breadth of benefit flows to all relevant beneficiary groups (local or distant), and thereby show the full value of investing in productive and healthy natural capital.

## FINANCE

Money, or currencies, address three main functions: as measures of relative value, as means of exchange, and as stores of value. Over time, the function of storage of value has grown in importance, with finance emerging as the dominant repository or measure of wealth for individuals, companies, and countries. The value assigned to a currency represents a shared estimation of its value among people, even where a standard, such as gold, is used.<sup>64</sup> And as currencies have become entirely virtual, with “real” and digital currencies represented principally in computer storage, economic markets’ measures of value have become disconnected from real material value—resulting in multiple financial bubbles in recent decades.

This system model expresses the idea that nature, and the goods and services it produces that humans depend on and value, is the ultimate source of wealth. Extraction of these benefits and their sharing/circulation in society, with value added through the agency of people (work), converts natural capital into economic capital, which supports social capital. Nature regenerates itself in seasonal and annual cycles, increasing the flows from and total stock of capital across the system—in natural, economic, and societal forms, and that accumulates as financial capital. The exchange function of money facilitates these flows, and with technological change and the amplification made

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61 ISEP (2026).

62 United Nations (2021).

63 Costanza et al. (1997); Odum and Odum (2000).

64 Desan (2013); Middelkoop (2016).

possible by energy, automation, and organization, markets have emerged that maximize conversion of wealth from nature through economic and social capital, through and to financial capital. The dominant market-based value system has elevated finance as a primary store of value, which we can consider as a virtual “fourth capital” that dominates the “real” capitals. These values are described in the form of “underlying causes” of biodiversity decline and the current state of the Anthropocene systems model—degrading natural capital, undermining and eviscerating social capital, and cannibalizing economic capital (e.g., in mergers and acquisitions in the most aggressive corporate takeovers).<sup>65</sup> This concept opens a range of corollaries:

- a. Being a “nonreal” capital, finance does not do any “work” of its own—only when it is invested in (i.e., facilitates work on) another capital. Like any technology or tool, its influence can be positive or negative, depending on the purpose or values that guide its use, i.e., that determine the indirect and direct drivers associated with its application.
- b. The conversion of natural and social capitals into financial capital has played out over centuries and millennia, accumulating in financial capital. Roots of this process started with the Romans through taxation, using money as a mechanism of imperial control and wealth accumulation, and in more recent centuries with imperialism and colonialism, the emergence of capitalism, and globalized trade, all coded in law.<sup>66</sup> These systems are characterized by the transfer of (natural and social) capital from some parts of the globe and their people, to others, which can be traced by trends in natural, economic, social, and financial capital accumulation over space and time.<sup>67</sup>
- c. The current polycrisis (biodiversity decline, climate change, pollution, and others) represents the failure of markets to maintain the integrity of nature and justice and equality in society. These are rational consequences of the extractivist values that drove those markets.<sup>68</sup> They thus do not represent “market failures” as the markets delivered precisely what they valued, but “values failures” as the rules guiding the markets are not appropriate for sustainable outcomes.<sup>69</sup> Reversing trends, consequently, requires values change, not just simple tweaks to current market systems (see the “Transition or transformation?” section).
- d. Repairing nature—biodiversity, climate, and other systems—requires expanding financial flows that are perceived as costs from \$220 billion nature-positive flows in 2023 to reach an estimated biodiversity financing need of \$722 billion to \$967 billion in 2030, and transforming close to \$7.3 trillion of nature-negative flows in the global economy to nature-positive flows.<sup>70</sup> The current value system sees these as costs, and even the most ambitious global targets (by 2030, raise direct flows for biodiversity to \$200 billion and convert \$500 billion of negative subsidies to positive, and by 2035, raise climate finance to \$300 billion per year) come nowhere close to these amounts.<sup>71</sup> The ratio of nature-negative to nature-positive finance in the global economic system is 30:1.<sup>72</sup> Reframing values to recognize the primary value of natural (and social) capital would reframe the required financial flows as rebalancing, or return, of over-extracted capital, now held in damaging financial capital, back into foundational and productive natural (and social) capital. That is, as investment or reinvestment.

65 IPBES (2022; 2024b).

66 Middelkoop (2016); Nölke (2026); Scott (2006); Pistor (2019).

67 Hickel et al. (2022a; 2022b).

68 IPBES (2022; 2024b).

69 Dasgupta (2021); Stern (2006); Obura et al. (2026).

70 UNEP (2026), xiii; Deutz et al. (2020), 8.

71 CBD (2022), 12; UNFCCC (2024).

72 UNEP (2026), xiii.

## BETTER DELIVERY ON THE SDGS

The three-element nature, economy, and society systems model is a minimum model describing the system.<sup>73</sup> But to meet the need for pragmatic alignment across countries and stakeholders, the SDGs are an operational disaggregation of it. However, as noted earlier, fixation on negotiated text diverted attention from the whole and interlinkages among the parts, to atomized delivery of individual elements, and hence the poor delivery of outcomes.<sup>74</sup> Further prioritization within goals, of targets and indicators with insufficient consideration of the whole, further amplified contradictions that harm delivery of the framework.

With assessment of goal delivery due in 2030, this analysis calls for actors and countries to recognize the systemic nature of the goals framework, and its relevance to individual context when localized and context-specific narratives are the focus.<sup>75</sup> To enable this, applying “blurred vision” to the formal framing of the SDGs liberates actors to develop and strengthen their own sustainability narratives as well as more nuanced reporting on the SDGs.<sup>76</sup> This may unlock enhanced alignment and collective action that is needed to advance progress on the goals, both locally and aggregated to larger scales. Multiple initiatives already foster localized interpretation of the SDGs to motivate independent action, such as the United Nations Global Compact focused on business adoption of the SDGs, or the 17 Rooms initiative and its focus on institutions such as universities developing individualized SDG strategies.<sup>77</sup>

## Post-2030 policy

In late 2027, the United Nations will formally initiate discussions on a post-2030 framework to replace Agenda 2030 and the SDGs. In support of this process, it is important to recognize that the degree of multilateral consensus and goodwill for a shared outcome is far below that in the run-up to 2015. Acknowledging this, a range of scenarios and pathways may be envisioned from the current framework (SDGs and Agenda 2030) to their successor, acknowledging the very real possibility of significant retreat to less ambition than the current goals.<sup>78</sup> Nevertheless, on the side of continued positive ambition, a baseline may be considered as the same set of goals and principles simply being rolled over past 2030, learning from lessons to date, potentially consolidating, adjusting, or adding goals and/or targets, and streamlining indicators and measurements. A second general option is a stronger science foundation, such as on planetary limits and social foundations that may help to identify new thresholds and guardrails for new goals and targets, though this is challenged by geopolitical sensitivity over the science. A third general option is to incorporate advances in understanding of justice and equity, including through policy declarations from the United Nations, such as the Pact for the Future and Our Common Agenda.<sup>79</sup> A fourth option may be to prioritize more narrowly on more achievable and tractable areas, at the risk of losing sight of the forest for the trees—that without fully comprehensive and joined-up action, true sustainability is unlikely to be achievable.

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<sup>73</sup> Obura et al. (2026).

<sup>74</sup> Nilsson et al. (2018); Singh et al. (2018); United Nations (2024).

<sup>75</sup> Obura (2021); Renaud et al. (2022).

<sup>76</sup> Obura (2026, forthcoming).

<sup>77</sup> See more on the United Nations Global Compact at <https://unglobalcompact.org/>; see more on the 17 Rooms initiative at <https://www.brookings.edu/projects/17-rooms/>.

<sup>78</sup> Kasumba (2026); IDOS (2026).

<sup>79</sup> See more on the Pact for the Future at <https://www.un.org/pact-for-the-future/en>; see more on Our Common Agenda at <https://www.un.org/en/common-agenda>.

An approach that strengthens mechanisms of implementation while enabling diverse national approaches could include the systems approach presented here, offering countries and actors the opportunity to commit to a systemic outcome (of balance, or balanced “growth”) with freedom to pursue an approach they may find more aligned with national priorities and culture. Critically, however, all must acknowledge their interdependency and mutual interest, to commit to forging alignment under a global vision, sufficient ambition to achieve global balance, and to avoid competitive harm. This systems framing offers some key solutions:

- If the same or minimally updated goal framework is retained, countries and actors can focus on improved implementation led by systems approaches. Most critically, let’s not throw the baby out with the bathwater.
- If an altered goal structure is preferred, of critical importance are their interlinkages and integration. This may be addressed through complementary and systemic targets and supporting indicators, and a focus on integrated—and not isolated—achievement.
- Essential is to ensure extension of the framing (system) across scales from global to local and back, enabling contextual differentiation, where goals and interactions may be expressed more tangibly for varied contexts, but actively delivered. This is enabled by flexibility and guidance on context- and scale-appropriate indicators, which may be used for reporting and alignment among actors at their scales, with upward aggregation.
- Explicit connections to existing agreements and institutions, to link commitments across specific themes. For example, the Global Biodiversity Framework and other multilateral environmental agreements linked to nature goals, the Paris Agreement linked to climate change as well as in relation to economics and trade, food, health, equality, and rights, and others. Forging more explicit linkages and recognition across sectoral instruments.<sup>80</sup>
- In between the poles of no agreement and global consensus, leadership by mini-lateral groups, regions, or coalitions of the willing may enable the strongest engagement and delivery in specific geographies and contexts. This approach may focus on enabling collective action and future integration and upscaling, rather than acceptance of lowest-common-denominator agreements and minimal ambition.

Beneath the rhetoric of disagreement and nationalism in multilateral arenas, and in the loudest voices in mainstream and social media, a strong undercurrent of common cause is voiced, as well as of common and trusted findings among sciences and knowledge systems.<sup>81</sup> Rebuilding the simple idea of sustainability, through a mechanistic understanding of the dependencies of economy and society on nature on a finite planet, may yet hold sway to deliver strong guidance for future pathways to sustainability.

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<sup>80</sup> CBD (2022); UNFCCC (2015).

<sup>81</sup> Turcu (2025); LRF (2026).

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## THREE

# **PRESERVING WATERSHED INTEGRITY FOR PEOPLE AND NATURE: ALIGNING GOVERNANCE WITH HYDROLOGICAL STRUCTURE AND TIME**

Masahisa Nakamura

## **Transforming watershed governance**

Watershed systems are widely recognized as fundamental units for managing water resources, ecosystems, and human well-being. Watershed governance has therefore long sought greater integration across sectors and scales, most prominently through integrated water resources management. More recent United Nations and United Nations Environment Programme (UNEP) discussions have placed renewed emphasis on the continuity of the full hydrological cycle and on the interconnections among terrestrial, surface-water, groundwater, coastal, and marine systems. These developments point toward a more explicitly full-cycle approach to water governance.<sup>1</sup>

However, persistent challenges remain. Integration across sectors and scales has often proven insufficient in addressing persistent challenges related to water quality, ecosystem degradation, and resource sustainability. A key limitation lies in the misalignment between governance responses and the structural and temporal characteristics of watershed systems. In many basins, governance responses continue to struggle to align interventions with how

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<sup>1</sup> Global Water Partnership (2000); United Nations Environment Assembly (2024); UNEP (2025).

water systems actually behave. Water quality degradation, sediment accumulation, groundwater depletion, and ecosystem decline often develop gradually over long periods, while governance responses tend to be shaped by shorter-term priorities and administrative boundaries.

A key reason for this gap lies in how watershed systems are understood. Watersheds exhibit a continuum of conditions ranging from retention-dominated to flow-dominated environments, with processes unfolding over varying spatial and temporal scales.<sup>2</sup> While connectivity is widely acknowledged, less attention has been given to differences in system behavior across space and time. As a result, interventions are often designed to address visible problems without fully engaging with the processes that generate them. Consequently, governance responses are frequently shaped by sectoral mandates and short-term considerations, leading to mismatches between intervention and system dynamics.

This chapter argues that improving watershed governance requires a shift in emphasis—from integration as a structural objective to alignment as a dynamic process. Effective governance emerges progressively through iterative, cyclic processes of planning, implementation, monitoring, and adjustment, rather than from predefined integrated designs and institutional arrangements. The perspective developed here draws on several decades of accumulated experience in lake basin management practice, including global case-based learning from diverse lake basins, human resource development, basin-level strategy formulation, and contributions to global water discussions.<sup>3</sup> These experiences demonstrate that improving governance depends on cyclic processes that progressively strengthen key governance functions.

Drawing on the accumulated experience in lake-centered basin management, this chapter introduces a hydro-structural lens for interpreting watershed behavior and aligning governance more effectively with the continuum of retention and flow that characterizes real-world watershed systems. This chapter further suggests that such alignment can be operationalized through a platform process of iterative governance strengthening over time, enabling progressive adaptation across diverse basin contexts.

Building on this perspective, the chapter also points to a practical pathway for implementation, based on iterative, experience-driven processes that enable governance systems to progressively align with basin dynamics. The chapter concludes that maintaining watershed integrity requires governance systems capable of continuous learning and alignment with system behavior, supported by practice-based processes that sustain ecosystem services across interconnected water systems.

## Watershed systems as dynamic and heterogeneous

Watersheds exhibit a wide range of conditions, from retention-dominated environments—such as lakes, wetlands, reservoirs, and groundwater-connected systems—to flow-dominated riverine systems. In retention-dominated environments, water, sediment, and pollutants tend to accumulate, often producing delayed system responses. These systems may appear stable over long periods, even as underlying conditions gradually deteriorate. In contrast,

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<sup>2</sup> Jones et al. (2017).

<sup>3</sup> ILEC (2005).

flow-dominated environments tend to transmit impacts more rapidly across space. However, they are often influenced by upstream retention processes that determine the timing and magnitude of downstream effects.

Most basins combine these conditions, forming interconnected systems in which accumulation and propagation processes interact. Observed conditions, therefore, reflect both present influences and accumulated past processes. Understanding this continuum is essential for designing governance responses that align with system behavior.

## Temporal mismatch and governance challenges

A defining feature of watershed systems is that many underlying processes unfold gradually and remain only partially observable. By the time impacts become visible, they often reflect long-term cumulative processes.

Governance responses, however, are typically triggered by present conditions. This creates a persistent temporal mismatch: Interventions respond to what is visible now, while system dynamics reflect past influences and continue to evolve. This mismatch becomes particularly pronounced in systems where retention and flow processes interact across space and time.

The conditions observed in this system are not unique. Similar combinations of retention-dominated and flow-dominated components are found in basin systems across continents, ranging from small catchments to large trans-boundary basins, and across diverse climatic and socioeconomic contexts. In many such systems, governance challenges arise from the same underlying factors: delayed system responses, cumulative impacts, and fragmented sectoral arrangements. The patterns of gradual adjustment observed in the Lake Biwa-Yodo River-Osaka Bay system (see box 3.1) can therefore be understood as representative of a broader class of basin dynamics that remain insufficiently recognized in current water governance practice.

## A hydro-structural lens for understanding basin behavior

To interpret these dynamics more systematically, this chapter introduces a hydro-structural lens—a practical way to understand how water behaves under different conditions and how governance can align with these dynamics (see box 3.2). Key dimensions include the degree of retention versus flow, position within the basin, connectivity across system components, level of regulation, and intensity of diversion.

These dimensions influence whether impacts accumulate or propagate, and how governance responses need to be calibrated accordingly.<sup>4</sup>

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4 ILEC and RCSE (2014).

### BOX 3.1

## The Lake Biwa-Yodo River-Osaka Bay system

The Lake Biwa-Yodo River-Osaka Bay system provides a widely cited example of basin management. However, it is often misunderstood as a success achieved through coordinated planning and effective institutional design.

In reality, governance in this system evolved over several decades through a series of fragmented, sector-driven responses to emerging problems.

Early efforts focused on flood control and water resource development. As economic growth accelerated, new challenges emerged, including eutrophication, industrial pollution, and increasing urban water demand. These issues were addressed through separate policy initiatives, infrastructure investments, and regulatory measures, often with limited coordination.

Over time, it became evident that isolated interventions were insufficient. Water quality improvements lagged behind expectations, and downstream impacts persisted. This led to the introduction of additional measures, including lake water quality conservation planning, expanded monitoring systems, and adjustments to institutional arrangements.

Even then, progress was gradual. Improvements in environmental conditions took years to materialize, and in some cases decades. Governance continued to evolve through repeated cycles of planning, implementation, and revision, with different sectors adjusting their roles and interactions over time. This experience highlights that governance alignment is not achieved through a single integrated plan, but through sustained, incremental adjustment under conditions of uncertainty and delayed response.

A key institutional mechanism supporting this process is the Law Concerning Special Measures for Conservation of Lake Water Quality, under which designated lakes are subject to periodically revised conservation plans based on national policy. This long-term process of adjustment later found expression in broader policy developments, including the Basic Act on the Water Cycle, which promotes more coordinated and comprehensive management of water systems at the national level.

**SOURCES:** Nakamura et al. (2020); Government of Japan (1984); Ministry of the Environment, Japan (2020); Government of Japan (2014).

## BOX 3.2

# Early recognition of lake basin diversity and its governance implications

An important but often overlooked contribution by Ballatore and Muhandiki (2005), subsequently drawn upon and extended in ILEC and RCSE (2014, Annex 1), described the wide variation in the biophysical characteristics of lake basins and the practical management implications of these differences. Their work helps show why management approaches need to reflect how each basin functions in practice (see table 3.1).

TABLE 3.1

## Linking hydro-structural conditions to governance implications

| Hydro-structural condition                                                        | Typical system behavior                                                         | Governance implications                                                                       | Key risks if misaligned                                           |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>Retention-dominated systems</b> (lakes, wetlands, groundwater-connected zones) | Accumulation of nutrients, sediments, pollutants; delayed response; long memory | Long-term monitoring; precautionary policies; sustained investment; cross-sector coordination | Gradual, often unnoticed degradation; difficult and slow recovery |
| <b>Flow-dominated systems</b> (river channels, steep basins)                      | Rapid propagation of impacts; short response time                               | Real-time management; upstream-downstream coordination; early warning systems                 | Rapid spread of impacts; downstream transfer of problems          |
| <b>Mixed retention-flow systems</b> (most basins)                                 | Interaction of accumulation and propagation; spatial and temporal variability   | Integrated but adaptive governance; iterative learning; flexible coordination mechanisms      | Misinterpretation of system signals; fragmented responses         |
| <b>Highly regulated systems</b> (dams, diversions)                                | Altered flow regimes; artificial stabilization or disruption                    | Strong institutional coordination; rule-based management; periodic reassessment               | Overconfidence in control; unintended downstream impacts          |
| <b>Highly connected systems</b> (surface-groundwater-coastal linkages)            | Cross-domain interactions; hidden pathways                                      | Cross-sector governance; integrated information systems; shared data platforms                | Policy gaps between sectors; invisible system linkages ignored    |
| <b>Heavily utilized systems</b> (urban, agricultural, industrial pressures)       | Multiple competing demands; cumulative stress                                   | Allocation mechanisms; stakeholder participation; financial sustainability                    | Overuse, conflict, and inequitable access                         |

**SOURCE:** Author's compilation, drawing on Ballatore and Muhandiki (2005) and ILEC and RCSE (2014).

# Governance as cyclic strengthening and progressive alignment

The patterns described in the preceding sections are not theoretical abstractions. They reflect accumulated experience from decades of basin management practice, in which governance systems have evolved amid uncertainty, delayed system responses, and sectoral fragmentation.

A central lesson emerging from these experiences is that governance effectiveness develops through iterative processes of planning, implementation, monitoring, and adjustment, as reflected in established lake basin management practice.<sup>5</sup> Through these processes, governance capacity is strengthened over time, allowing responses to become more closely aligned with how basin systems actually behave.

This process is inherently iterative. Interventions are introduced based on partial understanding, their effects are monitored over time, and subsequent adjustments are made as new information becomes available. Through repeated cycles of action and learning, governance systems gradually improve their ability to respond to both visible problems and underlying processes.

Importantly, this evolution is neither linear nor uniform. Different aspects of governance develop at different rates, influenced by institutional constraints, resource availability, and shifting societal priorities. As a result, governance systems often exhibit imbalances, where certain functions are relatively well developed while others remain weak. Addressing these imbalances requires sustained effort over extended periods.

At the same time, governance does not operate within a single unified structure. It is distributed across multiple sectoral systems—such as water supply, agriculture, flood management, and environmental protection—each with its own mandates, decisionmaking processes, and planning cycles. The challenge, therefore, is not only to strengthen governance within individual domains, but also to align these domains in ways that reflect the interconnected nature of basin systems.

## ENTRY POINTS AND PROGRESSIVE EXPANSION OF SCOPE

In practice, governance processes rarely begin with a comprehensive understanding of the entire basin system. Instead, they are typically initiated in response to specific problems or sectoral priorities, such as deteriorating water quality, increased flooding risk, or growing demand for water resources.

These initial entry points are necessarily partial. They reflect immediate concerns and available capacities rather than a complete picture of system dynamics. However, they play a crucial role in initiating action.

As interventions are implemented, their limitations become evident. Measures that address one aspect of the system often reveal interactions with other components, such as upstream-downstream linkages, land-water interactions, or competing sectoral demands. These emerging insights prompt adjustments in both understanding and practice.

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<sup>5</sup> Ibid.

Over time, this leads to a gradual expansion of governance scope. What begins as a localized or sector-specific effort evolves into a broader engagement with the basin system as a whole. This expansion is not planned in advance but emerges through experience, as governance systems respond to the complexity of real-world conditions.

## **SECTORAL COEVOLUTION AND THE CHALLENGE OF ALIGNMENT**

A defining feature of basin governance is its distribution across multiple sectoral systems, each of which evolves according to its own logic. These systems differ in their objectives, institutional structures, regulatory frameworks, and planning cycles.

As a result, governance challenges often arise not from the absence of action but from the misalignment of actions across sectors. For example, measures to increase water supply may conflict with efforts to improve water quality, while land-use changes may undermine flood management strategies.

Alignment among these sectoral systems cannot be imposed through a single coordinating mechanism. Instead, it emerges gradually as sectors adjust their practices in response to shared challenges and evolving understanding of system dynamics.

This process of coevolution is inherently complex. It involves negotiation, learning, and adaptation across institutional boundaries. It also requires mechanisms for communication, information sharing, and joint problem-solving.

Over time, repeated interactions among sectoral systems can lead to more coherent patterns of action. However, this coherence is always provisional, subject to further adjustment as conditions change.

## **CYCLIC PROCESSES AS THE CORE MECHANISM OF GOVERNANCE IMPROVEMENT**

The gradual alignment of governance with basin dynamics is enabled by cyclic processes that link planning, implementation, monitoring, and revision.

These cycles provide a structured yet flexible framework for managing uncertainty. They allow governance systems to act based on available knowledge, assess the outcomes of interventions, and incorporate new information into subsequent decisions.

Crucially, cyclic processes enable governance systems to engage with delayed and cumulative system responses. Because the effects of interventions may take years or even decades to become fully apparent, a one-time approach to planning is insufficient. Continuous monitoring and periodic reassessment are essential for adjusting strategies in light of emerging evidence.

Over extended periods, these cycles strengthen governance capacity. Weaknesses in institutional arrangements, information systems, technical measures, or financial mechanisms can be identified and progressively addressed. This leads to a more balanced and resilient governance structure.

At the same time, cyclic processes provide a means of coordinating across sectoral systems that operate on different temporal rhythms. By creating opportunities for periodic reflection and adjustment, they help align actions across different domains, even when those domains are governed by distinct institutional cycles.

## Moving forward: From fragmented efforts to structured learning processes

The implications of the above analysis are practical and immediate. The key issue facing many basin systems is not the absence of governance frameworks, but the difficulty of making them function effectively under real-world conditions characterized by uncertainty, limited information, and institutional fragmentation.

In this context, progress does not require the creation of entirely new structures. Instead, it can begin from existing governance arrangements, however partial or fragmented they may be.

Entry points may include ongoing sectoral programs, established monitoring systems, or specific water bodies where problems are most visible. These entry points provide opportunities to initiate cyclic processes of action and learning.

What is required is the deliberate strengthening of these processes so that they can:

- Link actions to system understanding.
- Incorporate monitoring and feedback.
- Support periodic reassessment and adjustment.

Over time, this approach enables governance systems to move beyond isolated interventions toward more coherent and adaptive patterns of action.

Importantly, this process also provides a means of bridging differences among sectoral systems. By creating shared reference points—such as monitoring results, observed system responses, and agreed-upon objectives—it becomes possible to align actions across domains without requiring full institutional integration.

In this way, governance evolves not through structural redesign, but through the accumulation of experience and the gradual alignment of practices.

## Implications for global application and emerging challenges

The conditions described in this chapter are widely observed across basin systems, consistent with global assessments showing widespread pressures on lakes and their basins.<sup>6</sup>

In many of these systems, retention-dominated environments play a central role in sustaining ecosystem functions and human livelihoods. At the same time, they are particularly vulnerable to cumulative degradation, with impacts that may extend across entire basin systems.

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<sup>6</sup> UNEP-DHI Centre and UNEP (2016).

Despite their importance, these dynamics remain insufficiently reflected in current water governance approaches. Recent global discussions, including the U.N. 2023 Water Conference, have called for stronger integrated water resources management, cross-sectoral planning, and governance addressing the whole hydrological cycle.<sup>7</sup> The perspective developed here complements these discussions by bringing the structural and temporal characteristics that shape the behavior of particular basin systems more explicitly into view. Yet, lakes and reservoirs remain insufficiently recognized despite their central role in water security and climate resilience.<sup>8</sup>

Consequently, a significant gap persists between the realities experienced in basin systems and the frameworks intended to guide their management.

This gap is especially consequential in many low-income and water-dependent settings, where livelihoods rely heavily on water but effective governance frameworks and institutional capacity are often limited.<sup>9</sup> In such contexts, the challenge is not only to improve coordination but also to build the capacity for sustained, adaptive management.

Addressing this challenge requires mobilizing both local and global capacities. Locally grounded processes of learning and adaptation must be supported by broader efforts to share knowledge, develop human resources, and strengthen institutional frameworks.

The perspective presented in this chapter suggests that such efforts can be guided by a focus on cyclic processes of governance improvement and alignment with system behavior. By grounding action in observed realities and progressively expanding understanding, it becomes possible to bridge the gap between global aspirations—particularly the emphasis on integrated water resources management [Sustainable Development Goal (SDG) 6.5] and the protection and restoration of water-related ecosystems (SDG 6.6)—and local conditions.<sup>10</sup>

## **TOWARD A GLOBAL PLATFORM PROCESS FOR PROGRESSIVE BASIN GOVERNANCE**

While the preceding discussion highlights structural and temporal challenges in basin governance, it also points toward a practical pathway for addressing them. The experience accumulated across diverse basin systems suggests that governance improvement does not emerge from the adoption of any single comprehensive framework, but from the gradual strengthening of governance functions through structured, iterative processes.

Over several decades, practice-based efforts in lake and basin management have demonstrated the value of what may be described as a platform process—a sustained, cyclic approach that brings together policy development, institutional coordination, stakeholder engagement, knowledge generation, technological application, and financial mechanisms within a shared process of learning and adjustment.<sup>11</sup>

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7 United Nations (2023).

8 Global Water Partnership (2000); Hirji and Duda (2025).

9 UNESCO World Water Assessment Programme (2024); UNEP and UN-Water (2024).

10 United Nations (2015).

11 ILEC (2007); ILEC and RCSE (2014).

Such a process typically evolves through repeated cycles of:

- Diagnosing system conditions and governance gaps.
- Formulating and implementing response measures.
- Monitoring system behavior and intervention outcomes.
- Periodically revising strategies based on accumulated experience.

Importantly, this process does not require fully integrated institutional arrangements at the outset. It can begin within existing sectoral structures and progressively expand in scope and coherence as understanding deepens and coordination improves. In this sense, the platform process provides a practical mechanism for aligning governance with the structural and temporal characteristics of basin systems over time.

The relevance of this approach extends beyond individual basins. The challenges described in this chapter—delayed system responses, cumulative impacts, and fragmentation across sectors and scales—are widely observed across regions. They are particularly pronounced in systems where retention-dominated components such as lakes, wetlands, and reservoirs play a central role, yet remain insufficiently recognized in prevailing governance approaches.

Current United Nations discussions on accelerating progress toward SDG 6 and shaping the post-2030 agenda increasingly emphasize systemwide coordination and attention to the full hydrological cycle.<sup>12</sup> However, translating these directions into effective basin-level practice remains a major challenge.

The platform process described above offers a way to operationalize these aspirations. By grounding governance in iterative cycles of action and learning, and by linking sectoral efforts through shared processes rather than pre-defined structures, it provides a means of:

- Progressively strengthening governance capacity.
- Aligning interventions with system behavior.
- Bridging the gap between global policy aspirations and local realities.

At a global scale, this suggests the need to promote and support such platform processes across basin systems, with attention to the diversity of hydro-structural conditions and socio-institutional contexts. This does not imply replicating a single model but rather adapting a common process framework to different settings.

Key elements of such global promotion may include:

- Development of practice-oriented guidance based on accumulated experience.
- Strengthening of human and institutional capacity for iterative governance.
- Mechanisms for knowledge exchange and comparative learning across basins.
- Sustained support for long-term monitoring and evaluation.

Through such efforts, it becomes possible to move beyond episodic interventions toward continuous governance processes that sustain watershed integrity over time.

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<sup>12</sup> United Nations System Chief Executives Board for Coordination (2024); UNEP (2025).

# From recognition to sustained governance practice

The analysis presented in this chapter points to a fundamental challenge in watershed governance: the persistent misalignment between basin system behavior and the design and implementation of governance responses.

Watershed systems are shaped by the interplay of retention and flow processes that operate across space and time. In many cases, particularly in retention-dominated environments, system changes occur gradually and remain only partially visible until they reach advanced stages. Once such conditions emerge, recovery is often difficult and prolonged, and impacts may extend beyond the immediate area to affect downstream and connected systems.

These characteristics imply that governance cannot rely on episodic interventions or one-time planning efforts. Instead, it must be understood as a sustained process of adjustment, capable of responding to delayed system behavior and evolving conditions.

Experience accumulated over several decades of basin management practice demonstrates that such adjustment is possible through cyclic processes that link planning, implementation, monitoring, and revision. Through these cycles, governance capacity is progressively strengthened, enabling more effective responses to both visible problems and underlying system dynamics.

A critical aspect of this process is the gradual strengthening and alignment of key governance functions—policy, institutions, participation, technology, information, and finance—across multiple sectoral domains. Because these functions evolve under different institutional conditions and temporal rhythms, alignment cannot be achieved through a single coordinating framework. It must emerge through sustained interaction, learning, and adaptation over time.

At the same time, it is important to recognize that retention-dominated components of basin systems are not only vulnerable but also central to sustaining ecosystem services that support human well-being and ecological stability. Governance that focuses solely on mitigating problems risks overlooking these broader values. By linking governance processes to ecosystem service outcomes, it becomes possible to move beyond reactive responses toward the sustained realization of system potential.

The experience reflected in the Lake Biwa-Yodo River-Osaka Bay system and insights from earlier efforts to understand basin diversity indicate that these patterns are not exceptional. They are widely observed across basin systems of different scales and contexts. This suggests that the challenges identified in this chapter are not isolated but rather represent a broader, insufficiently addressed dimension of global water governance.

Addressing these challenges requires not only refining existing frameworks, but also actively promoting sustained, platform-based processes of governance strengthening that enable continuous alignment with basin system behavior. It calls for strengthening governance as a practice—grounded in real system behavior, supported by cyclic learning processes, and capable of evolving over extended periods.

In many parts of the world, particularly where livelihoods and ecosystems depend directly on water systems, the need for such governance capacity is urgent. Bridging the gap between global aspirations and local realities will

depend on the ability to develop and sustain these processes across diverse contexts, with support from global efforts to promote shared learning and capacity development.

By focusing on alignment with hydrological structure and time, and by building on accumulated practice, watershed governance can move beyond recognition toward sustained and adaptive action—supporting both the protection and the long-term realization of the values embedded in interconnected water systems.

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## FOUR

# MANGROVE ECOSYSTEM CONSERVATION AS NATURE-BASED SOLUTIONS FOR ADDRESSING GLOBAL CHALLENGES

Noriaki Sakaguchi

## Global mangrove trends and the drivers of loss

Mangrove is the generic term for plants that inhabit intertidal zones in tropical and subtropical coastal areas. Sixty-nine species from 18 plant families are recognized as mangrove plants worldwide.<sup>1</sup> Mangroves have unique forms, especially in their aerial roots and viviparous propagules, as a result of their adaptation to the intertidal environment. There are four types of roots that tangle on the forest bed: stilt, knee, cone, and buttress. They also develop uniquely shaped viviparous propagules, hanging down from branches. Mangroves have succeeded in physiological adaptation to saline brackish water. Their roots filter out over 90% of salt content in seawater entering their roots, and also exchange gas, absorbing oxygen and giving off carbon dioxide, at the surface of roots, and store the absorbed gas in their roots under inundation and oxygen-poor soil.<sup>2</sup> Thanks to their adaptation to the intertidal zone, mangroves develop green belts along coastal areas, which protect coastal people from storm waves and coastal erosion.

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<sup>1</sup> Duke (2017), 18.

<sup>2</sup> Scholander (1968); Krishnamurthy et al. (2014).

Mangroves' adaptation abilities, however, have not spared them from decline. The global mangrove extent drastically decreased by 3.76 million hectares (ha) over 20 years from 1980 (18.8 million ha) to 2000 (15.04 million ha), at a rate of 0.19 million ha/year.<sup>3</sup> However, the reduction rate slowed to around 11,300 ha/year from 2000 (15.04 million ha) to 2015 (14.87 million ha), then reversed, increasing through 2025 (15.53 million ha) due to growing efforts in the protection and restoration of mangrove forests.<sup>4</sup>

Goldberg et al. analyzed the causes of mangrove reduction. Between 2000 and 2016, 2.1% (3,363 km<sup>2</sup>) of global mangrove area was lost, an average loss of 0.13% per year.<sup>5</sup> Conversion to commodities, such as aquaculture ponds, rice paddies, and oil palm plantations, served as the primary driver of mangrove loss, resulting in 47% (1,596 ± 42 km<sup>2</sup>) of global losses during the period.<sup>6</sup> Shoreline erosion represented the second driver of global mangrove loss at 27% (912 ± 41 km<sup>2</sup>), followed by extreme weather events contributing 11% of their loss (361 ± 31 km<sup>2</sup>).<sup>7</sup> The main drivers of mangrove loss were different among regions. As Goldberg et al. detailed, conversion to commodities was the primary driver of their loss in Asia. Shoreline erosion and extreme weather events were the main causes in North and South America, Australia, and Oceania. Africa remained the only continent where nonproductive conversion by mining activities, including petroleum extraction, was the primary cause of mangrove loss.

## What mangroves provide: Four interlocking ecosystem services

Understanding what is being lost requires looking more closely at the range of services mangroves provide. Multiple mangrove ecosystem services contribute to addressing global and local challenges, such as climate change mitigation, coastal protection, enhancement of coastal communities' livelihoods, and biodiversity.

### CLIMATE CHANGE MITIGATION

The amount of carbon storage per unit area of mangrove ecosystems is 1,023 ± 88 standard error of the mean (s.e.m.) megagrams of carbon/ha, which is much higher than that of terrestrial tropical forests.<sup>8</sup> Therefore, the conservation and restoration of mangrove ecosystems effectively contribute to climate change mitigation. Below-ground carbon storage in soils accounted for the majority of total carbon storage at 71%-98% in estuarine mangroves and 49%-90% in oceanic mangroves.<sup>9</sup> This is because the carbon in mangrove ecosystems is stored not only through carbon fixation by photosynthesis but also through their complex root systems trapping organic matter flowing from upstream rivers and the sea during high tide. This organic matter accumulates on the forest floor and is stored below ground for long periods without decomposition under anaerobic soil conditions.

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3 FAO (2007), 9; FAO (2025), 41.

4 FAO (2025), 41.

5 Goldberg et al. (2020), 5846.

6 Goldberg et al. (2020), 5847.

7 Ibid.

8 Donato et al. (2011), 294.

9 Ibid.

# COASTAL PROTECTION

Furthermore, mangroves not only trap organic matter but also effectively trap and accumulate sediments, which plays a significant role in protecting coastlines from sea-level rise and coastal erosion caused by climate change. The median soil accretion rates measured across various mangrove habitats—fringe, riverine, interior, and overwash island (see table 4.1)—are higher than the sea-level rise rate (3.7 mm/year between 2006 and 2018).<sup>10</sup> Compared to sea levels between 1995 and 2014, the projected mean sea-level rise by 2100 under 1.5°C (Shared Socioeconomic Pathway SSP1-1.9) and 2.0°C (SSP1-2.6) global warming scenarios is 0.28-0.55 m and 0.32-0.62 m, respectively.<sup>11</sup> Using the midway point of 2005 as the baseline, the annual rates of sea-level rise by 2100 under SSP1-1.9 and SSP1-2.6 scenarios are projected to be 2.9-5.8 mm/year and 3.4-6.5 mm/year, respectively.

**TABLE 4.1**  
**Vertical soil accretion rates (mm/year) in different mangrove habitats**

| Habitat type    | Accretion rate (mm/year) |
|-----------------|--------------------------|
| Fringe          | 1.6-8.6                  |
| Riverine        | 6.5-13.0                 |
| Interior        | 0.7-20.8                 |
| Overwash island | 4.4-6.3                  |

**SOURCE:** Krauss et al. (2014).

Mangroves also have a tsunami reduction effect. Yanagisawa et al. analyzed the tsunami reduction effect of mangrove ecosystems based on their field surveys and numerical models conducted in Banda Aceh, Indonesia, after the 2004 Indian Ocean tsunami. Compared to the areas without mangrove forests, the presence of mangrove forests in their study effectively reduced tsunami force. When comparing the tsunami reduction effects among 10-, 20-, and 30-year-old mangrove forests, the tsunami reduction performance (inundation depth and hydrodynamic force) of “20-year-old or 30-year-old mangrove forest is more effective than 10-year-old when the tsunami inundation depth exceeds approximately 4m because 10-year-old mangroves were largely destroyed by the more than 4m tsunami and its reduction performance decreased.”<sup>12</sup> This suggests that young forests are less effective against large tsunamis, demonstrating the importance of long-term conservation of mangrove forests.<sup>13</sup> However, when tsunami heights exceeded 9m, mangrove forests of all ages were toppled, and their reduction effect was lost.<sup>14</sup>

10 IPCC (2023), 5.  
11 IPCC (2021), 21.  
12 Yanagisawa et al. (2010).  
13 Yanagisawa et al. (2008).  
14 Yanagisawa et al. (2010).

## PROVIDING LIVELIHOODS FOR COASTAL COMMUNITIES

Mangroves, which serve as habitats for various marine organisms, provide abundant fishery resources to coastal communities. In addition, the unique forms and landscapes of mangroves, along with their rich biodiversity, are also utilized as tourism resources. An economic valuation based on a literature review of fisheries and tourism in mangrove forests around the world suggests a mean economic value of \$23,613/ha/year for fisheries, and a mean economic value of \$37,927/ha/year for tourism, indicating that mangroves serve as a livelihood foundation for coastal communities.<sup>15</sup>

## BIODIVERSITY

Mangroves generate and provide habitats for marine organisms, especially for juvenile fish and invertebrates. Based on 481 field measurements of density for juvenile fish and juvenile and resident invertebrates across 37 commercially important mangrove-affiliated species, mangroves are estimated to support almost 735 billion juvenile fish, bivalves, prawns, and adult crabs annually. This suggests that mangroves provide nursery sites essential for the juvenile stages of fish and invertebrates in their life history, and mangroves contribute to livelihoods and global food security.<sup>16</sup> In the comparison of meio-benthos biodiversity between undisturbed and disturbed mangrove ecosystems, the taxonomic richness and abundance of meio-benthos fauna were significantly higher in the sediments of undisturbed mangroves than in the sediments of disturbed mangroves.<sup>17</sup>

## From services to solutions: Mangroves as nature-based solutions

As mentioned above, mangrove ecosystem conservation can serve as nature-based solutions (NbS), addressing not only a single challenge but also multiple challenges simultaneously, such as climate change mitigation and adaptation, natural disaster risk reduction, enhancement of local communities' livelihoods, and biodiversity. Therefore, NbS through mangrove ecosystem conservation can be considered highly effective solutions that provide multiple benefits for people.

## CHALLENGES IN TROPICAL COASTAL AREAS

Coastal areas of developing countries in the tropics, especially in small island developing states (SIDS), are exposed to coastal flooding and erosion, and storm waves due to sea-level rise and frequently occurring large-scale typhoons caused by climate change. The sediment accumulation and wave-reduction effects of mangrove ecosystems, mentioned above, reduce disaster risks, and strengthen coastal resilience to climate change. In addition, since coastal communities in developing countries highly depend on mangrove ecosystems, which provide fishery and tourism resources, the mangrove loss and degradation seriously impact their livelihoods. Therefore, when we consider coastal protection measures and projected extreme events caused by climate change or natural disasters in mangrove habitats of developing countries, we have to take into account securing such multiple mangrove ecosystem services.

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<sup>15</sup> Salem and Mercer (2012), 369.

<sup>16</sup> zu Ermgassen et al. (2025).

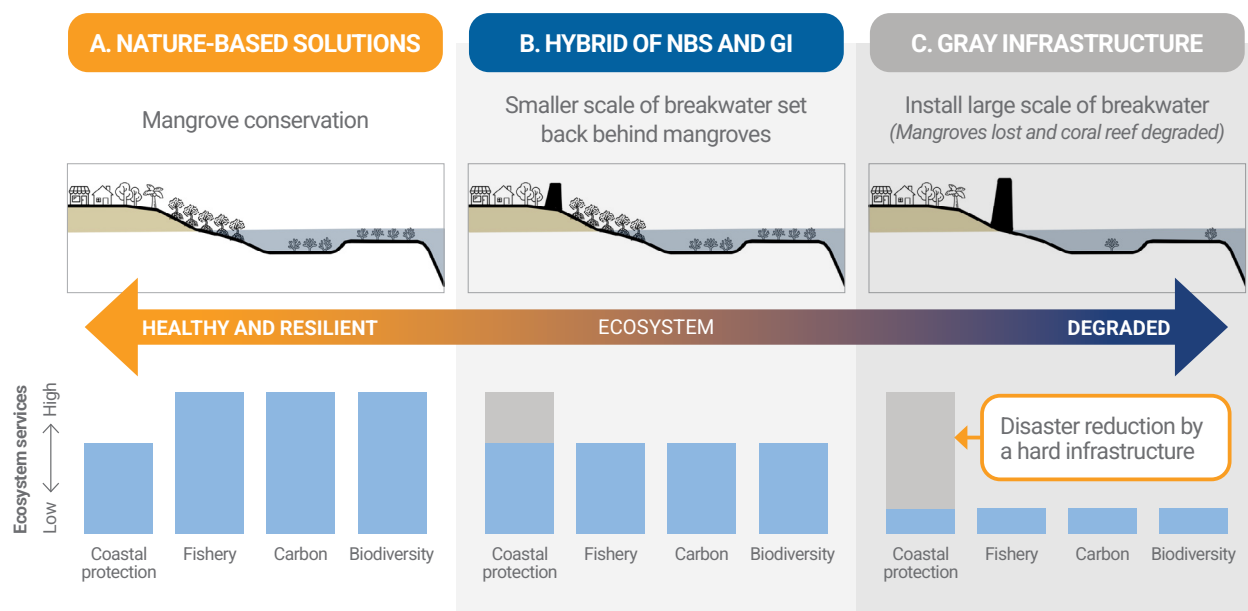
<sup>17</sup> Carugati et al. (2018).

## CHOOSING AMONG GRAY, HYBRID, AND NATURE-BASED COASTAL PROTECTION

The predicted status of various ecosystem services—coastal protection, fishery resources, carbon sequestration, and biodiversity—is shown schematically in figure 4.1, corresponding to each coastal protection measure against extreme events caused by climate change or natural disasters: NbS, hybrid of NbS and gray infrastructure (GI), and gray infrastructure.

FIGURE 4.1

### The predicted status of various ecosystem services corresponding to coastal protection measures



**SOURCE:** Author's own analysis and design.

If a large-scale breakwater is constructed along the coastline, cutting down all mangroves (figure 4.1C), a definite effect in preventing coastal erosion and storm waves can be expected. However, the construction of breakwaters would cause the loss of all mangroves inhabiting the area and degradation of ecosystem services. Since mangroves provide spawning and nursery sites as well as feeding grounds for coral fish and other organisms and trap sediment and purify the water flowing from land to coral reefs, the loss of mangroves leads to the degradation of coral reef ecosystems.

Consequently, the construction of large-scale breakwaters for coastal protection results in, as a trade-off, biodiversity loss in whole coastal ecosystems, reduction of carbon sequestration capacity for climate change mitigation, and a decrease in fishery resources important for communities' livelihoods. Building infrastructure is very costly, creates high future expenses, and lacks synergistic benefits such as nursery habitats for edible fish and recreational value.<sup>18</sup> On the other hand, coastal protection through mangrove conservation as NbS can secure multiple ecosystem services, including not only coastal protection but also carbon storage, biodiversity, and provision of fishery resources, and, as a result, enhance the livelihoods and resilience of coastal communities (figure 4.1A).

<sup>18</sup> IPBES (2019), 22.

When examining which approach—gray infrastructure or NbS—should be installed, the comparison should not be based solely on the coastal protection effect, but should also include the amount of each of the other services—carbon sequestration, biodiversity, and fishery resources—that people can derive from coastal ecosystems.

In the case that the coastal hinterland is densely populated and is exposed to high waves, coastal floods, and erosion with higher risks, installing gray infrastructure should be considered to protect coastal people. When the exposure and risk to such disasters are lower, one can consider installing a hybrid of NbS and gray infrastructure to maintain the multiple services of mangrove ecosystems at a certain level through sustainable mangrove management (figure 4.1B).

## WHY MANGROVE NATURE-BASED SOLUTIONS ARE NOT YET MAINSTREAM IN COASTAL PROTECTION

Despite the multiple benefits of mangrove ecosystems, mangrove conservation and restoration have not yet been mainstreamed in coastal protection as NbS for climate change adaptation and disaster risk reduction. The primary reason is a lack of quantitative assessments of mangrove ecosystems' capacity for coastal protection. A review of 423 studies on mangrove ecosystem services revealed that the vast majority, 354 studies (84%), focused on carbon sequestration, highlighting the significant attention paid to the high carbon sequestration capacity of mangrove ecosystems.<sup>19</sup> In contrast, fewer than 20 studies focused on coastal protection.<sup>20</sup> A lack of scientific data on the effectiveness of coastal protection by mangrove ecosystems hinders the application of mangroves as NbS. Meanwhile, regarding gray infrastructure, guidelines for breakwater design have been established to ensure resistance against wave heights and energy by calculating the necessary scale and strength to withstand projected storm waves and tsunamis. In Japan, the Ministry of Land, Infrastructure, Transport and Tourism developed the "Guideline on Breakwater Design for Resistance to Tsunami" in 2013.<sup>21</sup>

As mentioned above, the advantage of the conservation and restoration of mangrove ecosystems as NbS lies in their ability to deliver multiple benefits simultaneously, including coastal protection, carbon sequestration, biodiversity, provisioning fishery resources, and ensuring livelihoods for coastal communities. To mainstream mangrove ecosystem conservation as NbS, it is essential to simultaneously evaluate and demonstrate these multiple ecosystem benefits. However, the same review of mangrove ecosystem services revealed that only 22% (94 of 423 studies) evaluated multiple services simultaneously; and specifically, only 10 studies (2%) addressed both coastal protection and carbon sequestration, while just five (1%) covered coastal protection and fisheries, indicating a significant lack of multiple-services assessments.<sup>22</sup> Therefore, to advance the mainstreaming of mangrove ecosystem conservation as NbS, there is an urgent need to develop indicators and methodologies for quantifying each ecosystem service and to conduct assessments of multiple ecosystem services.

Furthermore, while global guidelines for mangrove restoration are already in place, there is also a need to develop NbS guidelines for strengthening coastal resilience while securing multiple ecosystem services based on quantitative assessments.<sup>23</sup>

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19 Lee et al. (2025), 2, 4.

20 Lee et al. (2025), 5.

21 Japan, MLIT (2013).

22 Lee et al. (2025), 5.

23 For more on global guidelines for mangrove restoration see Beeston et al. (2023).

# Global efforts for mangrove conservation

The Convention on Biological Diversity (CBD) adopted the Kunming-Montreal Global Biodiversity Framework for 2030 at the 15th Conference of the Parties (COP15) to achieve a world of living in harmony with nature by 2050. The framework's mission is to mobilize urgent action to halt and reverse biodiversity loss and place nature on a trajectory toward recovery by 2030. To achieve the mission, the framework set up 23 targets that include not only targets for conserving biodiversity itself, such as restoring at least 30% of areas of degraded ecosystems (target 2) and conserving and managing at least 30% of particularly important areas for biodiversity (target 3), but also those for leveraging NbS, such as minimizing the impact of climate change on biodiversity through NbS (target 8) and enhancing nature's contributions to people, including ecosystem services, through NbS for the benefit of all people and nature (target 11).<sup>24</sup>

To move toward a transition to sustainable climate action, the conservation and restoration of mangrove ecosystems is important for ecosystem-based adaptation and disaster risk reduction.<sup>25</sup> Numerous research results have found that mangrove ecosystem services effectively contribute to climate change mitigation and adaptation, disaster risk reduction, and the enhancement of communities' livelihoods through providing fishery and tourism resources as mentioned above. In response to widespread understanding of the importance of mangrove ecosystems' contribution to addressing global challenges, the international community has recently established global initiatives or frameworks to strengthen and accelerate the conservation of mangroves, as follows:

## GLOBAL MANGROVE ALLIANCE AND MANGROVE BREAKTHROUGH

At the World Ocean Summit in 2018, the Global Mangrove Alliance (GMA) was established with the participation of nongovernmental organizations (NGOs), international organizations, research institutes, and countries.<sup>26</sup> At the 27th Conference of the Parties (COP27) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Sharm El-Sheikh, Egypt, in 2022, Mangrove Breakthrough was launched as a global mangrove conservation initiative with the GMA.<sup>27</sup> Mangrove Breakthrough sets the following goals to be achieved by 2030: (1) halt loss and degradation, (2) recover half of the recent loss, (3) double the protected areas, (4) conserve 15 million ha, and (5) mobilize \$4 billion to achieve the targets.<sup>28</sup> These initiatives have produced deliverables to be used for the protection, restoration, and sustainable management of mangroves at global and local levels. For example, "The State of the World's Mangroves" has been published annually by the GMA to report the changes in global mangrove areas and their drivers. The report utilizes and analyzes the data and information from the platform "Global Mangrove Watch," which provides remote sensing data and tools for monitoring mangrove conservation.<sup>29</sup>

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24 CBD (2022).

25 CBD (2020).

26 See more on the Global Mangrove Alliance at <https://www.mangrovealliance.org/about-us>.

27 See more on Mangrove Breakthrough at <https://www.mangrovebreakthrough.com/about>.

28 Mangrove Breakthrough (n.d.).

29 See "The State of the World's Mangroves 2026" at <https://www.mangrovealliance.org/news/the-state-of-the-world-s-mangroves-2026>; see more on the "Global Mangrove Watch" at <https://www.globalmangrovewatch.org/>.

## MANGROVE ALLIANCE FOR CLIMATE

The Mangrove Alliance for Climate (MAC) was also established as a government-led mangrove conservation framework at the UNFCCC summit at COP27 in 2022.<sup>30</sup> The Standing Committee, co-chaired by the United Arab Emirates (UAE) and Indonesia, is responsible, as the highest body, for providing strategic guidance and making decisions.<sup>31</sup> The UAE serves as the secretariat to implement and monitor MAC-convened activities in coordination with member states. There are 30 countries with mangroves that are partners with the MAC and whose mangrove area exceeds 60% of the total mangrove area in the world.<sup>32</sup>

The mission of the MAC strategy is to conserve and restore mangrove ecosystems through international cooperation, blue carbon solutions, local community engagement, collaborative research, and knowledge exchange, supported by the private sector and nonprofits to achieve a sustainable future. The strategy sets up four strategic initiatives: (1) knowledge exchange, (2) policy development, (3) restoration and rehabilitation, and (4) capacity building.<sup>33</sup>

## COLLABORATION BETWEEN MANGROVE BREAKTHROUGH AND THE MAC

Mangrove Breakthrough and the MAC, both established in 2022, are deepening their collaboration. Mangrove Breakthrough, led by international NGOs, has published numerous scientific findings, information, and technical guidelines through extensive mangrove conservation activities at the local level, and has developed its financial roadmap up to 2030. However, the involvement of national governments is essential in order to implement mangrove conservation in alignment with national policies and legislation while mobilizing public funds. Since the MAC is a government-led framework, the collaboration between Mangrove Breakthrough and the MAC is considered to effectively function to implement mangrove conservation at the national level.

## Indonesia: A case study for policy and rehabilitation in the world's largest mangrove nation

How countries address mangrove decline is best seen through a country example. Although Indonesia has the largest mangrove extent in the world, it saw a reduction from 4.2 million ha in 1980 to 2.31 million ha in 2014.<sup>34</sup> From 2000 to 2012, mangrove loss in Indonesia was mainly caused by the conversion to aquaculture in Kalimantan and Sulawesi, and the conversion to oil palm plantations in Sumatra and Kalimantan.<sup>35</sup> However, the mangrove extent increased to 3.40 million ha in 2025 thanks to its rehabilitation and conservation efforts.<sup>36</sup>

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30 See more on the Mangrove Alliance for Climate at <https://mangrovealliance4climate.org/about/>.

31 The Gulf Observer (2026).

32 MAC (n.d.-b).

33 MAC (n.d.-a).

34 Ilman et al. (2016); Rahadian et al. (2019), 167.

35 Richards and Friess (2016).

36 FAO (2025), 40.

## POLICIES TO ADDRESS CLIMATE CHANGE MITIGATION AND MANGROVE REHABILITATION

According to the “2024 Biennial Transparency Report,” greenhouse gas (GHG) emissions from the Land Use, Land-Use Change, and Forestry (LUCF) sector in 2022 were the second highest at 22.58% of total emissions, following the GHG emissions from the energy sector (53.42%).<sup>37</sup> In the second nationally determined contribution (NDC) plan submitted to the UNFCCC in 2025, Indonesia set a net-zero GHG emissions target by 2060.<sup>38</sup> In the Forestry and Other Land Use (FOLU) sector, efforts to reduce GHG emissions through the suppression of forest loss and degradation and the restoration of degraded forests are expected to turn the FOLU sector from a GHG emission source into a GHG sink by 2030. Since healthy mangrove ecosystems have higher carbon sequestration capacity, Indonesia identifies mangrove restoration as one of the key measures to increase carbon sequestration and suppress emissions from soil as a mitigation action in the FOLU sector.

The Indonesian government committed to accelerating the restoration of mangroves targeting 600,000 ha by 2024 through Presidential Regulation No. 120 of 2020.<sup>39</sup> As the concrete implementation plan, Indonesia developed the National Mangrove Rehabilitation Roadmap 2021-2030 in 2021, aiming to accelerate the rehabilitation of 600,000 ha of degraded mangrove forests, ensure the sustainable management of rehabilitated mangrove forests, and achieve a GHG net sink in mangrove ecosystems by 2030.<sup>40</sup> Since 2022, the Indonesian government, supported by the World Bank, has been conducting the “Mangroves for Coastal Resilience (M4CR) Project” as an NbS.<sup>41</sup> The project serves not only to conserve biodiversity but also to strengthen coastal resilience against coastal flooding and abrasion as adaptation measures, increase carbon sequestration as a mitigation measure, and enhance communities’ livelihoods through the rehabilitation of 41,428 ha of lost or degraded mangrove areas in the four target provinces—North Kalimantan, East Kalimantan, North Sumatra, and Riau—by April 2027.<sup>42</sup> The M4CR Project rehabilitated 13,344 ha, involving 162 community groups in 52 villages, as of April 2025.<sup>43</sup>

In 2024, the Ministry of Environment and Forestry of Indonesia established the World Mangrove Center (WMC). The WMC functions as an integrated global hub for promoting research, capacity building, knowledge sharing, and policy dialogues on the conservation of mangrove ecosystems, all important to addressing global challenges such as climate change mitigation and adaptation, and biodiversity conservation.<sup>44</sup> The WMC is based in Bali and consists of at least three institutions/facilities: (1) the President Joko Widodo Mangrove Nursery Center developed in 2022 for the G20 Summit; (2) the Mangrove Information Center (MIC) established in 2003, supported by the Japan International Cooperation Agency (JICA); and (3) the Mohamed bin Zayed-Joko Widodo International Mangrove Research Center, whose establishment the UAE committed to support in 2024. Thus, the WMC is established and managed in cooperation with international partners.

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37 Republic of Indonesia (2025a), 2.

38 Republic of Indonesia (2025c).

39 Republic of Indonesia (2020).

40 Republic of Indonesia, Ministry of Environment and Forestry, Ministry of Marine Affairs and Fisheries, and Peatland and Mangrove Restoration Agency (2021).

41 See more on M4CR at <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/793041653404341879>.

42 World Bank (2025), 5.

43 World Bank (2025), 2.

44 See more on the World Mangrove Center at <https://worldmangrovecenter.org/en/about-us>.

# International cooperation for mangrove conservation—the JICA/Indonesia example

JICA has extensive cooperation with Indonesia in mangrove conservation, spanning 34 years since 1992, as shown in table 4.2.

TABLE 4.2

## Long-term cooperation for mangrove conservation between Indonesia and JICA

| Year      | Project title and main activities                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1992-1999 | Project on the Development of Sustainable Mangrove Management <ul style="list-style-type: none"> <li>• Developed techniques for rehabilitation and sustainable management.</li> <li>• Published nursery and rehabilitation manuals.</li> <li>• Rehabilitated degraded mangroves (256 ha) in Bali and Lombok.</li> </ul>                                                                                                                                                                          |
| 2001-2006 | Project on the Mangrove Information Center (MIC) <ul style="list-style-type: none"> <li>• Established the MIC as an information-sharing hub.</li> <li>• Developed and implemented training programs and dissemination strategies.</li> <li>• Developed and implemented environmental education and ecotourism programs using the MIC and relevant facilities.</li> </ul>                                                                                                                         |
| 2007-2010 | Project on the Sub-Sectoral Program on Mangroves <ul style="list-style-type: none"> <li>• Developed guidelines for sustainable management and monitoring.</li> <li>• Developed five demonstration sites to disseminate knowledge, techniques, and lessons for sustainable mangrove management.</li> </ul>                                                                                                                                                                                        |
| 2011-2014 | Project on Mangrove Ecosystem Conservation and Sustainable Use in the Association of Southeast Asian Nations (ASEAN) Region <ul style="list-style-type: none"> <li>• Shared good practices and lessons learned in the ASEAN region.</li> <li>• The ASEAN Mangrove Network (AMNET) was approved as a cooperation mechanism for mangrove conservation in ASEAN.</li> </ul>                                                                                                                         |
| 2022-2023 | Follow-up Project on the Mangrove Information Center <ul style="list-style-type: none"> <li>• Renovated MIC exhibition and training facilities.</li> </ul>                                                                                                                                                                                                                                                                                                                                       |
| 2026-2029 | Project on Strengthening Capacity of Sustainable Management of Mangrove for Ecosystem-based Adaptation to Climate Change <ul style="list-style-type: none"> <li>• Strengthen MIC functions for capacity enhancement and CEPA (communication, capacity building, education, participation, and awareness).</li> <li>• Develop models for rehabilitation and sustainable management.</li> <li>• Enable the WMC to function as a global hub for capacity building and knowledge sharing.</li> </ul> |

**SOURCE:** Author's own compilation of JICA and Indonesia's collaborations.

Recently, Indonesia's Ministry of Forestry and JICA started a "Project on Strengthening Capacity of Sustainable Management of Mangrove for Ecosystem-based Adaptation to Climate Change." The project aims to strengthen capacity for sustainable mangrove management through an ecosystem-based adaptation to climate change approach and strengthen environmental and social resilience in coastal areas through developing community-based sustainable mangrove business models on silvofishery and ecotourism.<sup>45</sup>

According to Indonesia's 2021 National Mangrove Map, 756,183 ha have been identified as potential mangrove areas, and 83.55% (631,802 ha) of the area consisted of aquaculture ponds.<sup>46</sup> In order to achieve the 600,000 ha restoration target in the National Mangrove Rehabilitation Roadmap 2021-2030, it is essential to rehabilitate mangroves within these aquaculture ponds. Since such aquaculture ponds serve as a source of livelihood for local communities, it is crucial to ensure that aquaculture and mangrove restoration coexist through the understanding and cooperation of local communities.

Silvofishery is one of the approaches that enables the coexistence of aquaculture and mangrove rehabilitation. This method involves planting mangroves within a portion of the aquaculture pond. Planted mangroves in a pond provide natural feed—various plankton and benthic organisms—for farmed shrimp and fish, thereby reportedly enhancing productivity. Silvofishery systems also maintain water quality within acceptable ranges for aquaculture operations.<sup>47</sup> Introducing silvofishery into ponds that are classified as potential mangrove forest areas enables the conversion of a certain portion of the pond area into mangrove forests. The current Indonesia and JICA project aims to develop a silvofishery model that balances mangrove restoration with aquaculture while contributing to the improvement of local livelihoods. Furthermore, given the significant value of mangroves' unique landscapes and rich biodiversity as tourism assets, the project also develops a community-based ecotourism model that utilizes the restored mangrove ecosystems, thereby promoting a balance between mangrove conservation and sustainable use.

By deploying the silvofishery and ecotourism models as sustainable social forestry businesses that contribute to enhancing the livelihoods of local communities, the project aims to scale up mangrove rehabilitation and sustainable management, thereby contributing to the achievement of the 600,000 ha restoration target in Indonesia's National Mangrove Rehabilitation Roadmap 2021-2030 and the GHG net sink by 2030 in the FOLU sector as the NDC target.

The project will also support the enhancement of the WMC as a global hub for capacity building and knowledge sharing for mangrove conservation targeting mangroves inhabiting the Association of Southeast Asian Nations (ASEAN) member states, collaborating with the ASEAN Mangrove Network (AMNET). AMNET, as a cooperation mechanism for mangrove conservation in the ASEAN region, formulated the "ASEAN Strategy on Sustainable Mangrove Ecosystem Management 2024-2030."<sup>48</sup> This ASEAN strategy aims to achieve the conservation and sustainable management of mangrove ecosystems to ensure ecosystem health and coastal resilience by 2030 while contributing to international commitments to address global challenges. Strategy 2, specifically, among the five strategies to achieve this objective, promotes capacity enhancement for the protection, restoration, and sustainable management of mangrove ecosystems.<sup>49</sup> Collaborating with AMNET, the project contributes to capacity enhancement and the promotion of knowledge and experience sharing for mangrove conservation in the ASEAN region.

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45 JICA (2024).

46 Republic of Indonesia (2021a); Nurhati and Murdiyarso (2023), 13; Noviar (2023).

47 Harefa et al. (2025).

48 ASEAN (2024).

49 ASEAN (2024), 50.

# Scaling mangrove restoration and conservation: Mobilizing capital to ensure ecosystem services

Projects such as these cannot be sustained or replicated at scale without addressing the question of finance. To ensure the multifaceted services of the mangrove ecosystem, and to scale up sustainable management such as mangrove restoration, silvofishery, and ecotourism, sufficient funding, as well as the establishment of systems and guidelines to appropriately guarantee ecosystem services, are necessary.

## FUNDING MOBILIZATION

In 2023, Mangrove Breakthrough published “The Mangrove Breakthrough Financial Roadmap” to achieve the target of 15 million ha of mangrove area conservation by 2030.<sup>50</sup> As mentioned previously, Mangrove Breakthrough recommended that \$4 billion be mobilized to implement the projects under the initiative and achieve the target. It is expected that \$2.8 billion will come from public finance and the remaining \$1.2 billion from private or commercial finance.<sup>51</sup>

Regarding public funding mobilization, while it is fundamental to raise funds according to the circumstances of each implementation country, since mangrove ecosystem conservation significantly contributes to climate change mitigation and adaptation, it is recommended to utilize the large-scale Green Climate Fund (GCF). As shown in table 4.3, nine projects that include mangrove restoration and sustainable management have been conducted to date with funding from the GCF. Most of these projects aim to strengthen coastal communities’ resilience against climate change through mangrove restoration. The project in Vietnam, completed in 2024, restored a total of 4,028 ha of mangroves.<sup>52</sup> Projects in India and Cuba are targeting the restoration of 10,575 ha and 11,427 ha of mangroves, respectively, by the end of their projects.<sup>53</sup> If all the projects in table 4.3 achieve their mangrove restoration targets, more than 32,880 ha of mangroves will be restored.

Driven by intercorporate competition to achieve carbon neutrality by 2050, the global voluntary carbon market is projected to grow to \$50 billion by 2030.<sup>54</sup> Consequently, mobilizing private capital to develop mangrove conservation and restoration projects, which generate higher carbon sequestration, offers an effective pathway to scaling up these efforts. One example of a mangrove restoration project within the voluntary carbon market is the “Mangrove Restoration and Coastal Greenbelt Protection Project” underway since 2011 in Aceh and North Sumatra, Indonesia.<sup>55</sup> Implemented by the local Indonesian NGO Yagasu, this project aims to restore 10,000 ha of mangrove areas, previously lost to conversion into aquaculture ponds, while simultaneously improving the livelihoods of local communities.<sup>56</sup> The project is expected to sequester a total of 4.5 million tons of carbon over a 20-year period, with carbon credits generated under Verra’s Verified Carbon Standard scheme.<sup>57</sup> The project has secured investment from the France-based Livelihoods Carbon Fund, in which numerous major companies have invested, including Hermès, Chanel, Danone, MCB, and Michelin.<sup>58</sup>

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50 Ring et al. (2023).

51 Ring et al. (2023), 53.

52 Data is from the Vietnam project report at <https://www.greenclimate.fund/portfolio/projects/fp013>.

53 Data is from the projects’ reports. The India project’s report is at <https://www.greenclimate.fund/document/2023-annual-performance-report-fp084-enhancing-climate-resilience-india-s-coastal>; the Cuba project’s report is at <https://www.greenclimate.fund/document/coastal-resilience-climate-change-cuba-through-ecosystem-based-adaptation-mi-costa>.

54 Blaufelder et al. (2021).

55 WWF (2022).

56 Ibid.

57 Ibid.

58 WWF (2022); Livelihoods Funds (2026).

TABLE 4.3

## Climate action projects including mangrove conservation, funded by the Green Climate Fund

| No.     | Country       | Project title                                                                                                              | Focus         | Mangrove action                                   | Budget (in millions) | Period              | AE*/EE**                                                                                                                                                         |
|---------|---------------|----------------------------------------------------------------------------------------------------------------------------|---------------|---------------------------------------------------|----------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FP003   | Senegal       | Increasing the resilience of ecosystems and communities through the restoration of the productive bases of salinized lands | Adaptation    | Restoration (250 ha)                              | \$8.2                | Feb. 2020-Feb. 2027 | Centre de Suivi Écologique/Union internationale pour la conservation de la nature/ Réseau Africain pour le Développement Intégré/ Institut National de Pédologie |
| FP011   | The Gambia    | Large-scale Ecosystem-based Adaptation in The Gambia: developing a climate-resilient, natural resource-based economy       | Adaptation    | Restoration and sustainable management            | \$25.5               | Aug. 2017-Jan. 2026 | United Nations Development Programme (UNDP)/ Ministry of Environment, Climate Change and Natural Resources                                                       |
| FP013   | Vietnam       | Improving the resilience of vulnerable coastal communities to climate change related impacts in Viet Nam                   | Cross-cutting | Restoration (4,028 ha)                            | \$40.5               | Jul. 2017-Jul. 2024 | UNDP/Ministry of Agriculture and Rural Development                                                                                                               |
| FP084   | India         | Enhancing climate resilience of India's coastal communities                                                                | Cross-cutting | Restoration (10,575 ha)                           | \$130                | Jun. 2019-Jun. 2027 | UNDP/Ministry of Environment, Forest and Climate Change                                                                                                          |
| FP157   | Cuba          | Coastal Resilience to Climate Change in Cuba through Ecosystem Based Adaptation – “MI COSTA”                               | Adaptation    | Restoration (11,427 ha)                           | \$44.3               | Sep. 2021-Sep. 2029 | UNDP/Environmental Agency (AMA) of the Ministry of Science, Technology and Environment (CITMA)                                                                   |
| FP235   | Ecuador       | Mangroves for climate: Public, Private and Community Partnerships for Mitigation and Adaptation in Ecuador                 | Cross-cutting | Restoration (4,850 ha) and sustainable management | \$45.9               | Aug. 2024-Aug. 2030 | Conservation International Ecuador (CI)/CI                                                                                                                       |
| SAP 025 | Guinea-Bissau | Adaptation of agricultural production systems in Coastal Areas of Northwest Guinea-Bissau                                  | Adaptation    | Restoration (250 ha) and sustainable management   | \$10.0               | Sep. 2023-Sep. 2028 | Sahara and Sahel Observatory/Ajuda de Desenvolvimento de Povo para Povo Guinea-Bissau                                                                            |
| SAP 036 | Sierra Leone  | Sierra Leone Coastal Resilience Project                                                                                    | Adaptation    | Restoration (1,500 ha) and sustainable management | \$26.9               | Dec. 2024-Dec. 2029 | Save the Children Australia/Save the Children Sierra Leone and others                                                                                            |
| SAP 049 | Mexico        | Sustainable Communities for Climate Action in the Yucatán Peninsula                                                        | Adaptation    | Restoration and sustainable management            | \$32.7               | Aug. 2025-Feb. 2035 | Mexican Fund for the Conservation of Nature A.C. (FMCN)/FMCN and Sureste Sostenible A.C.                                                                         |

\*AE = Accredited Entity; \*\*EE = Executing Entity

**SOURCE:** Author's own compilation of project information from the GCF website (<https://www.greenclimate.fund/portfolio/all?search=mangrove>) and the respective project reports.

## THE NEED FOR NATIONAL SYSTEMS

While private companies show significant interest in the carbon market, and the mobilization of private funds for mangrove restoration is expected, mangrove plantation activities aimed at generating carbon credits may lead to trade-offs. These include the potential for reducing other ecosystem services, such as biodiversity, by focusing solely on carbon sequestration and straining the livelihoods of local communities by restricting their use of natural resources. Therefore, in the restoration and conservation of mangrove ecosystems, it is necessary to establish regulations and guidelines that properly ensure their multiple services and guarantee the livelihoods and welfare of local communities.

Also at the 2022 UNFCCC summit at COP27, the “High-Quality Blue Carbon Principles and Guidance” was published to achieve three co-benefits: people, nature, and climate.<sup>59</sup> Aiming to equitably and transparently improve outcomes for people, nature, and climate, five principles were created for the development and deployment of high-quality blue carbon projects and credits: “1) safeguard nature, 2) empower people, 3) employ the best information, interventions, and carbon accounting practices, 4) operate locally and contextually, and 5) mobilize high-integrity capital.”<sup>60</sup>

To ensure that the carbon sequestration results of mangrove restoration and conservation projects, funded by private capital mobilization through the voluntary carbon market, are incorporated into national GHG inventories and contribute to achieving NDC targets, it is essential to establish national regulations, including registration, measurement, reporting, and verification (MRV), and carbon credit allocation for carbon credit generation projects, including mangrove ecosystem restoration and conservation. Without regulations like these in place, the results of GHG reduction achieved through domestically implemented projects will likely flow overseas.

In 2021, the Indonesian government established Presidential Regulation No. 98, “Implementation of Carbon Pricing to Achieve the Nationally Determined Contribution Target and the Control of Greenhouse Gas Emissions in National Development,” which promoted the achievement of NDC targets through market-based instruments consisting of carbon trading, results-based payments, and carbon tax, based on GHG emissions and reductions.<sup>61</sup> Additionally, the government enacted its Ministry of Forestry Regulation No. 6 of 2026 concerning “Procedures for Carbon Trading through Greenhouse Gas Emission Offsets in the Forestry Sector,” to strengthen the governance of carbon trading in the forestry sector, ensuring it is credible, transparent, and inclusive, and integrate a nesting framework to prevent double-counting and align with its FOLU Net Sink 2030 target.<sup>62</sup>

Few countries have developed systems like Indonesia’s. It is recommended that countries that have not yet established carbon pricing systems in the forestry sector, including mangroves, urgently develop a plan to balance the promotion of private capital mobilization with proper mangrove restoration and conservation.

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59 Friends of Ocean Action et al. (2022).

60 Friends of Ocean Action et al. (2022), 10-11.

61 Republic of Indonesia (2021b); note: Presidential Regulation No. 98 has since been repealed and replaced by Presidential Regulation No. 110 of 2025 “Implementation of Carbon Economic Value Instruments and National Greenhouse Gas Emission Control” and builds upon the carbon and GHG governance goals set forth (see Republic of Indonesia (2025b)).

62 Republic of Indonesia (2026); Republic of Indonesia, Ministry of Environment and Forestry (2023).

## Integrated mangrove ecosystem management

As previously mentioned, mangrove ecosystems provide multiple benefits to people, including carbon sequestration, coastal protection, disaster risk reduction, biodiversity, and provisioning fishery and tourism resources, ensuring the livelihoods and welfare of local communities. In order to optimize mangrove ecosystem services and ensure their conservation and sustainable management on the ground, it is vital to adopt an “adaptive management” approach that includes scientific monitoring of the ecosystem services and impacts of human activities, analysis of their interaction, and comprehensive assessment to guide planning, implementation, and improvement. Furthermore, given that various human activities affect the mangrove ecosystem, it is necessary to establish a management mechanism that facilitates information sharing and coordination among stakeholders representing both the conservation and utilization interests.

In the planning and implementation of projects based on the NbS approach, including ecosystem-based adaptation (EbA) and ecosystem-based disaster risk reduction (Eco-DRR), it is essential to adopt such integrated ecosystem management as a fundamental principle, across both coastal and terrestrial ecosystems.

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## FIVE

# INDIGENOUS PEOPLES AND NEW PATHWAYS FOR SUSTAINABILITY IN AMAZONIA

David Cotacachi, Fany Kuiru Castro, Tatiana Schor, and Verónica Tejerina

**“We were not born to live in scarcity.”**  
Uitoto principle, Colombian Amazon

## Indigenous Peoples, nature, and sustainable development

The relationship between Indigenous Peoples and nature is increasingly central to debates on sustainable development.<sup>1</sup> Far from being solely a cultural issue, this relationship has direct implications for ecosystem conservation, environmental stability, and natural resource management at a global scale.

Few regions illustrate this relationship as clearly as Amazonia. This vast ecological system not only harbors some of the world’s most important tropical forests but is also home to hundreds of Indigenous Peoples whose liveli-

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<sup>1</sup> This chapter refers specifically to Indigenous Peoples, and not necessarily to local communities, following the recommendations of the United Nations Permanent Forum on Indigenous Issues, which has called for a clear distinction between Indigenous Peoples and local communities and warned against using a combined category that treats them as a single group. See more: CBD/WG8J/12/7—Recommendations from the United Nations Permanent Forum on Indigenous Issues to the Convention on Biological Diversity.

hoods, knowledge systems, and governance structures are closely tied to their territories. Understanding how these dimensions interact is essential for designing development and conservation policies that are both effective and sustainable.

This chapter examines how these relationships shape conservation, development policy, and territorial governance in practice. First, it describes the characteristics of Amazonian Indigenous Peoples and their ties to the territory. It then analyzes how this relationship has contributed to ecosystem conservation, as well as the key pressures affecting the ecosystem and the economic interests driving those pressures. Finally, the chapter explores emerging tools and innovations aimed at strengthening this relationship in the context of current sustainable development challenges.

## Characteristics of Indigenous Peoples worldwide

Indigenous Peoples share several common features, including historical ties to their territories, distinct cultural identities, and governance systems that differ from those of modern states.<sup>2</sup> These characteristics are important for understanding why public policies are not always effective in Indigenous territories, particularly when Indigenous communities have not been directly involved in their design and implementation.<sup>3</sup>

The World Bank estimates that approximately 476 million Indigenous people live worldwide, representing about 6% of the global population. Indigenous Peoples live in more than 90 countries and tend to concentrate in territories with high ecological value, including tropical forests and other critical ecosystems.<sup>4</sup> Indigenous Peoples occupy or use approximately one-quarter of the Earth's land surface, including 37% of natural areas.<sup>5</sup> Areas with high levels of Indigenous cultural diversity also tend to overlap with regions of high biodiversity, underscoring the role of Indigenous Peoples in global conservation efforts.<sup>6</sup>

Amazonia illustrates these dynamics clearly, since the overlap between biological and cultural diversity is especially pronounced. The region contains not only some of the world's richest ecosystems, but also a high concentration of Indigenous Peoples whose livelihoods and governance systems are closely linked to these environments. Amazonia therefore offers an important context for understanding how conservation, territory, Indigenous Peoples, and development interact in practice.

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<sup>2</sup> IDB (2006).

<sup>3</sup> Indigenous territories are lands, waters, and natural resources that Indigenous Peoples have traditionally occupied, used, managed, or to which they have cultural, spiritual, and historical connections. Indigenous communities refer to specific local settlements, villages, or groups of Indigenous people living in a particular area.

<sup>4</sup> World Bank (2020).

<sup>5</sup> Fernández-Llamazares et al. (2024).

<sup>6</sup> Gorenflo et al. (2012).

# Amazonia and Indigenous Peoples<sup>7</sup>

Amazonia spans more than 6.7 million km<sup>2</sup> and is home to approximately 40% of the world's remaining tropical forests.<sup>8</sup> Functioning as a major carbon sink, the region stores between 150 billion and 200 billion metric tons of carbon and is home to over 10% of global terrestrial biodiversity.<sup>9</sup> This biome of global importance is shared by eight countries: Brazil, Colombia, Bolivia, Ecuador, Guyana, Peru, Suriname, Venezuela, and one territory, French Guiana.<sup>10</sup>

In addition to its exceptional biological diversity, Amazonia is characterized by remarkable cultural and linguistic diversity. Around 240 Indigenous languages have been identified across Amazonia, nearly 70% of them in Brazil.<sup>11</sup> These languages embody generations of accumulated knowledge and reflect the longstanding relationships Indigenous Peoples have developed with their territories and surrounding ecosystems, including species found nowhere else on the planet. Approximately 379 Indigenous Peoples inhabit Amazonia, while approximately 136 Indigenous groups remain in voluntary isolation, largely avoiding contact with broader society.<sup>12</sup>

These connections to territory also have important ecological implications. Indigenous territories play a fundamental role in the ecological integrity of Amazonia, including by helping maintain ecosystem connectivity. Together, they encompass nearly 2.4 million km<sup>2</sup>, representing approximately 28.5% of the region (see figure 5.1).<sup>13</sup> They also contain about 45% of the Amazon basin's remaining intact forests, underscoring their importance for forest connectivity, biodiversity, and ecosystem resilience.<sup>14</sup>

## THE INEXTRICABLE RELATIONSHIP BETWEEN INDIGENOUS PEOPLES AND THE FOREST

Archaeological evidence indicates that Indigenous Peoples have inhabited Amazonia for at least 12,000 years.<sup>15</sup> Rather than being ecosystems isolated from human intervention, Amazonian landscapes have historically been shaped by interactions between Indigenous communities and their environment. This longstanding relationship has fostered extensive knowledge of biodiversity, climate patterns, medicinal plants, as well as sustainable land and forest management practices. Embedded within the cultural, social, and governance systems of Indigenous Peoples, this knowledge represents an important resource for conservation and sustainable development in Amazonia.

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7 This section provides a background of Indigenous Peoples in Amazonia and summarizes a fuller description of the topic available in the Inter-American Development Bank (IDB) report “Diversity, Development, and Conservation in Amazonia,” in “Amazonia: A Journey Toward Prosperity and Resilience” of which authors of this chapter were featured contributors. As this chapter draws on the IDB report, some text is directly drawn from the report and used for descriptive summarization purposes in this chapter. See Acioli et al. (2025).

8 WWF (2014); UNESCO (n.d.); World Bank (n.d.).

9 Leal Filho et al. (2025); WWF (n.d.).

10 World Bank (2023).

11 Acioli et al. (2025), 169.

12 Indigenous groups refer to different Indigenous populations in a general, descriptive, or comparative way; Ballesteros et al. (2025), 26.

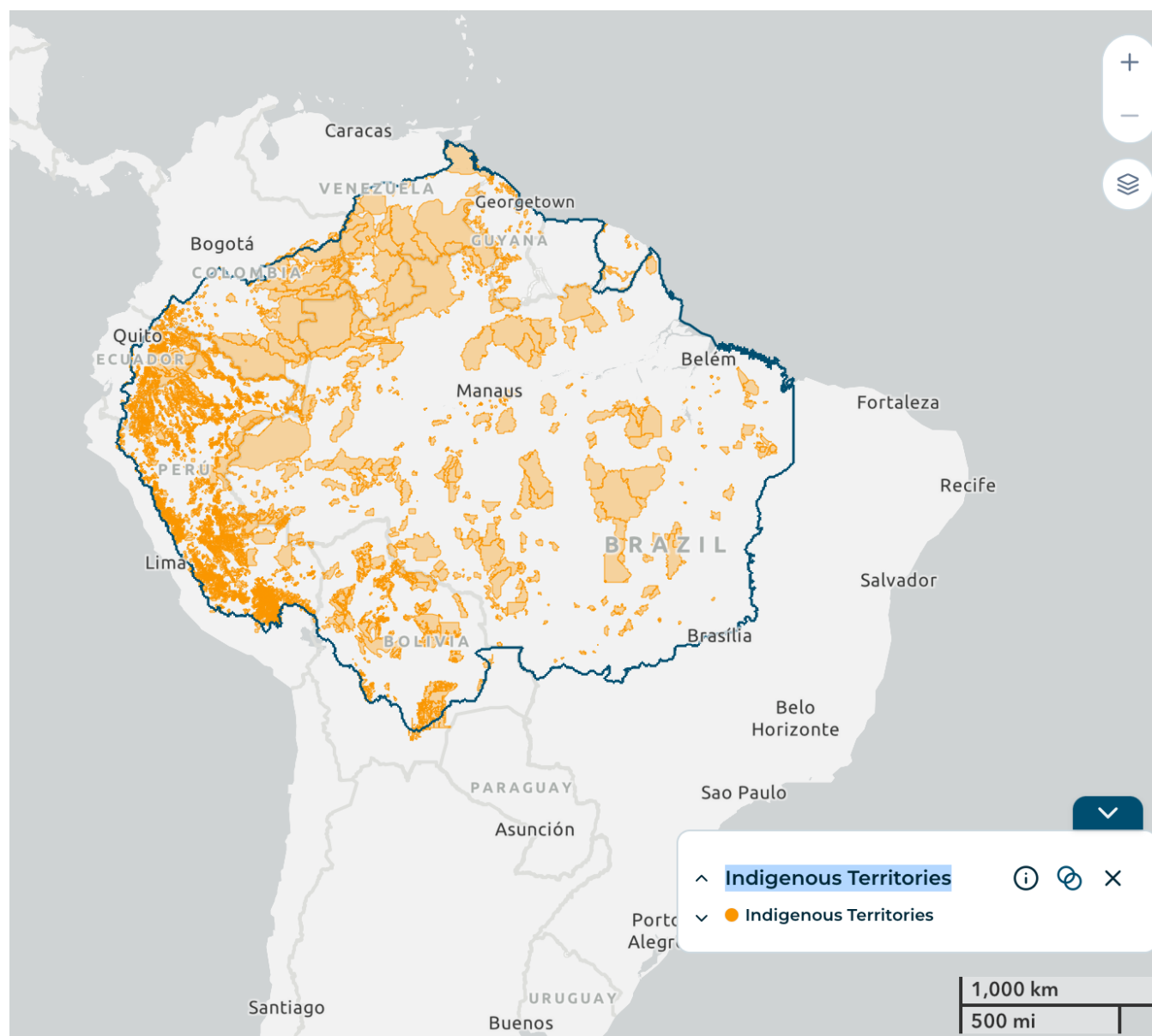
13 Bergamaschi, Fernandes, and Elacqua (2025), 122; RAISG (2023a).

14 FAO and FILAC (2021).

15 Nascimento et al. (2022); Neves et al. (2021).

FIGURE 5.1

## Indigenous territories in Amazonia



SOURCE: IDB (n.d.-b).

Evidence shows that Indigenous territories maintain some of the highest levels of ecological integrity in the Amazon basin.<sup>16</sup> Despite increasing pressures on land and natural resources, these territories consistently exhibit lower deforestation rates than surrounding areas.

In Ecuador, for example, a georeferenced assessment of lands enrolled in the Socio Bosque conservation incentive program found that 99% of Indigenous territories remained free from deforestation, even as surrounding areas experienced forest loss.<sup>17</sup> These results point to Indigenous territorial governance as an important factor in maintaining forest cover, with conservation incentives potentially reinforcing existing territorial management systems.

Evidence from Peru points in the same direction. Research comparing different conservation governance systems has found lower levels of forest loss in Indigenous territories. One study examining nearly 3,000 land units between 2006 and 2011 found lower forest loss in Indigenous territories than in conventional protected areas.<sup>18</sup> A second analysis covering the period from 2005 to 2021 reached similar conclusions regarding their effectiveness in limiting forest loss.<sup>19</sup> These results add to the evidence that Indigenous governance can make a substantial contribution to forest conservation.

## INDIGENOUS TERRITORIES AS STRATEGIC CARBON SINKS

Although deforestation dynamics in Indigenous territories vary according to local pressures—such as agricultural expansion, mining, and oil extraction—evidence shows that forests managed by Indigenous Peoples in the Amazon basin play an important role in global environmental regulation. Collectively, these territories function as significant net carbon sinks.

Evidence from the Amazon basin also highlights the contribution of Indigenous territories to reducing emissions and supporting economic activity with lower net emissions. An analysis covering nine countries found that, from 2001 to 2021, forests within Indigenous territories removed roughly 460 million metric tons of CO<sub>2</sub>e from the atmosphere each year, while generating about 120 million metric tons in annual emissions.<sup>20</sup> This resulted in a net removal of approximately 340 million metric tons of CO<sub>2</sub>e per year.<sup>21</sup> By comparison, forests outside Indigenous territories experienced sufficiently high levels of deforestation to become net carbon emitters over the same period.

These outcomes are linked not only to lower rates of forest loss, but also to Indigenous governance systems, land-management practices, traditional livelihoods, and cultural values associated with the forest. Together, these factors contribute to preserving forest cover and maintaining ecological functions that support regional and global environmental stability (see figure 5.2).

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16 MapBiomass (2021).

17 Zurita-Arthos and Cotacachi (2019).

18 Schleicher et al. (2017); Acioli et al. (2025), 173.

19 Negret et al. (2026).

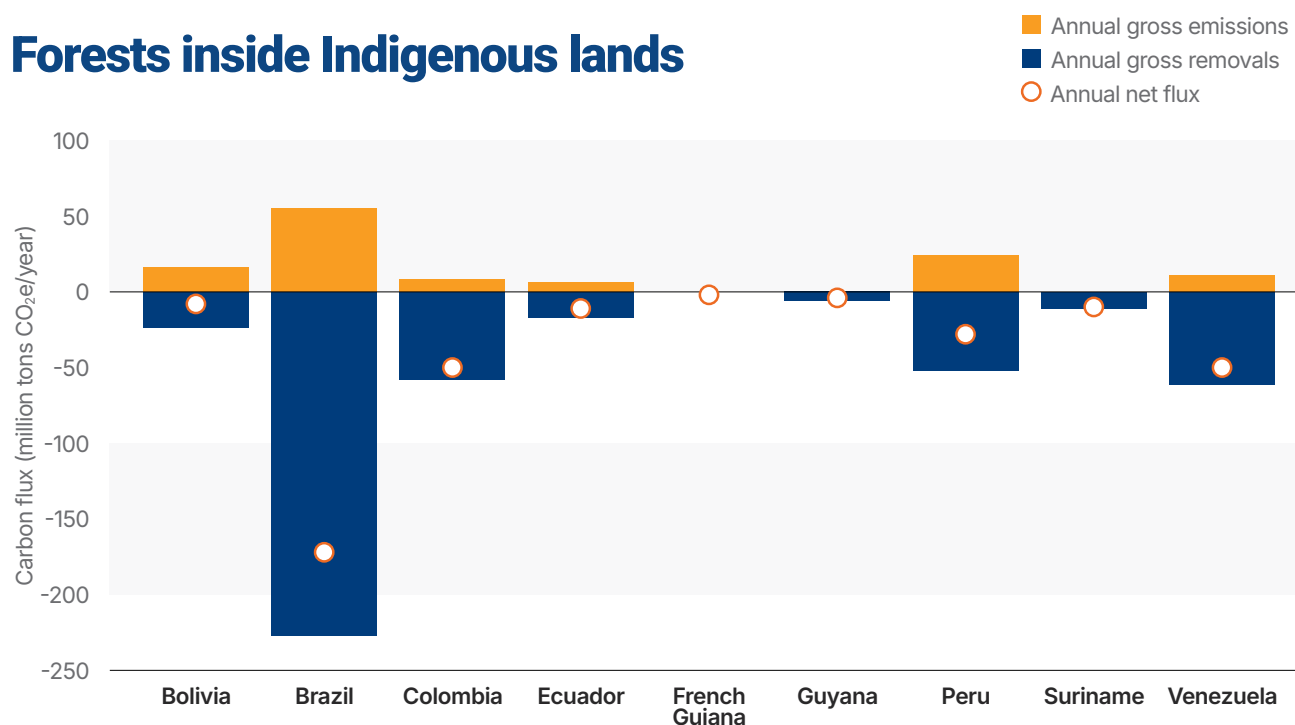
20 Veit, Gibbs, and Reytar (2023).

21 Ibid.

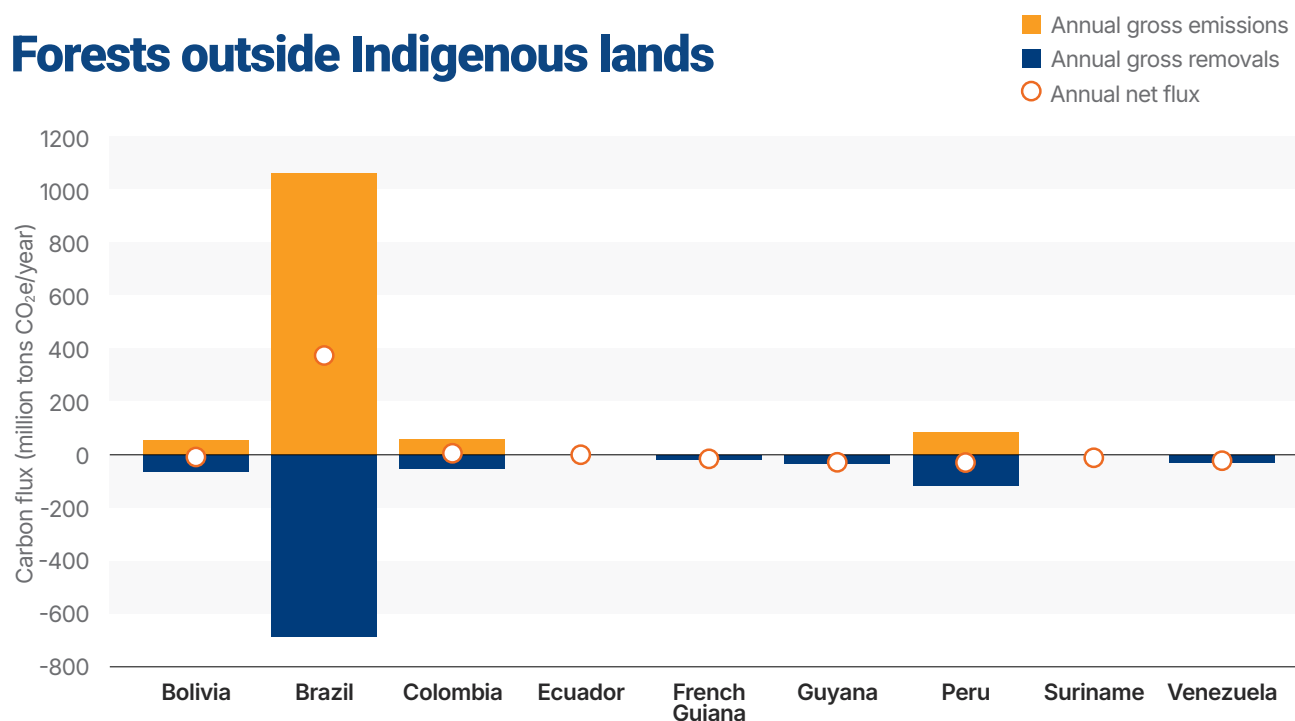
FIGURE 5.2

## Carbon emissions and removals in Amazonia

### Forests inside Indigenous lands



### Forests outside Indigenous lands



**SOURCE:** Adapted from Veit, Gibbs, and Reyta (2023), licensed under CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>). Spelling, terminology, scale, and colors modified to conform to Brookings style.

## INDIGENOUS WORLDVIEWS AND FOREST PROTECTION

For many Indigenous Peoples in Amazonia, the forest is not simply a source of material resources but a living and interdependent system encompassing plants, animals, water, soil, ecosystem functions, and intangible and spiritual dimensions of the territory. Disrupting these relationships can affect ecological conditions as well as community well-being and cultural continuity. These worldviews can shape norms of reciprocity, restraint, and responsibility in the use of natural resources. Where traditional knowledge, practices, and institutions continue to play a central role, such principles can be reflected in customary norms and governance arrangements that shape access to, use of, and management of natural resources and territory.

The Kichwa People of Sarayaku in Ecuador provide a clear example. Their concept of *Kawsak Sacha*, or the “Living Forest,” understands territory as a living entity constituted by relationships among humans, animals, plants, and spiritual beings.<sup>22</sup> From this perspective, extractive activities can threaten not only the environment, but also territorial integrity and the foundations of collective life.<sup>23</sup> Elsewhere in Amazonia, similar principles are reflected in customary rules governing particular species and places. Among Tikuna, Yagua, and Cocama communities, for example, cultural understandings surrounding certain fish species such as the arapaima, or paiche (*Arapaima gigas*), have shaped practices and norms governing when and how the species can be harvested.<sup>24</sup> Similar customary principles can shape the use and management of other species.

Indigenous relationships with the forest are also evident in systems of medicinal knowledge. Species such as dragon’s blood (*Croton lechleri*), guayusa (*Ilex guayusa*), and cat’s claw (*Uncaria tomentosa*) are used in traditional practices related to health, healing, and well-being.<sup>25</sup> Among some peoples, ceremonial practices involving the ayahuasca vine (*Banisteriopsis caapi*) also form part of broader systems of healing, knowledge transmission, and engagement with the territory.<sup>26</sup> Because forest ecosystems sustain these medicinal resources and the knowledge associated with them, forest protection is closely linked to community health and cultural continuity.

These examples illustrate how Indigenous worldviews are translated into knowledge systems, institutions, customary norms, and concrete practices of territorial stewardship. Recognizing these approaches can inform conservation and development policies that strengthen, rather than replace, Indigenous governance.

This raises a central question: If Indigenous territories have proven effective in conserving forests, biodiversity, and critical ecosystem functions, why do they continue to face increasing pressures? Addressing this question requires examining the challenges affecting Indigenous Peoples in Amazonia, the political and economic dynamics that sustain these pressures despite evidence of effective Indigenous governance, and the emerging strategies and institutional instruments aimed at strengthening conservation and sustainable development efforts.

A central part of this challenge is implementation. Today, several countries are signatories to international instruments that protect the territorial rights of Indigenous Peoples, and most governments have public policies aimed at promoting conservation and sustainable development.<sup>27</sup> Yet the central challenge is no longer simply adopting rules or commitments but ensuring effective implementation.

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22 Oikonomakis (2024).

23 Ibid.

24 Acioli et al. (2025).

25 de Albuquerque et al. (2025); Noriega et al. (2025); Marques et al. (2025).

26 Lenaerts (2006); Zuluaga Ramírez (2005).

27 Cotacachi (2020).

## Coordinator of Indigenous Organizations of the Amazon Basin (COICA) and the rise of Indigenous governance in the Amazon

For thousands of years, Indigenous Peoples have lived in the Amazon with a simple but powerful conviction: No one should face scarcity in a place of such abundance. A saying from the Uitoto people captures this idea: “We were not born to live in scarcity; we were born to live in abundance.” The Amazon’s freshwater, forests, and extraordinary biodiversity have long provided the material, cultural, and spiritual foundations for a full life.

Today, that vision is increasingly at odds with reality. For more than a century, outside actors seeking rubber, gold, oil, timber, animal hides, and other natural resources have reshaped Amazonian ecosystems. These waves of extraction have also disrupted social structures, cultural practices, and Indigenous knowledge systems that for generations guided communities’ relationships with the forest, water, and biodiversity.

Consequently, the Amazon has often been understood through the priorities of outsiders interested in its resources, while Indigenous voices have been pushed to the margins of national and global debates. In response to this long history of exclusion, Indigenous leaders from across the Amazon basin came together in Lima, Peru, on March 14, 1984, to establish the Coordinator of Indigenous Organizations of the Amazon Basin (COICA). The organization was created to defend the territorial rights of Amazonian Indigenous Peoples, strengthen their political representation, and protect cultural continuity amid growing threats to the region.

Today, COICA brings together Indigenous organizations from Amazonian countries, including AIDESEP in Peru, APA in Guyana, CIDOB in Bolivia, COIAB in Brazil, CONFENIAE in Ecuador, FOAG in French Guiana, OPIAC in Colombia, ORPIA in Venezuela, and OIS in Suriname.\* It has become one of the world’s most significant regional Indigenous organizations in terms of territorial representation, giving collective voice to more than 511 Indigenous Peoples across the Amazon basin.

Over the past four decades, COICA has helped Amazonian Indigenous Peoples speak for themselves in regional and global forums. Its work has strengthened Indigenous governance across countries and helped position the Amazon as essential to biodiversity conservation, environmental stability, and cultural survival.

COICA now plays an active role in international discussions on environmental and biodiversity governance, shaping global agendas and advancing Indigenous leadership as central to protecting the Amazon. In doing so, Indigenous Peoples are not only defending their place as the forest’s historic inhabitants; they are also asserting their role as strategic leaders in Amazonian governance and in global responses to environmental and ecological challenges.

**SOURCE:** Fany Kuiru Castro, General Coordinator, COICA. See more about COICA at <https://coicamazonia.org/quienes-somos/>.

\*Asociación Interétnica de Desarrollo de la Selva Peruana (AIDESEP)  
Amerindian Peoples Association (APA)  
Confederation of Indigenous Peoples of Bolivia (CIDOB)  
Coordination of Indigenous Organizations of the Brazilian Amazon (COIAB)  
Confederation of Indigenous Nationalities of the Ecuadorian Amazon (CONFENIAE)  
Fédération des Organisations Amérindiennes de Guyane (FOAG)  
Organización Nacional de los Pueblos Indígenas de la Amazonia Colombiana (OPIAC)  
Organización Regional de Pueblos Indígenas de Amazonas (ORPIA)  
Organization of Indigenous People (OIS)

# Threats to the Amazonian biome and the challenges facing Indigenous Peoples

Despite its global importance in regulating the water cycle, stabilizing the environment, and conserving biodiversity, Amazonia has become increasingly vulnerable to deforestation and ecosystem degradation. The combined pressures of agricultural and livestock expansion, the extraction of natural resources, illegal logging, and infrastructure development continue to accelerate forest loss across the region. According to the Monitoring of the Andes Amazon Program (MAAP), approximately 33.7 million hectares (83.4 million acres) of primary forest have been lost since 2002—an area larger than the state of New Mexico.<sup>28</sup> In addition, another 10.6 million hectares have been degraded by fires, intensifying pressures on Amazonian ecosystems and reducing their capacity to provide ecosystem services.<sup>29</sup> If current deforestation trends continue, several studies warn that significant parts of the Amazon could approach an ecological threshold, shifting within a few decades toward degraded ecosystems similar to tropical savannas and completely losing their capacity for regeneration.<sup>30</sup>

## AGRICULTURE AND LIVESTOCK

Agricultural expansion and livestock are among the main drivers of deforestation in the Amazon. Extensive livestock ranching, soybean and oil palm monocultures, and associated infrastructure have accelerated forest loss across Amazonian countries. According to MapBiomass Amazonia, between 1985 and 2022, nearly 80% of deforested areas in the Amazon basin were converted into pastureland, while another 14% was used for crop production.<sup>31</sup> Likewise, a large share of fires recorded in the region occurs in areas previously deforested or degraded by agricultural and livestock activities, where fire is used to clear land for grazing and farming.<sup>32</sup> Hence, many Indigenous territories face increasing territorial pressures, shrinking areas of traditional use, and impacts on livelihoods and food security.

## MINING

Among the main drivers of Amazonian degradation is the expansion of illegal gold mining, one of the primary threats to Indigenous territories and protected areas. Studies by the Amazon Geo-Referenced Socio-Environmental Information Network (RAISG) and MAAP identified at least 49 sites affected by illegal mining across the Amazon basin, including 20 in Indigenous territories and 16 in protected areas.<sup>33</sup> Between 1985 and 2023, the area devoted to mining in the Amazon increased by more than 1,000%, while the region lost more than 88 million hectares of forest cover.<sup>34</sup>

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28 Finer et al. (2025).

29 Ibid.

30 Wunderling et al. (2026).

31 Ferreira (2026).

32 NASA Earth Observatory (2019).

33 RAISG (2023b).

34 MapBiomass Amazonia (2024).

Illegal gold mining generates severe socio-environmental impacts through mercury contamination of rivers and aquatic ecosystems that support the livelihoods of numerous Indigenous communities. Studies in Mundurucu communities in Brazil have found elevated levels of mercury in human hair samples, associated with both illegal mining activities and the consumption of contaminated fish.<sup>35</sup> Similar patterns have been documented across Amazonian countries, where prolonged exposure to methylmercury has been linked to neurological, cognitive, and developmental disorders, particularly among children.

## ILLEGAL LOGGING

Illegal logging is one of the main illicit economies driving forest degradation in the Amazon and other tropical forests around the world. According to INTERPOL, it accounts for between 15% and 30% of global timber production, with some of the most severe cases concentrated in the Amazon basin.<sup>36</sup> INTERPOL has reported estimates indicating that illegal logging may account for up to 80% of logging activity in the Brazilian state of Pará and between 40% and 60% in Peru.<sup>37</sup>

In addition to its environmental impacts, illegal logging affects Indigenous communities through the loss of traditional livelihoods, including hunting, fishing, subsistence agriculture, and the use of forest resources. It also increases pressure on Indigenous territories and areas of biocultural importance. Due to its illicit nature, illegal logging is frequently linked to criminal networks, land conflicts, corruption, and violence against Indigenous leaders and environmental defenders.

## CHALLENGES FACING INDIGENOUS PEOPLES

The impacts of deforestation and the expansion of extractive activities in Amazonia extend beyond environmental degradation. For many Indigenous Peoples who depend directly on the natural resources of their lands and territories, the rapid loss of forests, rivers, and biodiversity threatens food security, livelihoods, and cultural survival.

At the same time, many Indigenous communities face longstanding conditions of poverty, marginalization, and limited state presence, reflected in insufficient access to health services, education, infrastructure, and sustainable economic opportunities. In Amazonia, at least 4.3 million people live in monetary poverty, with an average municipal poverty rate of approximately 54%.<sup>38</sup> These structural vulnerabilities are further intensified by related impacts—including floods, fires, ecosystem disturbances, and disease outbreaks—as well as by conflicts associated with agribusiness, mining, and illegal logging.

One of the most critical challenges facing Indigenous Peoples is the lack of land regularization, territorial titling, and effective protection of ancestral territories. Across large parts of Amazonia, many communities still lack full legal recognition of their lands, while others face overlapping mining, oil, forestry, and agro-industrial concessions.<sup>39</sup> An Inter-American Development Bank (IDB) study found that irregular land tenure, together with inconsistent law

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35 Basta et al. (2021).

36 INTERPOL (2019), 12.

37 Ibid.

38 Bagolle, Costella, and Goyeneche (2023).

39 Quijano Vallejos et al. (2020).

enforcement and other enabling factors, facilitates land grabbing, illegal mining, selective logging, and related environmental crimes.<sup>40</sup> Ultimately, insecure land tenure can weaken communities' capacity to exercise territorial governance and manage natural resources sustainably. Consistent with the conservation outcomes noted earlier, legal recognition is a critical factor in maintaining these results.<sup>41</sup>

## Political economy of Amazonian degradation

Research on Amazonian development highlights how economic incentives and unequal bargaining power can concentrate benefits among better-resourced actors, while Indigenous communities and ecosystems may bear a disproportionate share of social and environmental costs. At the same time, public institutions may face significant capacity constraints in regulating and protecting the Amazon, particularly where enforcement resources are limited, governance is weak, or short-term economic priorities compete with territorial and environmental protection.

Likewise, evidence shows that less than 1% of international environmental finance between 2011 and 2020 was directed to Indigenous communities for land tenure and forest management.<sup>42</sup> This gap underscores the distance between global commitments and the financial resources needed to secure Indigenous territorial governance in practice.

### EXTRACTIVE RENTS AND THE PRESSURE ON INDIGENOUS LANDS

Illegal and quasi-legal extractive activities generate far higher returns than legal, sustainable, and small-scale economic activities. This asymmetry creates strong incentives for the occupation, transformation, and control of Indigenous territories and areas of high conservation value.

The World Bank and several regional studies have noted that rising international gold prices have driven the rapid expansion of illegal mining in the Amazon, particularly in Brazil, Colombia, and Peru. For example, in Peru, according to the Financial Intelligence Unit (UIF), reports identifying illegal mining as a possible predicate offense for money laundering involved approximately \$8.21 billion between 2012 and 2020, representing nearly 58% of the total value reported during that period.<sup>43</sup>

Over the past decade, global demand for critical minerals has grown rapidly, driven by the expansion of renewable energy and related technologies. According to the International Energy Agency, the global market for critical minerals is currently valued at more than \$300 billion and could more than double by 2035.<sup>44</sup> This rising demand for critical minerals exposes a central contradiction: while international frameworks increasingly promote the protection

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40 Lesenfants et al. (2024).

41 Stevens et al. (2014).

42 Hatcher et al. (2021).

43 Observatorio de Minería Ilegal (2024); SBS (2022).

44 Ionova (2026).

of Indigenous territories, growing demand for minerals used in renewable energy systems and related technologies is creating new extractive pressures on Indigenous lands where many of the minerals needed for that transition are located.<sup>45</sup> Brazil occupies a strategic position in this context, holding between 19% and 23% of the world's known rare earth reserves—the second largest share after China—and accounting for approximately 93% of global niobium production in 2025.<sup>46</sup> Niobium is a key mineral used in the production of lightweight, high-strength steels for energy infrastructure, gas pipelines, and aircraft engines.<sup>47</sup> Growing demand for these minerals is intensifying extractive pressures on the Brazilian Amazon, adding to existing pressures associated with gold and other mineral extraction.

Similar dynamics can be observed in the expansion of agribusiness, cattle ranching, and deforestation, driven by growing domestic and international demand for agricultural products, meat, timber, and other commodities. These markets create strong economic incentives for the occupation and transformation of Indigenous territories, particularly in areas with limited state presence.<sup>48</sup> Across large parts of the Amazon frontier, where development opportunities and access to formal economies remain limited, these activities also serve as sources of income for many Indigenous communities and rural populations, albeit within contexts marked by deep social inequalities.<sup>49</sup> As a result, commercial interests linked to global supply chains and export markets often exert greater political, institutional, and economic influence than environmental conservation goals and the protection of Indigenous rights.

## ORGANIZED CRIME

The high profits associated with extractive industries, combined with limited state presence and the geographic isolation of large parts of Amazonia, have facilitated the expansion of criminal organizations linked to illegal mining, drug trafficking, and illegal logging.<sup>50</sup> These networks can control natural resources and logistics routes and may deepen local dependence on informal or illicit economies where viable development alternatives are limited.

Violence against environmental and territorial defenders remains disproportionately concentrated in Amazonia. According to Global Witness, more than one-fifth of the 177 murders of environmental defenders recorded worldwide in 2022 occurred in the Amazon region, where at least 39 people were killed, including 11 Indigenous persons.<sup>51</sup> These figures reflect the growing intensity of conflicts associated with extractive activities and illicit economies, as well as the vulnerability of communities involved in protecting Amazonian forests. In this respect, the expansion of organized crime in Amazonia cannot be understood solely as a security challenge, but also as an expression of broader political-economic dynamics linked to territorial inequality, economic exclusion, weak governance, and competition over strategic natural resources.

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45 Owen et al. (2023).

46 Ionova (2026); U.S. Geological Survey (2026), 135.

47 Ionova (2026).

48 Quijano Vallejos et al. (2020).

49 Hanusch (2023).

50 UNODC (2023); Libertun de Duren et al. (2025).

51 Global Witness (2023).

## LAND TITLING

Land titling is one of the main priorities for Indigenous Peoples in Amazonia. However, progress in these processes remains limited due to technical, administrative, and institutional constraints, as well as complex economic and territorial dynamics associated with access to and use of strategic natural resources. From this perspective, the recognition and protection of Indigenous territories can come into tension with extractive activities and economic expansion, particularly in areas under strong mining and agro-industrial pressure.

In some contexts, competing political, economic, and territorial priorities can delay or weaken processes for recognizing and titling Indigenous lands.

In practice, territorial security does not depend solely on legal recognition or formal land titling. Many Indigenous territories remain vulnerable to invasions, illicit economies, and extractive pressures, while effective protection continues to be limited in many Amazonian contexts. For example, impact assessments of Ecuador's Socio Bosque conservation incentive program show that several Indigenous communities, despite having formal land recognition, continue to seek additional protection mechanisms against invasions and illegal activities.<sup>52</sup> These dynamics illustrate that, although titling is fundamental, it does not guarantee effective territorial security in the face of growing economic pressures on Amazonia. Therefore, territorial security requires tangible mechanisms for monitoring, control, and territorial governance, as well as sustained institutional capacity and financial investment.

Furthermore, decisions regarding land titling, land-use planning, and the recognition of collective rights are often shaped by political, economic, institutional, and territorial development priorities. A clear example is the case of Indigenous Peoples in voluntary isolation. Protecting their territories requires restricting outside access, which can conflict with economic interests seeking access to areas of high strategic and extractive value. For example, the ancestral territories of the Waorani Nation of Ecuador have historically been exposed to pressures linked to oil expansion and extractive activity in the Ecuadorian Amazon.<sup>53</sup> As a result, debates over free, prior, and informed consultation, territorial recognition, and the protection of Indigenous Peoples reflect persistent tensions between strategic use of natural resources and the territorial rights of Indigenous Peoples.

## DIVERSITY AMONG AMAZONIAN INDIGENOUS PEOPLES

Amazonia is home to more than 500 Indigenous Peoples with highly diverse sociocultural structures, languages, governance systems, levels of market integration, and territorial conditions.<sup>54</sup> Not all Indigenous communities face the same threats or possess the same institutional capacities. Some have more secure land tenure and well-established organizational structures, while others have only partial or insecure territorial rights and face limited state presence.

There are also significant differences in proximity to roads, urban centers, and extractive frontiers, including mining, hydrocarbons, logging, and agricultural expansion. These factors directly influence levels of territorial pressure, conflict, and exposure to illicit economies. Against this background, one of the main challenges for governments is to avoid one-size-fits-all approaches that treat Indigenous Peoples as a uniform category. Public policies designed without effective community participation and without considering local differences may prove ineffective or even exacerbate territorial and social tensions.

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52 Perafán and Pabón (2019); Arriagada et al. (2018).

53 IACHR (2019); Scazza and Nenquimo (2021).

54 COICA (n.d.).

# Emerging strategies and institutional innovations in Amazonia

In response to the multiple drivers of Amazonian degradation, new strategies and institutional approaches are emerging to transform traditional development models in the region. These include efforts to strengthen Indigenous territorial governance, new environmental finance and direct financing mechanisms, and Indigenous-led bio-economy approaches linked to conservation and sustainable development.

## STRENGTHENING INDIGENOUS TERRITORIAL GOVERNANCE

In Indigenous territories, positive conservation outcomes are often rooted in traditional governance systems that view natural resources not only as economic assets but also as vital to livelihoods, social organization, and cultural identity. Therefore, public policies, institutional strategies, and development programs increasingly recognize the role of Indigenous governance and support its strengthening, particularly in land-use planning, environmental monitoring, institutional capacity building, and the consolidation of self-governance systems.

Several initiatives from the region show that incorporating digital and geospatial tools into community monitoring systems can strengthen territorial surveillance, improve the detection of illegal activities, and enhance transparency in environmental management. An impact assessment conducted in Amazonian regions of Ecuador and Peru found that community monitoring supported by advanced technologies significantly increased the detection and reporting of environmental liabilities, including oil spills, compared with control groups.<sup>55</sup> In Ecuador, these findings contributed to the incorporation of specific provisions on community monitoring into the Organic Law on the Special Amazonian Territorial Circumscription.<sup>56</sup>

Furthermore, evidence suggests that technology can be integrated with traditional knowledge systems without undermining Indigenous cultural identity. The Kara Solar project financed through the IDB's Amazonia Forever program, for example, promoted river transportation systems powered by renewable energy for the Achuar Indigenous Nation in the Ecuadorian Amazon and has been recognized as a model for co-production of knowledge and technology between Indigenous communities and external partners.<sup>57</sup> Together, these experiences point to a gradual shift away from approaches focused narrowly on conservation and toward models grounded in territorial governance, Indigenous participation, and locally rooted development.

These initiatives have also strengthened the technical and negotiating capacities of Indigenous organizations in national and international decisionmaking forums. In recent years, Indigenous organizations have gone from having a limited presence in high-level global forums—such as the Conferences of the Parties (COP)—to exerting growing influence in international debates on environment, biodiversity, and development. This process has been supported by multilateral organizations, governments, nongovernmental organizations, and international cooperation programs that have expanded funding, technical assistance, and opportunities for direct participation for Indigenous Peoples and local communities.

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<sup>55</sup> International Initiative for Impact Evaluation (2020).

<sup>56</sup> Ibid.

<sup>57</sup> Vila-Viñas, Crespo, and Martens (2020); see more on the Kara Solar project at <https://karasolar.com/our-story-1>.

For example, at the 16th Conference of the Parties (COP16) to the Convention on Biological Diversity (CBD), held in Cali, Colombia, in 2024, parties agreed to establish the Cali Fund to channel resources derived from the use of genetic resources toward biodiversity conservation and support for Indigenous Peoples and local communities.<sup>58</sup> This reflects not only the stronger institutional and governance capacity of Indigenous organizations, but also their growing ability to influence and directly shape global financing and environmental governance mechanisms that are better aligned with Indigenous Peoples' priorities, ways of life, and knowledge systems.

## NEW FINANCIAL MECHANISMS

Several financial mechanisms aimed at conservation and emissions reduction, including payments for environmental services (PES) and Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD+), have faced challenges related to governance, benefit sharing, and long-term financial sustainability.<sup>59</sup> In many cases, these programs were designed primarily to maximize environmental outcomes, while social, territorial, and institutional dimensions affecting Indigenous Peoples were treated as secondary considerations or co-benefits. In some contexts, this approach limited local ownership, long-term sustainability, and the effective strengthening of Indigenous territorial governance.

Likewise, questions have been raised about the additionality of some programs, as many Indigenous territories keep forests standing even without financial incentives because of the forests' intrinsic value to livelihoods, social organization, and cultural identity.

In response, new financial mechanisms combine environmental objectives with institutional strengthening, poverty reduction, Indigenous participation, bioeconomy initiatives, and development with identity. For example, programs such as Socio Bosque in Ecuador, Bolsa Floresta in Brazil, and the Low Carbon Development Strategy in Guyana have combined conservation incentives with social investment, organizational strengthening, and support for sustainable livelihoods.<sup>60</sup>

Concurrently, larger-scale financial instruments are emerging to mobilize capital toward both environmental and social objectives. For instance, the Amazonia Bond Issuance Guidelines, promoted by the IDB and the World Bank, seek to channel resources toward conservation, forest restoration, bioeconomy initiatives, and sustainable development in Amazonia.<sup>61</sup> Unlike traditional green bonds, they combine environmental, social, and governance objectives, including social safeguards and Indigenous participation. The guidelines for their issuance were developed through consultations with governments, Amazonian Indigenous organizations from eight countries, financial institutions, and civil society organizations, and they include criteria related to transparency, participation, and benefit sharing.<sup>62</sup>

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58 CBD (2024).

59 See more on REDD+ at <https://unfccc.int/topics/land-use/workstreams/redd/what-is-redd>; Nyengere et al. (2026); Le et al. (2024).

60 See more on Socio Bosque at <https://doi.org/10.18235/0001451> and <https://www.ambienteyenergia.gob.ec/ambiente/programa-socio-bosque/>; see more on Bolsa Floresta at <https://www.amazonfund.gov.br/en/projeto/Forest-Assistance-Program-/>; see more on the Low Carbon Development Strategy at <https://lcds.gov.gy/>.

61 Hajek, Amoa, and Killeen (2025).

62 Ibid.

In addition, the Amazon Biocorridor Fund is a recent debt-for-nature swap mechanism launched by Ecuador with support from the IDB, the U.S. International Development Finance Corporation, The Nature Conservancy, and other financial partners.<sup>63</sup> The initiative is expected to channel approximately \$460 million toward forest and wetland conservation, strengthening protected areas, protecting rivers, and supporting Indigenous Peoples and local communities.<sup>64</sup> By design, this instrument addresses the limitations of previous models by integrating conservation with Indigenous governance, local development, and sustainable livelihoods, reflecting a broader shift toward more integrated approaches to innovative finance.

Another emerging global initiative launched at COP30 is the Tropical Forest Forever Facility (TFFF). Led by Brazil, the TFFF aims to provide countries with stable, long-term, results-based financing for the verified conservation of nearly 1 billion hectares of tropical and subtropical broadleaf forests across 70 countries.<sup>65</sup> Its principal innovation lies in combining public and philanthropic contributions with private capital and using investment returns to finance conservation payments. The facility also commits to directing at least 20% of its resources to Indigenous Peoples and local communities living in these high-value ecosystems.<sup>66</sup> By the end of 2025, approximately \$6.7 billion had been pledged toward a total capitalization target of \$125 billion.<sup>67</sup>

## INSTITUTIONAL INNOVATIONS AND DIRECT FUNDING

Recent changes in Amazonian governance have also been accompanied by institutional innovations within multilateral organizations and international financing mechanisms. In recent decades, institutions such as the IDB have progressively incorporated specific policies, safeguards, and mechanisms for engagement with Indigenous Peoples, largely in response to the growing advocacy and participation of Indigenous organizations. This approach has encouraged more direct forms of dialogue, consultation, and participation that extend beyond minimum compliance with environmental and social safeguards and standard project management procedures.

It has also contributed to the development of financing and cooperation mechanisms with greater Indigenous participation in setting priorities and in program implementation and monitoring, gradually strengthening direct representation, territorial governance, and the institutional capacities of Amazonian Indigenous organizations.

This procedure is reflected in recent initiatives such as the IDB's Amazonia Forever program, in which Indigenous Peoples and their organizations moved from a primarily consultative role to more direct participation in setting priorities related to the bioeconomy, finance, territorial monitoring, and environmental governance.<sup>68</sup> The program explicitly incorporated the inclusion of Indigenous Peoples as a cross-cutting priority and developed direct financing mechanisms in partnership with Indigenous organizations such as COICA and other Amazonian organizations.<sup>69</sup>

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63 Fondo Biocorredor Amazónico (n.d.).

64 IDB (2024).

65 Tropical Forest Forever Facility (n.d.).

66 Ibid.

67 UNFCCC (2025); see more on TFFF at <https://tfff.earth/>.

68 IDB (n.d.-a).

69 Ibid.

The IDB and COICA's Amazonia for Life Fund, for example, was designed to finance bioeconomy initiatives developed and implemented directly by Indigenous organizations, reducing reliance on external technical intermediaries.<sup>70</sup> Mechanisms of this kind respond to longstanding demands from Indigenous Peoples for more direct access to international financing and seek to address persistent barriers to financial inclusion.<sup>71</sup>

70 See more on the Amazonia for Life Fund at <https://www.amazoniaforlife.fund/>.

71 COICA (2021).

## BOX 5.2

### Institutional innovation at the Inter-American Development Bank (IDB)

"In 2023, the Inter-American Development Bank's Amazonia Forever program launched MINGA, an institutional initiative aimed at strengthening direct financing, participation, and self-determination among Amazonian Indigenous Peoples.

The initiative is structured around three main components. The first is the MINGA team itself, composed primarily of Indigenous professionals working within the IDB Amazonia Forever Coordination Unit who support Indigenous, Afro-descendant, and traditional community organizations in identifying priorities, co-designing projects, and navigating approval, implementation, and monitoring processes. At the operational level, the initiative also promotes the hiring of Indigenous consultants with knowledge of local contexts, languages, and territorial governance systems.

The second component is the incorporation of Indigenous organizations as IDB implementing agencies. This approach seeks to strengthen technical, administrative, and operational capacities so that these organizations can manage resources from multiple donors without relying on external technical intermediaries.

The third component is continuous and proactive dialogue with grassroots Indigenous organizations. This dialogue goes beyond the formal consultation processes required by law or policies, or by minimum safeguard standards and instead seeks to create meaningful spaces for participation throughout the project cycle. The objective is to support the development of joint solutions, agreements, and adjustments while ensuring that initiatives remain aligned with the priorities, needs, and timelines of Indigenous organizations themselves. These projects are financed primarily through two Amazonia Forever funds. The first is the Amazon Bioeconomy and Forests Management Multi-Donor Trust Fund (AMDTF), supported by Germany, Italy, the Netherlands, Switzerland, and the United Kingdom. The second is the Amazon Bioeconomy Fund, a regional program financed by the Green Climate Fund. Although the initiative is recent, it has begun to support direct financing and capacity-building arrangements with Indigenous organizations."<sup>\*</sup>

In 2024, the Interethnic Association for the Development of the Peruvian Rainforest (AIDESEP), which represents more than 2,439 Indigenous communities, became the first Indigenous organization to manage \$1 million in direct financing for the implementation of bioeconomy projects and Indigenous life plans in the Peruvian Amazon. Similarly, in 2025, comparable financing initiatives were approved for organizations such

\*Drawn from Acioli et al. (2025) in Galindo, Giles Álvarez, and Rocha (2025).

as the Confederation of Indigenous Nationalities of the Ecuadorian Amazon (CONFENIAE) and the Coordination of Indigenous Organizations of the Brazilian Amazon (COIAB). By 2027, direct financing mechanisms are expected to benefit the main Indigenous organizations across the eight Amazonian countries.

The process faces some challenges, including ongoing consultation processes, continuous operational training, and mechanisms for addressing complaints and grievances. However, one of its main outcomes has been to strengthen trust, local ownership, and project sustainability, while also demonstrating the capacity of Indigenous organizations to manage large-scale financial resources without external intermediation.

This approach is consistent with the IDB's efforts to strengthen engagement with Indigenous Peoples as strategic partners and to expand appropriate direct-financing mechanisms for Indigenous organizations and communities.

The process has also generated important institutional lessons for the IDB, particularly regarding the need to make operational procedures more flexible and adaptable to better support the design and implementation of projects developed in partnership with Indigenous organizations.

**SOURCES:** Acioli et al. (2025) as seen in Galindo, Giles Álvarez, and Rocha (2025); Forest Peoples Programme (n.d.); IDB (n.d.-c); the IDB project database can be found at <https://www.iadb.org/es/project-search>.

## BIOECONOMY AND INDIGENOUS ECONOMY

Various conceptual frameworks developed by Amazonian Indigenous Peoples are increasingly being incorporated into debates on conservation and sustainable development in the region. One of the most relevant is the concept of the Indigenous economy. While contemporary approaches to the bioeconomy emphasize the sustainable use of biological resources to promote innovation and economic activity, the Indigenous economy complements these approaches by incorporating collective and community well-being, as well as the protection of ecosystems and territories that sustain Indigenous livelihoods. In this way, it offers a broader perspective on sustainability.

The economies of Amazonian Indigenous Peoples are closely linked to traditional livelihoods based on forests, biodiversity, land, and other natural resources. They also depend on traditional knowledge systems and skills related to hunting, fishing, gathering, agriculture, and craftsmanship, as well as community organization and local commercial networks. Many Indigenous communities produce food, fibers, oils, non-timber forest products, and other bioproducts used in sectors such as food production, pharmaceuticals, cosmetics, tourism, and construction. Their territories also deliver ecosystem services of local and global significance, including biodiversity conservation, carbon sequestration, landscape preservation, and water regulation.

In this context, the Indigenous economy can be understood as a system grounded in the traditional knowledge, practices, values, and principles that shape Indigenous communities' relationships with ecosystems and the sustainable use of biological resources. From this perspective, Indigenous economies may offer important opportunities to promote more sustainable development pathways in Amazonia and diversify the region's prevailing economic model.

Both the bioeconomy and the Indigenous economy are increasingly viewed as approaches with significant potential for promoting sustainable development in Amazonia. For example, a World Resources Institute analysis suggests that the Brazilian Legal Amazon could achieve stronger economic outcomes under a low-carbon development pathway. By 2050, GDP could reach about \$268 billion if emissions and deforestation are brought under control, compared with \$260 billion under the current economic model (2020 values), a difference of roughly \$8 billion.<sup>72</sup> The study also estimates that this pathway could reduce emissions by 94% and create around 312,000 jobs.<sup>73</sup> Together, these projections suggest that a bioeconomy-based development model could deliver economic gains while also reducing emissions and expanding employment opportunities.

## Implications for sustainable development priorities

The evidence presented in this chapter invites a broader reflection on the role of Indigenous Peoples and their governance systems in the long-term global environment and sustainable development agenda. Indigenous territories maintain high levels of ecosystem integrity, store carbon, protect biodiversity, and regulate water systems, generating benefits that extend well beyond Amazonia and carry global significance. Indigenous territorial governance therefore has direct implications for sustainable development priorities, particularly related to environment stability, terrestrial ecosystems and biodiversity conservation, reduced inequalities, water security, and institutional governance.

Achieving these objectives, however, requires a fundamental shift in how global frameworks engage with Indigenous Peoples. A central issue for a long-term agenda is whether these frameworks can move beyond treating Indigenous Peoples primarily as “vulnerable populations” or “beneficiaries of environmental policies,” and instead recognize them as strategic governance partners with decisionmaking capacity and direct fiduciary authority. In practice, Indigenous Peoples are among the actors best positioned to implement tangible measures for ecosystem protection, territorial governance, and long-term sustainability.

A second implication concerns the need to strengthen governance models that more effectively integrate conservation and development objectives. In the Amazon—and in other regions of the world—pressures associated with extractive economies, global markets, organized crime, and weak institutions require strategies that connect conservation with social inclusion, territorial governance, and sustainable development. In this context, emerging mechanisms related to finance for the environment, direct financing, and Indigenous economies should be understood not only as environmental instruments, but also as strategies for strengthening ecological and socioeconomic resilience, institutional capacity, and territorial stability.

This shift also has implications for the institutions that finance and support implementation. Effective implementation will require institutional change within financing agencies themselves. Many existing procedures, including fiduciary requirements, safeguards, procurement rules, reporting systems, and administrative timelines, were designed primarily for governments, large nongovernmental organizations, or consulting firms. Consequently, they often create technical and operational barriers to more direct engagement with Indigenous organizations. If Indige-

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<sup>72</sup> Nobre et al. (2023), 23.

<sup>73</sup> Ibid., 15.

nous organizations are to serve as meaningful implementation partners, financing agencies will need to adapt their processes to Indigenous Peoples' territorial, institutional, and cultural realities. Too often, the burden of adaptation has fallen on Indigenous Peoples, who are expected to fit into externally designed systems. The IDB's work in the Amazon region shows that a different approach is possible: one based on co-design, institutional strengthening, technical support, more appropriate financing mechanisms, and implementation arrangements grounded in Indigenous governance.

Implementation, however, remains a central challenge. Although global frameworks, national laws, and public policies already incorporate broadly accepted principles regarding the importance of protecting Indigenous territories, effective enforcement at the local level remains weak. Moreover, several sustainable development priorities continue to be pursued in sectoral and fragmented ways, creating the risk of tensions or contradictory outcomes, as illustrated by some clean energy adoption efforts that produce unintended impacts in Indigenous territories. Accordingly, the implementation of conservation and development measures requires stronger institutional coordination, sustained territorial monitoring, and clearer accountability mechanisms.

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## **PART II**

# How to incentivize change



## SIX

# ALIGNING NATURE, FINANCE, AND DEVELOPMENT: INNOVATIONS FOR THE TRIPLE CRISIS

Arend Kulenkampff and Julie McCarthy

## Nature at the center of the triple crisis

Low- and middle-income countries (LMICs) are confronting a convergence of crises that are no longer separable in policy or finance: accelerating nature loss, intensifying climate shocks, and rising sovereign debt burdens.

Nature now sits at the center of the “triple crisis” because the same economic choices that deepen debt vulnerabilities are also accelerating climate shocks and ecosystem breakdown—and in LMICs these pressures collide directly in fiscal space and sovereign risk. As of 2026, there is at least a 70% probability that the five-year global mean temperature for 2025-2029 will exceed 1.5°C above pre-industrial levels, underscoring how close the world is to sustained climate overshoot.<sup>1</sup> At the same time, global financial flows continue to drive environmental decline: The “State of Finance for Nature” report by the United Nations Environment Programme (UNEP) estimates \$7.3 trillion per year in nature-negative finance flows in 2023, roughly 30 times larger than finance directed toward nature-based solutions.<sup>2</sup>

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<sup>1</sup> World Meteorological Organization (2025).

<sup>2</sup> UNEP (2026).

While debt burdens have risen, development finance has retreated. The World Bank reports that developing countries paid out \$741 billion more in debt service than they received in new financing over 2022-2024—the largest gap in 50 years—and net public flows turned negative in 2023-2024.<sup>3</sup> Once estimated illicit financial flows, conservatively in the hundreds of billions a year, are added to debt service, outflows of public and illicit capital exceed what arrives through aid and new lending, even as development needs escalate.<sup>4</sup>

The 2024 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) “Nexus Assessment” shows it is critical to recognize that the current debt, biodiversity, water, food, health, climate, and overall inequality crises are deeply interconnected and that siloed policy responses risk undermining each other.<sup>5</sup> Climate change and ecosystem degradation undermine growth, fiscal stability, and export performance. Higher risk perceptions raise borrowing costs, compress fiscal space, and discourage investment in resilience, particularly for LMICs. Debt distress, in turn, limits governments’ ability to invest in the natural capital that underpins long-term development.

This “triple crisis” is increasingly recognized in global policy discourse, from the Bridgetown Initiative to the Expert Review on Debt, Nature and Climate.<sup>6</sup> Nonetheless, the global financial architecture has been slow to adapt. Sovereign risk assessments, debt sustainability analyses, and capital market instruments continue to treat nature largely as an externality or downside risk, rather than as a productive asset capable of strengthening macro-fiscal resilience.

And yet, ecological degradation is no longer a peripheral or future risk. It is already embedded in the system and now actively manifesting as:

- fiscal stress at national and subnational levels
- rising insurance losses and market withdrawal
- rising credit losses and de-banking
- macroeconomic volatility and repricing of assets
- supply chain disruptions and revenue at risk
- constraints on and disruption of development and growth pathways

Treating nature as niche is simply no longer credible economics—rather, nature is increasingly recognized as core economic and financial infrastructure. This chapter explores how innovative finance for nature offers a practical pathway to realign incentives across the environment, the financial system, and the real economy to reflect this reality.

This chapter argues that the core challenge is not a shortage of capital but a failure of translation: The gains from investing in natural capital cannot yet travel through the decision systems that govern sovereign creditworthiness, debt sustainability, and market access. Until they can, nature-positive investments will remain fiscally invisible—competing for scarce budget resources rather than strengthening the fiscal position of the countries that make them. This failure is directly relevant to the post-2030 development agenda: a successor framework that does not resolve it will reproduce the same structural gap as the Sustainable Development Goals (SDGs)—goals without the

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3 World Bank (2025c), xi; see also World Bank (2025b); ONE Campaign (2026); and Harcourt et al. (2025).

4 Tax Justice Network (2024). The report estimates global losses to cross-border tax abuse at approximately \$492 billion annually, with lower-income countries bearing the heaviest losses relative to their tax revenues.

5 IPBES (2024).

6 See more on the Bridgetown Initiative at <https://www.bridgetown-initiative.org/>; Expert Review on Debt, Nature and Climate (2025).

financial architecture to reach them. Innovative finance for nature is beginning to show how this translation can be built: through instruments that link performance to credibility, mechanisms that embed resilience into debt and risk frameworks, and country platforms that connect landscape-level outcomes to sovereign balance sheets. The innovations examined here are not peripheral to the next development framework—they are a precondition for it.

The chapter proceeds as follows: The first two establish why nature is macro-critical for LMICs and how the debt-nature feedback loop operates, illustrated through Uganda’s work on resilience-adjusted sovereign finance. Then, the chapter examines the main instruments now in use: sustainability-linked bonds and debt swaps, climate-resilient debt clauses, sustainability-linked insurance, and the role of central banks in treating nature as a systemic risk. Next, the chapter moves to landscape and market-level mechanisms—payments for ecosystem services, biodiversity credits, nature as infrastructure, and the bioeconomy as a structural development strategy. The remaining sections take up the challenge of embedding nature into credit risk frameworks, and address the risks of poor design, fragmentation, and niche confinement—and the guardrails needed to avoid them. The conclusion draws out what it would take to move from pilot innovation to the institutional change required for nature to function as a foundation of resilient development in a post-2030 agenda.

## Why nature matters for development finance

### NATURE AS A MACRO-CRITICAL ASSET

For many LMICs, natural capital is not peripheral to the economy—it is foundational. Agriculture, forestry, fisheries, tourism, hydropower, and bio-based industries account for a large share of employment, exports, and fiscal revenues. Degradation of ecosystems therefore transmits directly into macro-fiscal stress through multiple channels: lower growth, higher volatility, balance-of-payments pressures, and increased contingent liabilities from disasters. Making nature “macro-critical” is not merely a rhetorical device: It would mean, concretely, that nature-related risk and resilience factors enter debt sustainability and sovereign credit analyses, that sovereign credit ratings methodologies factor in the vital role of ecosystem services as foundations of economic dynamism, resilience, and export competitiveness, and that natural capital appears in public investment programming and national fiscal frameworks alongside conventional infrastructure. The chapter’s instruments should be evaluated against this standard.

Mainstream financial analysis has to date largely treated nature in asymmetric terms: Climate and environmental hazards are increasingly modeled as risks, but interventions that reduce those risks are not recognized in a proportionate or systematic way. This creates a structural bias and disincentive: Governments and companies are penalized for vulnerability but not rewarded for active steps to improve resilience.

Recent analytical work highlights how this asymmetry influences cost of capital calculations, both quantitatively as well as qualitatively.<sup>7</sup> Quantitative stress tests can now simulate how nature loss scenarios impact risk metrics at the country, portfolio, and counterparty levels.<sup>8</sup> Qualitative factors such as governance and institutional strength play a decisive role in credit ratings, yet these factors are often assessed through evaluation criteria and indicators

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<sup>7</sup> NatureFinance (2026).

<sup>8</sup> Lewsey (2022); ECB (2026).

that generally fail to capture the resilience-enhancing effects of environmental policies. As a result, countries that invest in nature-based solutions may see no benefit in terms of creditworthiness and borrowing costs, even when those investments are materially reducing long-term financial and fiscal risk in practice.

## THE DEBT–NATURE FEEDBACK LOOP

The interaction between sovereign debt distress and nature loss is not incidental. Fiscal constraints delay investment in land restoration, watershed protection, and climate-resilient agriculture. Environmental degradation then increases exposure to floods, droughts, and commodity shocks, raising future fiscal costs and the prospect of major economic shocks. This feedback loop is particularly visible in countries where soft commodities—particularly vulnerable sectors in a rapidly warming world—dominate foreign exchange earnings.

Uganda provides a clear illustration of this dynamic (see more in box 6.1). Climate variability and land degradation threaten agricultural productivity and export performance, while high debt burdens and rising debt service costs limit the fiscal space for investment in adaptation and resilience. Recent work shows that targeted investments in climate- and nature-resilient agro-industrialization could increase medium-term growth while reducing macroeconomic volatility—yet these benefits are largely invisible in conventional risk pricing and credit assessment frameworks.<sup>9</sup> Breaking this loop requires mechanisms that can translate proactive resilience into improved creditworthiness.

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<sup>9</sup> Uganda, Ministry of Finance (2026).

## BOX 6.1

# Uganda as a proof point: Making nature and resilience macro-critical

Uganda illustrates how investments in nature and climate resilience can be reframed from unmitigated fiscal costs into macro-critical credit strengths—if they are made visible within debt and credit frameworks.

Like many low-income countries, Uganda faces tightening fiscal space from rising global interest rates and elevated debt burdens. At the same time, its economy remains highly exposed to climate variability and ecosystem degradation, particularly in agriculture, which underpins growth, exports, and livelihoods. Sovereign risk assessments by credit ratings agencies and international financial institutions capture these vulnerabilities on top of the budgetary outlays on climate-proofing infrastructure and regenerative agriculture, but they understate the stabilizing effects of these measures.

To address this asymmetry, Uganda is pioneering a key performance indicator (KPI)-tagging approach to macro-fiscal planning and public financial management that explicitly connects sector-level projects and programs to improved macro-fiscal outcomes. The approach operates across three levels. National-level KPIs embed resilience priorities—such as climate-smart agriculture and ecosystem restoration—into fiscal and development strategies. Program and project KPIs verify delivery on the ground, shifting assessments from policy intent to demonstrated performance. Macro-fiscal KPIs then translate these outcomes into impacts on growth, volatility, external balances, and debt dynamics, making resilience financially material for IMF debt sustainability analysis and sovereign credit rating assessments.

Initial modeling has estimated the reduction in expected losses for 100-year flood and drought events under future climate conditions in terms of GDP impacts and knock-on effects on debt sustainability and credit metrics. Preliminary analysis indicates that combined adaptation and resilience measures across both hazards preserve 0.76 percentage points of GDP during severe climate years and keep public debt's present value about 1.1-1.2 percentage points of GDP lower than it would be without mitigation throughout the projection period. These initial findings capture only the quantitative impacts of the modeled shocks; hence, the uplift is likely to be much greater once other sectors, transmission channels, and qualitative factors are taken into account.

By converting resilience performance into measurable, verifiable evidence, Uganda demonstrates how nature-positive investments can improve credit narratives rather than compete with them for scarce fiscal space—offering a practical blueprint for aligning nature, development, and sovereign finance in debt-constrained settings.

**SOURCE:** Uganda, Ministry of Finance (2026), vi. Results are preliminary; full analysis incorporating chronic climate effects is forthcoming.

# From risk to resilience: Innovations in sovereign and public finance

## SUSTAINABILITY-LINKED SOVEREIGN FINANCING

Sustainability-linked financing (SLF) aims to reorient sovereign debt markets toward measurable climate, nature, and development outcomes. At its core are sustainability-linked bonds (SLBs) and sustainability-linked loans (SLLs), where sovereign issuers commit to defined sustainability targets—with financial terms such as interest margins or pricing linked to achieving those KPIs.<sup>10</sup> SLBs and SLLs complement “use-of-proceeds” instruments by introducing performance-based financial incentives: Rather than earmarking funds for specific projects, they link financing terms to the achievement of agreed sustainability targets or KPIs.

For sovereigns, this shift is particularly important. It allows governments to integrate sustainability goals directly into core fiscal planning and debt management strategies, rather than treating them as isolated projects or ancillary objectives. Côte d’Ivoire’s “Sustainability-Linked Financing Framework” demonstrates how nature-relevant KPIs—such as improved forest cover and increased renewable energy capacity—can be embedded in sovereign financing with transparent reporting structures and third-party verification (see box 6.2). There have been several examples of SLBs to date such as Chile and Uruguay.<sup>11</sup>

Beyond these, debt-for-nature swaps—in which a portion of a country’s external obligations is restructured or repurchased at a discount in exchange for locally funded environmental investment commitments—are re-emerging as mechanisms that link debt relief with conservation and climate action.<sup>12</sup> Examples include transactions in Belize and Barbados that redirect savings toward marine protection and resilience, and multilateral efforts such as the Global Hub on Debt for Development Swaps launched with support from Spain and the World Bank to scale such approaches.<sup>13</sup> Recent analysis suggests that pairing SLBs, SLLs, and debt swaps with credit enhancement tools like guarantees or credit risk insurance could reduce perceived risk, attract private capital, and make sustainability-linked sovereign financing more scalable and impactful.<sup>14</sup>

Crucially, sustainability-linked instruments can create a credible signaling mechanism. When KPIs are well designed and independently verified—through a debt restructuring or a new SLB issuance—they provide forward-looking information to investors and rating agencies about policy commitment, institutional capacity, and delivery performance, both on nature and climate specifically, and on broader fiscal governance. However, while issuance of such instruments remains relatively small-scale and sporadic, the signals are not yet strong enough to shift risk perceptions and pricing. Realizing that potential also hinges on complementary changes in sovereign risk measurement and

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10 NatureFinance (2023).

11 OECD (2024).

12 Whiting (2024).

13 Nature Conservancy (2022); Inter-American Development Bank (n.d.); World Bank (n.d.).

14 Task Force on Credit Enhancement for Sustainability-linked Sovereign Financing (2025).

pricing methodologies, including updates to the World Bank-IMF debt sustainability analysis frameworks for LMICs and market access countries.<sup>15</sup> Credit ratings agencies will need to accord greater weight to resilience and adaptation policies in their rating criteria, and look past their short time horizon to see the positive medium-term impacts that such interventions have on credit profiles.<sup>16</sup> Hence, the signaling potential is real, but it remains largely unrealized in operational terms.

## BOX 6.2

# Côte d'Ivoire's 'Sustainability-Linked Financing Framework': Nature performance meets sovereign finance

Côte d'Ivoire provides one of the most advanced examples of how nature-related performance can be embedded directly into sovereign financing terms.

Building on earlier green and social bond issuances, the government introduced a Sustainability-Linked Financing Framework that links borrowing costs to performance on clearly defined climate and nature indicators. The framework focuses on two macro-critical sectors. In energy, a KPI tracks the share of non-hydro power renewable energy in installed electricity capacity, supporting energy security and climate resilience. In forestry, KPIs track gross forest cover loss and gain, addressing deforestation risks that threaten exports, rural livelihoods, and long-term growth.

What distinguishes Côte d'Ivoire's approach is not only KPI selection but the supporting credibility infrastructure. Targets are aligned with national strategies and Nationally Determined Contributions, assessed for ambition and feasibility, and underpinned by robust monitoring, reporting, and verification systems using geospatial data. The financing structure incorporates both interest rate step-ups and step-downs, penalizing underperformance while explicitly rewarding overachievement.

By explicitly linking forest and energy outcomes to the cost of capital, Côte d'Ivoire's SLF Framework operationalizes the principle that natural capital stewardship strengthens sovereign creditworthiness. It demonstrates how sustainability-linked instruments can move beyond signaling to become incentive-compatible tools, aligning investor returns with nature-positive development outcomes and offering a scalable model for other nature-rich LMICs.

**SOURCE:** World Bank (2025a).

<sup>15</sup> World Bank (2026a; 2026b).

<sup>16</sup> NatureFinance (2026).

## CLIMATE- AND NATURE-RESILIENT DEBT CLAUSES

Climate-resilient debt clauses (CRDCs)—sometimes called debt pause clauses—address a different dimension of the triple crisis: liquidity shocks that tend to follow natural disasters.<sup>17</sup> These clauses allow temporary suspension of debt service after predefined climate events, providing fiscal breathing space without triggering default. They are not a solution in and of themselves, but they are an important enabler for more structural reforms—preserving the fiscal capacity and policy credibility that sustainability-linked instruments require to function.

Recent experience shows that, when included ex ante into debt contracts and under certain strict conditions, CRDCs can avoid being treated as credit negative by rating agencies and can even enhance resilience by reducing the likelihood of destabilizing ratings downgrades and disorderly defaults. While CRDCs do not directly finance nature investments, they complement sustainability-linked instruments by protecting fiscal space during shocks that can derail progress on achieving their performance targets. Efforts like the London Coalition on Sustainable Sovereign Debt, launched by the U.K. government around the 2025 U.N. Financing for Development Conference, are seeking to advance innovations in new debt contracts, including expanded CRDCs as well as new Majority Voting Provisions, to promote transparency, more orderly restructurings, and more resilient borrowing frameworks.<sup>18</sup>

## CREDIT ENHANCEMENT AND BLENDED STRUCTURES

For many LMICs, the challenge is not willingness to adopt performance-linked instruments, but rather, accessing markets on affordable terms. Credit enhancement—through the provision of guarantees, insurance, or concessional capital by development finance institutions—is another important enabler that can play a catalytic role for structural solutions.

Recent analysis suggests that credit-enhanced sustainability-linked sovereign transactions could refinance tens of billions of dollars in existing debt while embedding climate and nature performance into financing terms (see box 6.3 for more information).<sup>19</sup> By reducing risk for private investors, these structures can crowd in capital at scale, provided governance and monitoring systems are robust.

## CENTRAL BANKS AND NATURE AS A SYSTEMIC RISK

There is growing acknowledgment among central banks and financial supervisors that nature degradation carries macro-critical financial risks that cannot be separated from climate risks. Research such as Nicola Ranger’s 2023 “The Green Scorpion” study for the Network for Greening the Financial System (NGFS) demonstrated that nature and climate risks interact strongly with complex feedback, creating nonlinearities and tipping points that significantly underestimate actual risks when assessed in isolation.<sup>20</sup> The NGFS subsequently published a conceptual framework in 2024 establishing a three-phase risk assessment framework to help central banks identify sources of physical and transition risks, assess economic impacts, and evaluate risks to the financial system, while acknowledging that existing models persistently underestimate nature loss consequences.<sup>21</sup> Subsequent work on nature-re-

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17 Sustainable Sovereign Debt Hub (2025).

18 Singla (2025).

19 Task Force on Credit Enhancement for Sustainability-linked Sovereign Financing (2025).

20 Ranger (2023).

21 Network for Greening the Financial System (2024).

lated stress tests for the U.K. found that there could be a 12% loss to U.K. GDP as a result of nature degradation, and when nature-related risk amplifications are incorporated into climate scenarios, the overall impact of climate change on the U.K. economy is estimated to double beyond present NGFS forecasts.<sup>22</sup>

Pioneering integrated scenario work is now being directly undertaken by leading central banks such as the European Central Bank (ECB), further reinforcing the material consequences of treating climate and nature risks separately. A collaborative project between the ECB, Potsdam Institute for Climate Impact Research, NatureFinance, and the University of Minnesota published results in late 2024 showing that climate-only policy scenarios fail to safeguard biodiversity while presenting significant economic risks to the agricultural sector.<sup>23</sup> The direction of travel is clear: Nature risk is shifting from peripheral concern to core prudential requirement, with central banks increasingly exploring integrated climate-nature scenarios, standardized disclosure frameworks, and stress testing protocols that recognize financial stability depends on ecological stability.

### BOX 6.3

## MDB Task Force on Credit Enhancement for Sustainability-Linked Sovereign Financing for Nature and Climate report

The Task Force on Credit Enhancement for Sustainability-Linked Sovereign Financing for Nature and Climate report examines how credit enhancement mechanisms can support sovereign sustainability-linked financing, particularly in emerging markets and developing economies. The report identifies barriers—such as high cost of capital, limited track records for nature-related instruments, and uneven investor understanding—and outlines specific ways credit enhancement can address them. These include expanding partial credit guarantees to reduce lender risk; using risk insurance and first-loss facilities to improve credit profiles for bonds linked to climate and nature targets; standardizing performance measurement and reporting frameworks to increase investor confidence; and integrating credit enhancement more systematically into debt structuring and refinancing operations to lower borrowing costs. The Task Force also suggests enhancing coordination among multilateral development banks, regional financiers, and bilateral partners to make these tools more accessible and strengthening sovereign capacity for designing and monitoring sustainability-linked instruments. Taken together, these recommendations aim to make financing for nature and climate outcomes more feasible within constrained sovereign debt environments.

**SOURCE:** Task Force on Credit Enhancement for Sustainability-linked Sovereign Financing (2025).

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<sup>22</sup> Green Finance Institute (2024).

<sup>23</sup> NatureFinance (2024a).

# Beyond sovereigns: Nature finance at multiple scales

## PAYMENTS FOR ECOSYSTEM SERVICES AND NATURE CREDITS

At subnational and landscape levels, payments for ecosystem services (PES) and emerging nature credit markets offer mechanisms to reward stewardship directly. These instruments create revenue streams linked to measurable ecological outcomes—such as carbon sequestration, watershed protection, wildlife protection and/or biodiversity conservation.

Costa Rica’s decades-old PES program through its national forest financing fund, FONAFIFO, has become the gold standard, having reversed deforestation with forest cover now at nearly 60% (up from 40% in 1987).<sup>24</sup> The U.K.’s Environmental Land Management scheme has become one of the most significant PES expansions in Europe, with U.K. agri-environment payments reaching approximately £1.121 billion in 2024—a 51% increase from 2023—as England transitioned away from EU-era farm subsidies toward rewarding farmers for delivering biodiversity, carbon, and water-quality outcomes.<sup>25</sup> Alongside this, the mandatory Biodiversity Net Gain was introduced in England in February 2024, requiring developers to produce at least a 10% net gain in biodiversity.<sup>26</sup>

Globally, the number of forest carbon PES schemes has grown substantially, with over 710 active forest carbon programs recorded by 2024, up from roughly 550 such schemes in 2018, reflecting continued momentum especially tied to voluntary carbon markets and biodiversity commitments made after the Conference of the Parties.<sup>27</sup> The Organisation for Economic Co-operation and Development (OECD) reported in 2025 that biodiversity-positive subsidies and PES are gaining traction across member countries, though a striking funding gap remains: From 2021 to 2023, less than 0.6% of \$295 billion in annual agricultural support across 54 countries was directed toward environmental public goods like biodiversity, underscoring the scale of reform needed.<sup>28</sup> In the Global South, climate finance has helped drive community-based PES expansions, particularly in African rangelands and forest zones, with new projects in Uganda, Tanzania, and elsewhere aiming to bundle carbon storage with livelihood benefits, though insecure land tenure remains a persistent barrier to scale.<sup>29</sup>

Biodiversity credit markets are another possible mechanism to address the estimated \$700 billion annual financing gap for nature conservation, though they remain nascent with global sales totaling only \$8 million to date.<sup>30</sup> The International Advisory Panel on Biodiversity Credits, launched by the U.K. and France in June 2023, released its first framework at COP16 in October 2024, establishing principles for “high-integrity” credits that prioritize Indigenous Peoples and local communities as co-owners and participants, with 31 pilot projects now underway across 21 countries.<sup>31</sup> On the ground, Colombia’s Terrasos has emerged as a pioneer, having sold \$7 million in biodiversity credits through its Habitat Banks model, which now spans almost 6,000 hectares of preserved or restored ecosys-

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24 UNFCCC (n.d.).

25 Nemar (2025).

26 United Kingdom, Department for Environment, Food & Rural Affairs (2023).

27 UN Forum on Forests Secretariat (2025).

28 OECD (2025), 21.

29 Wunder et al. (2012).

30 Deutz et al. (2020), 13; World Economic Forum (2023), 5.

31 Terrasos (n.d.); International Advisory Panel on Biodiversity Credits (2024), 8.

tem managed for at least 20 years with technical, financial, and legal guarantees, using blockchain technology for transparency.<sup>32</sup> NatureFinance’s Africa biocredit scoping study identified over 30 biodiversity credit projects across the continent representing an “unmatched range of investment opportunities” across diverse ecosystems beyond what carbon markets offer, though the report warns that without proper regulation, the market risks repeating carbon credit problems around measurable impacts and community benefits.<sup>33</sup>

Overall, significant challenges remain for these instruments: Most developers are currently stacking biodiversity credits with carbon credits until demand materializes, debates around offsetting versus contribution remain unsettled, there is no active trading market yet, and critics warn against “putting a price on nature” across vastly different landscapes without proper equivalence standards—though optimistic projections suggest the market could reach \$7 billion by 2030 and \$180 billion by 2050 if integrity concerns are adequately addressed.<sup>34</sup>

## NATURE AS INFRASTRUCTURE

Treating ecosystems as infrastructure reframes conservation and ecosystem services as productive investment rather than static conservation. Mangroves, wetlands, and forests can deliver flood protection, water regulation, and erosion control at lower cost than gray infrastructure.<sup>35</sup> Yet public investment frameworks often struggle to appraise these benefits, let alone integrate them into project development and execution.

Innovative finance approaches—blending public budgets, insurance mechanisms, and private capital—are beginning to address the gap between the scale of ecosystem service value and what gets financed from an infrastructure lens. The Asian Infrastructure Investment Bank (AIIB) has become a significant driver of this shift, arguing in its flagship “Investing in Nature as Infrastructure” report and subsequent work that ecosystems should be treated as governable, investable assets on par with roads or energy grids—accessible through national infrastructure plans, blended finance, and public-private partnership structures.<sup>36</sup> For example, AIIB’s 2025 \$1 billion Climate-Focused Policy-Based Loan to Brazil explicitly ties sovereign lending to mangrove protection, carbon market development, and biome regeneration under Brazil’s Ecological Transformation Plan, illustrating how ecosystem service commitments can be embedded directly in sovereign finance instruments.<sup>37</sup> Box 6.4 further details Cape Town’s water bond as an example of a nature-based investment. A joint 2025 report by AIIB, the European Bank for Reconstruction and Development (EBRD), and the Paulson Institute goes further, proposing public-private partnerships for nature as a standardized delivery model, with guarantees, insurance products, and biodiversity credits identified as the three most underused tools for de-risking nature finance at scale.<sup>38</sup>

Despite growing rhetorical consensus around nature as infrastructure, mainstreaming it through multilateral development bank (MDB) lending and capital markets faces deep structural barriers. MDB efforts remain largely siloed or project-based rather than embedded across operations. As the World Resources Institute noted following COP30, where MDBs launched harmonized tracking principles and a common nature finance taxonomy, genuine mainstreaming requires integrating nature-positive principles across entire institutional portfolios, a

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32 Cavano (2024).

33 NatureFinance (2024b).

34 Cole and Eis (2024).

35 Nature4Climate (n.d.).

36 Douglas and Zou (2024).

37 Asian Infrastructure Investment Bank (2025).

38 AIIB, EBRD, and Paulson Institute (2025).

task most banks are still far from.<sup>39</sup> A compounding problem is the persistent skills gap within project origination and technical teams: MDB staff are predominantly trained in gray infrastructure disciplines—civil engineering, transport, energy—and lack the ecological and natural capital expertise needed to identify, design, and appraise nature-based projects at the project preparation stage, producing a systematic bias toward concrete solutions long before financing decisions are made.<sup>40</sup>

This is exacerbated in capital markets by a lack of standardized metrics: unlike carbon, biodiversity is inherently location-specific with over 570 competing measurement approaches and no agreed international standard, meaning

#### BOX 6.4

## Cape Town's water bond: Nature as infrastructure in practice

Cape Town's water crisis from 2017 to 2018 forced the city to confront a fundamental infrastructure question: how to secure water supply at the lowest long-term cost while reducing climate risk. The response offers a clear example of “nature as infrastructure” in practice.

Following the crisis, the City of Cape Town issued a municipal water bond to finance investments that would improve water security. While conventional gray infrastructure options—such as desalination plants and new dams—were considered, analysis showed they were among the most expensive options, with high energy use, long construction timelines, and ongoing operating costs.

Instead, a significant portion of the city's water strategy focused on nature-based solutions, particularly the removal of invasive alien plant species from key catchment areas. These species consume far more water than native vegetation, reducing runoff into dams and aquifers. Clearing invasive plants allows natural ecosystems to recover and significantly increases water yield—often within a few years.

Studies conducted for the city showed that invasive species eradication delivers water at a lower cost per cubic meter than many gray alternatives, while also providing co-benefits such as reduced fire risk, improved biodiversity, and job creation. Importantly, these interventions function like traditional infrastructure: They deliver a measurable, reliable service—water supply—at scale.

The Cape Town water bond demonstrates how nature-based solutions can be treated, financed, and governed as infrastructure, rather than as ancillary environmental projects. For investors and policymakers, the lesson is clear: When ecosystems are correctly valued and managed, investing in nature can be the cheapest and most effective option for building climate-resilient public infrastructure.

**SOURCE:** RMB (2026).

39 Neunuebel, Laxton, and Bulbena Janer (2025).

40 Lund Larsen (2019).

ecosystem service benefits cannot yet be priced or traded in ways legible to bond markets or sovereign balance sheets.<sup>41</sup> The AIIB-EBRD-Paulson Institute joint report is candid about the consequence: Many nature-based solutions that deliver core infrastructure services are still classified as environmental interventions and excluded from sovereign infrastructure pipelines entirely, locked out of the capital planning frameworks through which finance actually flows.<sup>42</sup> Until nature is embedded in national accounts and MDB project classification as a standardized and legitimate infrastructure solution—and until origination teams have the expertise to propose it—the private sector signals needed to catalyze large-scale capital allocation will remain absent.

## SUSTAINABILITY-LINKED INSURANCE

Sustainability-linked insurance—which extends the KPI-linking logic of sustainability-linked debt to risk-transfer markets, adjusting premiums or coverage in response to measurable resilience or nature-protection actions by policyholders—is an important emerging area worth flagging.<sup>43</sup> On its own, insurance smooths expenditures over time rather than channeling new resources into nature, and with the LMIC protection gap exceeding 90%, the immediate challenge is closing the coverage gap itself.<sup>44</sup> That gap is also an opportunity: Narrowing it can be written directly into sustainability-linked sovereign debt as a KPI, so that measurable gains in disaster coverage—and the resilience investments that make risks insurable—are rewarded through financing terms. A nearer-term entry point lies in instruments governments already fund: Many states subsidize agricultural insurance premiums—Brazil’s rural premium subsidy program among them—and such support can be tied more explicitly to resilience-enhancing measures, conditioning it on practices like agroecology or watershed protection that lower underlying risk.<sup>45</sup> Linked this way, public insurance spending can become a much stronger lever for adaptation rather than only a means of loss compensation as this field matures.

## NATURAL CAPITAL ACCOUNTING: NATURE ON THE BALANCE SHEET

Natural capital accounting is the practice of measuring and valuing stocks of natural assets—forests, wetlands, soils, water, biodiversity—and the ecosystem services they provide and integrating that information into economic and financial decision-making at both national and corporate levels.

On the public sector side, natural capital accounting has been advancing in recent years through the U.N. System of Environmental-Economic Accounting, with over 90 countries compiling accounts by mid-2024 and the 2025 update to the System of National Accounts now formally integrating natural capital—a significant step toward making ecosystem assets visible in systems of national accounts.<sup>46</sup> The Coalition of Finance Ministers for Climate Action has called on finance ministries to embed natural capital valuation into policy and budget decisions, yet as the Nature on the Balance Sheet Initiative’s May 2025 roadmap—produced by the Capitals Coalition, The Landbanking Group, Systemiq, and the Center for Global Commons—candidly noted, there remain very few examples of natural capital satellite accounts actually driving public policymaking, and nature-negative subsidies continue at scale.<sup>47</sup> Systemiq’s contribution to the Independent High-Level Expert Group on Climate Finance COP30 report similarly

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41 Bruegel (2023).

42 AIIB, EBRD, and Paulson Institute (2025).

43 WWF (2026).

44 Ibid., 4.

45 Souza, Pereira, and Stussi (2022).

46 SEEA (n.d.); European Commission et al. (2025).

47 Capitals Coalition et al. (2025).

drew on this initiative's analysis to frame natural capital recognition as a prerequisite for the integrated climate finance agenda, positioning the shift from optional disclosure to sovereign balance sheet recognition as central to mobilizing the \$1.3 trillion in annual flows needed for climate and nature by 2035.<sup>48</sup>

In the private sector, the pace of institutional adoption of natural capital accounting has accelerated considerably, though translation into binding financial recognition remains nascent. The Task Force on Nature-related Financial Disclosures' (TNFD) final recommendations, published in September 2023, had attracted over 733 organizational adopters across 56 countries by COP30 in November 2025—including asset managers overseeing \$22.4 trillion.<sup>49</sup> The Landbanking Group has gone a step further, developing a remote-sensing and contracting infrastructure that unitizes measured improvements in soil, water, climate, and biodiversity into nature assets capable of being booked as intangible assets under the International Financial Reporting Standards.<sup>50</sup> Together these efforts represent meaningful convergence, but the critical enablers—accounting standards, assurance frameworks, regulatory safe harbors, and nature risk ratings—are still relatively immature and must align before natural capital valuation becomes a mainstream input to investment decisions at scale.<sup>51</sup>

## THE BIOECONOMY AND STRUCTURAL TRANSFORMATION

Nature-based sectors can also underpin long-term growth, not only conservation. For finance ministries in particular, a sustainable bioeconomy—economic activity that uses renewable biological resources while regenerating rather than depleting them—functions as a growth, diversification, and risk-management strategy that channels commercial resources into nature and can strengthen fiscal resilience. For nature-rich low- and middle-income countries it offers a route to expand exports, move up value chains, and reduce dependence on volatile commodity cycles, and where bioeconomy resilience outcomes are measurable, they can be linked to performance-based and sustainability-linked finance. See chapter 9 by Monique Atouguia and Dorothy Maseke on the bioeconomy for a fuller account.

# Making nature count in financial risk frameworks

## RESOLVING THE NATURE RISK DILEMMA

The rollout of nature risk management and reporting frameworks such as TNFD poses a dilemma for financial institutions (FIs). Integrating nature risks into their credit risk management frameworks can help to elucidate critical nature risks and dependencies, but it also implies extra costs and adjustments to risk pricing and portfolio exposures that may clash with commercial objectives. If such changes are not adopted industry-wide—e.g., because TNFD is not integrated in financial regulation—then an FI that unilaterally prices in nature risks may put itself at a

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48 Bhattacharya et al. (2025), 6.

49 Task Force on Nature-Related Financial Disclosures (n.d.).

50 Thomas (2025).

51 Capitals Coalition (n.d.).

disadvantage relative to competitors that do not. If nature risks are reported but not acted on, then the FI can be accused of greenhushing. If the FIs do integrate nature risks across the industry, then the adverse impacts on credit affordability and access can lead to de-banking, mirroring developments in the insurance sector.

These dynamics can be illustrated by way of the basic credit risk formula:

$$\text{Expected Loss (EL)} = \text{Probability of Default (PD)} \times \text{Loss Given Default (LGD)} \times \text{Exposure at Default (EAD)}^{52}$$

All else being equal, integrating nature risks into credit modeling weakens repayment capacity ( $\uparrow$ PD) and impairs collateral quality ( $\uparrow$ LGD), with higher expected losses forcing lenders to raise interest rates on and/or cut exposure ( $\downarrow$ EAD) to counterparties vulnerable to nature risks and dependencies. The dilemma is that efforts to account for nature in lending decisions result in costlier and scarcer credit.

To avoid this outcome, FIs have two basic options: (a) encourage interventions to mitigate the impact of nature-related risks ( $\downarrow$ ELs,  $\downarrow$ LGD); or (b) use nature as an asset to collateralize loans ( $\downarrow$ LGDs). An example of the former is regenerative agriculture, such as planting shade trees or no-till farming, which has been shown to lessen nature risks and strengthen resilience against climate shocks. The incentives embedded within nature-based solutions, such as interest-rate reductions linked to biodiversity KPIs, are designed to incentivize borrowers to undertake such actions.

However, financial incentives may not be sufficient to compensate for the extra transaction costs and time required to implement risk-reductive measures. For instance, transitioning to regenerative agriculture can entail significant investments, forgone production, and long lead times before the interventions bear fruit. The incentives must also be strong enough to overcome ingrained habits, vested interests, and biased systems favoring conventional farming practices, which may be reinforced by the increased uncertainty of weather patterns and commodity prices in a climate-stressed environment. It may be difficult to disentangle the idiosyncratic from the systemic nature risks; in other words, those over which the borrower has some control versus those that require collective action or government intervention.

Furthermore, financial incentives also do not address the fundamental problem that most agricultural producers are underbanked or unbanked. Households and small and medium-sized enterprises (SMEs) form the backbone of the bioeconomy, yet only 24% of adults in LMICs borrow through formal credit, according to the latest Findex Survey—a figure that is substantially lower in the rural and agricultural sectors.<sup>53</sup> Lack of collateral is a primary barrier to financial inclusion (see chapter 8 by Felipe Faria, Morgan Gillespy, and Guido Schmidt-Traub on the role of supply chain financing). In LMICs, real property is a requirement in approximately 80% of secured lending, yet households and SMEs own only movable assets and lack formal title to their land.<sup>54</sup> Recent fintech innovations have emerged to streamline collateralization, for instance through movable asset registries on the blockchain, yet they do not meaningfully make up for the paucity of fixed assets. Nature assets may offer an alternative to plug the collateral gap in a way that also addresses the nature risk dilemma.

Nature acts as a store of carbon that can be monetized via credits in the regulatory and voluntary carbon markets. The carbon is stored in soil, trees, and biochar (a charcoal-like substance created by heating organic biomass via pyrolysis in a way that sequesters carbon). The resulting credits can be sold via forward sale agreements to offtakers who want to offset or inset their carbon emissions. These forward contracts represent receivables that can be collateralized for

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52 EL = The main variable in pricing loans. PD = The likelihood that the borrower will not pay. LGD = The portion of the total exposure expected to be lost if a default occurs (= 1 – recovery rate). EAD = Total value an institution is exposed to at the time of default.

53 World Bank (2025d), 129.

54 World Bank (2019); World Bank (2022), 6.

loans or “discounted” in working capital credit. For example, an agroforestry cocoa producer can secure a loan against an off-take agreement of biochar credits that will be generated from the detritus of future harvests. The farmers can unlock capital from physical nature assets that otherwise have limited or no productive value under conventional farming systems, while using the lower cost of borrowing to finance the regenerative transition.

## BRINGING NATURE INTO QUALITATIVE ANALYSIS

Many of the nature finance solutions outlined above rely on robust monitoring, reporting, and verification (MRV) systems to verify outcomes and track performance to which financial incentives are linked. However, whereas climate risks have widely recognized quantitative measures for mitigation and adaptation (e.g., CO<sub>2</sub>-equivalent emissions; economic losses from catastrophic events), measures of biodiversity or the state of nature more broadly lack common metrics across all countries and biomes. Whereas climate and nature risks from floods and drought can be quantified with reasonable accuracy and increasingly at the sovereign level, the risk-reductive benefits of natural capital or resilient infrastructure remain difficult to capture (at least so far). Furthermore, many aspects of nature risk and resilience are inherently qualitative, such as the quality of environmental regulation and enforcement.

Qualitative analysis is generally not treated with the same degree of rigor as quantitative analysis, especially in sovereign risk assessments, which often omit key aspects of nature risk and resilience. The metrics used to measure governance and institutional quality generally omit or understate the importance of the environment and resilience. For instance, the World Bank’s Worldwide Governance Indicators (WGIs), which carry significant weight in Fitch’s and Moody’s institutional assessments, do not meaningfully capture the quality of a country’s environmental policies and regulations—so the steps a government takes to strengthen ecological resilience leave little or no trace in its institutional score, even when they materially reduce long-term fiscal risk.<sup>55</sup> The gap is not in the economics, but in the decision systems.

Upgrades to the WGIs and other institutional assessment frameworks can help to correct the asymmetry. KPI-linked approaches offer another way forward. By defining clear, verifiable indicators that link nature-based solutions project-level outcomes to macro-fiscal performance, countries can convert “credibility” into measurable evidence. Uganda’s ongoing work on agro-industrialization and nature illustrates how resilience investments can be mapped to growth, volatility, and debt dynamics in a way that is legible to investors and rating agencies.

## Challenges and guardrails

Innovative finance for nature is promising but not without real risks, and understanding them is essential to getting the approach right. Three stand out as particularly important.

The first is the risk of poor design undermining real-world outcomes. Many nature finance instruments—sustainability-linked bonds, biodiversity credits, results-based payments—rely on KPIs to trigger or validate financial rewards. But KPIs can be gamed. In carbon markets, investigative analysis has found that in some project categories, fewer than 16% of issued credits correspond to actual emissions reductions; biodiversity faces analogous risks, where loosely defined indicators or selective reporting can significantly overstate conservation impact.<sup>56</sup>

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<sup>55</sup> NatureFinance (2026).

<sup>56</sup> Senken (2026); zu Ermgassen et al. (2025).

The Campaign for Nature has been particularly pointed on a related systemic risk: that inflated expectations for voluntary private finance could allow governments to abdicate their public financing responsibilities, even though most biodiversity services function as public goods. MRV systems—the technical infrastructure used to verify that ecological outcomes have actually been delivered—remain expensive, fragmented, and in many contexts nascent. A 2025 review by the Nature Tech Collective noted that biodiversity MRV is particularly scattered, with multiple competing methodologies and no settled standard, making comparison across projects and landscapes difficult.<sup>57</sup> Public goods here means non-excludable, non-rival benefits that the market cannot adequately price or sustain on its own, and which therefore ultimately require public funding, regulation, and policy.

The second risk is fragmentation. The nature finance landscape currently comprises dozens of distinct instruments—PES schemes, biodiversity credits, blue bonds, debt-for-nature swaps, sustainability-linked bonds, blended finance vehicles—deployed by a dispersed set of donors, development banks, foundations, and private investors, often with different metrics, timelines, and governance structures. Setting up blended finance structures alone is described by the World Economic Forum as fundamentally complex, with lengthy negotiations and high transaction costs that impede stakeholder alignment.<sup>58</sup> One World Resources Institute study found that some companies are using more than 3,000 metrics to describe nature-related outcomes in sustainability disclosures, and that they currently spend 43% more on sustainability reporting than on sustainability innovation—a striking illustration of how compliance overhead can crowd out the action it is meant to incentivize.<sup>59</sup>

The third and perhaps most structural risk is that nature finance remains confined to a niche—a specialist environmental, social, and governance corner of capital markets—rather than influencing the core fiscal and investment decisions that shape land use, infrastructure, and economic development. This is rapidly starting to change as the relationship between nature, climate, debt, and macro-fiscal risk and resilience becomes increasingly evident. Nonetheless, private finance for nature had only reached \$102 billion as of 2024, while UNEP’s “State of Finance for Nature” 2026 found that \$7.3 trillion still flows annually into nature-negative activities—meaning that for every dollar invested in protecting nature, around \$30 is simultaneously being spent to destroy it.<sup>60</sup>

Addressing these challenges requires sustained investment in data infrastructure and institutional capacity, as well as international coordination on standards that make outcomes comparable and trustworthy. It also requires an honest reckoning with the limits of marketization. Not all ecological values can or should be translated into financial instruments—the intrinsic value of biodiversity, the cultural and spiritual relationships between Indigenous communities and their landscapes, and the long-term resilience services provided by intact ecosystems do not map neatly onto investable assets or tradable credits.

Crucially, the ultimate ambition of nature finance is not simply to channel more private capital into conservation projects at the margins of the economy: It is to shift the incentive structures, business models, and investment decisions of the real economy itself—agriculture, infrastructure, energy, manufacturing—so that nature-positive outcomes become the default rather than the exception. The objective is not to financialize nature indiscriminately, but to ensure that where finance does shape incentives, it does so through well-designed, verifiable instruments embedded in robust public policy frameworks—so that capital flows through the real economy in ways consistent with long-term development and environmental outcomes (a sustainable bioeconomy), rather than merely creating a parallel green niche while the core economy continues on a nature-negative and carbon-intensive trajectory.

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57 Campaign for Nature (2024); Nature Tech Collective (2025).

58 Alvarado (2024).

59 Choi and Czebiniak (2025).

60 UNEP FI (2024); UNEP (2026), xiv.

## From pilot innovation to systems change

The triple crisis of nature loss, climate change, and debt distress demands more than incremental adjustments. It requires rethinking how value, risk, and resilience are recognized in financial systems in a world beset by mounting environmental degradation and climate shocks.

The experience from landscapes like Southern Bahia and platforms such as the Bioeconomy Challenge underscores a central lesson of the triple crisis: Nature, finance, and development cannot be aligned instrument by instrument, project by project. Alignment emerges only when incentives are coherent across scales—from farmers and ecosystems at the ground level, all the way up to sovereign balance sheets and global capital markets.

Innovative finance for nature is beginning to show how this coherence can be built: by stacking capital, linking performance to credibility and results, and embedding inclusion into financial instrument design and outcomes. The task ahead is not more invention, but institutionalization—ensuring that nature-positive outcomes systematically translate into financial advantage for countries, financial institutions, companies, and communities that are actively taking steps to reduce vulnerability. The deeper obstacle is not economics. The economic case for investing in nature as infrastructure for development is increasingly established. The obstacle is institutional: the failure to integrate these insights into the practical models and decision systems used by the IMF, World Bank, ministries of finance, and ratings agencies. When the integration happens, investing in nature ceases to be a fiscal burden or a side project, and becomes what it has always been: a foundation of resilient development.

The negotiation of a post-2030 development framework presents the first real opportunity to build this institutionalization from the ground up rather than retrofit it. A successor to the SDGs that does not embed nature and resilience into its financial architecture will reproduce the same failure: goals without the fiscal mechanisms to reach them. What the next framework must include at its core is not a separate nature goal or a climate finance target alongside others, but the integration of natural capital into the economic logic through which development is financed and measured.

Concretely, this means debt sustainability frameworks that price resilience as well as vulnerability; sovereign credit methodologies that reward demonstrated adaptation and resilience investment; national accounts that make natural capital visible alongside produced capital; and public investment programming that treats ecosystems as core economic and financial infrastructure. The SDGs created a general blueprint for what needs to happen. The post-2030 agenda must establish how it gets financed—and nature has to be a central part of the answer—not as an add-on, but as a structural feature of the financial architecture that makes the rest possible.

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## SEVEN

# NATURE'S BLACK MARKETS: HOW ENVIRONMENTAL CRIME UNDERMINES CLIMATE, CAPITAL, AND SUSTAINABLE DEVELOPMENT

Robert Muggah and Ilona Szabó de Carvalho

## Environmental crime is a structural constraint

Environmental crime is a neglected structural constraint on sustainable development. Progress on protecting forests, oceans, and terrestrial ecosystems is badly off track. Yet standard explanations of financing gaps, weak institutions, and climate shocks capture only part of the problem. Environmental crime cuts across nearly every relevant goal but remains largely absent from Sustainable Development Goal (SDG) reviews, national reporting, and development strategies. This is not simply a matter for police and customs. Environmental crime is embedded in the political economies where development institutions operate. It weakens regulation, raises investment risk, and allows illegal commodities to undercut the incentives created by climate and biodiversity finance.

The chapter develops a three-tier account of the damage. Environmental crime first destroys ecosystems and contaminates food and water systems. It then corrodes governance as criminal actors use coercion and collusion to weaken oversight and launder proceeds. The damage ultimately reaches markets and public finance by undercutting compliant producers, deterring investment, and obstructing development goals. These effects occur together and reinforce one another. Strategies confined to interdiction and prosecution therefore underperform. A key recommendation is that enforcement be aligned with market governance and finance.

The chapter is divided into five sections. The first sets out the scale and structure of environmental crime and its links to illicit finance. The second distinguishes survival-driven illegality from organized criminal enterprise. The third explains how ecological damage travels through institutions, markets, and public finances. The fourth compares how these dynamics manifest across the Americas, Africa, Asia, and Europe. The final section proposes an integrated response agenda built around territorial de-risking, targeted deterrence, tighter market gates, and crime-sensitive finance.

## The scale and structure of environmental crime

Environmental crime is best understood as a set of interlocking illicit markets that thrive where governance is weak, borders are porous, and commodity prices are high.<sup>1</sup> These include land grabbing and illegal logging, illicit mining including artisanal and small-scale gold mining and illegal industrial extraction, large-scale illegal, unreported, and unregulated (IUU) fishing, wildlife trade across both iconic and lesser-known species, and trade in waste and hazardous material.<sup>2</sup> Their proceeds mingle with corruption, fraud, and violence, with proceeds laundered through the formal economy, which is why they now appear more often in financial crime typologies and risk assessments.<sup>3</sup> Environmental crime therefore acts simultaneously as an ecological driver of climate change and biodiversity loss and as a political-economic mechanism that corrodes state capacity and deters lawful investment in frontier jurisdictions.

The climate and biodiversity implications of environmental crime are immediate and measurable. In major tropical biomes, a large share of deforestation is illegal and linked to land grabbing, timber extraction, illicit mining, and illegalities related to agriculture and cattle ranching. Recent years have brought exceptionally high losses of humid tropical primary forest. Fires and land conversion have inflicted particularly severe damage in Amazonia, while agricultural clearing, charcoal production, and increasingly frequent fires are placing sustained pressure on the Congo Basin.<sup>4</sup>

These dynamics erode the conditions required to deliver forest protection commitments, biodiversity targets, and nationally determined contributions (NDCs). They also undermine the credibility of market-based and results-based climate finance by increasing uncertainty over permanence, leakage, and governance quality in high-risk jurisdictions. Environmental crime directly affects the bankability of climate and nature investments, especially where land tenure is contested and enforcement is inconsistent.

These markets survive because supply chains convert remote extraction into commodities that can be moved, financed, processed, and exported. Frontier extraction zones are connected to transport corridors, ports, and financial centers through mechanisms that are organized and central to how illicit value is created. This connectivity stabilizes and scales illicit rents while linking environmental crime to the formal economy through laundering and the use of legal corporate vehicles.<sup>5</sup> In such settings, compliance becomes a competitive disadvantage, and development finance confronts risks that field enforcement alone cannot remove.

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1 UNEP and INTERPOL (2016); UNODC (2024).

2 FATF (2021); Europol (2025a); Muggah and Szabó de Carvalho (2025).

3 FATF (2020; 2021); Waisbich et al. (2022b).

4 Goldman, Carter, and Sims (2025); Shapiro et al. (2023); Potapov et al. (2025).

5 FATF (2020; 2021).

The scale of illicit nature-harmful finance changes how environmental crime should be understood. A widely cited estimate placed annual criminal proceeds from environmental crime between \$110 billion and \$281 billion.<sup>6</sup> The true figure may be higher, although the available estimates remain uncertain. Environmentally harmful subsidies are larger still. A 2022 assessment put them at no less than \$1.8 trillion annually across sectors ranging from fossil fuels and agriculture to transport and construction. An updated estimate put the total at roughly \$2.6 trillion in 2023 when other environmentally damaging activities were included.<sup>7</sup>

Environmental crime is therefore part of a wider incentive failure in global commodity and financial systems. It is the least governed and most extreme expression of a structural misalignment that formal finance has not yet corrected, and in some cases continues to reproduce through commodity lending, subsidies, and infrastructure investments that open frontier regions to extraction before governance systems can manage the resulting pressures.

## Survival and enterprise

Environmental crime follows two overlapping logics that are frequently conflated in policy discourse. Survival-driven illegality occurs when people enter prohibited activities because lawful alternatives are absent or cannot meet basic needs.<sup>8</sup> Enterprise-driven criminality is different: Organized networks deliberately exploit natural resources and governance failures to generate and launder illicit rents at scale.<sup>9</sup> Both can lead to deforestation, depleted fisheries, and poisoned rivers, but they arise from different incentives. Treating them alike produces responses suited to neither.

Survival-driven illegality is widespread across frontier regions and often draws communities into illicit economies. A smallholder may clear protected forest because tenure is insecure and legal agriculture cannot absorb a failed season. An artisanal miner may use mercury because safer technologies and formalization support are unavailable.<sup>10</sup> Fishers may ignore seasonal restrictions when legal catches no longer sustain a household.<sup>11</sup> In each case, illegality is situational rather than vocational. It is a rational response to structural conditions rather than an expression of criminal disposition. That distinction should determine whom policy targets and whether enforcement is likely to work.

Organized criminal networks systematically exploit survival-driven illegality. Networks recruit labor from economically marginal communities by offering cash advances and equipment together with protection unavailable from legal employers or public programs. They launder organized extraction through the cover of subsistence activity, deliberately blurring the boundary between community-level illegality and coordinated criminal enterprise.<sup>12</sup> Where livelihoods are tied to illegal economies, communities face strong incentives to withhold information from authorities and absorb enforcement risk on behalf of organizing actors. These mechanisms are central to the durability of illegal economies.

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6 Nellemann et al. (2018), 15.

7 Koplow and Steenblik (2022), 6; (2024), 5.

8 Hübschle (2025).

9 van Uhm and Nijman (2022).

10 Ayambire et al. (2024); UNEP (2018; 2025).

11 See more information on fisheries in FAO (2024).

12 Waisbich et al. (2022b).

Interdiction that dismantles an organized network without altering the survival conditions sustaining participation usually displaces environmental crime rather than reducing it. When a logging operation is closed or a mining network disrupted, the underlying labor force and economic logic remain intact. Activity migrates to adjacent territories, and successor networks reconstitute. In many cases, the same actors resume operations once enforcement pressure recedes. This displacement or “balloon” effect is well documented across commodity frontiers and helps explain why intense enforcement often fails to produce durable reductions.<sup>13</sup> Displacement is the predictable structural outcome of strategies that target organized supply without addressing the conditions that make illegal economies the rational choice for frontier communities.

Understanding the incentive environment that makes environmental crime durable matters for market governance. Due diligence regimes such as the EU Deforestation Regulation (EUDR) and traceability frameworks such as the Lacey Act are not extensions of enforcement into trade.<sup>14</sup> They are attempts to correct a structural market failure in which formal finance and trade have long been complicit in nature-harmful outcomes. The implication for development practitioners and financiers is direct. Secure tenure, mining formalization, community fisheries management, and rural investment are not ancillary complements to an enforcement agenda. They are among the most powerful instruments available for altering the survival incentives on which organized environmental crime depends.

## Measuring the impacts of environmental crime

The three-tier framework that follows distinguishes three categories of causal mechanism through which environmental crime damages development prospects: ecological damage, governance failure, and economic loss (see table 7.1). The layers operate simultaneously. Environmental crime can destroy an ecosystem, compromise the regulator meant to protect it, and distort the surrounding market at the same time. Addressing only one layer leaves the system that reproduces the harm largely intact.

### FIRST-ORDER EFFECTS

First-order effects are ecological and climatic. Environmental crime accelerates the destruction of high-carbon forests, pollutes soils and waterways, and depletes marine resources through illegal extraction and pollution.<sup>15</sup> Illegal land conversion and illegal logging reduce carbon sinks, increase land-use emissions, and weaken hydrological recycling that supports regional rainfall patterns. These processes increase susceptibility to fire and drought, triggering feedback loops that undermine ecosystem stability.<sup>16</sup> In marine environments, illegal, unreported, and unregulated fishing reduces the resilience of fish stocks and disrupts trophic dynamics, while waste trafficking and pollution degrade coastal ecosystems that provide storm protection and carbon sequestration functions.

Forest-related crimes illustrate this with clarity. Where land grabbing and illegal logging enable rapid conversion, they generate a pathway from forest loss to emissions, weaker rainfall, and greater fire risk. Illegal conversion also tends to follow rather than precede the licit financial signals—roads, credit, and land speculation—that open frontier

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13 UNODC (2024).

14 European Commission (2025); Lacey Act (1981; 2008).

15 UNODC (2024); UNEP and INTERPOL (2016).

16 Bernstein and Muggah (2025); Muggah (2022).

regions to extraction. Enforcement strategies that target illegal activity while leaving this illicit financial infrastructure intact address the margin of the problem, not its structural roots.

Illicit mining and toxic pollution illustrate another pathway for first-order harm. Mercury from artisanal and small-scale gold mining bioaccumulates through aquatic food webs, exposing miners and riverine communities while degrading biodiversity in watersheds that are often central to nature-based climate solutions.<sup>17</sup> The result is a degradation of ecosystem services on which livelihoods and public revenues depend. In many emerging market and developing economies, artisanal mining, fisheries, and forest industries are macro-critical sectors. Where illegal extraction dominates, royalties go uncollected, export revenues are laundered offshore, and governments inherit the health and remediation costs that illegal operators externalize onto frontier communities. Wildlife trafficking compounds these harms by removing keystone species and weakening ecosystem resilience.<sup>18</sup>

## SECOND-ORDER EFFECTS

Second-order effects operate through governance and institutional integrity. Illicit timber, gold, land conversion, and waste schemes depend on bribery, intimidation, fraudulent permits, and corporate fronts to launder proceeds and insulate organizers from accountability.<sup>19</sup> These dynamics weaken regulators and courts, compromise licensing, and reduce the chance that monitoring signals will translate into successful prosecutions. They also increase risks to environmental defenders and community leaders, shrinking civic space in precisely those territories where enforcement and community governance are most needed.<sup>20</sup>

The Amazon Basin illustrates how these second-order impacts manifest on the ground. Frontier extraction is embedded in broader logistical and financial ecosystems that connect forest edges to processing hubs, export corridors, and finance nodes.<sup>21</sup> Decisive leverage sits at chokepoints such as mills, ports, traders, and financiers, rather than only at the forest edge, which helps explain why site-level enforcement so often fails to produce durable results.<sup>22</sup> Proceeds from environmental crime move through the same channels used for fraud and narcotics, making this a financial integrity and rule-of-law challenge as much as an environmental compliance issue.<sup>23</sup>

## THIRD-ORDER EFFECTS

Third-order effects extend into markets and public finance. Illicit commodity supplies undercut compliant producers, distort prices, and raise jurisdictional risk, deterring long-term capital and raising the cost of finance for legitimate firms in frontier territories.<sup>24</sup> The result includes fewer formal jobs, weaker value chains, and less public revenue. Land grabbing and illegal conversion also affect food security by displacing communities and degrading the land, water, and ecosystem services that underpin agricultural productivity.

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17 UNEP (2018; 2025).

18 UNODC (2024).

19 FATF (2020; 2021); Igarapé Institute (2026).

20 Global Witness (2025).

21 Nobre, Muggah and Szabó de Carvalho (2026).

22 Igarapé Institute (2024; 2026).

23 FATF (2020; 2021).

24 World Bank (2019).

Environmental crime lowers the ceiling on what development finance can achieve, even when climate and biodiversity projects are technically sound. Blended finance may crowd in private capital, but it cannot by itself correct markets where illicit supply makes compliance uncompetitive. The damage is therefore larger than an environmental externality: It distorts markets and weakens institutions, redirecting development trajectories in ways that aggregate fiscal data rarely capture.

The fiscal consequences extend well beyond damage to the investment climate. In several resource-rich economies, illegal or informal extraction supplies a substantial share of nationally important export industries and sustains entire local commercial ecosystems. Estimates suggest that illegal gold production in Peru has approached the scale of legal output, that artisanal and small-scale mining supplies roughly 40% of Ghana's gold, and that illicit production may account for most Colombian gold.<sup>25</sup> In the Solomon Islands, a logging industry marked by widespread illegality has at times generated about 70% of goods exports and supported a significant share of employment.<sup>26</sup>

Much of this production escapes royalties and payroll contributions, although some is laundered through formal exporters and may generate limited customs or tax receipts. Governments meanwhile absorb the costs of enforcement and environmental restoration, together with damaged infrastructure. The resulting loss is therefore twofold: foregone revenue from resources that should contribute to the public budget and additional expenditure to repair the harms created by their extraction. In mineral-rich and forest-rich developing economies, this can materially weaken the domestic revenue base available for public services and social protection.

The destruction of natural assets deepens the fiscal damage by eroding the productive base from which future revenues flow. Fisheries pushed beyond recovery thresholds stop generating license fees or export earnings. Cleared forests lose their capacity to support concession income or emerging payments for carbon and ecosystem services. Mercury-contaminated soils and waterways can remain impaired for decades. For sovereign borrowers in the Amazon Basin, Congo Basin, and coastal West Africa, environmental loss becomes fiscal loss.<sup>27</sup> It can durably reduce the productive asset base that underpins fiscal resilience and debt serviceability. Development finance institutions that ignore the pace of natural-asset liquidation risk understating sovereign vulnerability in precisely the jurisdictions where their exposure is greatest.

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25 Chin et al. (2026); Akeliwira (2026); OAS (2022).

26 Cruz and Tozaka (2023).

27 Agarwala et al. (2026).

TABLE 7.1

## Impacts of environmental crime on SDGs

| Impacts             | Mechanism                                                                                                                                                                                | Measurable indicators                                                                                                                                                                                                                                                                                                                    |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>First-order</b>  | Illegal land conversion, logging, artisanal and small-scale gold mining (ASGM) mercury releases, wildlife trafficking, illegal, unreported, and unregulated (IUU) fishing, waste dumping | Hectares of tree cover loss and primary forest loss per year; fire-linked loss share; CO <sub>2</sub> emissions from land-use change; river mercury concentrations; number of keystone species poached or seized; fish stock status and IUU share of catch; volume of hazardous waste intercepted                                        |
| <b>Second-order</b> | Corruption, intimidation, permit fraud, money laundering, institutional or state capture, criminal use of corporate fronts                                                               | Number of corruption cases and asset freezes; beneficial ownership disclosures for high-risk firms; suspicious activity reports linked to timber, gold, wildlife, waste; joint operations and prosecutions; protection for whistleblowers and environmental defenders; time to adjudicate eco-crime cases                                |
| <b>Third-order</b>  | Price undercutting by illicit supply, capital flight from frontier regions, higher risk premiums, disrupted value chains                                                                 | Private investment volume in forest and coastal jurisdictions; cost of capital spread for compliant producers; formal job creation in bioeconomy and legal fisheries; share of procurement and lending using geolocation and traceability; Taskforce on Nature-related Financial Disclosures (TNFD) adoption; coverage of material sites |

**SOURCE:** Authors' own compilation.

# The geography of environmental crime

## THE AMERICAS

The impact framework developed above finds its most acute expression in the Americas, where environmental crime has undergone a structural transformation over the past decade. It has shifted from opportunistic extraction toward the deliberate integration of illicit natural-resource economies into broader organized-crime portfolios.<sup>28</sup> Criminal networks once associated primarily with drug trafficking have diversified into illegal logging, gold mining, and land grabbing, attracted by high commodity prices, lower enforcement risk, and the ease with which natural-resource revenues can be laundered through land and commodity markets. The convergence of drug trafficking organizations and environmental crime networks is now well documented in Brazil, Colombia, Peru, and Venezuela, where the same corridors, financial intermediaries, and political protection structures serve multiple illicit markets simultaneously.<sup>29</sup> This changes the policy diagnosis. In the Americas, environmental crime is increasingly an organized criminal economy that requires disruption strategies calibrated to networked, adaptive adversaries.

First-order impacts are severe and compounding. Forest crime accelerates land conversion and degrades high-carbon ecosystems central to climate stability, contributing directly to record tropical primary-forest loss in Amazonia in recent years.<sup>30</sup> Illegal gold mining generates elevated mercury concentrations in sediments and fish across impacted river systems, linking illicit extraction to biodiversity loss, food-web contamination, and the degradation of watersheds central to nature-based climate solutions.<sup>31</sup> These harms are reproduced through durable networked systems that connect remote frontiers to national and international markets, making first-order damage spatially extensive and structurally persistent.<sup>32</sup>

Second-order harms follow from the political protection and institutional capture on which these markets depend. Illegal operations rely on falsified documentation, corruption, coercion, and the co-optation of local regulatory and judicial structures to insulate organizers from accountability.<sup>33</sup> The result is a governance environment in which legal firms face higher compliance costs and higher risks, while illegal firms externalize costs and use bribery or violence to protect rents. Environmental defenders and community leaders operate under sustained threat in precisely the territories where enforcement and community governance are most needed, and where development finance most needs them to function.

Third-order effects become visible as illicit supply chains reach consumer markets and financial centers. Investigative reporting has traced allegedly illegal timber from Pará through laundering mechanisms to buyers in the European Union and the United States, illustrating how frontier illegality is monetized through global trade channels and how third-order market distortions connect directly to consumption economies.<sup>34</sup> Multilateral development banks and regional lenders have expanded blended finance and technical assistance tools aimed at frontier investment constraints, while jurisdictional forest carbon approaches are testing results-based payments designed to shift

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28 Muggah (2025b); Muggah, Abdenur, and Szabó de Carvalho (2019); Waisbich et al. (2022b).

29 Muggah (2023).

30 Goldman, Carter, and Sims (2025).

31 Risso et al. (2021).

32 Waisbich et al. (2022a).

33 FATF (2020; 2021).

34 EIA (2025).

incentives at scale.<sup>35</sup> Enforcement can disrupt flows. But durable progress requires territorial de-risking through tenure security, transparent permitting, and viable legal livelihoods—conditions that organized crime actively works to prevent from taking hold.

## AFRICA

Africa's environmental crime challenge is shaped by the interaction of fragile institutions, fiscal leakage, and survival-driven illegality at scale. The distinction between subsistence and enterprise matters especially where state capacity is thin and public budgets are already constrained. Illegal extraction in mining, forestry, and fisheries can leave a large hole in the revenue base while shifting remediation, security, and health costs onto government.<sup>36</sup> The first-, second-, and third-order consequences are mutually reinforcing and collectively undermine food security, public revenues, and coastal livelihoods across the continent.

First-order impacts are most visible in fisheries depletion and ecosystem degradation. West Africa is a major and persistent hotspot for IUU fishing, with weaknesses in monitoring, control, and surveillance, and transshipment practices carrying serious implications for fish stock resilience and the food systems coastal communities depend on.<sup>37</sup> Wildlife trafficking compounds these ecological harms. For example, sustained pressure on species such as pangolins and elephants removes keystone species from ecosystems already under stress from land conversion and climate variability, making landscapes less able to absorb shocks and recover from droughts, fires, and floods.<sup>38</sup> Illegal extraction of gold and a growing range of critical energy transition minerals introduces mercury and other contaminants into watersheds, degrading the ecosystem services on which livelihoods and public revenue depend.<sup>39</sup>

Much of this first-order damage is generated by structural constraint rather than criminal intent. Artisanal miners in the Democratic Republic of the Congo, Mali, and Zimbabwe engage in unlicensed extraction because formal tenure and licensing systems are inaccessible, prohibitively costly, or captured by elites who exclude small operators.<sup>40</sup> Farming communities clear protected land at forest edges because tenure insecurity, failed seasons, and the absence of viable legal livelihoods leave no credible alternative.<sup>41</sup> Fishing communities in West Africa exceed catch limits or operate in restricted zones because industrial-scale illegal fishing has already degraded the legal economy they once depended on.<sup>42</sup> These actors are embedded in illegal economies by structural condition, not criminal vocation.

That distinction has direct consequences for the design of conservation finance instruments. The Tropical Forest Forever Facility (TFFF), the LEAF Coalition, and jurisdictional Reducing Emissions from Deforestation and Forest Degradation (REDD+) programs all need credible institutions that connect performance payments to action on the ground.<sup>43</sup> LEAF and other jurisdictional REDD+ mechanisms explicitly require safeguards, participation, benefit

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35 World Bank (2019); ART (2024a); LEAF Coalition and Emergent (2023a; 2025).

36 World Bank (2019); UNODC (2024).

37 Doumbouya et al. (2017).

38 UNODC (2024).

39 UNODC (2025).

40 Ngwerume and Muchemwa (2025).

41 Robinson, Holland, and Naughton-Treves (2011).

42 Environmental Justice Foundation (2017).

43 See more on the Tropical Forest Forever Facility at <https://tfff.earth/about-tfff>; see more on the LEAF Coalition at <https://www.leafcoalition.org/home>; see more on REDD+ at <https://unfccc.int/topics/land-use/workstreams/redd/what-is-redd>.

sharing, and respect for tenure rights, whereas the TFFF's legitimacy and durability depend on channeling benefits to Indigenous Peoples and local communities. Where illegal activity is rooted in survival, finance that ignores those incentives may displace people, produce paper compliance, and weaken claims of additionality or permanence.

Second-order harms arise where organized networks layer onto survival-driven illegality. Where port controls are weak, inspection regimes are under-resourced, and political protection is purchasable, wildlife traffickers normalize bribery and permit fraud, weakening oversight across entire regulatory systems.<sup>44</sup> Illicit wildlife, extractives, and other criminal markets intersect with drugs and human smuggling across East and Southern African corridors and hubs, increasing the probability of violence and institutional capture.<sup>45</sup>

Third-order impacts follow as illicit extraction siphons value offshore, destabilizes legal commodity markets, and reduces fiscal space for development investment. The fiscal resilience implication is direct and politically significant. As illegal economies reproduce themselves within the revenue base of already fragile states, they reinforce the conditions for continued crime and constrained public investment.<sup>46</sup> For development finance institutions operating in these jurisdictions, fiscal leakage is not a background condition to be noted and set aside. It is a primary constraint on the governance quality and investment returns on which their instruments depend.

## ASIA

Asia's role in environmental crime is shaped by end-market demand and the laundering of commodities through dense manufacturing, shipping, and trade-finance systems. Wildlife products, luxury timber, seafood, and minerals extracted illegally in Asia and elsewhere can be processed, repackaged, and sold into formal supply chains with relative ease.<sup>47</sup> Border control alone cannot solve this. The deeper problem is persistent consumer and industrial demand for commodities whose provenance regulators and buyers do not consistently verify. In this sense, Asia sits at the downstream end of supply chains whose upstream harms have been documented in the preceding sections.

First-order ecological harms are extensive and varied. High-value timbers remain central to trafficking flows, while significant Asian demand and transit roles across multiple wildlife taxa contribute to biodiversity loss in producer regions across Southeast Asia, Africa, and the Americas.<sup>48</sup> Illegal sand mining adds a further under-governed dimension, generating riverbank erosion, habitat degradation, and community displacement in support of construction booms rarely subject to provenance scrutiny.<sup>49</sup> Artisanal and small-scale gold mining hotspots in parts of Indonesia and the Philippines introduce mercury into stressed watersheds, with bioaccumulation risks that degrade ecosystem services and compromise food security for riverine communities.<sup>50</sup> Regional fisheries remain under severe pressure, with repeated calls for stronger monitoring, control, and surveillance reflecting the persistent gap between regulatory ambition and enforcement capacity.<sup>51</sup>

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44 FATF (2020; 2021).

45 Global Initiative Against Transnational Organized Crime (2025); UNODC (2025).

46 World Bank (2019).

47 UNODC (2024); FATF (2021).

48 UNODC (2024).

49 UNEP (2019).

50 UNEP (2018).

51 Saraphaivanich, Suthipol, and Imsamrarn (2024); Yleaña and Velasco (2012).

Second-order harms operate through the laundering mechanisms that are among Asia's most distinctive contributions to global environmental crime. Illegal commodities enter legitimate trade flows at sawmills, fish processing facilities, refining operations, and trade finance channels that provide the documentary cover required for cross-border movement.<sup>52</sup> This deliberately obscures provenance, weakens regulatory oversight, normalizes document fraud, and erodes the credibility of certification systems that markets and financiers rely on to distinguish legal from illegal supply. Where these second-order governance harms are entrenched, the cost of compliance rises for legitimate producers while the returns to laundering remain high, a dynamic that persistently concentrates market share in the hands of actors willing to falsify provenance.

Third-order consequences extend through the same supply chains into consumer markets and investment portfolios. Illicit timber, fish, and minerals undercut compliant producers and increase trade disruption risks for firms exposed to due-diligence regimes and buyer requirements. Where illegal extraction dominates macro-critical sectors, royalties go uncollected, and export revenues are misdeclared, constraining domestic resource mobilization in the jurisdictions that need it most. The region's growing share of Taskforce on Nature-related Financial Disclosures (TNFD) early adopters suggests increasing recognition among financial institutions that nature-related risks and illicit exposure are financially material.<sup>53</sup> Adopter status, however, reflects a disclosure commitment rather than proof of implementation quality or full site-level coverage.<sup>54</sup> Nevertheless, if sustained, this shift could raise the reputational and regulatory cost of association with unverified provenance and begin to alter the incentive conditions that make supply chain laundering so durable.

## EUROPE

Europe lies at the consumption end of the supply chains whose ecological costs have been documented across the Americas, Africa, and Asia. It is therefore both part of the problem and a potentially decisive market gate. European demand for soy, palm oil, cocoa, cattle, timber, seafood, and increasingly critical minerals has often absorbed illegally sourced or nature-harmful production without systematic provenance checks. The financial flows that supported that production, and the trade infrastructure that moved it, operated within the formal European economy. That history matters for designing future policy. The EUDR and related due-diligence rules mark a significant change because they move responsibility upstream from the border to the operator placing goods on the market.

The first-order ecological consequences of European consumption-side complicity are felt primarily in producer regions rather than on European territory. European demand for agricultural commodities has been materially connected to tropical deforestation in the Amazon, the Congo Basin, and Southeast Asia, contributing to primary forest loss that directly undermines climate mitigation, biodiversity commitments, and the hydrological stability on which regional agriculture depends.<sup>55</sup> At home, waste trafficking illustrates a domestically generated dimension of first-order harm. Organized networks exploit cross-border loopholes and legal business structures to move hazardous waste across jurisdictions, externalizing disposal costs onto communities and ecosystems.<sup>56</sup> A Europol-supported operation in Croatia in February 2025 targeted a network suspected of illegally disposing of 35,000 metric tons of

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<sup>52</sup> APG (2023); FATF (2020; 2021); EIA (2019; 2017).

<sup>53</sup> See more on TNFD adopters at <https://tnfd.global/engage/tnfd-adopters/tnfd-adopters-list/>.

<sup>54</sup> TNFD (2024).

<sup>55</sup> Pendrill et al. (2019).

<sup>56</sup> Europol (2025a).

hazardous waste imported across borders, illustrating precisely how legal logistics infrastructure is repurposed for environmental crime when regulatory arbitrage creates the opportunity.<sup>57</sup>

Second-order governance harms in Europe manifest differently from how they do in frontier regions but are analytically equivalent. The use of corporate fronts, document fraud, and regulatory arbitrage to move illegal commodities and hazardous waste through European markets corrodes the integrity of customs, certification, and financial oversight systems on which the single market depends.<sup>58</sup> Financial crime units across European countries have increasingly incorporated environmental commodity typologies, reflecting the finding by the Financial Action Task Force (FATF) that proceeds from environmental crime move through the same channels as fraud and narcotics.<sup>59</sup> The mechanism of using legal business structures to externalize costs and obscure provenance is the same political economy of regulatory arbitrage visible in Asia's supply chain laundering and the Americas' frontier extraction. The geography changes, but the logic does not.

Third-order consequences follow through supply chains and investment portfolios. Where European trade and finance have persistently failed to distinguish legal from illegal provenance, compliant producers in frontier jurisdictions have faced a structural competitive disadvantage, investment in legal alternatives has been suppressed, and the fiscal and governance conditions in producer countries have been weakened by the demand pull that European markets helped create. Tightening market access standards through the EUDR and related instruments can shift those dynamics. Regulation (EU) 2025/2650 postponed full application to December 2026 for large operators and June 2027 for small enterprises, meaning the practical test of these instruments lies immediately ahead.<sup>60</sup> Europe's most consequential contribution to reducing global environmental crime lies in market access discipline, alongside enforcement assistance to producer countries. Rigorous implementation of demand-side measures can close the market access that makes environmental crime globally profitable.

## Uneven progress

Environmental crime takes different forms across regions, but familiar conditions recur: weak governance, fiscal leakage, and demand that ignores provenance. International responses have addressed only fragments of this system. Despite growing awareness, environmental crime remains marginal to the mainstream SDG agenda and is seldom treated in national reporting as a cross-cutting constraint. Multilateral engagement has grown over the past decade, yet it remains partial and uneven. Environmental crime is still frequently treated as a specialized enforcement domain rather than as a structural driver of governance degradation, illicit financial flows, and investment deterrence that shapes development trajectories.<sup>61</sup>

Normative progress is also moving through the U.N. crime prevention system. In 2021, U.N. General Assembly resolution 76/185 recognized that the U.N. Transnational Organized Crime Convention (UNTOC) and the U.N. Convention Against Corruption (UNCAC) can be used to combat environmental crimes and the corruption that enables

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57 Europol (2025b).

58 FATF (2020; 2021).

59 FATF (2021).

60 Regulation (EU) 2025/2650 (2025).

61 Muggah (2025d; 2026); Scanlon and Motamayor (2026).

them.<sup>62</sup> This matters because it shifts the response beyond environmental cooperation alone and toward tools with greater deterrent value, including mutual legal assistance, asset recovery, and financial investigation. Momentum has continued under UNTOC. In October 2024, Parties adopted Resolution 12/4, asking UNODC to convene an expert group to assess how the Convention applies to crimes that affect the environment, identify legal gaps, and consider options including a possible protocol.<sup>63</sup> Sessions held in mid-2025 and early 2026 suggest growing political attention and a pathway toward stronger international cooperation.<sup>64</sup> Civil society and expert legal networks are also helping turn legal debates over definitions, liability, and jurisdiction into practical options for governments.

Operational cooperation has also intensified through law enforcement coalitions and intergovernmental bodies. Coordinated operations jointly led by INTERPOL and the World Customs Organization have become major vehicles for synchronized action. For example, Operation Thunder resulted in the seizure of close to 20,000 live animals and the arrest of 365 suspects through coordinated action from customs, police, and wildlife authorities across 138 countries and regions.<sup>65</sup> The significance lies in the institutionalization of intelligence sharing and multi-agency coordination across dozens of jurisdictions, capabilities that compound over time when properly resourced.

Since a regional agreement in Belém in 2023, there has been a steady stream of police operations targeting environmental crime across Latin America.<sup>66</sup> Operation Madre Tierra VII involved hundreds of arrests and seizures spanning logging, mining, wildlife trafficking, and pollution across Latin America, reinforcing the inference that environmental crime is a networked set of markets most efficiently degraded by targeting chokepoints rather than dispersed field operations.<sup>67</sup> Similar dynamics are visible in Europe through Europol-supported coordination and the EU EMPACT framework, where waste and pollution crime have been elevated as priority organized crime threats.<sup>68</sup> Cooperation has improved while remaining uneven across regions and commodities, constrained by legal gaps, limited investigative capacity, and weak financial investigations.

Market access has tightened significantly through due diligence and traceability requirements. The EUDR, the U.K. forest risk commodity approach, and the U.S. Lacey Act framework are emblematic of demand-side strategies intended to reduce facilitation of illegal conversion and laundering by requiring operators to demonstrate legality and provenance.<sup>69</sup> These regimes do not substitute for enforcement on the ground, but they alter incentives along supply chains, particularly when paired with customs targeting and satellite-based monitoring. Their effectiveness depends on implementation capacity and on whether compliance pathways are accessible to small and medium enterprises and smallholders.

Traceability-based enforcement has expanded beyond forests into waste and climate-relevant pollutants. Specifically, the World Customs Organization's Operation DEMETER XI illustrates the use of customs-led interventions to intercept illegal shipments of hazardous waste and illicit trade in ozone-depleting substances and hydrofluorocarbons, including cases involving misdeclaration and concealment.<sup>70</sup> States increasingly combine trade data and

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62 Muggah (2025b; 2026); U.N. General Assembly (2021).

63 Conference of the Parties to the United Nations Convention against Transnational Organized Crime (2024).

64 Muggah (2025c; 2026); UNODC (2026).

65 Interpol (2025a).

66 Muggah (2024a; 2024b).

67 Muggah (2026); Interpol (2025b).

68 See more on the EU EMPACT at [https://home-affairs.ec.europa.eu/policies/internal-security/law-enforcement-cooperation/empact-fighting-crime-together\\_en](https://home-affairs.ec.europa.eu/policies/internal-security/law-enforcement-cooperation/empact-fighting-crime-together_en).

69 Barclay (2023).

70 World Customs Organization (2026).

customs risk engines with field patrols to identify high-yield chokepoints, an approach with direct spillover benefits for climate objectives where illegal trade includes climate-forcing substances.

Financial and integrity-based approaches have expanded markedly, shaped by FATF typologies and a growing emphasis on beneficial ownership transparency. Following the money remains the highest-leverage strategy for identifying networks and stripping illicit profits, while beneficial ownership transparency reduces the use of anonymous corporate vehicles that facilitate laundering across timber, gold, waste, and wildlife supply chains.<sup>71</sup> The U.S. Department of the Treasury's Amazon Region Initiative Against Illicit Finance, launched in 2024, offered a prototype for linking finance and enforcement through training and information sharing among Amazon countries.<sup>72</sup> Beyond political disruption in the U.S. since 2025, persistent constraints include uneven capacity and the failure to turn intelligence into prosecutions.

Civil society and research networks have become increasingly central to this ecosystem. Mapping and investigative journalism provide actionable intelligence that helps banks, buyers, and prosecutors identify priority nodes and typologies. In the Amazon, cartography of environmental crime networks provides the evidentiary foundation for financial investigations and targeted enforcement.<sup>73</sup> In Africa, corridor mapping identifies convergence among wildlife trafficking, extractives, and other illicit markets, enabling multi-benefit intervention designs.<sup>74</sup> These networks do not replace state capacity. But they increasingly provide the information and public pressure that make enforcement more precise and impunity harder to sustain.

## A policy agenda that accounts for environmental crime

Effective responses to environmental crime require simultaneous action across several interconnected fronts. No single instrument can shift the system on its own. Enforcement without structural alternatives displaces criminal activity rather than ending it. Finance without integrity allows illicit proceeds to sustain the networks that enforcement is trying to dismantle. Development investment without market reform leaves compliant producers at a persistent competitive disadvantage. The agenda below is therefore organized around one practical test: whether it makes lawful activity more attractive than illegal extraction for communities, firms, and governments.

### DE-RISK TERRITORIES

Narrow place-based enforcement rarely works where illegal economies are sustained by insecure tenure, weak state presence, and laundering channels. Criminals fill governance vacuums the state has not closed and offer economic returns that legal alternatives cannot yet match. A more effective strategy is territorial de-risking that includes deliberately reducing the conditions that make illegal activity more attractive or less risky than legal alternatives. This means treating tenure reform, public services, and formalization as the core of the prevention architecture itself.<sup>75</sup>

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<sup>71</sup> Igarapé Institute (2023).

<sup>72</sup> U.S. Department of the Treasury (2024).

<sup>73</sup> Waisbich et al. (2022a).

<sup>74</sup> Global Initiative Against Transnational Organized Crime (2025).

<sup>75</sup> FATF (2020); ART (2024a).

Territorial de-risking should create predictable lawful returns through secure tenure and community enterprises that reward stewardship. Jurisdictional carbon and nature finance can reinforce those returns when safeguards are credible and benefits reach the people whose land-use decisions matter.<sup>76</sup> Public services and connective infrastructure reduce dependence on illicit patronage. Financial controls must then close the channels through which commodities and proceeds are laundered.<sup>77</sup> TNFD-aligned disclosure can reinforce this architecture by making nature loss and exposure to environmental risk financially material to boards and lenders.<sup>78</sup>

## UPGRADE DETERRENCE WHERE IT COUNTS

Scarce enforcement capacity should be concentrated where it can raise costs sharply and disrupt the greatest volume of criminal activity. The highest-leverage points are usually not the forest edge or the fishing ground. They are along transport corridors, at mills and refineries, in ports and export terminals, in trade finance channels, and at the corporate and beneficial ownership nodes that conceal the organizers who profit most and risk least. Governments and enforcement agencies should invest in fusing satellite alerts, customs anomalies, and suspicious transactions into integrated prosecutable strategies rather than operating them as parallel information systems that never connect. The gap lies in converting intelligence into cases, asset freezes, and sanctions that reduce expected profitability for criminal networks.

International cooperation is indispensable to this agenda. This is because supply chains span producer, transit, and consumer countries that no single jurisdiction can police alone. Governments should prioritize joint intelligence, coordinated targeting, and cross-border prosecution. Operation Green Shield in mid-2025 mobilized more than 1,500 officers across Brazil, Colombia, Ecuador, and Peru, generating arrests, asset seizures, and recoveries across fuels, minerals, and wildlife—demonstrating that coordinated targeting can degrade multi-crime ecosystems rather than simply displacing activity from one jurisdiction to the next.<sup>79</sup>

In Africa and Asia, INTERPOL and World Customs Organization operations such as Operation Thunder show what synchronized border and inland checks can achieve when intelligence is shared in real time. In Europe, joint investigations supported through Europol and EMPACT are the necessary model for tackling waste trafficking networks that exploit legal logistics infrastructure across multiple jurisdictions.<sup>80</sup> Chokepoint enforcement, asset recovery, and financial disruption can reduce the expected returns to environmental crime more effectively than dispersed field operations.

## EMBED CRIME-SENSITIVE CLIMATE AND NATURE FINANCE

Development financiers are exposed to environmental crime through the jurisdictions and commodity systems in which they operate. Their instruments can either reinforce or undermine the conditions that make legal economies competitive. Environmental crime exposure should therefore be incorporated into project appraisal and lending conditions rather than treated as a reputational risk to be managed at the margins. Concrete tools are available. For example, integrity covenants can tie disbursement to measurable governance milestones such as land titling, mer-

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76 ART (2024a); LEAF Coalition and Emergent (2023a; 2025).

77 FATF (2020).

78 TNFD (2023; 2024).

79 Muggah (2025d).

80 Europol (2025b).

cury phase-out, or fisheries monitoring. Beneficial ownership screening can be applied to counterparties in high-risk commodity sectors. Nature-related risk disclosure aligned with TNFD recommendations can make environmental crime exposure legible to boards and investors in ways that current reporting frameworks do not require. This would prevent development finance from operating blind to one of the structural conditions most likely to erode project viability and long-run returns.

The financial integrity dimension of this agenda deserves particular emphasis. Environmental crime proceeds move through the banking, trade finance, and corporate structures on which development finance institutions also rely. Institutions providing commodity-backed lending or sovereign budget support in high-exposure jurisdictions without adequate anti-money laundering controls and provenance checks are materially exposed to illicit financial flows whether or not they recognize it. The Amazon Region Initiative Against Illicit Finance, launched by the U.S. Treasury in 2024, offered a prototype for aligning finance and enforcement through training, intelligence sharing, and strengthened prosecutorial support.<sup>81</sup> That model could be adapted and scaled across other high-risk basins and commodity systems. Development finance institutions that lead on this agenda can reduce their own exposure while helping close the financial infrastructure that makes environmental crime at scale economically rational.

## SCALE JURISDICTIONAL REWARDS

Changing land-use behavior at scale requires making legal stewardship more financially attractive than illegal extraction. Jurisdictional climate finance is one of the few mechanisms designed to shift incentives across entire landscapes. ART TREES (Architecture for REDD+ Transactions (ART) and its standard, the REDD+ Environmental Excellence Standard (TREES)) and LEAF Coalition results-based payments pay sovereign and subnational governments for verified reductions in deforestation and forest degradation, combining program-level integrity with advance payment mechanisms that fund the monitoring and governance systems that results-based systems require.<sup>82</sup> Where they work, they create a direct financial incentive for governments to reduce illegal economies operating within their territories, align community interests with conservation, and generate public revenue that does not depend on extraction. That is precisely the incentive realignment that enforcement alone cannot achieve.

That potential depends on reforms often treated as secondary. Communities need enforceable tenure rights. Anti-corruption controls must prevent criminal capture, while independent monitoring gives buyers confidence. Benefit sharing must be transparent enough to ensure that financial rewards reach the communities whose land-use decisions determine outcomes on the ground rather than disappear through intermediaries.<sup>83</sup> Development finance institutions should make these conditions part of financing agreements, not leave them as aspirations.

## TIGHTEN MARKET GATES AND TRACEABILITY

Demand-side measures matter because they function as trade controls and because they represent a structural correction to commodity markets. Formal commodity markets have long absorbed illegally sourced and nature-harmful production without systematic provenance verification, while the financial flows supporting that production operated within the formal economy. The EUDR, the UK forest risk commodity framework, and the Lacey Act are all attempts to correct decades of commodity lending and trade finance that rewarded expansion without requiring

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81 Muggah (2024a); U.S. Department of the Treasury (2024).

82 ART (2024a); LEAF Coalition and Emergent (2023a; 2023b; 2025).

83 UNODC (2024).

producers to demonstrate legality or low-deforestation provenance. Governments and development finance institutions should treat these instruments as the most significant structural correction to commodity market incentives currently in force and push to extend their ambition to critical minerals, seafood, and livestock supply chains where provenance verification remains weak or absent.

Implementation will determine whether this agenda succeeds. Traceability systems and customs risk engines must let smallholders and smaller firms prove compliance without pricing them out of the market. Where the necessary infrastructure is weak, development finance institutions should help build it rather than assume that regulation will conjure it into existence. Traceability must also reach hazardous waste, ozone-depleting substances, and fluorinated greenhouse gases, where concealment and false declarations remain common.<sup>84</sup> The goal is a trading and finance system in which illegal or unverified provenance raises cost and risk for the operator rather than being absorbed invisibly into global supply chains at the expense of ecosystems, public revenue, and compliant producers.

## SHARPEN THE FIGHT AGAINST MERCURY AND IUU FISHING

Artisanal and small-scale gold mining is among the world's largest sources of mercury pollution and one of the most entrenched forms of survival-driven illegality across the Amazon, West Africa, and Southeast Asia. Addressing it requires a development response alongside enforcement. Governments should accelerate Minamata-aligned national action plans that phase out mercury, formalize miners, and open access to safer extraction technologies and legal buyers.<sup>85</sup> Formalization reduces toxic emissions and can sever the supply chain relationships through which criminal networks provide mercury, purchase gold, and launder the proceeds through refining and export operations.<sup>86</sup> Development finance institutions could fund formalization programs as financial integrity investments as much as environmental ones and support the treatment of illegal mining operations as organized criminal enterprises subject to financial investigation as well as field enforcement.

IUU fishing imposes comparable ecological and fiscal damage in coastal economies where fisheries are macro-critical sectors and monitoring capacity is chronically under-resourced. Full implementation of the Agreement on Port State Measures (PSMA)<sup>87</sup> would significantly raise expected costs for illegal fishing operations at the point where they are most vulnerable. Strengthened monitoring and surveillance systems should be treated as sovereign fiscal investments rather than donor-funded technical assistance, given the royalty and export revenue at stake.<sup>88</sup> West Africa is an urgent priority because chronic governance gaps, industrial-scale foreign illegal fishing, and the displacement of small-scale livelihoods produce ecological, institutional, and fiscal harms at once. Development finance institutions should make fisheries monitoring capacity a standard component of blue economy lending and budget support conditionality.

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84 European Union (2024); European Anti-Fraud Office (2025).

85 UNEP (2025).

86 UNEP (2018; 2025); Muggah (2025a).

87 See more on PSMA at <https://www.fao.org/port-state-measures/en/>.

88 FAO (2024); World Bank (2019).

## A diagnostic imperative

Environmental crime is a structural constraint on climate action and development because its damage does not stop at the ecosystem. It corrodes institutions, distorts markets, weakens sovereign revenues, and reduces the returns to lawful investment. Criminal networks do not generate these harms alone. They emerge from a continuum of incentive failures in which harmful subsidies, poorly sequenced infrastructure, and commodity finance that ignores provenance create the conditions that illegal activity then exploits. A financial system still unable to exclude illicit proceeds then keeps that activity profitable.

A credible response must connect instruments that are too often applied to separate problems. Each element depends on the others to function. Enforcement works best at chokepoints, backed by financial investigation and asset recovery. Market reform works when due diligence and customs controls lower the value of unverifiable supply. Development policy works when tenure, formalization, and public services reduce dependence on illegal economies. Financial integrity binds the system together. Without it, illegal proceeds keep flowing, political protection can still be bought, and illegal extraction remains profitable whatever happens at the forest edge, the fishing ground, or the mine site.

For the development community, the central task is diagnostic. Environmental crime is a political-economy problem rooted in the same distorted incentives and weak fiscal systems that development institutions already spend billions trying to correct. The instruments needed to address it—land policy, livelihood finance, formalization, market access, and financial controls—are already within reach. The binding constraint is less a shortage of resources or technical capacity than a failure to deploy these instruments as one system. Used together, they offer a powerful and comparatively inexpensive way to reduce environmental crime. Durable progress begins with that recognition.

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## EIGHT

# REWIRING FOOD VALUE CHAINS FOR PEOPLE, NATURE, AND PROSPERITY

Felipe Faria, Morgan Gillespy, and Guido Schmidt-Traub

## Food systems at a crossroads

The decade to 2030 is decisive for food systems. The Sustainable Development Goals (SDGs) provide a shared framework for tackling hunger (SDG 2), climate change (SDG 13), biodiversity loss (SDG 15), and inequality (SDG 10). Food systems sit at the intersection of these goals, yet progress remains uneven. Without structural reform, gains in one domain risk being offset by regression in another, for example, higher output achieved through land expansion; poverty reduction undermined by climate shocks; or export growth secured at the expense of ecosystems and long-term resilience.

Food systems are foundational to human well-being and economic development. They feed 8 billion people, employ more than a quarter of the global workforce, and anchor livelihoods across rural and urban economies.<sup>1</sup> At the same time, food and land-use systems generate roughly one-third of global greenhouse gas emissions and are the primary causes of deforestation, biodiversity loss, and freshwater depletion.<sup>2</sup> As climate volatility, soil degradation, and water stress intensify, the sector is increasingly exposed to the environmental risks it has helped create. Resilience is therefore not only an environmental objective but a macroeconomic and fiscal imperative. These interactions create reinforcing feedback loops between nature, the economy, and society. Degraded ecosystems reduce agricultural productivity, increase price volatility, and weaken rural livelihoods, while economic pressures can drive

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<sup>1</sup> FAO (2024).

<sup>2</sup> FOLU (2019), 12.

further land conversion, resource depletion, and environmental decline. Food systems, therefore, sit at the center of a two-way relationship: Nature underpins economic and social well-being, while the choices made by producers, consumers, firms, and governments determine whether natural capital is maintained or eroded.

Despite widespread recognition of these pressures, progress toward sustainable and inclusive food systems remains patchy. Regenerative production models, forest protection initiatives, and smallholder inclusion strategies continue to struggle to scale. Structural barriers persist, including fragmented land and forest data; weak or misaligned policy incentives; opaque first-mile sourcing; and limited access to affordable transition finance. These constraints dampen investment, entrench short-termism, and shift risk onto the smallholders and forest communities least able to absorb it.

A lack of technical solutions is not the problem. Pathways to improve yields, restore soils, reduce deforestation, and strengthen livelihoods are well documented. The challenge lies in translating pilots into system-wide change. Incentives are embedded not at the level of individual farms, but in the commercial relationships that connect production, trade, finance, and consumption. Without reshaping those relationships, reforms remain incremental and vulnerable to reversal.

A value-chain perspective offers a practical entry point for systemic transformation. Value chains connect producers, traders, processors, retailers, and financiers; they are where procurement standards, trade finance, credit terms, and traceability systems converge.<sup>3</sup> When aligned with policy and financial reform, value-chain governance can internalize environmental and social costs that are currently externalized. When misaligned, it reinforces land expansion, short payback horizons, and ecological risk.

This chapter argues that rewiring food value chains—by aligning policy, finance, and technology—is a pragmatic route to delivering more resilient, equitable, and nature-positive food systems. The sections that follow examine how value chains function as levers for transformation, drawing on soy and cocoa to illustrate both potential and limits, before turning to finance, policy, and implications for the SDGs and the post-2030 agenda.

Treating value chains as the primary unit of transformation has important implications for governance. Rather than relying on fragmented interventions at the farm, firm, or consumer level, it requires institutions capable of aligning actors across production, trade, finance, and consumption. In practice, this means strengthening multi-stakeholder platforms that bring together governments, producers, traders, financiers, and civil society to develop shared transition plans; aligning public incentives and private procurement around common outcomes; and improving transparency over financial and commodity flows.

## Value chains as levers for transformation

A value-chain approach examines the sequence of activities and relationships that connect production, processing, trade, and consumption for a given commodity. It asks where value is created, where risks and externalities arise, and how incentives are transmitted between actors. In food systems, this perspective is powerful because decisions affecting land use, farming practices, labor conditions, and environmental outcomes are rarely made in iso-

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3 Gereffi, Humphrey, and Sturgeon (2005).

lation at the farm level. They are shaped by procurement contracts, quality standards, financing terms, and market access conditions embedded in commercial relationships.

The intellectual foundations for this approach lie in research on global value chains (GVCs), which shows that governance structures within commodity chains shape how standards, upgrading, and risk allocation occur.<sup>4</sup> Sustainability requirements increasingly function as governance mechanisms, redistributing compliance costs upstream while enabling lead firms to manage reputational and regulatory exposure. Transformation, therefore, depends not only on technological feasibility but on how coordination and commercial power are structured.

A value-chain perspective complements, but does not replace, landscape and jurisdictional approaches. Landscape strategies align conservation and production within defined geographies and are essential for addressing spatial externalities such as deforestation, leakage, and watershed degradation.<sup>5</sup> Jurisdictional initiatives link procurement and finance to performance across states or provinces, reducing transaction costs and leveling standards among producers. Yet these place-based approaches often struggle to mobilize sustained private capital when producers remain embedded in global markets shaped by external demand. Value chains connect those place-based outcomes to market incentives and financial flows across borders.

The ability of value chains to shape incentives is significant but uneven. In many commodity systems, prevailing commercial structures reward land expansion over productivity, short payback horizons over long-term resilience, and informality over compliance. Credit design, trade finance arrangements, and procurement practices often prioritize volume and cost minimization, reinforcing short-term production decisions rather than investment in soil health, traceability, or risk management. Public policy can compound these distortions when subsidies and regulatory frameworks favor input intensity or land conversion.

Even where leading firms adopt ambitious sourcing standards, transformation remains partial if a critical mass of buyers does not move in parallel. Certification experiences illustrate this constraint: Higher standards in one market segment rarely shift global production norms when alternative demand channels remain available. Lasting transition, therefore, depends less on market concentration alone and more on coordinated shifts across policy frameworks, financial systems, and technological infrastructure.<sup>6</sup>

These three domains—policy, finance, and technology—function as institutional complements. Policy establishes baseline rules through land governance, subsidy structures, and regulatory certainty. Finance determines whether sustainable practices are economically viable at scale, particularly for smallholders and small and medium-sized enterprises (SMEs) facing longer investment horizons. Technology reduces information asymmetries through traceability, geolocation, and digital monitoring, enabling risk differentiation and accountability. Progress in one area yields limited results unless reinforced by the others.

How these dynamics play out depends on value-chain structure. In export-oriented chains such as soy or palm oil, concentrated traders and buyers can rapidly transmit sourcing standards when aligned. In smallholder-dominated chains such as cocoa, traceability is more complex and value add is concentrated downstream, limiting producer leverage and making income and service provision central to sustainability. In domestically embedded chains such

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4 Ibid.

5 Lambin et al. (2014).

6 IPCC (2023).

as beef or staple grains, political economy constraints are often stronger, as production is tied closely to national consumption, employment, and identity.

Value chains therefore do more than transmit goods—they structure markets. Lead firms, traders, financiers, and standards bodies shape procurement norms, allocate risk, and determine access to capital. When policy, finance, and technology align within these relationships, environmental and social costs can be internalized and capital redirected toward resilience. When misaligned, value chains reinforce degradation and inequality. The question is not whether value chains matter, but how they are governed and financed. Their transformative potential depends on whether incentives, risk allocation, and investment decisions are aligned around long-term resilience rather than short-term extraction.

## Case study: Soy in the Brazil-China value chain

Soy illustrates both the potential and the limits of a value-chain approach to food system transformation. Several structural features shape incentives within this chain: producer and trader concentration; the export-oriented nature of trade; limited product differentiation; the relative feasibility of traceability; and the economics of transition, including capital intensity and payback periods. Brazil and the United States together account for roughly two-thirds of global production, while China imports around 60% of its soy from Brazil.<sup>7</sup> This combination of concentrated supply, consolidated intermediation, and stable export demand gives a relatively small number of actors outsized influence over land-use outcomes, trade finance, and production practices. Yet the short payback horizon of conventional expansion and the low differentiation of bulk soy reinforce incentives for land conversion unless financial and policy signals are deliberately realigned.

China's role is central. Analysis by the Food and Land Use Coalition, Re-WIRE, highlights that Chinese demand, driven by feed requirements and long-term food security concerns, creates stable, large-volume offtake relationships that shape trader behavior and investment decisions in Brazil.<sup>8</sup> Unlike the European Union, which has adopted mandatory due diligence requirements through the EU Deforestation Regulation (EUDR), China has historically relied more on supplier assurances, voluntary commitments, and bilateral engagement to promote sustainable sourcing.<sup>9</sup> These differing governance approaches influence how sustainability incentives are transmitted upstream through the soy value chain.

The concentration of actors within the soy value chain creates both opportunities and challenges for transformation. A relatively small number of traders, processors, financiers, and buyers influence sourcing practices across large geographies, giving them significant capacity to scale traceability systems, sustainability standards, and financing innovations. At the same time, market power and information asymmetries can obscure how risks, costs, and benefits are distributed across the chain. Traceability is, therefore, not only a technical challenge but also a political-economy challenge. Its effectiveness depends on who controls information, who bears compliance costs, and how incentives are transmitted between downstream market actors and upstream producers.<sup>10</sup>

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7 FOLU, Systemiq, and WBCSD (2025), 7.

8 Ibid.

9 Ibid.

10 Santos, Zaytseva, and Serrano (2025).

Applying the Re-WIRE analytical framework to the Brazil-China corridor across five dimensions—systemic risks, production impacts, transition status, economic feasibility, and financial flows—identified a structural mismatch: While deforestation- and conversion-free (DCF) sourcing has reduced certain risks and improved traceability, the underlying incentives embedded in rural credit, trade finance, and procurement practices continue to favor expansion and short payback horizons over long-term resilience.<sup>11</sup>

Systemic risk is increasingly shared. Climate variability in Brazilian production regions directly affects Chinese feed markets, while evolving regulatory pressures, including European due diligence requirements, create spillover effects that influence how Chinese buyers assess supply chain resilience. Re-WIRE's analysis underscores that China's growing engagement in traceability dialogue and green finance reform represents a potential, though still emerging, leverage point.<sup>12</sup>

Over the past decade, the soy value chain has demonstrated that rapid progress is possible around a narrowly defined objective. Voluntary commitments by major traders, supported by satellite monitoring and farm-level traceability, have substantially reduced soy-driven deforestation in the Brazilian Amazon biome.<sup>13</sup> The Amazon Soy Moratorium is associated with a sharp decline in soy-linked deforestation in that region.<sup>14</sup> Yet Trase data indicates that soy-associated deforestation and conversion reached roughly 790,000 hectares in 2022, much of it concentrated in the Cerrado, where clearing remains legal or weakly enforced.<sup>15</sup> These gains demonstrate how downstream demand and credible monitoring can shift sourcing norms at scale but also show that voluntary compliance cannot offset broader land-use pressures where legal clearing and enforcement gaps remain.

The soy case also highlights why value-chain progress remains fragile when incentives are only partially aligned. DCF compliance addresses one acute risk—deforestation exposure—but does little to resolve broader structural pressures, including soil degradation, climate vulnerability, biodiversity loss, and livelihood inequality. Progress remains politically contested, as illustrated by mounting opposition to the Amazon Soy Moratorium amid shifting state-level tax incentives and legal challenges.<sup>16</sup> When sustainability requirements are perceived as externally imposed rather than aligned with domestic productivity and competitiveness goals, coalitions can weaken and hard-fought gains can stall.

A significant challenge lies in how finance flows through the value chain. Re-WIRE highlights that Brazil's rural credit system provides the majority of formal finance to soy producers, yet lending remains concentrated among larger farms and sustainability-linked credit lines account for only a small share of total flows.<sup>17</sup> Intra-value-chain finance, through forward contracts, input pre-financing, and barter arrangements often rivals formal credit in scale but is rarely tied to environmental or social performance. These instruments are structured to secure supply and manage short production cycles, with underwriting based on yield history rather than land-use outcomes. Without integrated traceability systems and financing aligned with transition payback periods, sustainability criteria remain largely outside the financial architecture of the chain.

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11 FOLU, Systemiq, and WBCSD (2025).

12 Ibid.

13 Heilmayr et al. (2020).

14 Ibid.

15 Pereira and Bernasconi (2025).

16 Wenzel (2026).

17 FOLU, Systemiq, and WBCSD (2025).

It also shows that Chinese financial institutions and trading firms increasingly participate in pre-financing and infrastructure investment linked to the soy corridor.<sup>18</sup> Yet sustainability-linked lending and environmental risk segmentation remain limited in cross-border trade finance. Integrating traceability and nature-risk metrics into China-facing credit lines represents a largely untapped leverage point.

The financing architecture produces a structural asymmetry: Producers most capable of complying with DCF requirements are often least in need of incentives to change, while mid-sized producers in high-risk regions face thin margins and limited access to capital. These actors represent a critical pivot point for transformation.

Finally, the economic logic of “produce-and-protect” remains under-integrated into mainstream finance. Brazil’s competitiveness in soy, including its capacity for double-cropping, depends in part on stable rainfall patterns supported by intact forests. Recent research estimates that the rainfall-generation services of the Brazilian Legal Amazon amount to tens of billions of dollars annually, yet such ecosystem values rarely enter credit assessments or procurement pricing.<sup>19</sup> Making deforestation-free sourcing the market baseline is a necessary foundation, but not an endpoint.

Lasting progress within the soy value chain requires three reinforcing shifts:

- **First, embed sustainability conditionality into the financial plumbing of the value chain.** Trade finance, pre-financing arrangements, and working capital terms should incorporate traceability and risk segmentation so that access to liquidity reinforces environmental performance rather than operating independently of it.
- **Second, redirect both public and private finance upstream toward productivity-enhancing and regenerative systems on existing land.** Integrated crop-livestock-forest systems, pasture recovery, and soil restoration approaches can raise yields and diversify income but often require longer tenors, grace periods, and risk-sharing instruments aligned with transition payback periods.
- **Third, align value-chain incentives with place-based governance.** Demand-side commitments and trade finance can generate powerful signals, but outcomes depend on land-use governance, enforcement capacity, and producer legitimacy at state and municipal levels. Linking jurisdictional planning with value-chain procurement and finance can reduce leakage and stabilize gains over time.

Taken together, the soy case shows that value chains can rapidly redefine sourcing baselines when concentrated actors align. But lasting change depends on whether compliance is embedded in finance, reinforced by public policy, and linked to productivity and resilience. Where value-chain action substitutes for deeper institutional reform, progress remains partial and reversible. Where incentives across policy, finance, and technology are realigned, value chains can materially alter land-use trajectories.

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<sup>18</sup> Amendolagine, Presbitero, and Rabellotti (2024).

<sup>19</sup> Baker et al. (2026), 1.

## Case study: Cocoa in the West Africa-EU value chain

Cocoa offers a useful counterpoint to soy because it is also a highly concentrated and strategically important value chain, yet the main challenges, and therefore the levers of change, look very different. West and Central Africa produces roughly 70% of the world's cocoa, with Côte d'Ivoire and Ghana accounting for around two-thirds of global supply.<sup>20</sup> On the demand side, the EU remains the world's largest importer of cocoa beans, accounting for approximately 58% of global imports (around 1.8 million tons in 2023).<sup>21</sup> This concentration, where dominant origins supply a dominant consumer-processing region, creates a theoretical basis for rapid progress through downstream standards and due diligence. In practice, cocoa demonstrates why environmental compliance alone rarely delivers lasting outcomes when the production base is smallholder-dominated, and the political economy is defined by poverty, weak bargaining power, and social risk.

Over the past decade, sustainability efforts in cocoa have expanded through certification, company programs, and multi-stakeholder initiatives. One example is the Cocoa & Forests Initiative (CFI), launched in 2017, bringing together the governments of Côte d'Ivoire and Ghana, major cocoa and chocolate companies, and partners under a shared commitment to curb cocoa-driven deforestation and promote climate-resilient production.<sup>22</sup> These efforts increasingly rely on technology-enabled traceability, including farm mapping and geolocation, because credible proof of origin is central to both voluntary commitments and emerging regulation.

The EUDR reinforces this direction.<sup>23</sup> Although implementation timelines have shifted, the structural change remains that access to European markets increasingly depends on due diligence and evidence that commodities are not linked to deforestation and forest degradation. Cocoa is therefore moving toward a compliance-baseline logic like soy, but within a far more fragmented and socially complex production system.

Despite expanded sustainability architecture, cocoa continues to exhibit persistent poverty and labor risks that undermine long-term environmental outcomes. One synthesis report found that a majority (73-90%) of surveyed households in Côte d'Ivoire and Ghana fall short of living income thresholds.<sup>24</sup> Low and volatile incomes translate into underinvestment: Aging trees are not replanted, pest management is inadequate, and yield gaps persist; together, these conditions can increase pressure to expand cultivation into forest margins.

Child labor remains an acute risk, closely linked to chronic household poverty and weak rural service provision. An EU partnership summary estimates that as many as 1.56 million children work in cocoa production across Côte d'Ivoire and Ghana.<sup>25</sup> Evidence suggests that sustainable progress requires bundled interventions, for example, combining monitoring and remediation with education access, productivity support, and income stabilization, rath-

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20 Wessel and Quist-Wessel (2015); USDA FAS (2025).

21 CBI (2023), 1.

22 See more on the Cocoa & Forests Initiative on their webpage at <https://www.idhsustainabletrade.com/initiative/cocoa-and-forests/>.

23 See more on the EU's deforestation regulation at [https://environment.ec.europa.eu/topics/forests/deforestation/regulation-deforestation-free-products\\_en](https://environment.ec.europa.eu/topics/forests/deforestation/regulation-deforestation-free-products_en).

24 van Vliet et al. (2021), 1.

25 European Commission, Directorate-General for International Partnerships (2021), 6.

er than isolated compliance measures.<sup>26</sup> The critical barrier therefore differs from soy: whereas soy centers on land-use incentives and conditional finance, cocoa is constrained by structural poverty, low farm-gate incomes, and limited public services. Traceability-focused compliance will not address these ongoing social drivers.

Unlike soy, concentration in cocoa is asymmetric. Downstream segments—trading, processing, and chocolate manufacturing—are relatively concentrated, while upstream production in West Africa is overwhelmingly smallholder and highly fragmented, limiting collective producer leverage.<sup>27</sup> Farmers operate on small plots with insecure tenure, limited access to services, and high exposure to climate variability and disease. Regulated farm-gate pricing and forward-selling practices can insulate farmers from downside volatility but also limit their ability to capture upside during price spikes, leaving margins thin. When large cross-border price gaps emerge, informal trade expands, complicating traceability and governance.

The cocoa case illustrates why environmental compliance must be paired with income, productivity, and governance reforms. It also highlights why sequencing across policy, finance, and technology differs from soy.

- **First, make compliance workable by financing transition rather than merely auditing it.** Traceability and deforestation-free requirements impose new costs—mapping, documentation, farm upgrades—that must be offset through productivity support, replanting programs, input access, and credit facilities reaching farmers and cooperatives. Living-income-focused policies, such as the Living Income Differential introduced by Côte d'Ivoire and Ghana, reflect attempts to strengthen the income floor, though effectiveness depends on implementation and market transmission.<sup>28</sup>
- **Second, embed social risk management as a core operating requirement.** Given the scale of child labor risk, monitoring systems must link to remediation, education access, and livelihood support. Compliance cannot be document-based alone; it must be embedded in household economics.
- **Third, align producer-country governance with market incentives.** Pre-competitive coordination initiatives have shown potential to align forest protection and productivity goals but remain vulnerable when under-financed or politically contested. Due diligence in consuming markets ultimately depends on land governance, farmer registries, and enforcement capacity in producing regions.
- **Finally, treat technology as enabling infrastructure rather than a substitute for reform.** Farm geolocation and digital monitoring are indispensable in a due-diligence era, but without parallel finance and institutional support, they risk becoming compliance costs that concentrate market access among better-resourced actors.

Like soy, cocoa demonstrates that concentrated value chains can accelerate coordination downstream. But cocoa underscores a deeper lesson: Compliance layered on top of poverty and weak governance is unlikely to result in

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26 NORC at the University of Chicago (2020).

27 Li et al. (2025).

28 Boysen et al. (2023).

lasting change. In the West Africa-EU corridor, environmental requirements are necessary foundations.<sup>29</sup> Without parallel reforms that raise incomes, close yield gaps, strengthen cooperative governance, and integrate social risk remediation into supply-chain operations, progress will remain partial and vulnerable to leakage and backlash.

## Financing the transformation

Rewiring food value chains ultimately rises or falls on finance: who pays, when they pay, and what gets priced in. If value chains are governance architectures that shape markets, finance is the mechanism through which those architectures translate ambition into behavior. Credit allocation, trade finance, procurement-linked liquidity, and risk pricing determine whether deforestation-free, regenerative, and socially responsible practices remain peripheral or become economically rational.

Achieving this transformation requires two complementary changes in how finance is deployed. First, redirect existing financial flows that reward land expansion and resource depletion. Second, mobilize capital structures capable of underwriting transitions with longer payback horizons and higher upfront costs.

The transition challenge is fundamentally economic. Many practices that improve resilience and environmental outcomes, including agroforestry, regenerative agriculture, pasture restoration, and deforestation-free production, require upfront investment while generating benefits over longer time horizons. Farmers and value-chain actors often face higher initial costs, uncertain returns, and limited access to affordable finance. In many cases, market premiums remain too small, inconsistent, or short-lived to offset these costs. As a result, practices that generate long-term benefits for society can remain financially unattractive for individual producers and firms. Closing this gap is therefore one of the central challenges of food-system transformation.

Globally, agricultural support remains heavily misaligned with sustainability objectives. The Food and Agriculture Organization of the United Nations (FAO) estimates that support to agricultural producers is currently around \$540 billion per year, much of it delivered through measures that distort markets, are unevenly distributed, and damage both the environment and human health. If current trends continue, this support could rise to almost \$1.8 trillion by 2030.<sup>30</sup> Redirecting even a fraction of this support toward sustainable production and protection would significantly narrow the transition financing gap today. Yet the practical challenge is less about inventing new pools of money than redesigning the plumbing, i.e., turning routine financial decisions into vehicles for transformation.

The scale required is substantial. Recent syntheses estimate that agrifood systems require over \$1 trillion per year in investment over the coming decade to align with climate and nature objectives, while current flows toward sustainable food systems remain far below that level.<sup>31</sup> Funding needs are concentrated in emerging markets, particularly in preventing land-use change and scaling regenerative production. Pilots will not move the needle unless designed as underwriting templates embedded in mainstream finance.

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<sup>29</sup> Krausing and Said Birch (2023).

<sup>30</sup> FAO, UNDP, and UNEP (2021).

<sup>31</sup> Climate Policy Initiative (2024), 5.

The soy and cocoa cases illustrate why finance is critical. In soy, concentrated traders shifted sourcing norms, yet credit design and trade finance largely operate independently of environmental risk segmentation. In cocoa, compliance requirements expand, but smallholder producers lack capital to invest in replanting, agroforestry, and productivity improvements. In both systems, the barrier is the capital structure.

At the producer level, scaling regenerative and forest-positive production requires instruments that close the gap between perceived and actual risk-return profiles. The issue is not only access to working capital and long-term credit, but how eligibility criteria, collateral requirements, and tenor assumptions systematically favor short-cycle models. Regenerative transitions often generate positive net returns over time, but with delayed cash flows and higher initial uncertainty that conventional underwriting frameworks discount.

Brazil provides a useful illustration of both opportunity and constraint. Plano Safra channels concessional agricultural finance at scale, and instruments such as RENOVAGRO offer preferential rates for low-carbon agriculture, including integrated crop-livestock-forest systems and pasture recovery.<sup>32</sup> This demonstrates that subsidy reform can retarget concessionality toward practices that generate public-good returns. Yet unless credit design matches transition economics, through longer amortization periods, grace periods, and risk buffers, even well-intentioned programs remain underutilized.

One of the largest near-term opportunities lies in intra-value-chain finance: the everyday mechanisms connecting farmers, intermediaries, processors, and buyers. Forward contracts, input pre-financing, supply-chain finance, and working capital facilities can rival formal agricultural credit in scale, yet typically remain blind to environmental and social performance. When traceability systems credibly segment low- from high-risk supply, financiers can price risk, structure covenants, and offer differentiated terms. Finance then becomes the delivery channel for sustainability rather than an afterthought.

Emerging models demonstrate this logic. Sustainability-linked loans tie borrowing costs to environmental and social performance metrics, creating incentives for upstream improvements. Supply-chain finance programs increasingly offer preferential payment terms to compliant suppliers. Their significance lies less in novelty than in embedding sustainability within existing commercial infrastructure.

Across commodities, the biggest barrier is not the availability of capital but the willingness to finance transition risk. A broader set of financial instruments will also be needed to support transition at scale. Sustainability-linked loans can reward progress against environmental and social outcomes through preferential borrowing terms, while blended-finance structures can help absorb early-stage transition risk. Insurance has an equally important role. As climate volatility increases, risk-transfer mechanisms can help producers, lenders, and governments manage the growing costs of droughts, floods, and other shocks. At a systemic level, climate and nature risks are increasingly relevant to banking supervision, sovereign creditworthiness, and fiscal stability. Integrating these risks into lending practices, financial regulation, and sovereign risk assessments can help shift capital toward more resilient produc-

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32 KCI (2025).

tion systems while reducing exposure to future shocks. Scalable models, therefore, depend on structured risk-sharing. A financing stack clarifies the allocation of risk:

- **Commercial capital**<sup>33</sup> holds diversified exposure linked to predictable cash flows, such as procurement-backed lending or portfolio-based credit.
- **Catalytic capital**, either public or philanthropic, absorbs early-adoption risk, first-loss tranches, and verification infrastructure costs.
- **Value-chain actors** provide credit enhancement through long-term offtake agreements, working-capital facilities, price floors, interest buydowns, or barter arrangements, reflecting the resilience benefits they capture downstream.

This allocation reflects comparative advantage in risk-bearing and recognizes that private capital will not finance systemic land-use transitions at scale without aligned risk mitigation.

Outcome-based revenue streams such as carbon credits, biodiversity payments, or watershed services can strengthen the investment case for agroforestry, restoration, and produce-and-protect systems. However, these markets remain small relative to agricultural finance and are often inaccessible to smallholders due to high development and verification costs. They should function as accelerators and risk buffers rather than the primary engines of profitability. Significant scale depends on productivity gains, stable market access, and reduced exposure to climate and price shocks.

The deeper transformation is institutional. Nature and resilience must become legible within core decision systems, including credit committees, procurement policies, fiscal planning, and portfolio allocation models. Climate volatility is already increasing agricultural losses and affecting sovereign risk profiles.<sup>34</sup> Transition finance is therefore not only an environmental imperative but a financial stability concern.

Two system-level enablers are particularly important:

- **Standardized disclosure and reporting.** Emerging climate- and nature-related disclosure frameworks reduce information asymmetry and make environmental risk visible within financial decisionmaking. Their significance lies in whether they reshape underwriting criteria, loan covenants, and portfolio construction.
- **Forward-looking risk modeling.** Traditional reliance on historical yield data is increasingly misaligned with accelerating climate variability. Integrating scenario analysis, geospatial risk data, and nature-risk metrics into credit assessments is essential if transition investments are not to appear artificially risky relative to conventional practices built on outdated climate assumptions.

Technology underpins these shifts. Geospatial traceability, digital farmer registries, remote sensing, credit-scoring tools, and interoperable data platforms reduce transaction costs and enable risk differentiation. When embedded

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33 Commercial capital refers to private, return-seeking finance deployed on market terms. It comes from commercial banks, institutional investors (pension funds, insurers), asset managers, private equity, infrastructure funds, hedge funds, corporates' balance sheets, and non-bank lenders. It is typically provided through loans, bonds, equity, project finance, receivables/trade finance, and leasing, structured to meet market risk/return hurdles.

34 Kling et al. (2025).

in commercial workflows, they reinforce incentives through lower interest rates, earlier payment, and preferential access, rather than merely documenting compliance.

Financing transformation is about restructuring mainstream capital flows within value chains so that environmental stewardship, social inclusion, and long-term productivity become embedded in ordinary financial decisions. Where finance remains detached from environmental and social objectives, value-chain gains remain fragile. Where capital is deliberately rewired, through risk-sharing, conditional liquidity, and incentive-aligned credit design, value chains can redirect land-use trajectories at scale.

## Policy as the ultimate accelerator

Value chains transmit incentives through procurement, finance, and trade relationships, but public policy determines whether those incentives reinforce or undermine resilience. If finance transmits incentives, policy defines the rules of the game: property rights, subsidy structures, disclosure requirements, trade access, fiscal priorities, and enforcement capacity. Without policy alignment, even sophisticated value-chain initiatives remain partial and vulnerable to reversal.

Research across political economy and environmental governance shows that lasting land-use transitions require coordinated public authority. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment (2019) identifies subsidy reform and institutional alignment as primary levers for reversing biodiversity loss.<sup>35</sup> Similarly, the Intergovernmental Panel on Climate Change (IPCC) concludes in its Sixth Assessment Report (2022) that mitigation in agriculture and land use depends on enabling conditions—policy coherence, regulatory certainty, and public investment.<sup>36</sup>

Policy matters at three interconnected levels: multilateral and financial governance, trade and regulatory regimes, and national fiscal and land-use frameworks.

### MULTILATERAL AND FINANCIAL GOVERNANCE

At the global level, financial and accounting standards increasingly incorporate natural capital into risk assessment and macroeconomic planning. The integration of climate risk into financial supervision, advanced by the Network for Greening the Financial System (NGFS), demonstrates how systemic risk can reshape regulatory expectations.<sup>37</sup> Disclosure frameworks, including the Taskforce on Nature-related Financial Disclosures (TNFD) and the International Sustainability Standards Board (ISSB), aim to make ecosystem dependencies visible within corporate and financial reporting.<sup>38</sup>

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35 See the IPBES Global Assessment (2019) at [https://files.ipbes.net/ipbes-web-prod-public-files/inline/files/ipbes\\_global\\_assessment\\_report\\_summary\\_for\\_policymakers.pdf](https://files.ipbes.net/ipbes-web-prod-public-files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf).

36 See the IPCC's sixth assessment report at <https://www.ipcc.ch/assessment-report/ar6/>.

37 See the Network for Greening the Financial System webpage at <https://www.ngfs.net/en>.

38 See the Taskforce on Nature-related Financial Disclosures webpage at <https://tnfd.global/>; See the International Sustainability Standards Board webpage at <https://www.ifrs.org/groups/international-sustainability-standards-board/>.

Their significance lies not in disclosure alone, but in capital allocation. If regulators require financial institutions to model how nature-related shocks—such as deforestation bans, ecosystem collapse, and water scarcity—can affect loan books and portfolios, banks have incentives to price environmental risk, restrict capital to high-risk sectors, and offer more favorable terms to traceable and resilient producers.

Multilateral development banks (MDBs) and international financial institutions also play a catalytic role. Recent reforms emphasize integrating climate and nature into development finance.<sup>39</sup> When aligned with value-chain strategies, MDB instruments can de-risk jurisdictional sourcing, support rural credit reform, and embed sustainability conditionality within trade finance.

Yet governance remains fragmented. Agricultural trade, climate finance, biodiversity commitments, and food security are negotiated in separate forums. For value chains, this fragmentation produces mixed signals, sustainability-linked disclosure in some markets alongside subsidy and trade regimes that continue to reward expansion. Bridging these silos is essential if financial governance is to reinforce rather than dilute transformation.

## TRADE POLICY AND REGULATORY REGIMES

Trade policy increasingly functions as environmental governance. The EUDR represents a structural shift: Market access for commodities such as cocoa, soy, palm oil, and beef now depends on due diligence and proof of deforestation-free origin.<sup>40</sup> This alters the risk calculus of exporters and traders globally.

Research on hybrid governance shows that regulatory backstopping strengthens voluntary commitments.<sup>41</sup> When due diligence is mandatory, sustainability shifts from reputational preference to legal obligation. At the same time, trade-linked environmental measures must navigate concerns over sovereignty, equity, and World Trade Organization (WTO) compatibility. Historical disputes underscore the importance of transparency, non-discrimination, and proportionality.<sup>42</sup>

Trade policy can also facilitate transition through preferential tariffs, mutual recognition of traceability systems, and green public procurement. Conversely, export bans and ad hoc restrictions, often deployed during food price spikes, can destabilize value chains and deter long-term investment.

The soy and cocoa cases illustrate this dynamic. In soy, concentrated export corridors amplify regulatory signals. In cocoa, due diligence without parallel producer-country investment risks exclusion and leakage. Trade policy can accelerate change, but only when paired with upstream governance and finance.

## NATIONAL FISCAL AND LAND-USE POLICY

Ultimately, value-chain transformation hinges on national policy frameworks. Fiscal systems, rural credit design, land tenure security, and enforcement capacity determine whether sustainability commitments are feasible at scale.

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39 MDB Nature Working Group (2025).

40 European Commission (2026).

41 Lambin et al. (2014).

42 WTO and UNEP (2009).

Agricultural subsidy reform is central. The Organisation for Economic Co-operation and Development (OECD) finds that a substantial share of global agricultural support remains environmentally harmful or weakly targeted.<sup>43</sup> Redirecting subsidies toward ecosystem restoration, soil health, and climate resilience would alter production incentives more effectively than isolated pilots.

Land tenure security is equally critical. Secure property rights correlate with higher investment in soil conservation and long-term productivity.<sup>44</sup> In cocoa systems, weak tenure discourages replanting and agroforestry; in frontier soy regions, unclear enforcement undermines compliance and increases regulatory risk.

National value-chain strategies represent an emerging frontier. Governments can map strategic commodities across production, processing, trade, and employment nodes, aligning fiscal tools and credit facilities with resilience goals. Brazil's Produce, Conserve, Include (PCI) strategy in Mato Grosso demonstrates how state-level coordination can align conservation targets with productivity growth.<sup>45</sup> Similar efforts in African countries seek to combine agricultural transformation with forest protection and climate resilience.<sup>46</sup>

Embedding natural capital into macrofiscal frameworks strengthens these strategies. The System of Environmental-Economic Accounting (SEEA) provides standardized methods to integrate ecosystem services into national accounts.<sup>47</sup> Countries incorporating natural capital into fiscal planning are better positioned to assess trade-offs and attract climate-aligned finance. Recent Systemiq work with Uganda's Ministry of Finance illustrates this shift. The initiative integrates climate and nature resilience into macrofiscal planning—including debt sustainability, growth projections, medium-term expenditure frameworks, and sovereign risk assessments—reflecting growing recognition that climate and natural capital degradation can materially affect fiscal stability and sovereign borrowing costs.<sup>48</sup>

## POLICY AS ENABLER OF VALUE-CHAIN LEVERAGE

Value chains shape incentives only within policy environments that define contract enforceability, disclosure obligations, fiscal signals, and land governance. When public authority aligns these parameters with environmental and social objectives, value chains amplify transformation; when misaligned, they entrench depletion.

Policy functions as an accelerator in two ways. It reduces transition risk by providing regulatory certainty and coherent signals, and it reshapes relative returns—through subsidy reform, taxation, or enforcement—so that regenerative models become competitive without permanent concessional support.

Three priorities stand out through 2030:

1. Repurpose harmful subsidies toward resilience and regenerative productivity.
2. Mandate credible disclosure and due diligence to internalize environmental risk.
3. Align rural credit and fiscal planning with value-chain transition pathways.

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43 OECD (2023).

44 Besley (1995); Lawry et al. (2017).

45 See the Produce, Conserve, Include strategy webpage at <https://pcimt.org/en/>.

46 UN Food Systems Coordination Hub (2026).

47 See the System of Environmental-Economic Accounting webpage at <https://seea.un.org/>.

48 Systemiq (2025).

Policy does not substitute for value-chain action; it stabilizes and scales it. When public authority clarifies rules, enforces standards, and retargets fiscal incentives, value chains become conduits for transformation rather than vectors of risk.

## From 2030 to 2050: Delivering on the SDGs and beyond

The preceding analysis underscores that resilience in food systems will depend on aligning value-chain incentives with public policy and financial architecture. As the international community approaches the 2030 deadline for the Sustainable Development Goals (SDGs), the question is no longer whether change is necessary, but how transition pathways can be institutionalized and scaled. The next phase must move from incremental compliance to structural alignment.

Climate change is not simply an additional risk factor within existing food systems. Between now and 2050, it is likely to reshape the geography of production, trade, and investment. Some regions may experience declining suitability for key crops, rising adaptation costs, and more frequent production shocks, while others may become relatively more competitive. These shifts will affect global trade flows, infrastructure needs, and sourcing strategies, creating new pressures for governments, firms, and financial institutions to manage transition and adaptation simultaneously. Climate volatility should be understood as an increasingly powerful driver of value-chain transformation.

In the near term, the priority must be stabilization. Governments can embed natural capital and climate risks into fiscal planning, reform harmful subsidies, and establish legal frameworks for traceability and due diligence. Businesses can make deforestation-free production the market baseline, integrate traceability into procurement and trade finance, and redirect rural credit toward regenerative systems. Financial institutions can scale blended finance and strengthen forward-looking risk modeling to price climate and nature exposure more accurately. These actions align with IPCC findings that near-term mitigation and adaptation in land use are both feasible and cost-effective when enabling governance conditions are present.<sup>49</sup>

However, full delivery on existing SDG targets will not, on its own, guarantee resilient food systems beyond 2030. The SDGs articulate outcomes but do not specify transition pathways within value chains. They identify targets—zero hunger, climate action, life on land—but leave open the institutional sequencing through which production, trade, finance, and governance must evolve. Absent clearer transition pathways, progress risks remaining fragmented and overly dependent on voluntary action.

Looking beyond 2030 toward 2050, three structural shifts will be essential.

### **1. Natural capital and climate risks must be embedded in economic systems**

Treating nature as an externality has produced systemic economic risk. Ecosystem degradation undermines long-term agricultural productivity, increases climate volatility, and heightens financial instability. The critical challenge for the post-2030 agenda is not merely better measurement, but institutional integration: ensuring that environ-

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<sup>49</sup> IPCC (2023).

mental risk and ecosystem dependency are embedded within fiscal rules, credit allocation, and macroeconomic planning.

The next phase of reform may move beyond voluntary disclosure frameworks toward incorporating nature-related risk into prudential supervision, sovereign risk assessments, and capital allocation models. Evidence from financial regulation suggests that once risks are formalized within supervisory expectations, portfolio behavior shifts accordingly. If climate and ecosystem degradation are consistently reflected in underwriting standards and capital adequacy assessments, value chains that degrade natural capital will become structurally more expensive to finance than those that restore it.

In this context, value chains become transmission mechanisms through which macroeconomic risk recognition reshapes production decisions. When environmental exposure alters the cost of capital or market access conditions, sourcing strategies and investment patterns adjust across the chain. Institutionalizing nature risk directly influences which production models scale.

## **2. Develop shared value-chain transition pathways**

The energy sector has science-based decarbonization pathways that define milestones, technology deployment rates, and capital requirements. Food systems lack comparable, commodity-specific transition pathways. The comparison with energy systems is instructive for another reason. Many low-carbon energy technologies increasingly offer commercial advantages through lower operating costs, improved performance, or favorable market conditions. Food-system transitions are often different. Practices that improve soil health, restore ecosystems, reduce deforestation, or strengthen resilience frequently involve upfront costs, delayed returns, and benefits that accrue across society rather than directly to individual firms or producers. As a result, market forces alone are unlikely to deliver transition at the pace or scale required. Policy reform, institutional coordination, and targeted financial support are therefore essential conditions for food-system transformation.

Developing value-chain transition pathways would involve mapping, for major commodities:

- Baseline land-use and emissions trajectories.
- Productivity and yield-gap closure opportunities, including their economics.
- Required finance flows and de-risking instruments.
- Sequenced policy reforms.
- Social safeguards to protect livelihoods and food security.

Such pathways would clarify the distribution of costs and benefits across actors, reducing political resistance and investment uncertainty. They would also align private sector action with national development strategies, mitigating the risk that sustainability commitments are perceived as externally imposed constraints.

The soy and cocoa cases illustrate why explicit pathways matter. In soy, deforestation-free sourcing is a first milestone, but resilience requires subsequent steps in regenerative productivity and credit reform. In cocoa, due diligence is a starting point, but lasting outcomes require income stabilization, replanting cycles, and service delivery integration. Without sequenced pathways, compliance risks stagnating or generating unintended exclusion.

### 3. Political economy must anchor transition design

Transitions that ignore domestic political realities rarely last. Experience across countries suggests that environmental reforms are more likely to succeed when they align and reinforce economic and social incentives, rather than being pursued as standalone environmental objectives.<sup>50</sup> Policies perceived as threatening rural livelihoods or national sovereignty face resistance, even when technically sound.

Aligning resilience, productivity, and income objectives with environmental goals increases the chance of lasting change. For example:

- Regenerative agriculture, framed as productivity enhancement and climate resilience, gains broader support than conservation, framed solely as restriction.
- Land restoration linked to water security and rural employment resonates more strongly than biodiversity metrics alone.
- Trade compliance integrated into export competitiveness narratives can build domestic coalitions.

From 2030 to 2050, governance capacity will matter as much as technological innovation. Climate volatility, geopolitical instability, and demographic change will amplify pressure on food systems. Value chains that are rewired to reward stewardship, share risk, and internalize environmental costs can function as engines of inclusive growth. Those that remain structured around extraction and short-term arbitrage will amplify instability.

## GOVERNING THE TRANSITION

The challenge beyond 2030 is less about identifying solutions than about governing systemic change. Three institutional priorities stand out:

1. **Coherence across policy domains.** Agricultural, trade, climate, and fiscal policies must reinforce rather than contradict one another.
2. **Institutionalized risk pricing.** Climate and nature risks must be embedded in credit, insurance, and sovereign risk assessment.
3. **Equity safeguards.** Transition pathways must protect vulnerable producers and consumers, ensuring that costs are not shifted onto those least able to bear them.

Food systems are dynamic economic systems embedded in ecological limits. The SDGs established the direction of travel. The period from 2030 to 2050 must institutionalize the mechanisms—financial, regulatory, and market-based—through which value chains align with planetary boundaries and social inclusion.

The central argument of this chapter is that value chains are among the few institutional structures capable of linking upstream land-use decisions with downstream market incentives on a global scale. If governed deliberately,

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<sup>50</sup> Global Commission on the Economy and Climate (2018).

they can become vehicles for long-term resilience. If left to operate under misaligned incentives, they will continue to transmit ecological and social risk across borders.

The foundations for that choice must be laid this decade.

## A healthier food system for people and planet

Food systems are foundational to human welfare and economic stability, yet they are under mounting strain. They sustain livelihoods and nourish billions, but they are also deeply entangled with environmental degradation and rising climate risk. As ecological pressures intensify, systems that depend on stable soils, water cycles, and climate patterns are becoming more exposed to disruption. The challenge now is to redesign the economic logic that governs production, trade, and finance so that resilience, rather than depletion, becomes the norm.

This chapter has argued that value chains are central to that redesign. Far from passive conduits of trade, they are institutional architectures that shape incentives, allocate risk, and structure access to capital and markets. Because they link upstream land-use decisions to downstream consumption and finance, value chains operate at the scale required to influence global trajectories. When policy, finance, and technology align within them, environmental costs can be internalized and investment redirected toward stewardship. When misaligned, they transmit ecological and social risk across borders.

The cases of soy and cocoa illustrate both the potential and the limits of this leverage. Concentrated actors can rapidly shift sourcing norms, but compliance alone does not ensure lasting change. Without aligned finance, credible land governance, and income viability at the farm level, progress remains vulnerable to reversal. Lasting transformation depends on embedding resilience within the financial and policy architecture of value chains, not layering sustainability onto unchanged incentives.

The decade to 2030 will determine whether food systems can be stabilized. Beyond 2030, the challenge is institutionalization: embedding natural capital and climate risk into fiscal policy, financial supervision, trade regimes, and value-chain transition pathways that are explicit, sequenced, and politically grounded.

Delivering this transition will require different forms of engagement from different actors. Governments must align agricultural, trade, fiscal, and environmental policies around shared transition objectives and provide the regulatory certainty needed to support long-term investment. Firms must move beyond compliance-based approaches toward active stewardship of the value chains on which they depend, including financing transition, supporting traceability, and strengthening producer resilience. Financial institutions must integrate climate and nature risks into lending and investment decisions while expanding access to instruments that support longer-term transition pathways. Civil society, producer organizations, and development institutions have a critical role in ensuring accountability, building local capacity, and safeguarding equitable outcomes.

Rewiring food value chains is not a peripheral sustainability agenda. It is a strategy for safeguarding long-term productivity, macroeconomic stability, and inclusive growth in a climate-constrained world. The institutions that shape trade and finance can either reinforce extraction or anchor regeneration. The choice, and the architecture that follows, will shape the resilience and prosperity of the global economy in the decades ahead.

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## NINE

# THE BIOECONOMY AS THE LEAPFROG IMPERATIVE: GOVERNING FOR EQUITY AS THE KEY TO UNLOCK THE TRANSFORMATIVE POTENTIAL OF A GLOBAL BIOECONOMY

Monique Atouguia and Dorothy Maseke

## The post-fossil-fuel inflection point

For over two centuries, economic growth has been powered by fossil-fuel-derived and carbon-intensive technologies across industrial supply chains. This model delivered prosperity but relied on ecological externalization and extractive patterns. Planetary boundary science now demonstrates that climate stability and biodiversity integrity are no longer peripheral concerns but structural economic constraints.<sup>1</sup> The global bioeconomy is emerging as one of the few credible pathways capable of structurally displacing the fossil-fuel-based economic model. Rather than relying on finite, carbon-intensive inputs, the bioeconomy reorients production around renewable biological resources, circular material flows, and biological processes, alongside the renewable energy transition. This is not an incremental greening of existing systems; at its most transformative, it represents a fundamental shift in how

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<sup>1</sup> Rockström et al. (2009); Steffen et al. (2015).

energy, materials, food, chemicals, and medicines are produced, and how value is distributed across economies. It represents a reconfiguration of production systems around biological metabolism, a shift from fossil extraction to regenerative cycles.<sup>2</sup>

The often-cited economic potential of the bioeconomy remains striking: The global bioeconomy, currently estimated at \$4 to \$5 trillion, is projected to grow to as much as \$30 trillion by 2050.<sup>3</sup> This rapid expansion represents a potential sevenfold increase from its current value, serving as a critical pillar for sustainable economic development.

However, it is important to note that the bioeconomy is not inherently sustainable. Largely understood as replacing, where possible, fossil fuels with renewable biological resources as an economic base, it can carry similar environmental risks of land use change, competition with food production, and biodiversity loss. Many of the countries featured in this chapter have taken these factors into consideration and have policies and regulations in place, as well as participating in and conforming to international commitments. This includes the G20 High-Level Principles on Bioeconomy, which provide clear parameters on what a sustainable and equitable bioeconomy is.<sup>4</sup> True sustainability in the bioeconomy, as in other realms, requires intentional design to operate in a circular, resource-efficient, and waste-reducing manner—for this, a value web approach is most helpful.

It is also important to note that accelerating climate change and biodiversity loss mean that the window for harnessing the full potential of the bioeconomy is narrowing. Without protecting, restoring, and investing in the ecological infrastructure upon which the bioeconomy depends, its long-term viability and ability to deliver resilience may be significantly undermined.<sup>5</sup> So while the global trends and opportunities outlined in this chapter are indicative of the bioeconomy's potential to transition the global economy toward a more sustainable economic model, it is worth keeping in mind that the very crises that demand the shift to a more bio-based, circular, and sustainable economic model also threaten the opportunity to harness this potential. Likewise, much of this chapter will focus on equity concerns as a critical design characteristic for achieving a transformative new economic model.

That being said, beyond sustainability considerations, by positioning nature as a transition driver and shock absorber, the bioeconomy offers tools for adaptation and resilience. These range from climate-smart, drought-resilient crops to landscape restoration that reduces flood risk, sustainable forestry that stabilizes watersheds, and other nature-based solutions safeguarding infrastructure and livelihoods.<sup>6</sup> Decentralized bioenergy systems can improve energy security, especially in rural and peri-urban areas where grid access remains constrained.<sup>7</sup> Not only do these interventions limit climate- and biodiversity-related losses, but they also establish the basis for emerging economic activities in ecosystem services, bio-inputs, and resilient food systems.<sup>8</sup>

A structurally sound, sustainable, and regenerative bioeconomy should not replicate the extractive patterns that characterize much of the modern economy today. This applies both at the local level, in how Indigenous knowledge is recognized, valued, and fairly remunerated, and at the international level, in how resources, biodiversity, and genetic information from the Global South are utilized and valued across global supply chains.

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2 McCormick and Kautto (2013).

3 NatureFinance and IDB (2025).

4 See more on the G20 High-Level Principles on Bioeconomy at <https://www.gov.br/g20/en/tracks/sherpa-track/bioeconomy-initiative>.

5 NatureFinance and IDB (2025).

6 NatureFinance and IDB (2025); NatureFinance (2026).

7 NatureFinance (2026).

8 Ibid.

# Defining the bioeconomy

While there is no globally accepted definition of the bioeconomy and each country takes a different approach to policy and implementation, the bioeconomy is broadly “understood as turning renewable biological resources into higher-value products, industries, and jobs; replacing extractive, low-value exports with diversified, innovation-driven value chains.”<sup>9</sup> In short, the bioeconomy is an economy with a renewable biobase involving the use of biomass and biotechnology in the production of goods, services, and energy.”<sup>10</sup>

The bioeconomy represents far more than a shift in production systems. It offers a strategic pathway for decoupling economic growth from resource depletion, while enabling new forms of value creation and a new bio-based development approach. At its core, the bioeconomy seeks to improve resource efficiency by transforming renewable biological resources into valuable products and services with lower waste and reduced environmental impact. Figure 9.1 shows how it operates across a range of economic sectors.

FIGURE 9.1

## The bioeconomy is best understood as a broad framework



**SOURCE:** NatureFinance (2026).

**NOTE:** This framing is deliberately broad, encompassing the use of biomass and biotechnology in well-established sector-based categories, including the blue, green, red, white, and circular economies.

<sup>9</sup> Escobar and Laibach (2021); NatureFinance (2026), 20.

<sup>10</sup> Ólives (2024); NatureFinance (2026), 20.

When a whole-of-government, mainstream approach is taken with the bioeconomy, it is able to leverage natural resources and technologies to tackle:

- Natural resource scarcity, including food security, energy security, and various inputs across agriculture, construction, and manufacturing;
- Fossil resource dependence;
- Climate change;
- Waste generation;
- Loss of biodiversity; and
- Macroeconomic risks by investing in economic diversification and restoring ecological infrastructure.

While the bioeconomy is often framed in climate and nature circles in terms of the creation of value from extraction of raw materials from natural resources, a core element of it is primarily driven by bio-innovation and is knowledge-intensive in character.<sup>11</sup> Synthetic biology, AI-enabled protein modeling, and digital sequence information are accelerating biological innovation at unprecedented rates.<sup>12</sup> Industrial biotechnology now underpins sectors ranging from bio-based plastics to pharmaceutical bio-fermentation. The convergence of biology and data has led some analysts to describe this as the biological industrial revolution.<sup>13</sup> The commercial opportunity therefore lies in biological design capacity, value addition, intellectual property, and supply chain resilience, not simply raw biomass extraction. In practice, much of this innovation must take place within existing and established sectors and industries, to make them more circular, less resource-intensive, and less reliant on fossil fuels, while also creating entirely new value chains and industrial opportunities such as the use of biofuels, biofertilizers, and biomaterials such as bioplastics, among others (for example, see figure 9.2, which takes a cross-cutting value web approach to understanding the bioeconomy's cross-sectoral potential).

However, this emerging biological industrial revolution also carries significant risks. Increasingly, countries are beginning to view bio-innovation, genetic resources, and biological data not only through an economic lens but also as matters of strategic and national security importance. Control over biological data, sequencing capabilities, food systems, pharmaceutical innovation, and biomanufacturing capacity may increasingly shape geopolitical influence, industrial competitiveness, and economic resilience in the decades ahead.<sup>14</sup>

There is a concern that while this new revolution has the potential to create multibillion-dollar enterprises, advanced manufacturing ecosystems, and high-value intellectual property in more developed markets, it may simultaneously deepen existing inequalities in less developed economies if governance, financing, scientific capacity, and value retention mechanisms are not deliberately addressed. There is therefore a real risk that biodiversity-rich countries once again remain suppliers of raw biological materials and genetic resources, while the highest-value innovation, processing, ownership, and commercial benefits accrue elsewhere. As explored later in this chapter, this tension is becoming increasingly visible in discussions around digital sequence information, benefit-sharing, and bioeconomic sovereignty.

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11 Birch and Tyfield (2013); Levidow et al. (2012).

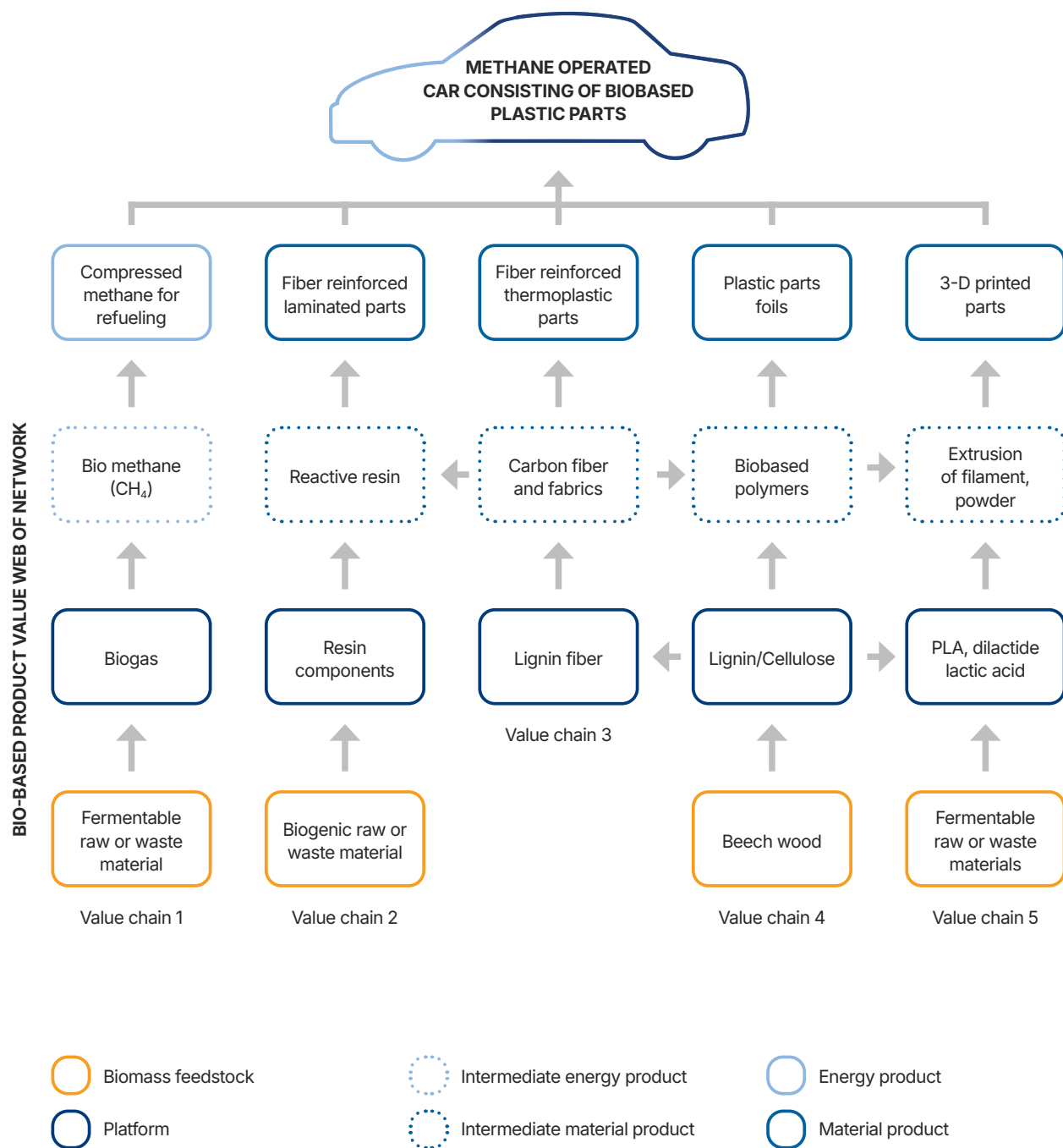
12 Das et al. (2026).

13 Stansfield and Borge (2025).

14 Ibid.

FIGURE 9.2

## Bio-based value webs in action



**NOTE:** A car built with bio-based plastic components and running on biomethane shows how biomass feedstock enters multiple value chains.

**SOURCE:** Adapted by NatureFinance from Lewandowski et al. (2026), 80, licensed under CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>). Spelling and visual presentation modified to conform to Brookings style.

# Global momentum to scale the bioeconomy

The recognition of this shift has been gaining greater traction in multilateral fora. As president of the G20 in 2024, Brazil led the creation of the G20 Bioeconomy Initiative (GIB), the first structured effort at a plurilateral level to define High-Level Principles on Bioeconomy.<sup>15</sup> These principles promote the circular use of biological resources, sustainable production, shared benefits, decent jobs, and innovation; they serve as a voluntary guide for member countries. The G20 initiative was designed to embed bioeconomy thinking across multiple policy dimensions, not just environment ministries but also industry, trade, science, and technology, precisely to ensure that bioeconomy agendas are coherent with broader development and innovation policies. Under the Brazilian and the subsequent South African G20 presidencies, the GIB has also started translating principles into actionable workstreams, including trade and innovation cooperation. Brazil's leadership on the bioeconomy deepened during its 2025 COP30 presidency, where it helped launch the Bioeconomy Challenge—a multistakeholder platform to operationalize the G20 principles and support measurable, inclusive market development by 2028.<sup>16</sup> For the first time at a COP summit, the bioeconomy was formally acknowledged as a strategic mechanism for accelerating the implementation of Nationally Determined Contributions (NDCs).<sup>17</sup> The Bioeconomy Challenge targets gaps in metrics, finance, market development, and Indigenous knowledge, aiming to make the bioeconomy measurable, investable, and inclusive.

South Africa's GIB in turn helped shape the establishment of the African Bioeconomy Finance Hub, set up to catalyze and drive investment into the potential of the African bioeconomy across four pillars: (i) policy enablement, (ii) capacity building, (iii) data and metrics, and (iv) investment catalyzation.<sup>18</sup> Likewise, Germany's Global Forum for Food and Agriculture in January 2025 took "Farming a Sustainable Bioeconomy" as its key theme, and in the Final Communiqué, over 60 agriculture ministers recognized the bioeconomy's role in a sustainable, resilient, and inclusive economy.<sup>19</sup> The Food and Agriculture Organization of the United Nations (FAO) has been convening global consultations toward a formal Bioeconomy for Sustainable Transformation (BEST) Partnership, with regional nodes under development, and held the first-ever Bioeconomy Innovations and Investment Forum in Bangkok in November 2025, drawing nearly 600 participants from governments, the private sector, investors, and civil society.<sup>20</sup> On the private capital side, dedicated investment vehicles are maturing, including Forbion's BioEconomy Fund, which launched in 2024 and was oversubscribed and closed at €200 million in 2025, with backers including public investment banks and mission-driven funds.<sup>21</sup>

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15 G20 Brazil (n.d.); NatureFinance and FGV (2024).

16 Bioeconomy Challenge (n.d.).

17 Federative Republic of Brazil (2024); NatureFinance (2025).

18 ANCA (2025).

19 GFFA (2025).

20 FAO (2025). The Forum was co-organized with 18 partners including the United Nations Conference on Trade and Development, United Nations Environment Programme, United Nations Economic and Social Commission for Asia and the Pacific, United Nations Educational, Scientific and Cultural Organization, United Nations Industrial Development Organization, and the Association of Southeast Asian Nations.

21 Forbion (2025).

# This multilateral momentum emerges from trends at national and regional levels

## THE BIOECONOMY AS AN INTERCONNECTED NATIONAL CLIMATE, NATURE, AND JOBS STRATEGY

At a national level, Brazil has recently elevated the bioeconomy to a strategic pillar of national development, embedding it in key long-term planning instruments. In 2024, the federal government launched its National Bioeconomy Strategy, framing the bioeconomy as a model of economic development that is fair, inclusive, and guided by science and traditional knowledge, with goals around sustainable use of biodiversity, job creation, technology development, and climate mitigation.<sup>22</sup> This strategy is integrated into broader frameworks such as the Ecological Transformation Plan and the Multi-Year Plan (2024-2027).<sup>23</sup> The strategy serves as a comprehensive framework to coordinate cross-sectoral policies and unlock the economic potential of the country's vast biodiversity and has formalized implementation through the National Bioeconomy Development Plan (PNDBio), which coordinates across several different federal ministries, aligning agriculture, industry, trade, and science to accelerate the commercialization of bio-based innovations.<sup>24</sup> Moreover, the inclusion of the bioeconomy in Brazil's NDC and National Biodiversity Strategies and Action Plans (NBSAPs) offers another instructive model.<sup>25</sup> A recent NatureFinance report asserted, "embedding bioeconomy development within international climate and biodiversity commitments, enables Brazil to achieve three objectives simultaneously: (i) to demonstrate practical pathways for meeting climate and nature goals; (ii) to enable cross-governmental collaboration with the bioeconomy as a national priority backed by presidential authority, and (iii) to unlock access to international climate finance that would otherwise remain unavailable for the scaling of the bioeconomy."<sup>26</sup> Under the "New Industry Brazil" program, bioeconomy and decarbonization are listed as one of six core missions, which include boosting biofuels, such as bioethanol, and expanding the sustainable use of biodiversity in industry.<sup>27</sup> The NDC sets targets such as increasing the share of biofuels in transport energy by 50% and raising the technological use of biodiversity by industry annually.<sup>28</sup>

Embedding the bioeconomy within the NDC sends a signal to markets and investors that biological innovation and renewable pathways are central to Brazil's climate mitigation and industrial policy, not just niche programs (box 9.1).

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22 Lopes, Corleto, and Chiavari (2024).

23 See more on Brazil's Ecological Transformation Plan at <https://www.gov.br/fazenda/pt-br/aceso-a-informacao/acoes-e-programas/transformacao-ecologica/novo-brasil-ecological-transformation-plan/novobrasilcartilhaingles.pdf>; see more on the Multi-Year Plan (2024-2027) at [https://www.gov.br/planejamento/pt-br/assuntos/planejamento/plano-plurianual/arquivos/mensagem-presidencial-ppa-2024-2027/2\\_mensagem\\_presidencial\\_web-1-1.pdf](https://www.gov.br/planejamento/pt-br/assuntos/planejamento/plano-plurianual/arquivos/mensagem-presidencial-ppa-2024-2027/2_mensagem_presidencial_web-1-1.pdf).

24 Bezerra et al. (2026).

25 See more on Brazil's NDCs at <https://ndcpartnership.org/country/bra>; see more on Brazil's NBSAPs at [https://app.climatepolicyradar.org/documents/brazil-national-biodiversity-strategy-and-action-plan-nbsap-2025\\_d2c7?c=UN-submission&at=Party&t=National+Biodiversity+Strategy+and+Action+Plan+%28NBSAP%29&cfn=target](https://app.climatepolicyradar.org/documents/brazil-national-biodiversity-strategy-and-action-plan-nbsap-2025_d2c7?c=UN-submission&at=Party&t=National+Biodiversity+Strategy+and+Action+Plan+%28NBSAP%29&cfn=target).

26 NatureFinance (2026).

27 See more on the "New Industry Brazil" program at <https://www.gov.br/fazenda/pt-br/aceso-a-informacao/acoes-e-programas/transformacao-ecologica/novo-brasil-ecological-transformation-plan/featured-programs/new-industry-brazil-and-the-ecological-transformation-plan>.

28 Federative Republic of Brazil (2024), 17.

#### BOX 9.1

### Brazil's bioethanol sector is a global leader

After decades of intentional policy and investment, Brazil's bioethanol industrial sector is now expanding from sugar-based ethanol into advanced bio-refineries, producing biokerosene and bio-based chemicals. This transition leverages agricultural strength for high-value industrial growth, reducing greenhouse gas emissions while driving industrial competitiveness. The transformation lies not only in emissions reductions but also in the strategic use of biology to rewire industrial competitiveness. Government mandates have long required ethanol blending in gasoline, creating guaranteed demand and a stable market for producers. Moreover, flexible-fuel vehicles (FFVs) account for over 80% of the Brazilian light-duty fleet, translating this into a value web from agriculture and advancing agro-producing into manufacturing and industrialization. The long-standing Brazilian bioethanol industry demonstrates how bio-based systems can substitute fossil fuels and associated emissions from the transport sector at scale, while anchoring domestic industrial value chains and jobs. This example illustrates how policy frameworks (mandates, incentives, institutional coordination) can unlock large-scale markets that align climate goals with economic competitiveness and help convert biological resources and innovation into diversified, low-carbon economic pathways.

**SOURCES:** IEA Bioenergy (2022); Federative Republic of Brazil (2021); Mark & Spark Solutions (2026).

## THE BIOECONOMY AS AN ECONOMIC TRANSITION PATHWAY

Demonstrating the power of economic mainstreaming, the European Union has positioned the bioeconomy as a cornerstone of its industrial and climate strategy, integrating it across agriculture, chemicals, materials, energy, and regional development.<sup>29</sup> Countries such as Finland and Germany have invested heavily in bio-based materials, industrial biotechnology, and circular biomanufacturing, explicitly targeting fossil-intensive sectors like plastics, construction, and chemicals.<sup>30</sup> What is transformative here is the intent to replace entire value chains, such as steel, cement, and petrochemicals, with bio-based and hybrid alternatives, backed by regulation, public finance, and market creation rather than voluntary sustainability claims. This approach draws lessons from the renewable energy transition and is already helping to create strong and growing markets for bio-based products.

India's bioeconomy approach illustrates the potential of the bioeconomy as an industrial diversification and resilience strategy. From renewable biofuels and industrial enzymes to vaccines and agricultural biotech, India's bioeconomy spans multiple sectors, now representing a solid and exponentially growing share of GDP, supporting jobs and aligning national goals on sustainability, health care, and manufacturing.<sup>31</sup> India's bioeconomy has grown from about \$10 billion in 2014 to about \$165.7 billion in 2024, marking a roughly 16-fold expansion in a decade, and putting the GDP share at just over 4%.<sup>32</sup> The largest areas of national focus are within bio-industrial sectors, which account for nearly half of India's total bioeconomy, with significant emphasis placed on biofuels, industrial enzymes, and other bio-manufactured products. India has grown bioethanol blending to 20% as of 2025, reducing

29 Crowell & Moring (2025).

30 Held (2026); CLIC Innovation (2025).

31 Republic of India (2025).

32 Ibid.

reliance on crude imports, boosting farm incomes, and cutting foreign exchange outflows.<sup>33</sup> It has also grown production of industrial enzymes, which are commonly used in detergents, textiles, and bioplastics.<sup>34</sup> This is followed by the growth in India's BioPharma sector, at 35% of the Indian bioeconomy, especially in vaccines and generics.<sup>35</sup> India produces 65% of global vaccines—a major export and global health contribution.<sup>36</sup> The growth of the Indian bioeconomy is being driven by a number of factors: a strong entrepreneurial environment; a large domestic market with uniform national regulation; highly skilled human capital; and, critically, the Biotechnology for Economy, Environment and Employment Policy (BioE3), a strategic framework designed to shift from traditional manufacturing to high-performance biomanufacturing, directly linking bio-innovation to economic growth, environmental sustainability, and job creation.<sup>37</sup>

## THE BIOECONOMY AT THE INTERSECTION OF POWER, INDUSTRIAL COMPETITIVENESS, AND NATIONAL SECURITY

China offers a different but equally consequential model. Through large-scale investment in industrial biotechnology, biomanufacturing, and synthetic biology, China is increasing bio-based production in pharmaceuticals, food ingredients, materials, and fuels.<sup>38</sup> This is framed less as an environmental agenda and more as a strategic industrial pivot, as China strives to become a biotech powerhouse: reducing dependence on imported fossil inputs, securing supply chains, and positioning biotechnology as a future engine of economic growth. The transformation lies in speed and scale—biology is treated as core infrastructure for a post-fossil-fuel industrial system.

This is demonstrated in China's 14th Five-Year Plan (FYP), which set a target of renminbi (RMB) 22 trillion (around \$3.28 trillion) for the Chinese bioeconomy by 2025.<sup>39</sup> The plan shifts focus from broad biotechnology to more specific, scalable high-value production and industrial applications, particularly biomanufacturing. In particular, it calls for accelerating research and development (R&D) and industrialization in areas such as biomedicine, biological breeding, biomaterials, bioenergy, and bioinformatics, while strengthening biosecurity risk prevention, control, and governance systems.<sup>40</sup> Like many other country case studies mentioned here, China's subsequent 15th FYP views bioeconomy tools as critical to reducing carbon emissions and achieving low-carbon growth, with a key departure point being an emphasis on "conversion, application, and ecosystem shaping," aiming for practical economic results from biotech.<sup>41</sup> In 2025, China's newly approved drugs and R&D pipelines accounted for over 30% of the global total.<sup>42</sup> China contributes around 70% of global bio-fermentation product output, especially in food additives and industrial enzymes, resulting in more than RMB 400 billion (around \$57 billion) in value.<sup>43</sup> This reveals the rapid industrial expansion and integration into core sectors such as medicine, agriculture, and chemicals.

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33 ETManufacturing Desk (2025); Mehan (2026); Republic of India (2026).

34 Republic of India (2025).

35 BIRAC (2024).

36 Republic of India (2025).

37 Republic of India (2025); BIRAC (2024).

38 Brown and Groenewegen-Lau (2025).

39 Ouyang and Liu (2022); Global Times (2022).

40 Ouyang and Liu (2022); Global Times (2022); Zhang et al. (2022).

41 Guo (2025).

42 Wu (2025).

43 Sedzro (2026).

China's bioeconomy anchors another striking trend: a broader industrial strategy in which biology and data are dual pillars of competitiveness, not separate sectors, and instead are recognized as fundamental to national security.<sup>44</sup> China's targets include improvements in fundamental biotech research, biosecurity governance, and the deployment of advanced computational tools like AI to enhance biotechnology's productivity and application scope, from drug discovery to precision agriculture and synthetic biology.<sup>45</sup> The practical implications are clear. China is investing not just in biological inputs but also in the digital architecture that multiplies their value: AI for genomics, high-performance computing for biological simulation, and integrated data platforms that connect research, industry, and markets. This positions China not only to scale biomanufacturing domestically but also to compete internationally in data-intensive biotech sectors where AI can sharply reduce development costs and time to market. Moreover, China's leadership has signaled that cooperation with technology partners, including neighboring countries like the Republic of Korea, around AI and bio-innovation is a priority, showing that these sectors are viewed as central to future economic diplomacy and global governance discussions.

The Republic of Korea has explicitly targeted AI-bio convergence as a core driver of industrial transformation, embedding this objective in high-level national strategies such as the National AI-Bio Strategy and the broader national innovation ecosystem supported by tens of billions in public and blended finance.<sup>46</sup> A central pillar of the Republic of Korea's strategy is digital biofoundries, facilities that use AI, automation, and robotics to standardize and automate synthetic biology processes, dramatically shortening experimental cycles and lowering costs. These biofoundries are intended both to spur commercial biotech innovation and to anchor domestic industrial capacity in areas such as biologics, advanced materials, and biomanufacturing.<sup>47</sup>

Recently, the Republic of Korea launched a National Bio Innovation Committee to coordinate biotechnology policy and ministries and drive investment and R&D, signaling the importance of an integrated national agenda that unites AI, biotech, and advanced computing.<sup>48</sup> Practical measures include plans to build high-performance computing infrastructure, integrate national bio-data systems, and foster public-private partnerships to drive AI-enabled research and industrial applications.<sup>49</sup> At the same time, the biotech economy in the Republic of Korea is seen as a "next growth engine" alongside semiconductors, backed by ambitious investment funds designed to integrate private capital into long-term innovation projects.<sup>50</sup>

## **THE BIOECONOMY AS A DRIVER OF GREEN INDUSTRIALIZATION, VALUE ADDITION, AND REDUCED RESOURCE EXTRACTION**

There are serious equity challenges to advancing the global and local bioeconomy. African countries have focused on using the biomass innovation-driven bioeconomy to propel them out of resource-extractive patterns into higher-value chains and more sustainable development.

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44 Iuvinale (2026).

45 Ibid.

46 Republic of Korea (2025a); IBBIS (2026).

47 Republic of Korea (2025b); KAIST Graduate School of Engineering Biology (n.d.).

48 Castillo Monagas (2026); The Pharma (2026); Lee (2025).

49 Ibid.

50 Chae (2026).

The East African Community (EAC) developed the first regional bioeconomy strategy in Africa, spanning 2021/22-2031/32, with the goal of transforming natural biological resources into sustainable economic opportunities.<sup>51</sup> The strategy aims to harness abundant agricultural lands and biodiversity to drive inclusive growth, create jobs, and improve resilience to global challenges like climate change. It serves to support the growth of bioindustries, from bioenergy to biochemicals, while promoting value addition and strengthening food and feed production with sustainable, bio-based technologies.<sup>52</sup> It has facilitated the development of regional platforms for innovation, research, and capacity building, including regional observatories and harmonized policy frameworks, and encouraged scientific and learning institutions, private sector actors, and government to collaborate on bioscience solutions. It also has a focus on clean bioenergy and circular processes that convert waste into useful products, reducing greenhouse gas emissions. By moving beyond exporting raw agricultural produce, the region can generate higher economic returns from bio-based goods, such as food ingredients, pharmaceuticals, biomaterials, bioenergy, among others. An example of putting this regional policy into practice is the International Centre of Insect Physiology and Ecology (icipe) and its flagship program, BioInnovate Africa (box 9.2).

#### BOX 9.2

### The International Centre of Insect Physiology and Ecology (icipe)

The International Centre of Insect Physiology and Ecology (icipe), and its flagship program, BioInnovate Africa, advances “a science- and innovation-driven bioeconomy across Eastern Africa. Supported by the Swedish International Development Cooperation Agency (Sida) and implemented in partnership with over 300 cooperation partners, BioInnovate operates across eight countries: Burundi, Ethiopia, Democratic Republic of Congo, Kenya, Rwanda, South Sudan, Tanzania, and Uganda. The program’s core mission is to translate cutting-edge bioscience into market-ready, biobased solutions, bridging persistent gaps between research, enterprise development, investment, and policy. Working across the full innovation pipeline—from laboratory discovery and early-stage de-risking to industry standards and regulatory support—BioInnovate plays a catalytic role in unlocking Africa’s bioeconomy potential. Innovations span agriculture, health, and waste valorization, including biofertilizers (e.g., Civu Rhizobia), biopesticides and fungicides (Triasper®, fungal biopesticides), Striga-resistant maize and finger millet, tsetse fly repellents, chitin-based wound-care products, biobased malaria supplements (SUPPACT), enzyme applications for leather processing, industrial effluent bioconversion technologies, mushroom substrate blocks, and Black Soldier Fly-based animal feed and insect-enriched foods now supplying markets and schools. BioInnovate Africa demonstrates that with the right enabling finance, partnerships, and policy environment, African scientists can deliver world-class biobased innovations, driving industrial transformation, job creation, and resilient development while reducing dependency on imported inputs and fossil-based systems. The program shows that the primary constraint is not scientific capacity but access to early-stage finance, market linkages, and policy support.”\*

\*Drawn from NatureFinance (2026).

**SOURCES:** See more on icipe at <https://www.icipe.org/>; see more on BioInnovate at <https://bioinnovate-africa.org/about-us/>; icipe (n.d.) and knowledge provided by icipe colleagues.

51 East African Community (2022).

52 Ibid.

Complementary to icipe programming, a recent initiative is the African Bioeconomy Finance Hub, which is a strategic intervention to reposition nature as a core driver of jobs, resilience, and industrial transformation across the continent.<sup>53</sup> Designed to outlast political cycles, the Hub seeks to translate bioeconomy policy ambitions into finance-ready roadmaps, investment pipelines, and measurable impact frameworks. Anchored in Africa and led by African institutions, the Hub aims to address systemic barriers that limit capital flows into biomanufacturing, regenerative agriculture, nature-based inputs, and circular bio-industries. Its ambition is structural: to shift Africa from exporting raw biological resources to capturing significantly greater value through local processing, innovation, and industrial upgrading. By targeting the capture of up to 50% of the final value of Africa's biomass by 2035 (up from less than 10% today), the Hub positions Africa not merely as a resource base but as a global bioeconomy leader.<sup>54</sup>

## Embedding equity in the bioeconomy to ensure its transformative promise

The following case studies (see box 9.3) illustrate not just Africa's institutional capacity to lead in the bioeconomy but the governance principles that must underpin any bioeconomy if it is to avoid reproducing existing extractive economic patterns.

The bioeconomy intersects directly with intellectual property regimes.<sup>55</sup> Patents on genes, enzymes, and biological processes can concentrate innovation rents in technologically advanced economies. Political economy scholars warn that biotechnology markets often exhibit rent-seeking dynamics under globalized IP regimes.<sup>56</sup> For developing economies, capacity building in patenting and domestic bio-innovation is therefore essential to avoid structural dependency.

Equity and justice therefore sit at the center of whether the bioeconomy constitutes a true transition. A bio-based economy that reduces carbon emissions but accelerates land concentration, undermines food security, or extracts biological wealth without fair returns will fail its transformative promise. Costa Rica, through its bioeconomy strategy linked to biodiversity governance and payments for ecosystem services, points toward alternative models where conservation, innovation, and local value creation are mutually reinforcing rather than in conflict.<sup>57</sup>

Equity in the bioeconomy is not only a moral consideration but a structural determinant of whether the bioeconomy delivers broad-based development or reinforces existing inequalities. Since the bioeconomy spans agriculture, health, energy, materials, and digital biotechnology, it has the potential to create employment across the entire skills spectrum—from advanced research and AI-enabled bio-design to farm-level biomass production and distributed bioprocessing. The critical question is whether value is concentrated at the top of the innovation chain or intentionally distributed along it.

At the high-skill end, the bioeconomy creates demand for researchers, bioinformaticians, fermentation engineers, regulatory specialists, and advanced manufacturing technicians. These are future-facing, knowledge-intensive

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53 ANCA (2025).

54 NatureFinance (2026), 91.

55 Drahos and Braithwaite (2002).

56 Birch and Muniesa (2020).

57 ECLAC (2020); UNFCCC (2020).

roles that anchor domestic innovation systems and attract investment. However, equitable growth requires deliberate investment in education pipelines—technical colleges, vocational biotech training, and university-industry partnerships—so that access to these jobs is not restricted to a narrow urban elite. Building local capacity in bio-manufacturing, quality control, and laboratory services enables countries to retain more value domestically rather than exporting raw biological materials and reimporting finished bio-based products. It also strengthens domestic innovation ecosystems by creating opportunities for highly skilled professionals locally, reducing the risk of brain drain and helping countries build long-term scientific, industrial, and technological competitiveness.

At the mid- and lower-skill levels, the bioeconomy can generate substantial employment in biomass production, feedstock logistics, bio-refinery operations, waste-to-value systems, and decentralized processing facilities. For rural economies in particular, this can mean new income streams from crop residues and agricultural waste, invasive species harvesting, regenerative agriculture, aquaculture, or forest stewardship. If designed inclusively, bio-based value chains can formalize informal work, increase incomes for smallholder producers, and strengthen regional economies rather than concentrating opportunity in metropolitan biotech clusters.

Equity also has a geographic dimension. Many biological resources are located in rural or biodiversity-rich regions, often inhabited by marginalized communities. A just bioeconomy requires benefit-sharing mechanisms, local ownership models, and transparent governance frameworks to ensure communities participate in and profit from commercialization.

Finally, inclusion within the bioeconomy must address both gender and generational participation. In many emerging markets, women play central roles in agriculture, health care delivery, and community-level natural resource management, yet they remain underrepresented in biotechnology leadership, advanced STEM fields, and high-value innovation ecosystems. At the same time, high levels of youth unemployment across many developing economies present both a challenge and an opportunity. Targeted entrepreneurship support, incubation funding, and skills development programs can help position the bioeconomy as a major source of employment and enterprise creation, particularly in areas such as digital biology, circular economy enterprises, and green manufacturing.

In more developed markets, inclusion must also address age-related barriers to participation in emerging industries. As the bioeconomy increasingly converges with AI, advanced computing, and automation, there is a growing need to support mid- and late-career professionals in transitioning into these new fields. Many highly skilled workers already possess deep technical and industrial expertise that remains highly relevant to the evolving bioeconomy. Supporting reskilling and lifelong learning can therefore help retain valuable knowledge, strengthen innovation systems, and ensure that technological transitions remain inclusive across generations.

### Case study: Valorizing African Indigenous knowledge<sup>58</sup> at the University of the Free State's Indigenous Knowledge-based Medicines and Innovations Centre in South Africa

The University of the Free State's Indigenous Knowledge-based Medicines and Innovations Centre in South Africa focuses on translating Indigenous knowledge systems (IKS) into scientifically validated, safe, and commercially viable health products. Unlike many purely laboratory-centric biotech projects, the Indigenous Knowledge-based Medicines and Innovations Centre engages directly with traditional health practitioners and Indigenous communities from across the continent to co-create research priorities and product development pathways, ensuring that the holders of knowledge are part of the value chain from discovery through to commercialization. For example, the platform recently received a grant from the World Health Organization to help develop equitable IP and benefit-sharing frameworks for traditional medicines—a vital step in ensuring that communities benefit economically from their knowledge rather than being sidelined when commercial products are developed. The Centre also actively trains postgraduate students, technologists, and researchers, creating pathways into biomanufacturing, pharmacology, and regulatory science, while simultaneously supporting community-level entrepreneurs in cultivating and processing Indigenous botanicals. This dual emphasis on high-level science and grassroots engagement helps broaden participation in the bioeconomy and creates jobs at many skill levels, from community producers and technicians to research fellows and knowledge managers. An illustrative example from South Africa on how to avoid biopiracy is that of the Rooibos Benefit Sharing Agreement, which was a constitutional court ruling which allowed for an annual levy of 1.5% of the profits of rooibos at “farm gate price” to go toward the Indigenous San and Khoi, recognizing their Indigenous knowledge and formative cultivation of the plant and its properties.

**SOURCES:** AMITD (n.d.); Damons (2025); Schroeder et al. (2020).

The above examples illustrate core principles that help avoid common equity pitfalls in rapidly developing bioindustries, including localized value creation and addition, inclusive knowledge systems and valorization, multilevel job creation and value web thinking, policy and institutional support, and the importance of regional collaboration and capacity building.

By combining scientific rigor, respect for and valorization of traditional knowledge, equitable benefit-sharing, and broad skills development, these initiatives illustrate how a bioeconomy can be both innovative and socially inclusive. They show that it is possible to create jobs, build shared prosperity, and drive technological advancement while ensuring that communities are meaningfully included and not left behind. However, equity requires intentional policy design: skills development across tiers, support for small, micro, and medium enterprises (SMMEs) and co-operatives, regional clustering strategies, and mechanisms that ensure value addition happens close to where biological resources originate. When structured this way, the bioeconomy becomes more than simply a technological transition. It evolves into a socially inclusive development pathway capable of driving innovation, creating shared prosperity, and supporting more equitable and resilient economies.

58 Indigenous valorization is the active process of validating, elevating, and integrating Indigenous knowledge, cultures, and practices into modern socioeconomic, political, or scientific frameworks. It ensures Indigenous communities benefit from their own heritage rather than having their resources or traditions extracted or exploited by others, without due remuneration and recognition.

# Intellectual property and asymmetry: Emerging debates around digital sequence information (DSI)

Digital sequence information (DSI) is increasingly emerging as a foundational asset within the global bioeconomy, underpinning innovation across biotechnology, pharmaceuticals, agriculture, synthetic biology, industrial biomanufacturing, health care, and nature-based industries. As advances in genomics, artificial intelligence, and bioinformatics accelerate, it is becoming central to the next generation of economic growth and scientific discovery. Globally, discussions around DSI have largely been shaped by priorities linked to innovation, open science, technological competitiveness, and the rapid sharing of scientific data. Many developed-country actors and scientific institutions have advocated for maintaining open access to DSI, arguing that open data supports scientific collaboration and innovation, reduces barriers to research, and enables advances in areas such as biodiversity conservation, food security, and health.<sup>59</sup>

The 1992 Convention on Biological Diversity (CBD) and the 2010 Nagoya Protocol established foundational principles on genetic resource sovereignty and benefit-sharing. Yet the rapid rise and expansion of DSI infrastructure have exposed governance gaps.<sup>60</sup> DSI challenges traditional access and benefit-sharing frameworks because, through bioinformatics, genetic sequence information can be accessed and utilized without the physical transfer of the underlying genetic resources or necessarily establishing an access and benefit-sharing agreement with their providers.<sup>61</sup>

Ongoing negotiations under the CBD Kunming-Montreal Global Biodiversity Framework reflect attempts to address this structural asymmetry. Without reform, biodiversity-rich nations risk becoming data providers in a global bioeconomy governed by Northern intellectual property systems.<sup>62</sup> Further, without deliberate policy choices around access, benefit-sharing, intellectual property, and domestic value addition, the bioeconomy could reproduce the extractive logic of the fossil economy under a greener label.

Increasingly, African policymakers, financiers, scientists, and development institutions are framing DSI not as a scientific or conservation issue but as a broader question of economic transformation, industrialization, nature finance, and sovereignty. Recent African-led dialogues have highlighted the need to move beyond narrow compliance-oriented access and benefit-sharing discussions toward systems that enable domestic value retention, local innovation ecosystems, and participation across the full DSI value chain.

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<sup>59</sup> Laird and Wynberg (2018).

<sup>60</sup> Ibid.

<sup>61</sup> Akpoviri et al. (2023).

<sup>62</sup> Birch (2017).

Importantly, emerging African dialogues on DSI are not positioning themselves in opposition to the Cali Fund or broader multilateral benefit-sharing efforts.<sup>63</sup> Rather, they seek to build on these foundations while reflecting African realities, aspirations, and concerns. African stakeholders increasingly recognize the Cali Fund as an important and potentially catalytic step toward acknowledging the value of biodiversity and the need for more equitable benefit-sharing in the DSI era.<sup>64</sup> At the same time, there is growing recognition that the voluntary nature of the Fund, uncertainties around scale, and questions around how value will ultimately flow back to biodiversity custodians mean that Africa cannot rely solely on external redistribution mechanisms.<sup>65</sup> In this framing, sovereignty is not understood as isolationism or resistance to global collaboration, but rather as the ability for African countries to participate in global DSI systems from a position of greater agency, capability, and value capture. The debates that have surrounded and given rise to the Cali Fund have previously been present in other areas such as critical minerals—namely that beneficiation or value addition must occur at the source of extraction.

A central theme emerging from African discussions is the importance of ensuring that Indigenous Peoples and Local Communities (IPLCs) are recognized not merely as passive beneficiaries but as active co-creators, custodians, and rights-holders within DSI-linked value chains. This reflects a growing recognition that biodiversity stewardship, traditional knowledge systems, and community governance structures form a critical foundation for the bioeconomy itself. Unsurprisingly, this mirrors concerns around IPLCs with respect to carbon and biodiversity credit schemes in relation to co-creation, benefit-sharing, and co-ownership. As such, equitable benefit-sharing mechanisms must go beyond symbolic inclusion and instead create meaningful pathways for communities to participate in and benefit from emerging bio-based industries.

As a result, African-led discussions are increasingly focused on developing complementary “no-regrets” approaches that strengthen domestic readiness to participate competitively and strategically within the emerging bioeconomy.<sup>66</sup> Recent initiatives have emphasized the need to invest in sequencing infrastructure, regional bioinformatics hubs, talent pipelines, data sovereignty systems, and fit-for-purpose financing mechanisms that can support African-led biodiscovery, biotechnology, and nature-positive enterprises. There is also growing recognition that concessional and blended finance may play a critical role in de-risking early-stage DSI-related opportunities and enabling investable business models to emerge. More broadly, African bioeconomy dialogues increasingly frame DSI within a wider green industrialization agenda aimed at enabling the continent to retain a greater share of the value derived from its biodiversity and biomass resources.

While global perspectives often prioritize openness, data sharing, and innovation speed, African perspectives place greater emphasis on value retention, fairness, local ownership, and ensuring that biodiversity-rich countries are not once again excluded from the highest-value segments of this emerging industrial revolution.

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63 See more on the Cali Fund at <https://thecalifund.org/>.

64 Singh (2026); Republic of South Africa (2026).

65 Shema, Sinyangwe, and Ayodele (2026).

66 Cox (2026).

# The bioeconomy as the leapfrog imperative

The global bioeconomy is no longer a peripheral sustainability narrative; it is becoming a defining arena of industrial strategy, economic resilience, and geopolitical positioning. From Brazil's integration of the bioeconomy into climate commitments, China's and the Republic of Korea's AI-enabled biomanufacturing ecosystems and biosecurity approaches, to Africa's emerging stance on data sovereignty, countries are repositioning biology as core infrastructure for a post-fossil-fuel future. What is unfolding is not incremental sectoral change but a reordering of value chains, innovation systems, and competitive advantage. Furthermore, the bioeconomy presents a pathway toward a more sustainable economic model in which decarbonization and biodiversity loss can be addressed while delivering on jobs, livelihoods, and development—a viable economic model for embedding the Sustainable Development Goals (SDGs).

Yet the rapid expansion of bio-based industries does not automatically translate into regenerative development. Without intentional governance, the bioeconomy risks reproducing extractive patterns under greener branding. Data-rich and capital-rich economies may consolidate control over intellectual property, digital sequence information, and synthetic biology platforms, while biodiversity-rich regions remain upstream suppliers of genetic material and biomass. In this scenario, the bioeconomy would merely substitute fossil extraction with biological extraction, leaving structural asymmetries intact.

Equity is therefore not a moral afterthought but a structural determinant of success. Access and benefit-sharing mechanisms must evolve to address digital biology, digital sequence information, and AI-enabled bio-design. Intellectual property regimes must balance innovation incentives with fair value capture. Localized value addition, whether through bio-refineries, industrial biotechnology clusters, or regional innovation ecosystems, must become a central design principle. The much-needed technical capacity must evolve at the same pace. Finance must move beyond pilot projects toward scaled, strategic investment aligned with national and continental development priorities.

For Africa and other biodiversity-rich regions, the bioeconomy represents perhaps the most credible leapfrog pathway beyond fossil-dependent development. Rather than replicating carbon-intensive industrialization, countries can align biodiversity assets with industrial upgrading, digital innovation, and blended finance. The result could be diversified economies, resilient supply chains, job creation across skill tiers and multiple generations, and strengthened economic sovereignty rooted in ecological regeneration. The emergence of continental frameworks and finance platforms signals that this shift is no longer theoretical but institutionally underway.

The bioeconomy, by integrating renewable inputs, circular metabolism, and biological regeneration, offers one of the few systemic pathways capable of aligning economic stability with planetary boundaries.

The choice before policymakers is therefore not whether to pursue a bioeconomy but how to shape it. Built on regeneration, inclusion, and shared and localized value, it can underpin a just and durable economic transition that has the potential for global competitiveness. Left to market forces alone, it risks becoming a biological extension of the model it seeks to replace.

The fossil age has been defined by extraction, exclusion, and inequity. The bioeconomy must be defined by regeneration, circularity, and inclusion. Its expansion is inevitable, and its potential is vast. Whether it becomes transformative will depend on governance, finance, and the courage to embed justice and equity at its core.

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