

Chapter 30 In Brief

The new bioeconomy in the Amazon: Opportunities and challenges for a healthy standing forest and flowing rivers



Mulheres indígenas sateré mawé abrem loja de artesanado (Foto: Alberto César Araújo/Amazônia Real)



THE AMAZON WE WANT
Science Panel for the Amazon

The new bioeconomy in the Amazon: Opportunities and challenges for a healthy standing forest and flowing rivers

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Key Messages & Recommendations

- 1) The Amazon is far from the scientific and technological frontier of the contemporary bioeconomy. The sustainable use of its socio-biodiversity is the main path for it to continue providing ecosystem services essential for life on the planet. At the same time, this offers opportunities to improve the living conditions of rural, forest, and urban populations, currently characterized by poverty, inequality, and threats to citizens' rights.
- 2) Making forest socio-biodiversity the epicentre of sustainable economic development requires recognizing the importance of knowledge accumulated by forest peoples over millennia, as well as valuing current regenerative practices of increasing importance in the region.
- 3) A bioeconomy is more than an economic sector; it synthesizes a set of ethical-normative values on the relationship between society and nature and their consequences. A bioeconomy can guide social life towards the regenerative use of the biotic, material, and energy resources on which we all depend. It provides immense opportunities for combating poverty and inequality through the sustainable use of forest biodiversity, not only in rural areas, but also in cities.
- 4) The social and economic base for the sustainable use of standing forests and flowing rivers is broad and diverse. It involves traditional activities of forest peoples, family farming that is marked by land uses with rich biodiversity, and commodity agriculture focused on the production of grain and meat, which is beginning to face the challenge of also contributing to standing forests and flowing rivers.
- 5) Growing global attention on forest devastation has mobilized diverse social and political forces in the Amazon in search of alternatives to predatory forms of development. International agreements, such as the Leticia Pact, stand out in this context, in addition to actions by subnational governments, coalitions of civil society organizations, companies, scientists, and representatives of forest peoples to promote the transition to a knowledge economy for nature.
- 6) One of the most important premises for the emergence of a new bioeconomy is changing the design and implementation of planned infrastructure projects. Meeting the population's basic needs, such as high-quality connections, agile transport services, and robust information to improve the commercialization of products, are basic objectives to which, in most cases, current infrastructure does not respond.
- 7) The Amazon has several respected teaching and research organizations for science and technology. With appropriate institutional investments and international collaboration, a new bioeconomy of standing forests and flowing rivers can emerge.

Abstract This chapter highlights the paradox between the Amazon's extraordinary socio-biodiversity and its distance from the scientific, technological, and market frontier of the contemporary bio-

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economy. It discusses the current socioeconomic structures available in the region, as well as challenges and pathways for a transition to a socially-fair and sustainable bioeconomy.

Introduction The starting point for stimulating a strong, diverse, and dynamic socio-biodiversity economy in the Amazon is the recognition that the region has been occupied by people who sustainably used and managed its gigantic wealth for thousands of years (see Chapters 8-13). Today, this immense potential is underutilized¹ and is being systematically destroyed (see Chapters 14-21). In addition, prevailing policy and infrastructure aims to make the Amazon a supplier of energy, minerals, and agricultural commodities, mostly benefiting those who live far from the Amazon²⁻⁴.

The current situation, characterized by environmental destruction, violence against Indigenous peoples and local communities (IPLCs), and pervasive criminality, sheds light on the urgent need to shift political and economic incentives. Instead, incentives should raise the level of human development, expand the use biodiversity in a sustainable manner, invest in infrastructure that meets the needs of people, and disseminate scientific and technological knowledge so the socio-biodiversity economy can become the epicenter of the region's development. It's also urgent to repress the invasion of public land and IPLCs' territories for illegal mining and wood exploitation.

Harnessing the potential of tropical forests without destroying them, converting their regeneration into an engine of economic growth, combining scientific knowledge with the knowledge systems of forest dwellers, and transforming the production and commercialization of commodities in a way that strengthens forest environments are some of the most important challenges encountered by a new bioeconomy.

An immense unrealized potential The Amazon's extraordinary and unique germplasm is highly unexplored⁵, despite the efforts of herbaria, research institutes, and ethnobotanical museums in the

region. Today, most of the literature on the bioeconomy comes from temperate countries, which have far less complex and diverse environments than tropical forests. This gap in the literature is indicative of how distant cutting-edge science and technology are from tropical forests. Latin America's greatest chance to assert itself and gain international economic importance is through the sustainable use of its natural resources and the systematic application of science and technology to exploration, processing, pharmaceutical discoveries⁶, and a plethora of new products including foods, pharmaceuticals, cosmetics, chemical compounds, new molecules, new materials, colorants, odorants, flavors, resins, genetic products, and products derived from bioengineering and biomimetics, all of which must be utilized in a sustainable manner with very high added value.

Diversity, the key feature for the bioeconomy in the Amazon Diversity is the most important feature of the current socio-biodiversity economy in the Amazon. According to the *Concertação para a Amazônia (2021)*⁷ ("Accord on the Amazon"), the current Amazonian bioeconomy can be classified into three types:

1. **Traditional bioeconomy:** This type is based on the biodiversity of native ecosystems. Its production hardly reaches large volumes. Given the richness of biodiversity on which these activities are based, they may gain importance for the pharmaceutical, cosmetic, and cutting-edge biotechnology sectors, once appropriate investments and arrangements are made.
2. **Forest management bioeconomy:** This type is suitable for regions where forests are disturbed or degraded. Here, production systems can be diverse, including agroforestry systems (AFS) and integrated crop-livestock-forest (ICLF) systems. Priority areas for restoration need to be assessed for the recovery of relevant ecosystem services, such as water and crop pollination.
3. **Commodities bioeconomy:** Large areas of the Amazon, particularly along the "deforestation arc",

are devoted to the production of commodities, and their operations generate high social and environmental impacts. These areas need to make their high yields compatible with the protection and strengthening of biodiversity, through the conservation of forest areas within agricultural properties, reductions in the use of chemical inputs, and integrated practices.

The current limited economy of forest socio-biodiversity The Amazon region is marked not only by technical limitations, but also by an almost complete absence of industrial processing as well as health-related obstacles that block its exports⁸. Another challenge is forest dwellers' dependence on incomplete and imperfect markets characterized by strong clientelism and power imbalances. For instance, the *aviamento* (a system in which workers rack up debts to the company for basic subsistence goods, often leading to slavery),^{9,10} and the *regatão* (a trading system that transports goods from cities to the countryside, and vice versa);¹¹ are historical legacies that persist, compromise the social framework, and prevent the development of a strong and competitive bioeconomy. In Bolivia, degrading forms of labor exploitation have marked the commercialization of nuts, including the *habilito* (a system where advanced payment for work promotes a cyclical system of workers' indebtedness) and the *enganche* (a type of debt slavery)¹².

Imbalances of power in the market structure are an obstacle to countless cooperatives and associations in the Amazon, who are unable to “identify the commercialization opportunities represented by the differentiated agricultural and extractive products that they produce”¹³. Concurrently, companies and producers miss out on the potential for new Amazonian products; intermediaries at the center of the value chain discourage innovation from producers, do not market new products, and discourage competitive markets. This stimulates a market structure that does not favor quality, supply regularity, transparent market information, or innovation, but promotes the status quo while also facilitating tax evasion.

Timber In the Arc of Deforestation of the Brazilian Amazon, the capacity for timber extraction has been depleted by the forestry sector, causing producers to seek new areas to harvest¹⁴. In addition, wood processing is inefficient, as only 41% of what is extracted is processed. Of this total processed, 72% corresponds to sawn wood, which has low added value¹⁵.

Corruption and predatory practices are perhaps no surprise given the high levels of illegality that dominate the timber sector. Legal, sustainable timber production can hardly compete with what some call “forest mining”¹⁶. Complex procedures for obtaining legal logging authorizations combined with unclear land rights¹⁷ discourage long-term, sustainable projects. The over exploitation of a few dozen species with high-commercial value¹⁸ and current management norms prevent the recovery of wood stocks, and represent a lost opportunity to the timber sector¹⁹. Instead, balanced use of the hundreds of wood species in the Amazon needs to be encouraged, supported by investment and innovation in processing and adding value to alternative species. Resources need to be channeled into the modernization of equipment, revenue, and productive processes; marketing of new species and products; and the domestication of native species for forest restoration.

Forest policies need to be reassessed and illegality needs to be controlled, as the timber sector could provide income and decent jobs at considerable scale. In Bolivia, for instance, 16 communal lands of origin and 10 Indigenous community lands held 111 approved management plans in 2013, covering nearly 1.8 million hectares and an annual allowable cut (AAC) of over 800,000 m³. Approximately 35% of the AAC is harvested annually, generating about USD 7.5 million in gross income and benefiting around 6,000 Indigenous households^{20,21}. In forest concessions in the Brazilian Amazon, in conservation units specifically designated for sustainable forest management, there is an annual extraction potential of 2-7 million m³ of wood²².

There is an additional opportunity based on the beauty and diversity of hardwoods in Amazon forests. As demand for tropical wood products is projected to increase in the coming decades²³, it is desirable to invest in large-scale AFS and forest enrichment systems to produce high-quality hardwoods in a relatively short time, which can be sustainably developed on already deforested or degraded land²⁴. This would combine sustainable and profitable timber production with ecological restoration, reduction of forest fragmentation, and recovery of ecosystem services, in addition to maintaining forest biodiversity and ecotourism potential.

Non-timber forest products (NTFPs) In the Amazon, traditional practices that combine agricultural systems with extractivist management are widespread. Agronomic research shows that farming systems are as important as cultivars to yield potential, and the combination of scientific and traditional methods is especially important. Even where there are species with more acceptance and market value, the system only functions when supported by an immense variety of plants.

In Brazil, açai (*Euterpe oleracea*) stands out. Its production value increased from BRL 220.3 million to 539.8 million between 2010 and 2016²⁵. Outside of protected areas in Bolivia and in Brazil, açai collection raised the incomes of thousands of families, with important multiplier effects on urban

occupations¹⁰; it is competitive when compared to cattle²⁶. An important fraction of the product comes from areas endowed with rich biodiversity, inspired by IPLCs practices^{10,27,28}, forming a mosaic of high-value agricultural, forest, and aquaculture landscapes²⁹. However, industrial policy aimed at long-term financing for innovative technologies to realize the full production potential of açai (and other products) are needed, as well as research to address sanitary challenges (e.g., Chagas disease transmission). Socio-biodiversity strengthening must also emerge within the scope of a circular bioeconomy.

A serious challenge to the economic success of açai is the production of processing waste. In Belém (Brazil) alone, 16 thousand tons of waste are produced daily. One possible solution is the production of “ecopanel” (similar to drywall or particleboard) from açai fruit fiber, a project supported by IDESAM (2021)³⁰ which illustrates the potential for the circular economy³¹.

Important initiatives have also been developed to increase production of Guaraná, involving Indigenous communities³² and reducing information asymmetry³³. The market for vegetable oils derived from forest species (e.g., *andiroba*, *ucuúba*, *cumarú*) is also booming. Although official data does not yet fully cover these products, which play an important role in the diversification of forest products and income sources, there are estimates that



Figure 30.1 Açai Photo: Embrapa/Ronaldo Rosa



Figure 30.2 Guaraná Photo: Embrapa/Ronaldo Rosa

45,751 families are engaged, generating around BRL 50 million in raw materials sales³⁴. However, these are usually technically inadequate production schemes with low added value³⁵, and whose capacity to generate income is compromised by the market structure in which they operate.

In the case of Brazil nuts, value chains move around USD 450 million globally and involve thousands of families, organized in several small communal businesses³⁶. Brazil has been losing ground in international trade due to lack of compliance with basic technological and sanitary regulations (Brazil nuts produced for export to the European Union must meet specific requirements due to the potential presence of aflatoxin) which are difficult for the majority of producers to meet because of their informal and small-scale production³⁷. The consequence is that Brazil, unlike Bolivia and Peru, is unable to realize its full potential revenue³⁷.



Figure 30.3 Brazil nuts and seedlings in the background *Photo: Embrapa/Ronaldo Rosa*

Extraction of natural rubber in the Amazon shows a sharp decline, with production falling by more than half between 2010 and 2016, and an even stronger reduction in production value²².

Non-timber forest products are extracted and commercialized by hundreds of individual producers, family networks, small associations, and cooperatives^{13,38}. These local organizations typically suffer from administrative and operational challenges (e.g., to negotiate sales and export contracts,

or to meet sanitary standards), as well as lack of access to transportation, storage, and processing infrastructure. These organizations are informal, do not maintain operational or accounting records, and depend on incomplete and imperfect markets^{38,39}. Of the 374 communal enterprises analyzed by Conexsus (2020)¹³, only 20% process their own products or add value. These initiatives do not have access to financing mechanisms and face challenges investing in infrastructure and working capital.

Fishing and pisciculture Fisheries have a major impact on food security and on the local and regional economies of the Amazon. In addition to providing food, fishing serves commercial, sport, and ornamental purposes. In the state of Amazonas (Brazil), pirarucu (*Arapaima gigas*) management areas generated a gross income of BRL 8 million from fishing permits, with a net income of around BRL 2,000 per family⁴⁰. This value is particularly significant when considering the average per capita monthly income of poor and extremely poor people in these areas is below BRL 140 and BRL 70, respectively.

One of the main threats to fisheries in the region is predatory fishing and high levels of bycatch. Fisherfolk discard tons of unwanted or untargeted fish so that high-value fish can fit in the boat. The low participation of fishing communities in management and governance processes is also a serious problem, which ends up stimulating predatory practices, reducing fish stocks, and heightening territorial conflicts between fisherfolk. In this sense, communal fishery agreements for the common use or shared management of certain lakes are important (see Chapter 15). Heavy metal contamination from illegal mining is also an alarming trend (see Chapter 21).

As with terrestrial value chains, lack of infrastructure limits the economic growth of fisheries. Lack of access to reliable energy subjects fisherfolk to the whims of local agents who own ice factories. The dearth of storage and processing facilities forces fishermen who live far from consumer cen-

ters to sell their products at extremely low prices to brokers with means of transportation. This is aggravated by the fragile social organization of the fisherfolk, which hinders the battle for fairer trade. A shortage of technical assistance and access to credit is also a challenge⁴¹.

Fish farming has grown in recent years; for example, it increased from 722,560 to 758,006 tons in Brazil between 2018 and 2019. However, this sector is still emerging and only 4% of fish exported from Brazil are farmed⁴². There are important bottlenecks preventing production at the smallholder level. Problems include low levels of technology throughout the entire production chain, low efficiency in feed production, poor business management processes, lack of collectives and associations, and lack of funding for research into effective production methods⁴³. Some measures could increase the potential of Amazonian fish farming, e.g., focusing on species with high nutritional value; finding ways to reduce transportation

costs; promoting integration and partnerships among fish farmers; improving breeding, processing capacity, transport, and marketing conditions; improving product quality; improving water management; and boosting the development of certification processes⁴³. Fish processing waste can be used to produce biogas, bio-jewelry, animal feed, and food for human consumption; this can reduce environmental impacts and be an additional source of income⁴¹.

Synergies between the bioeconomy and forest restoration Restoration not only reestablishes the forest's ecological functions, such as carbon and biodiversity⁴⁴, but also expands the supply of timber and non-timber forest products (see Chapters 28 and 29). These landscapes then create new opportunities for diversified supply chains, support innovation, create jobs and income, and ultimately improve local people's well-being. Independent of the restoration strategy involved, business opportunities are often created across the restoration



Figure 30.4 Agroforestry system with banana, cupuaçu, taperebá, açai, ingá, mogno, andiroba, and paricá Photo: Embrapa/Ronaldo Rosa

supply chain, involving, for example, seed collection (e.g., Xingu Seed Network), seedling production, plantation management, and harvesting of forest products⁴⁵.

Agroforestry is often seen as the most promising restoration strategy for family farmers living in the Amazon, due to its potential to reconcile conservation and socioeconomic objectives⁴⁶. Beyond the marketing of products, restoration using AFS is important for the well-being of rural families, providing food security through the cultivation of a wide variety of high-value products, and a range of other benefits such as climate mitigation and improved water and soil quality (see Chapters 28 and 29). Among emblematic examples led by farmers in the Brazilian Amazon are the CAMTA cooperative in Pará⁴⁷ and the RECA program in Rondônia.

Fruit trees Although agroforestry often includes a variety of plant species, the motivation for adopting systems is often based on a few individual species which can guarantee profitability. Açai is especially suitable for restoration in riparian zones that are subject to flooding and has the advantage of easy propagation and high seed availability. Demand for the species may increase not only because of the growing economy of pulp production, but for industrial products with higher added value. Another key native species for agroforestry is cocoa, due to its favorable market prices and high demand in the national and international market.

Timber Despite its great potential to improve vast areas of degraded pasture, silvopastoral systems primarily rely on exotic species, such as *Eucalyptus* spp. or Teca (*Tectona grandis*). This is in part due to limited market access for planted timber, scarcity of knowledge on silviculture of native species, and lack of financial support for tree crops that involve longer time frames and therefore more financial risk. Given consumer preference for more sustainable products⁴⁸ the cultivation of native timber species in restoration areas can boost the timber market. Fostering research and innovation is

crucial in this sector, which is still dominated by largely unspecialized activities.

Agro-industrial activities for producing medium-density fiberboard (MDF) are promising. Currently, the species *Shizolobium amazonicum* (Paricá), that naturally occurs in Brazil, Peru, and Colombia is the only native species with the capacity to replace exotic *Eucalyptus* and *Pinus* species. Paricá is fast growing and produces higher yields relative to *Eucalyptus* grown in 4- to 7-year cycles⁴⁹. Mahogany (*Swietenia macrophylla*) plantations also present high growth rates and commercial value⁴⁸. Efforts are needed to identify a diversity of fast-growing native species, as well as for improving the efficiency of timber processing and related machinery. Paragominas (Brazil), once infamous as the largest source of illegal timber in the Amazon, has transformed to become a good example of innovation in more specialized markets for planted timber.

Other products Restoration systems can provide diversified NTFPs, including rubber, gum, wax, fibers, aromatics, and medicines that can supply different sectors.

Funding and partnerships linked to restoration activities are emerging in the region, with Belterra and Conexsus mobilizing a large network of associations, cooperatives, and small- to medium-size companies to increase access to funding and markets for sustainable bioproducts. These should complement public policies, such as credit for restoration and institutional programs for purchasing products from family farmers engaged in restoration. The Food Procurement Program and the National School Meals Program in Brazil are good examples of initiatives that purchase socio-environmentally friendly produce from smallholders⁵⁰ that could be scaled up.

Tourism Natural beauty, biodiversity (e.g., bird-watching), cultural diversity, and historical landmarks drive increasing tourism⁵¹, putting the Amazon in a privileged position. There are opportunities to develop routes integrating the Amazon

with the Andes, possibly connecting to Inca trails and the Guyanese Massif, leveraging river routes throughout the entire region⁵².

However, the Amazon's potential is still limited in all countries of the region. In 2016, around 16.8 million people visited Brazilian parks (national and state), generating USD 1-2 billion and creating thousands of jobs⁵³, but less than 5% of those visits were in the Amazon. A similar result was found for the Colombian Amazon⁵⁴. Insecurity, lack of transport, and lack of infrastructure are some of the challenges that need to be overcome to strengthen the tourism sector in the region.

Following World Tourism Organization principles and based on experiences in the Ecuadorian Amazon, Arroyo and De Marchi (2017)⁵⁵ identified key criteria to be respected in the development of tourism, especially schemes that are community-based: (i) self-determination in the implementation and execution of the activity; (ii) plurality, reflecting all the players involved in touristic work; (iii) participation, which allows visualizing horizontal relationships in the practice of tourism activity; (iv) scope, in which articulation with other economic spheres is reflected; (v) transparency, which constitutes the honest and ethical management of the resources available for touristic activity; and (vi) progressivity and planning. It is also important to develop a tourism policy for the Amazon that respects the knowledge systems, cultures, religions, and local traditions that guarantee the conservation of socio-biodiversity.

Payment for Environmental Services (PES)

There are countless PES experiments in the Amazon involving the protection of water resources⁵⁶⁻⁵⁸ and of biodiversity⁵⁹. Castro et al. (2018)⁶⁰ estimate that PES initiatives in Brazil aimed at forest conservation in the States of Acre (Certificate of Family Production Unities) and Amazonas (Forest Grant) benefitted over 44,000 individuals from 2009 to 2015 and allocated over BRL 40 million. Other initiatives involve compensation for greenhouse gas reductions due to avoided deforestation, known as "Reduced emissions from deforestation and forest

degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks" (REDD+) of the United Nations Framework Convention on Climate Change (UNFCCC).

Several REDD+ initiatives have been implemented in the tropics, including in the Amazon^{61,62}. Although REDD+ initiatives demonstrate promising results^{61,63}, they still face several challenges, including leakage, unequal distribution of benefits⁶⁴⁻⁶⁶, and double counting. In order to address these, REDD+ is advancing to jurisdictional modalities and involving subnational governmental entities^{63,67-69}. In response, independent initiatives to accredit, monitor, and inform subnational REDD+ activities are multiplying.

On the PES demand side, it is necessary to guarantee that forest conservation projects generate carbon credits that are eligible to participate in the European Union Emissions Trading System (EU ETS) where charging for emissions surpluses is mandatory. On the supply side, it is necessary to advance the means for achieving socio-environmental safeguards^{70,71}, create procedures for the equal distribution of benefits⁷², and guarantee that the positive effects of these initiatives are as comprehensive, effective, and lasting as possible⁷³.

The full implementation of PES or its REDD+ variant will depend on progress in public policies. Law 14.119 (1/13/2021) enacted by the Brazilian Congress created the National Policy for Payments for Environmental Services, paving the way for third sector institutions, companies, and individuals to be compensated for conservation activities.

An emerging transition The transition towards a new bioeconomy is neither exclusively nor fundamentally technological, although science and technology have a crucial role. It involves, for example, infrastructure, new markets, changing social preferences, and the crucial relationship between science and traditional knowledge. It also involves cultural changes, a shared vision for forest socio-biodiversity in educational processes themselves,

and the need to include traditional knowledge about the environment in educational curricula at all levels.

This transition is already underway. It was paradoxically accelerated by recent increases in deforestation, fire, invasions of Indigenous territories and public areas, and the dire impacts of COVID-19 in the region. These events undermine the social legitimacy of current resource use models, opening up opportunities for the creation and expansion of unconventional models and multi-stakeholder initiatives, such as the “Accord on the Amazon”, composed of NGOs, corporate executives, scientists, and IPLCs. The social landscape within the Amazon has already changed significantly. Many prominent activist organizations are focused on strengthening entrepreneurship for the sustainable use of the forest, through the search for business partners, valuation of niche products within protected areas, and efforts to find solutions to expand and improve market conditions for innumerable socio-biodiversity products.

The emergence of a new standing forest and flowing rivers bioeconomy cannot be limited to the products analyzed above, nor even to the immense diversity of products that the Amazon produces. It also requires a deep transformation of commodity production systems. ICLF is already being implemented in many situations, offering a model to reduce the impact of Amazonian agricultural products. The agriculture and livestock commodities sector has every interest in ensuring that its production is certified not only as deforestation free, but also as enriching and sustainably using forests within their properties.

The diversity of actors There is an emerging, diversified network of forces that are not only opposed to destruction, but are jointly looking to enable a strong and competitive bioeconomy in the region, including investment funds, some large enterprises, Brazil’s largest private banks (advised by some of the country’s most important scientists and activists),⁷⁴ and food companies aiming to eliminate deforestation from their value chains⁷⁵.

Many of these companies have, until very recently, engaged in practices that led to deforestation and disrespect for the rights of IPLCs.

There is no guarantee that recent commitments will contribute to zero deforestation and the emergence of a nature-based knowledge economy in the Amazon, as the success of these initiatives largely depends on public policy measures that fall outside the scope of these sectors, especially with regard to land policies and the repression of illegality and crime. The role of sub-national governments and local legislative bodies in this regard is extremely important, including the Consortium of Governors of the Legal Amazon. At the same time, it is important that the investments made by these companies go through competitive processes and undergo rigorous, critical evaluations by specialists. These include the Brazilian Coalition on Climate, Forests, and Agriculture and the Accord on the Amazon.

Navigating the new bioeconomy: Challenges and recommendations Restoring the security of protected areas, Indigenous territories, and public lands against invaders is paramount. There is an urgent need to leverage intelligence and foster collaboration between different countries’ homeland security forces, since criminal activities operate across borders⁷⁶. Tracing the origin of illegal gold is critical⁷⁷. With regard to the establishment of a strong, competitive, and fair forest socio-biodiversity economy, a few fundamental objectives are described below (without being exhaustive).

Cities, infrastructure, and internal markets The majority of the Amazon’s population currently lives in cities (see Chapter 14), frequently presenting low Social Progress Index scores⁷⁸. The current forest socio-biodiversity economy depends on cities, where products are marketed and where most of the income generated is spent. In addition, people with strong ties to agricultural and forestry often seek a second urban residence for greater access to health or education facilities. Even farmers’ organizations are often based in cities. Thus, improving urban infrastructure, both in large centers

and rural municipalities, is critical to foster a dynamic bioeconomy.

Several relatively low-cost investments can stimulate promising markets for socio-biodiversity products and reduce dependence on intermediaries that block economic dynamism. These include improving the mobility of rural populations and their access to urban services, supporting information systems and accurate transportation schedules, increasing access to high-quality internet, and promoting technical and university courses in small municipalities. It is also essential that cities strengthen the markets in which family farmers operate, through cooperatives focused on the industrialization of what they already produce.

Reduce information asymmetry Information asymmetry between buyers and sellers is the trademark of many Amazonian value chains, which often results in prices below production costs. Information on markets is one of the most important premises for forest products to be commercialized based on modern, competitive structures that allow increased income and expansion of opportunities for producers; price guarantee policies are therefore important, but insufficient. It is essential that the production chains of socio-biodiversity products are mapped, fostering transparency to all participants and offering accessible information to producers. Information from institutionalized sources, such as a commodity stock exchange, is an important component for the emergence of dynamic and competitive markets⁷⁹.

Seals of quality, scale, and entrepreneurship Productive scale has always been connected to the simplification and homogeneity of natural environments transformed to produce agricultural products. One of the most important challenges a new bioeconomy of standing forests and flowing rivers faces is precisely that of integrating gains of scale organically with the strengthening of socio-biodiversity. In this sense, companies, such as Natura, and NGOs, such as Instituto Socioambiental, IMAFLORA, ICV, and others, pave the way for improvements not only in production techniques,

but also in the transparency of economic processes in the communities that are the real protagonists. Conexsus does important work organizing, legalizing, and introducing accounting techniques to associations and cooperatives. It aims to reduce the immense transaction costs embedded in relationships between companies and the communities that supply socio-biodiversity products.

Natura, for example, established relationships with agro-extractivist communities, generating income and encouraging local training, field research (i.e., in forest management, agro-extractive systems and sustainable agricultural production), and technological innovation. It invested in the research and development of ingredients and supported institutional strengthening of communities and cooperatives. Some of the raw materials used by Natura are also pre-processed in the communities themselves, through community agro-industries, which increases the added value.

Low-cost digital devices and software also allow for product and/or ingredient traceability which can be presented as a competitive asset of Amazonian products. The use of QR codes on products can reveal the origin of the product, who produced it, and the socio-environmental situation of the territory from where it comes. These devices also have the potential to demonstrate regeneration of degraded environments.

Governmental support for strengthening markets A commodity stock exchange will be further strengthened if governments adopt policies to guarantee minimum prices for forest socio-biodiversity products. Such a policy will reduce informality by generating production and market data and statistics and, therefore, stimulating evidence-based public policies. Furthermore, these policies encourage the calculation of production costs and highlight competitive opportunities. These programs already exist in Brazil, but their budgets are low, and the information does not reach the producers who need it most, exacerbated by the lack of technical assistance and low level of organization.

Other policies can play an important role in strengthening forest socio-biodiversity. In Brazil, the National School Meals Program requires meals to source a certain amount of content from family farms. Other institutions, such as public hospitals and prisons, can use similar practices to increase demand for socio-biodiversity products. Institutional markets are a way to offer security to producers and, thus, consolidate trade routes and support producers' organization.

Science, technology, and innovation The ambition to reduce the gap between the Amazon and the global scientific and technological innovation frontier presupposes the expansion of public and private investments in science and technology in the region. Investments in science, technology, and innovation are supported by an existing scientific community located not only in state capitals⁸⁰, but these networks need to be greatly expanded and strengthened. The budgets of the most important research organizations in the Amazon are far from sufficient given the territorial, demographic, and ecological importance of the region, and of the potential that it represents.

Strengthening Amazonian organizations is paramount; this could include courses at different levels (from field studies targeting secondary students to postgraduate studies) on socio-biodiversity. In addition, the emergence of a strong bioeconomy presupposes the creation of new research centers that are committed to achieving results vis-à-vis the use of resources. There are indications that conventional mechanisms for evaluating scientific research (e.g., publications in high impact journals) are insufficient to direct researchers' efforts towards the strategic objective of strengthening the emergence of a new bioeconomy. Incentives for innovation, including processes, techniques, brands, and patents, are needed. Leveraging the confluence of academic and traditional knowledge and global experiences in bioeconomy can attract significant venture capital investments. Today, forestry courses focus on a small number of tree species, mainly exotic, planted both for agriculture and logging. The re-

cent creation of the Forest Social Business School in the state of Amazonas (Brazil) is an important step in reconciling new educational modalities and approaches on biodiversity with entrepreneurship⁸¹.

Biodiversity molecules and shared benefits The presumed value of tropical forests' biodiversity for the pharmaceutical industry is predicated on the existence of cutting-edge technologies to identify compounds and understand their potential uses. This requires strategic alliances involving public and private research organizations.

Skirycz et al. (2016)⁸² propose that pharmaceutical companies share their chemical libraries through pre-competitive agreements. No one laboratory can seek to know the complete set of chemicals in the rainforest and their uses. Of the 15,000 plants estimated to have medicinal properties, less than 200 are used in the pharmaceutical industry. Reducing this gap is a scientific task that can give rise to technological innovation in laboratories, companies, and societies.

It is crucial that the mechanisms already established internationally under the Convention of Biological Diversity are improved to ensure the sharing of benefits obtained by research with the populations living in the forest and with the scientific institutions involved in the discoveries. Today, these mechanisms do not encourage research, hardly benefit the populations of tropical forests, and do not sufficiently advance scientific knowledge.

State and local information systems National statistical bodies' capacity is low when it comes to remote or difficult to access areas. At the same time, it is difficult to develop and comply with development plans in the absence of state and local statistical information. This is a field in which international cooperation, as well as cooperation between Amazonian territories, and the skills from the most developed areas of Amazonian countries will play a fundamental role.

Conclusions The Amazon's extraordinary diversity presents one of the main opportunities for the emergence of a new bioeconomy of standing forests and flowing rivers, valuing both academic and traditional knowledge, and promoting well-being and income generation for its inhabitants. Transforming tropical forests into an opportunity for the development of applied life science is a decisive aspiration which could benefit the whole of humanity. However, this presupposes that the bioeconomy opens the way not only to valuing the knowledge of those who directly explore the forest, but also the social emancipation of those who are currently in a situation of vulnerability. It also presupposes public policies that immediately address violence, illegality, and destruction, and strengthen infrastructure to improve the living conditions of the Amazon's inhabitants.

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