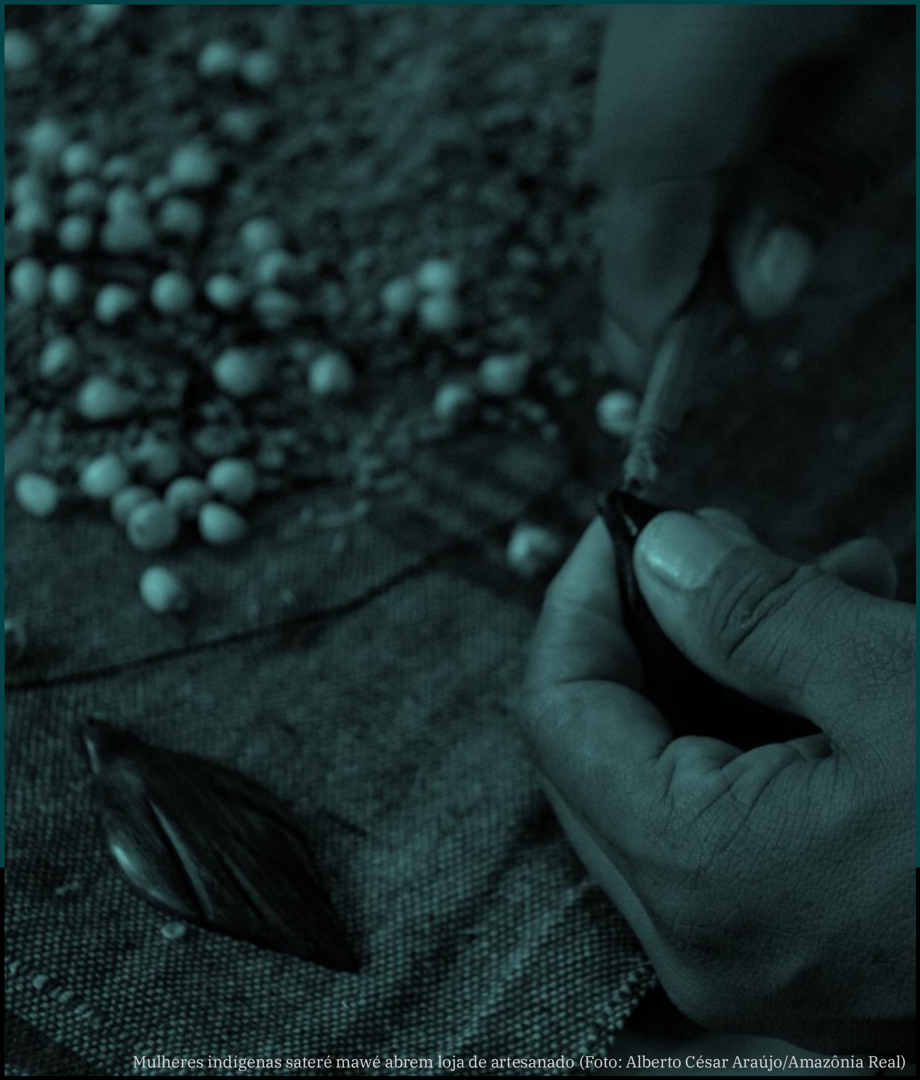
Amazon Assessment Report 2021

Chapter 30

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

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

About the Science Panel for the Amazon (SPA)

The Science Panel for the Amazon is an unprecedented initiative convened under the auspices of the United Nations Sustainable Development Solutions Network (SDSN). The SPA is composed of over 200 preeminent scientists and researchers from the eight Amazonian countries, French Guiana, and global partners. These experts came together to debate, analyze, and assemble the accumulated knowledge of the scientific community, Indigenous peoples, and other stakeholders that live and work in the Amazon.

The Panel is inspired by the Leticia Pact for the Amazon. This is a first-of-its-kind Report which provides a comprehensive, objective, open, transparent, systematic, and rigorous scientific assessment of the state of the Amazon's ecosystems, current trends, and their implications for the long-term well-being of the region, as well as opportunities and policy relevant options for conservation and sustainable development.

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Graphical Abstract

Figure 30.A Key premises for the emergence of a new bioeconomy of healthy, standing forests and flowing rivers.

The New Bioeconomy in the Amazon: Opportunities and Challenges for Healthy, Standing Forests and Flowing Rivers

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Key Messages

- 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 provides opportunities to improve the living conditions of rural, forest, and urban populations, currently characterized by poverty, inequality, and threats to citizens' rights.
- Making forest socio-biodiversity the epicenter 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.
- 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. The bioeconomy has the ambition to guide social life towards the regenerative use of the biotic, material, and energy resources on which we all depend. The opportunities that open up for combating poverty and inequality with the sustainable use of forest biodiversity are immense, not only in rural areas but also in cities.
- The social and economic base for the sustainable use of standing forests and flowing rivers is broad and diverse. It involves the traditional activities of forest peoples, family farming marked by land uses characterized by rich biodiversity, and all the actors in rural landscapes. Commodity agriculture focused on the production of grain and meat also has an important role to play, promoting regenerative practices and avoiding socioenvironmental harm.
- 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.
- One of the most important premises for the emergence of a new bioeconomy is to change the conception and forms of implementation of planned infrastructure projects. Environmentally-sensitive planning that meets the population's basic needs, such as high-quality connections, agile transport ser-

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vices, and high-quality information to improve the commercialization of products, are basic objectives to which, in most cases, current infrastructure does not respond.
- The Amazon has several respected science and technology teaching and research organizations. With appropriate institutional investments and international collaboration, a new bioeconomy of healthy, standing forests and flowing rivers can emerge.

Abstract

In the past twenty years, the bioeconomy has been increasingly recognized for its potential to create value and its contribution to sustainable development. Although most of the world's biodiversity is located in tropical regions, the main players generating scientific and technological literature on the bioeconomy are situated far from tropical forests. The chapter's fundamental starting point is the recognition that the Amazon's ecosystems have been occupied by people who have accumulated a deep knowledge about them, interacting and decisively contributing to its maintenance for thousands of years. It is critical to understand, highlight, and demonstrate the strategic role that Amazonian ecosystems and local people can and should play in the global emergence of the bioeconomy. Evidence is accumulating on the enormous potential to produce a range of products and improve the well-being of people from these forests. This strategic role is not straightforward because of the natural attributes of their ecosystems: a sustainable pathway to the bioeconomy has yet to be built, and should go through several fundamental elements, including: a) Recognition that, by ethical principles, strengthening the forest economy should support the improvement of local livelihoods; b) Institutional signaling against illegality and deforestation; c) Improvement in the quality of information about different products and their value chains; and d) Provoking the emergence of dynamic markets as alternatives to the incomplete, socially unfair, and imperfect markets that dominate the forest economy today. This chapter paves the way for a new vision of a healthy, standing forest and flowing river bioeconomy. First, it presents the bioeconomy as a recent field with no unified definition in international literature. After this, it describes how the bioeconomy of forest socio-biodiversity in the Amazon is still very limited. The low economic efficiency of current ways of using the forest is discussed, and the current economic exploitation of forest socio-biodiversity in three basic sectors are presented: timber, non-timber products, and fishing. Then, the following services related to the bioeconomy are presented: synergies with forest restoration, tourism, and payment for ecosystem services. Finally, it discusses the transition needed for healthy, standing forests and flowing rivers to become a vector for the prosperity of populations and solutions for global socio-environmental challenges.

Keywords: Bioeconomy, socio-biodiversity, standing forests, flowing rivers, tropical forests, Amazon.

30.1 Introduction

The starting point for stimulating the emergence of a strong and dynamic socio-biodiverse economy in the Amazon is recognizing that the most important tropical forest in the world has been occupied by people who have known how to make use of its immense wealth and have decisively contributed to its maintenance for thousands of years. In the pre-Columbian period, it is estimated that 8 to 10 million people lived in the Amazon, many of whom in villages of 10,000 inhabitants (Clement *et al.* 2015; see Chapters 8-10). Dense population clusters were recorded in the sixteenth century by Gaspar de Carvajal, a Dominican friar that accompanied Francisco de Orellana on his trip on the Amazon River (Plotkin 2020:101).

The social activities of these peoples were not based on the destruction of the forest. On the contrary, they decisively contributed to what the ethnobotanist William Balée (2013) called an "anthropogenic forest". Part of the current forest formation in the Amazon is a result of the management of various environments to "increase the abundance of plants used as food or fiber" (Plotkin 2020: 102; see Chapter 10). Ethnobotanical studies in the twentieth century increased our knowledge not only of flora, microorganisms, and the immense Amazon fauna, but also of their constant interaction with human populations (Schultes and von Reis 1995).

Despite the violence European colonization inflicted upon the Amazon's original peoples (see Chapter 9) and the promotion in the last fifty years of an economy based on the destruction of nature (Hern 1991; see also Chapters 14–20), the Amazon can still decisively contribute to solving some of the most relevant contemporary problems. This is due not only to the ecosystem services provided by the forest (Phillips *et al.* 2017; see Chapters 4–8), such as its function as a carbon sync (Yang *et al.* 2018), but also due to its biodiversity (Barlow *et al.* 2018; see Chapter 3) and the knowledge, techniques, and economic practices of the peoples who inhabit it (see Chapters 8, 10, and 13).

Today, this immense potential is underutilized (Vietmeyer 2008) and being systematically destroyed by deforestation and degradation, growing aggression against forest dwellers and their territories, extractivism that barely benefits those who live in the region, and frequently low-productivity agriculture and cattle ranching (see Chapters 14–20). Expansion of the agricultural frontier has been associated with degradation of the fundamental ecosystem services on which human societies depend (Garrett *et al.* 2017), starting with climate regulation, water supply, and biodiversity (see Chapters 17–24). Amazonian urban populations also do not benefit from land-use practices that degrade their wealth and export the very results of this destruction outside the region (Costa and Brondizio 2009). Infrastructure investments aim to make the Amazon a supplier of energy, minerals, and agricultural commodities, with benefits accumulating to those that live far from the Amazon's rural and urban areas (Chiavari *et al.* 2020; Antonaccio *et al.* 2020; Bebbington *et al.* 2020).

The fires that shocked the world in 2019, darkening the São Paulo sky in broad daylight (Setzer 2019; Barlow *et al*. 2020), raised awareness of the prevailing illegality and criminality in the region (Abdenur *et al.* 2020). These events drew attention mainly to the complacent attitude of several government administrations and agencies who promoted destructive practices in the name of supposed production of wealth. They often supported predatory practices, such as the invasion of Indigenous peoples' territories, the occupation of public areas, or illegal mining. More than that, these fires highlighted one of the most important paradoxes of the twenty-first century: the Amazon (and other tropical forests) are still not part of the scientific, technological, or market frontier of the contemporary bioeconomy. At the same time, aggression toward the forest and the people that currently inhabit it sheds even more light on an indispensable challenge that needs to be overcome for a strong and dynamic bioeconomy to take hold in the Amazon: transformation away from current agriculture and livestock commodities towards a sector that contributes to forest regeneration and offers goods and services that are recognized by different markets as strengthening of biodiversity. This orientation cannot be limited to forest areas. It must also reach the diversity of land use models in the Amazon, including the commodity production sector, wood production, forest regeneration, and mining. As discussed later in this chapter, the experience from farms that already use regenerative production methods and from hundreds of thousands of family farmers who enable their production through a rich polyculture, shows an abundant and diffused knowledge of the use of the forest. These current economic practices contain, albeit to a limited extent, precious lessons in the direction toward the sustainable development of rural areas in the Amazon.

30.1.1 An Immense Unrealized Potential

Literature on the socio-biodiversity of the Amazon and continues to grow, as shown by research programs, reports, and conferences connected to the most important botanical gardens in the world, as well as by interdisciplinary research from the region as well as international universities and laboratories. Evidence that destruction of the Amazon means the loss of valuable economic resources has been presented throughout the twentieth century (e.g., Rodrigues *et al.* 2009).

In 1941, Celestino Pesce published "Oilseeds from the Amazon", in which he studied a variety of native species. Many products were processed locally and exported, nationally and internationally. Pesce (1941) was an industrialist and, in 1913, bought a factory for processing ucuuba (*Virola surinamensis* (Rol.) Warb.). At the same time, his research resulted in a book, whose preface highlights the scarcity of use of an extraordinary and unique wealth.

In 1979, Richard Evans Schultes published a text in which he praised the Amazon as a source of new economically important plants. The article begins by mentioning those who regarded the Amazon as a "desert made of trees" which needed to be removed, a view which, according to Schultes, was on the rise in the late 1970s. For him, there were countless reasons to preserve the Amazon. At the time, climate change was not widely known and is not even mentioned in his article. Schultes (1979) proposed only one reason for the maintenance of the forest, a fundamental reason for the future of the human species: "its incalculable value as an unexplored emporium of germplasm for new economic plants". Schultes demonstrates that the Amazon rainforest "should be considered as one of the most important origin centers of cultivated plants", in contrast to the parsimony of the contribution of North America, Australia, and most of Africa.

In his article, Schultes mentions the 1975 National Academy of Sciences report called "Underexploited Tropical Plants with Promising Economic Value". The report selects thirty-six species (out of more than 400) that should receive special attention because of their economic potential. One-third of these were from the Amazon. It is interesting to note the connection Schultes establishes between this diversity and forest dwellers; "Nowhere in the world", he writes, "have native peoples used such a wide variety of plants in the preparation of products, such as arrow and ichthyotoxin poisons. And several ethnic groups have an extensive pharmacopoeia of presumed medicinal plants. The use of hallucinogens and other narcotics and stimulants is widespread. Everything points to the fact that the Amazon's flora is a real, almost unlimited, chemical factory - and a chemical factory that is almost untouched, waiting for the attention of scientific research" (Schultes 1979: 264).

In the aforementioned 1975 American report, the contrast between the potential of unexplored plants in tropical regions and its almost nil economic use is attributed to the concentration of research around some already consolidated plants (National Academy of Sciences 1975). The report highlighted the potential of products for industry, human and animal feeding, and chemicals, that scientists were not studying. This was partly due to the scarcity of institutions around the world that trained people in tropical botany.

Nevertheless, it is important to highlight the immense research efforts located in the Amazon; this includes herbaria and research institutes working on the Amazon's biodiversity. Brazilian herbaria, for example, contain hundreds of thousands of specimens (approximately 247,000 at INPA-INCT, 230,000 at Museu Emilio Goeldi, and 200,000 at Embrapa Eastern Amazon), while the herbarium at the Amazonian Scientific Research Institute in Colombia provides a database of 100,000 plants (Mendoza-Cifuentes *et al.* 2018). Its ichthyological and aquatic macroinvertebrate collections are also of great importance. Samuel Almeida, a researcher at the Museu Paraense Emílio Goeldi, wrote "Plants of the Future of the Northern Region," and listed no less than 93 species about which there is a reasonable level of information (Vieira *et al.* 2011). A book by Clay *et al.* (1999) is also an important example of scientific knowledge of Amazonian biodiversity and opportunities for its use. Research by the Brazilian Agricultural Research Corporation (EMBRAPA) shows that there are more than 250 species of palm trees in Brazil, more than half of which are located in the Amazon. However, research tends to prioritize a dozen of these (Lopes *et al.* 2015). The result is that even contemporary pharmacopeia is focused on the use of a small number of plants, which contrasts with the richness of tropical biodiversity, and particularly Amazonian forests (Barlow et al. 2018). According to a 2017 Kew Royal Botanic Gardens report, less than 16% of the species used in plant-based medicine are officially regulated. The number of native plants in the Brazilian pharmacopeia fell from 196 in the 1926 edition to 32 in 1959 and only four in 1997 (Allkin *et al.* 2017).

Despite the work of several ethnobotanical museums in the region, the Amazon's contribution of local plants to medicines for official pharmaceutical uses is negligible. The Sacata Museum, in Macapá (Brazil), contains a Pharmacy of the Earth with raw materials produced by communities in the region. Such initiatives do not go beyond the strictly local scope. Currently, the only Amazonian product included in the Brazil Unified Health Service (SUS)'s list is "cat's claw" (*Uncaria tomentosa*), a species discovered by its use by Indigenous communities in Peru, and that has a wide distribution in all Amazonian countries (Valente 2006).

These are just a few examples that illustrate the paradoxical distance between the greatest sociobiodiversity on the planet and the low utilization of such diversity. It is clear that this scarcity cannot exclude the existence of an economy of forest socio-biodiversity throughout the entire Amazon, which has social and market structures that are part of the culinary, material, religious, and therapeutical options of its populations, and which is strongly supported by the knowledge of Indigenous peoples and local communities (see Chapters 10 and 13).

However, utilization of this wealth and the benefit it can bring to forest dwellers, adjacent urban populations, and the world, are far below their potential. A meta-analysis by Paletto *et al.* (2020:270) analyzed 225 documents on forest bioeconomy published by 567 organizations from 44 countries; the most represented countries were Finland and Canada. Of the ten organizations that have published the most in the area of forest bioeconomy, there are none located in a country with tropical forests. Of all the works analyzed in the article (indexed by Scopus), the keywords "bioeconomy" and "tropical forests" never appear together. While this does not mean the absence of research on the use of biodiversity in tropical forests, it shows the scarcity of cutting-edge applied science and technology in tropical forest regions.

The economic consequence of inadequate use of the Amazon's forest biodiversity is well expressed in the work of Coslovsky (2021), referring to Brazil; between January 2017 and December 2019, the nine states of the Brazilian Amazon exported 955 different products. Of these, 64 agricultural or forest products allowed an annual turnover of USD 300 million. However, in the global market for these products, the participation of the Brazilian Amazon is negligible, under 0.2% of the total. The Amazon is unable to compete with countries whose development indicators are more or less equivalent to its own, and occupies a negligible part of markets which, given its potential, its presence could be much greater (Coslovsky 2021).

In fact, exploitation of the Amazon's socio-biodiversity has remained practically the same since the colonial period. Oils from Andiroba (*Carapa guianensis* Aublet.; Souza *et al.* 2019) and Copaíba (*Copaifera* spp.), for example, are still conventionally extracted, generating low economic return. The wealth of fish in the Amazon is not supported by adequate industrialization and refrigeration, as further discussed below. One of the most important assumptions for the emergence of a new bioeconomy of healthy, standing forest and flowing rivers is that it should be supported by an ambitious industrial policy that is based on the expansion of socio-biodiversity knowledge, and that results in technological innovations that benefit Amazonian populations through its elaboration processes, and the entire world through its use. Without an industrial policy capable of stimulating entrepreneurial initiatives that surpass current forms of production and use of the forest and rivers, there is no way to make biodiversity the decisive vector for the sustainable development of the Amazon.

The objective of this chapter is to suggest pathways for public policies and actions, both for businesses and civil society, to favor the emergence of a bioeconomy that contributes to raising the levels of human development, expanding the use of its biodiversity, exploiting its multiplier potential, stimulating environmentally-sensitive infrastructure investments that meet peoples' needs, and strengthening the scientific and technological knowledge necessary for the forest socio-biodiversity economy to become the epicenter of the region's development and an economic matrix that favors the expansion of socio-biodiverse areas.

These pathways are not limited to the sustainable economic use of what forest areas can and do offer. It is paramount that the value chains that produce agricultural and mineral commodities transform, not only to entirely eliminate forest destruction, but also to use less impactful techniques and inputs on biodiversity within production systems. Attention should be directed not only to forest dwellers, but also to the thousands of family farmers in the region (see Chapter 15). Many of them produce conventional products (e.g., dairy and cassava), often in a way that is compatible with preserving a rich biodiversity. One of the major obstacles to expanding this diversity is the instability of markets interested in their products.

It is clear that a new bioeconomy of a healthy, standing forest and flowing rivers will only have a chance to fulfill its vocation if it also benefits the Amazon's urban populations. Strengthening the connection between rural and peri-urban areas, through urban markets where socio-biodiversity products are commercialized, or stimulating existing or new companies to improve and disseminate this wealth, are key strategies to be developed. It is also important to improve research that will allow the emergence of new products, and expand the potential of forest products in gastronomy. Cities will play a fundamental role in the emergence of a new, dynamic, and competitive forest bioeconomy.

The emergence of a dynamic bioeconomy capable of altering the institutional environment and economic practices that have contributed to the destruction of the Amazon requires participation not only of the economic actors that are potentially interested in its use, but mainly the participation of forest dwellers, family farmers, settlers, and urban populations in the Amazon. It is paramount that the value chains that produce agricultural and mineral commodities are also transformed, in the sense that their activities contribute to forest conservation and regeneration, biodiversity strengthening, and that their production processes are tracked, allowing them to expose their products to markets that are connected to the global conservation movement. There are existing tools for the transparency and accountability of value chains, aimed at eradicating deforestation and promoting sustainable practices. Examples include Global Forest Watch Pro (GFW Pro), Trase, and the Accountability Framework. The Trase platform has been contributing to the transparency of soy and beef production in the Amazon, linking impacts in production regions with the global markets (Trase 2020; zu Ermgassen *et al.* 2020). It is also important that public, private, or associative financial resources contribute to maintaining and regenerating ecosystem services, for example through different forms of payment for environmental services (PES), favoring the sustainable use of biodiversity and knowledge from both science and the people who have contributed to keeping the forest standing until now.

This transformation must also be stimulated by research and educational institutions. Bearing in mind, for example, the importance of improving livestock sustainability in the Amazon, it is essential to invest in different research topics that support the development and scaling-up of integrated systems, such as those for crops, livestock, and forests, as several initiatives across the region are already exploring (Garrett *et al.* 2020). In the same way, it is necessary to stimulate research that addresses not only monoculture plantations (e.g., eucalyptus, pine), but forest ecosystems and their biodiversity. These examples should be expanded, as there is an urgent need to fill gaps in the taxonomy of organisms and the living wealth of biodiversity in all strata of Amazon forests (i.e. from the floor to the canopy) (Plotkin 2020).

This chapter is divided into seven sections, in addition to this introduction. Section 30.2 seeks to characterize the bioeconomy as one of the most important values of contemporary socio-environmental thinking and, at the same time, its strategic value for Latin America, and particularly the Amazon, to occupy a relevant place on the frontier of global scientific and technological innovation. This section summarizes some of the established definitions of the bioeconomy. It is important to clarify that, given the characteristics of tropical forests, the option was to show bioeconomy as a highly diversified reality in terms of players, products, and services, which is presented in section 30.3. Section 30.4 describes the most important characteristics of the techniques and markets prevalent in the use of forest socio-biodiversity, focusing on timber and non-timber forest products (NTFPs), as well as in fisheries. Section 30.5 shows the importance and potential of three key services: forest regeneration, tourism, and PES. Section 30.6 analyzes the transition from what has hitherto been an economy based on the destruction of nature to one based on knowledge of nature, with an emphasis on the actors and organizations involved. Section 30.7 makes policy recommendations, and section 30.8 summarizes the main conclusions.

In addition to the bibliographic sources cited in the text, this chapter is based on a set of interviews with socio-environmental activists, entrepreneurs, scientists, and other stakeholders.

30.2 Bioeconomy: More than a Sector, an Ethical Imperative

There is no consensual definition of bioeconomy. Rather than select a particular definition, this chapter presents the diversity of visions and highlights guiding principles.

A 2020 report by the United States National Academies of Science, Engineering and Medicine defines the bioeconomy as "economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences". They calculate that the bioeconomy corresponds to 5.1% of North American Gross Domestic Product (GDP), including the agricultural sector as a whole, as well as biotechnology (NASEM 2020). Use of biological data in medicine, renewable biomass production for energy, bioengineering, and synthetic biology all contribute to the approximately US $1 trillion value of the US bioeconomy.

In the European Union, the link between the economic use of biological resources and important scientific achievements of the twenty-first century was important in understanding bioeconomy as a strategic sector for economic growth (Birner 2018).

Aguilar and Patermann (2020) emphasize two fundamental dimensions of the contemporary bioeconomy. The first brings it closer to the pioneering work of Romanian economist Georgescu-Roegen (Georgescu-Roegen 1977; Carpintero 2006), by insisting on the need for a holistic approach that goes beyond its sectoral dimension. According to this vision, the entire economic system is transformed, and its development depends on co-evolution between society and nature. Fücks (2015: 201) goes so far as to speak of a "mode of production powered by the sun". There is an important line of contemporary thinkers, of whom René Passet, Herman Daly, Kenneth Boulding, and Partha Dasgupta are among the most influential, whose work shows that economic activity depends on services provided to humanity by nature, and that the sustainable use of biodiversity has a decisive function (Boulding 1966; Daly 1996; Passet 1996; Dasgupta 2021).

The second dimension to which Aguilar and Patermann (2020) bring attention is that the destruction of biodiversity and, at the same time, the immense potential of scientific advances to improve social life, give space for the emergence of a new relationship between countries, which they call biodiplomacy. This is not about challenging the sovereignty of each country over its respective territories and the legitimacy of conventional diplomacy, which turns primarily to the defense of national interests; this defense does not overlap with a "global and integrated approach to the management of global challenges that affect the biosphere" (p. 24).

European documents, discussions preceding the Convention on Biological Diversity (CBD), and academic contributions show that, much more than an economic sector, the bioeconomy can and should be considered as an ethical-normative imperative, i.e., as a value. Its economic importance is growing, but, at the same time, the European definition, which links bioeconomy to the circular economy, emphasizes that the bioeconomy is an essential component in achieving the goal that, in 2050, to use the CBD's expression, humanity will live in harmony with nature (CBD 2020).

In Latin America, many countries assimilate parts of the European or North American definitions. However, appropriate adaptations need to be made to regional socioeconomic and environmental contexts. A more socioecological vision (NASEM 2020) is vital for Amazonian countries to conserve their rich biodiversity and value the peoples that promote it. It is time to establish these visions since bioeconomy initiatives are emerging and national bioeconomy policies are being developed (e.g., Sasson and Malpica 2017; Lopez-Hernandez and Schanz 2019), as discussed below.

30.2.1 Why a new bioeconomy of healthy standing forests and rivers flowing?

Addressing the bioeconomy as a value in the case of tropical forests (and particularly the Amazon) means that economic activities, despite their wide variety of sectors, players, and technical resources, must always result in the strengthening of forest socio-biodiversity and in the improvement of living conditions of rural, peri-urban, and urban populations inhabiting the territory. It is about uniting what has been, until now, separated; improving the living conditions of its population, not through the destruction of nature, but through knowledge of it.

The idea of a new bioeconomy of healthy, standing forests and flowing rivers is therefore not rhetorical. The contemporary bioeconomy will increasingly rely on ethical and normative precepts directed to the transformation of society toward sustainable development pathways. This achievement should be supported by science and technology in order to repair the current destructive relations between society and nature. Unfortunately, the fact is that the translation of these values into practice is in its infancy in tropical forest regions.

One of the most surprising findings is the scarcity of references to tropical forests and the Amazon in scientific and technological literature on the contemporary bioeconomy. As previously highlighted, recent publications on botanical economics are fertile in pointing out the potential of the Amazon for a bioeconomy. However, poor practical implementation of this potential is shocking when one takes into account that this territory has the greatest biodiversity on the planet. The vast literature on Neglected and Underutilized Species (NUS) (Padulosi *et al.* 2019; Antonelli *et al.* 2020) expresses well the gap between the richness of biodiversity and the precariousness of its economic use.

This chasm is explained, first of all, by the unprecedented challenge represented by the sustainable use of the tropical forest, based on the knowledge economy, as already pointed out in an important document from the Brazilian Academy of Sciences (ABC 2008). In temperate countries, the bioeconomy is based on the strength of laboratories, planted crops, and very homogeneous forests. It includes the production of bioenergy, biomaterials, and resins, achievements often derived from the use of digital technologies to obtain molecules that are useful in the production of medicines. Also, new production techniques allow reduced use of pesticides and chemical fertilizers in agriculture, and new forms of animal feeding. These components of the bioeconomy arise in environments whose biological diversity is much less complex than that of tropical forests.

Harnessing the potential of tropical forests without destroying them, converting their regeneration into an economic growth engine, combining scientific knowledge with the knowledge systems of forest and river dwellers, and transforming the production and commercialization of commodities in a way that they can be integrated into the strengthening of Amazonian ecosystems, are some of the most important challenges encountered by a new bioeconomy of healthy, standing forests and flowing rivers. Until now, overcoming this challenge in the Amazon has been unsatisfactory.

A recent survey on bioeconomies around world shows that among the countries of the Amazon only Brazil, Colombia, and Ecuador have bioeconomic policies (German Bioeconomy Council 2018). Still, as is clear from a recently-released document by the National Confederation of Industry in Brazil (CNI 2020), these policies convey no strategy for an economy of forest socio-biodiversity to emerge in the Amazon. Likewise, a recent publication on bioeconomy in Latin America and the Caribbean from the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) cites the Amazon only once and focuses on what crops planted on the continent can offer (Rodríguez *et al.* 2019). In the important book on the bioeconomy organized by Lewandowski (2018), tropical forests are mentioned in only one section and there is only one quote about the Amazon.

The forest and associated ecosystems are recognized as a provider of ecosystem services but not as a territory in which contemporary scientific and technological achievements can represent a path for development. There is a gap between the richness of the ecosystems and the current ways of utilizing them.

30.2.2 Bioeconomy: A path to Scientific and Technological Innovation

Filling this gap is not only a matter of interest to those who live in the Amazon. A new bioeconomy of healthy, standing forests and flowing rivers offers a strategic pathway to bridge the gap that separates the Latin America of today from the global scientific and technological innovation frontier (IDB 2010). At the beginning of the 1980s, Latin America's industrial capacity was competitive on the world stage. Since then, the continent has gone through a process of re-primarization, which some authors do not hesitate to call neo-extractivism (Gudynas 2021; see also Chapter 14). The Harvard University Atlas of Economic Complexity (Haussman *et al.* 2013) shows that the density of Latin America's insertion in the global economy is marked by a low incorporation of knowledge, information, and intelligence. This is not to underestimate the importance of scientific and technological advances in Latin American agriculture–although these advances have been occurring far from the Amazon—but these results are not sufficient to bring the continent closer to the global frontier of scientific and technological innovation. Perez (2015), one of the most important researchers on technological revolutions of the modern era, advocates for a pattern of economic growth supported by natural resources. Her justification is that the prospects for the continent to assert itself as a significant exporter of televisions, automobiles, or microchips are low, since it has accumulated a delay in those areas that will not be overcome in the short term. It is in its natural resources and, above all, in the application of science and technology to sustainable management, processing, and pharmaceutical discoveries embedded in biodiversity, that Latin America finds its greatest chances to move from an economy whose international insertion is based on commodities, towards a pattern in which biodiversity products, based on the knowledge economy, gain increasing national and international importance. In fact, the greatest chance to reposition Latin America from a commodity-based economy toward a nature-based one is through the conservation of its natural resources and, above all, the application of science and technology. They are essential to promote sustainable management, processing, and pharmaceutical discoveries embedded in biodiversity and, ultimately, increasing national and international importance. This strategy should be followed to realize the ambition for the Amazon to become a contemporary bioeconomy. However, for a new economy of healthy, standing forests and flowing rivers to emerge in the Amazon, it is necessary to first compile a summary of the main current characteristics of the economic use of forest socio-biodiversity. This is the theme of the next section of this chapter.

30.3 Diversity, the Key Feature of the Amazonian Bioeconomy

Diversity is the most important feature of the current forest socio-biodiversity economy in the Amazon. This refers not only to the extraordinary and still highly unknown biological wealth of the region (see Chapter 3), but also to the variety of relations established between human populations and this biodiversity (see Chapters 10 and 13). Approximately two-thirds of the pan-Amazon's inhabitants live in urban areas. At the same time, the organization of these urban centers might differ from that of traditional, with different types of buildings and transportation networks, related to the close relationship of residents with the forest and family farming areas (see Chapter 14). Furthermore, as discussed in section 30.7, countries such as Brazil underestimate the demographic importance of its rural population, owing to the blurred boundaries between rural and urban areas.

During the process of occupation of the Amazon, family farming resulting from spontaneous migration, directed colonization, or settlements was very important; more than 700,000 family farmers live in municipalities within the Brazilian Legal Amazon alone (IBGE 2019). Although many incorporate elements of the polyculture tradition typical of forest populations into their production practices, the need for income generation often leads farmers to expand livestock areas, to the detriment of biodiversity (see Chapter 15).

Large farms also need to be considered, especially since land ownership concentration in the Amazon has been increasing in recent years, especially in Brazil (Romeiro *et al.* 2020). Although there are examples of farms that seek to regenerate previously deforested areas, there are large territorial units where deforestation is very high. Furthermore, this deforestation is linked to institutional degradation and violence; Sant'Anna and Young (2010) demonstrate increased homicide rates municipalities with greater deforestation in the Brazilian Amazon.

One of the most comprehensive analytical frameworks on the bioeconomy in the Amazon was produced by *Concertação pela Amazônia* ("Accord on the Amazon"), a network of individuals, organizations, and companies created in 2020. It represents an effort to develop proposals not only to stop violence and destruction but also to address the emergence of a strong and competitive socio-biodiversity economy in the region. This organization states an elementary but decisive finding: the extent of the territory, national traditions, varied ethnic compositions, languages, national legislation, and institutions of the Amazon should always be presented in their plurality (Concertação pela Amazônia 2021). Diversity is the key feature, asset, and challenge for the region.

Despite being developed within the scope of the Brazilian Amazon, the work of the *Concertação* is illustrative of a more general picture. Within the Amazon, there are "conserved regions" (where conserved forests dominate), the "arc of deforestation" (presenting extensive open areas and a few forest remnants, which have been degraded by logging and forest fires), "anthropized regions of converted forests" (usually associated with areas opened by productive activities), and "cities". Each of these regions can be characterized by its predominant activity and also by a specific proposed development agenda.

Even the areas with a predominance of trees are varied, as shown in Figure 30.1. This diversification ranges from conserved forest areas to native or exotic monocultures, passing through silvicultural enrichment of degraded forests, restoration of open areas, and the planting of long-cycle exotic species.

It is within Amazonian diversity and its forest continuum that Concertação classifies the current bioeconomy into three fundamental types. These types are what can truly be defined as the bioeconomy of the Amazon, with a clear difference between this bioeconomy and that described in international literature, which is not supported by such a rich and complex socio-biodiversity. It is important to note that none of these types exist in a pure state and that they serve primarily as a heuristic resource to describe the socio-biodiversity that marks the current use of the forest.

First, there is the traditional bioeconomy based on the biodiversity of native ecosystems. Its predominant activities are of an extractivist nature and carried out for self-consumption, commercialization with consolidated intermediaries (see below), and unprecedented commercial circuits linked to fair trade. The products derived from these activities hardly reach large volumes and only reach markets as niche products. Precisely because of the biodiversity richness on which these activities are based, they may gain importance for the pharmacological, cosmetic, and cutting-edge biotechnology segments. Strengthening businesses linked to this biodiversity is especially difficult, not only due to dependence on incomplete and imperfect markets, but also the regulation of access to benefits obtained with the use of biodiversity.

The second type of bioeconomy is based on forest management, and is suitable for regions where forests have undergone some type of disturbance or degradation (e.g., selective logging or fire). In the previous type, biodiversity is inherent to the activity; here production systems can be more or less diverse. There is a significant commitment from public and private organizations to implement agroforestry systems (AFS), including the Integration of Crop, Livestock and Forests (ILPF). In these regions, it is also important to identify priority areas to be restored for the provision of ecosystem services such as water and crop pollination.

The third type is the commodities bioeconomy. It may be surprising that agricultural and mineral commodities are included in this typological description, but this is justified for two reasons; 1) because of the impacts (so far, almost always destruc-

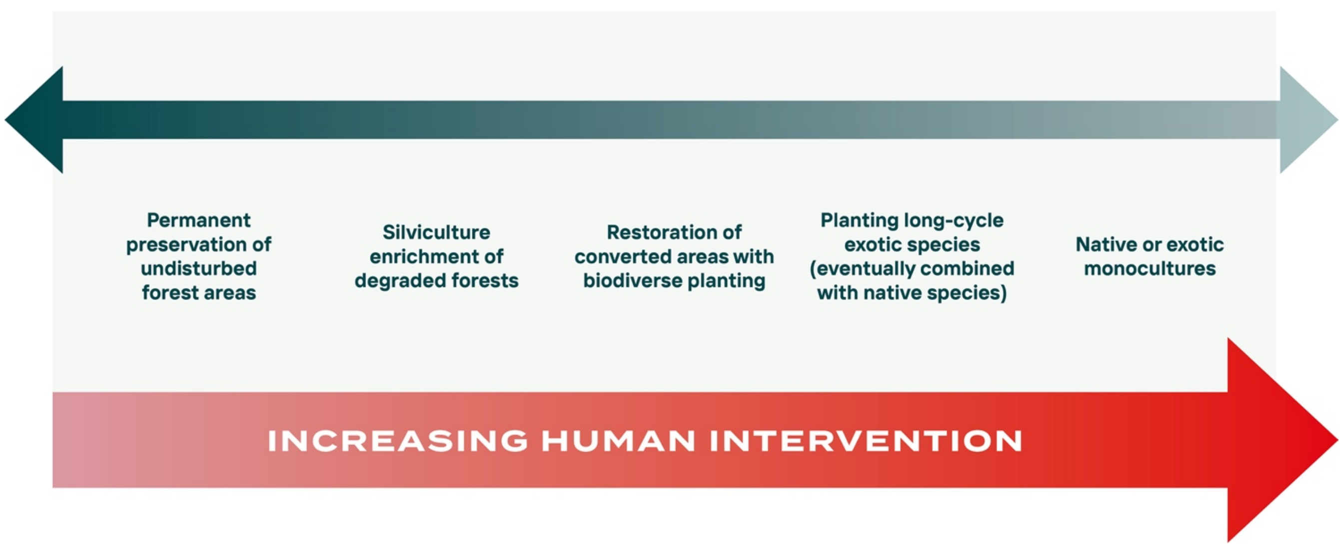

Figure 30.1 Continuum of human interventions on forest ecosystems varying on conservation status. Adapted from Concertação pela Amazônia 2021.

tive) that these forms of production have on biodiversity and ecosystem properties; and 2) given the large area that commodity production currently occupies in the Amazon, it is urgent that the areas directly and indirectly affected by them are also subject to regenerative processes capable of making their high yields compatible with the protection of terrestrial and aquatic ecosystems at landscape and regional scales. This involves not only the conservation of forest areas within agricultural properties and across landscapes, but also techniques that reduce the use of chemical inputs in agriculture (e.g., pesticides), avoid pollution by mining and agricultural activities, and that promote the emergence of innovative production systems.

The challenge of regenerative agriculture and livestock is not limited to large farms but also involves family farming and the different forms of land use in the Amazon. It is not uncommon, for example, for the production of small animals or freshwater fish to be dependent on extensive grain cultivation, whereas underutilized products from the region itself could meet this need. Agrarian systems in the planet's most biodiverse region cannot support its prosperity with techniques that threaten biodiversity and do not make use of its potential. This justifies the ambition that the supply of commodities in the Amazon be guided by the values of a bioeconomy.

The three segments above are presented based on assets and, especially, problems that need to be overcome for the emergence of a new bioeconomy. Moreover, precisely because it is a transition process, it is important to start by understanding the main features of the current economic use of the Amazon's socio-biodiversity.

The next section presents three sectors in more detail to underline some of the challenges presented above: timber, non-timber forest products, and fishing/pisciculture. Commodities are not analyzed here, since their impacts have already been studied in previous chapters (see Chapters 14, 15, and 17). However, it is essential that their production is compatible with the protection and regeneration of biodiversity within the properties and landscapes in which they are developed.

Finally, strengthening socio-biodiversity pillars in economic activities must emerge within the scope of a circular bioeconomy. One of the most severe consequences of the economic success of açaí (*Euterpe oleracea*) (see below) is an increase in waste without an appropriate destination. In Belém alone (State of Pará, Brazil), 16,000 tons of waste are produced daily. A proposal by IDESAM to produce fiber ecopanels from this waste illustrates the fundamental link between the sustainable use of biodiversity products and the circular economy, as pointed out by Schroeder (2019).

30.4 The Current Limited Economy of Forest Socio-biodiversity

The destruction of the largest tropical forest on the planet affects the Amazon as a whole, as seen in previous chapters. No country has deforested a great area than Brazil (Smith *et al.* 2021; see also Chapter 19). The Brazilian Amazon accounts for 9% of the country's GDP (Amazônia Legal em Dados 2021), but deforestation in the region (classified as land-use change) contributed to approximately 38% of Brazilian greenhouse gas (GHG) emissions in 2019, as inferred by Albuquerque *et al*. (2020).

Given its size and diversity, it is important to note that destructive forms of use and occupation in the Amazon do not occur everywhere. Indigenous territories (ITs) and protected areas (PAs) share a small proportion of the area deforested (13%), while covering more than half of the region's forests (see Chapter 16). The demarcation of territories belonging to Indigenous, *quilombolas*, and *ribeirinhos* peoples is a fundamental democratic achievement (Abramovay 2020a). Deforestation rates inside ITs are one half to one third that of unprotected areas with access to markets in Bolivia, Brazil, and Colombia (Ding *et al.* 2016).

The territories of Indigenous peoples and *quilombolas* contain one-third of all carbon stored in forests in Latin America, and more carbon than all the forests of the Democratic Republic of Congo and Indonesia combined (the two countries with the largest forest areas in the world after Brazil, FAO and FILAC 2021).

Some of these territories collectively manage forest resources, as discussed below. The harvesting of non-timber forest products is also important in these areas, as demonstrated by the Origens Brazil Seal, which certifies forest products meeting fair trade principles (Origens Brasil 2021).

Outside of protected areas, the collection of açaí, both in Bolivia and in Brazil, has consistently increased the income of thousands of families, having important multiplier effects on urban occupations (Costa 2020). A study by Lopes *et al.* (2018) shows that, unlike the overwhelming majority of extractivist products, income from açaí production is competitive with cattle production. Other studies have shown that açaí produced in agroforestry systems has even higher returns than soy on a per hectare basis (see Chapter 15). An important fraction of the product comes from areas endowed with rich biodiversity, inspired by the practices of traditional communities in the Amazon, as shown by the publications of Brondízio (2021), de Costa (2020), and Homma *et al.* (2006). Given rising demands, both in Latin American and globally, the production value and supply have been increasing. Açaí has the most advanced industry relative to the other current products extracted from the region, and this includes not only to juice, but also other açaí products (e.g., oil, ice cream).

Food safety is a concern; the consumption of fresh açaí pulp contaminated by the protozoan *Tripanosoma cruzi* has caused outbreaks of Chagas disease in some cities in the state of Pará (Brazil). This is easily prevented by processing açaí using sanitary techniques (de Oliveira *et al.* 2019). However, further scientific research and public measures are needed to completely solve this issue.

Açaí has anti-inflammatory properties (Machado *et al.* 2019) and an immense potential for prostate cancer treatment (Jobim *et al.* 2019). However, without an industrial policy aimed at long-term financing for research and an environment that supports innovation, it is highly unlikely for these potentials to be realized.

As discussed in section 30.6, the broad mobilization of the business sector to transform agricultural production to be compatible with conservation is a recent but significant trend, especially in Brazil. The company Sambazon has reached markets in Europe and the United States using a business model that meets demand for highly nutritious, organic, socially- and environmentally-responsible products (Tunçer and Schroder 2010).

However, these initiatives cannot disguise the prevailing conditions in the region, marked not only by technical limitations, an almost complete absence of industrial processing, and obstacles in achieving minimum health and safety standards required by key export markets (Valli *et al*. 2018); but also by forest dwellers' dependence on incomplete and imperfect markets characterized by strong clientelism and power imbalances. Historical legacies and systems such as *aviamento* and *regatão* persist and prevent the development of a strong and competitive bioeconomy. *Aviamento* is a system in which workers' debts to those who provide them with basic goods result in personal dependency that can lead to modern slavery (Guillen 2007). *Regatão* is a bartering system where goods from cities are brought to rural areas to be traded (often at unfair rates) for locally-produced agriculture and forest products (McGrath 1999).

These economic activities lead not only to permanent tax evasion, but, above all, to a market structure that does not favor quality, supply regularity, and innovation. Another critical challenge is the lack of access to information about commodity prices. A small group of players are involved in systems rooted in clientelist domination and who control the purchase of commodities produced in rural areas and sold to processors.

Figure 30.2 Açaí. Photo: Embrapa/Ronaldo Rosa.

30.4.1 Timber and Wood

The tropical timber market in the Brazilian Amazon has declined sharply in the past two decades, with native wood supply decreasing from 10.8 million m^3 in 1998 to 6.2 million m^3 in 2018. Similar to other extractive products (e.g., rubber), wood of Amazonian origin is being replaced in civil construction by wood from monoculture plantations, plastic, steel, and aluminum (Lentini *et al.* 2020).

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 harvest. This displacement pattern "occurred because the forestry industry in the Amazon remains essentially the same with regard to the continued need to explore new forests to guarantee its long-term survival, due to the slow progress observed in the adoption of large-scale sustainable management" (Lentini *et al.* 2020).

Wood processing is also inefficient, with only 41% extracted wood processed. Of this, 72% corresponds to sawn wood, which has low added value (Gomes *et al*. 2012). The furniture industry, the sector with the highest added value in the Amazon, has been losing competitive capacity in terms of the number of companies, jobs, and participation in exports.

Corruption and predatory practices are perhaps no surprise given the high levels of illegality that dominate the timber sector (see Chapter 14), outweighing legal sales by many times. For example, in the Brazilian state of Pará, a study found that, between 2017 and 2018, 70% of timber was harvested illegally (Cardoso and Souza-Junior 2020). Legal, sustainable timber production can hardly compete with what some call "forest mining" (Bryant *et al.* 1997). Illegality also marks logging in other countries, such as Colombia (EIA 2019) and Peru, as shown in a study conducted by the Center for International Forestry Research (CIFOR) (Mejía *et al.* 2015).

The predominance of illegality and unsustainable techniques is not due to a lack of knowledge regarding sustainable management of tropical wood. This knowledge exists, and there are many communities that apply it correctly. Proper forest management consists of removing only what can be recovered in a given time period (Brazilian legislation recommends approximately 35 years, varying with the volume harvested). It is necessary to calculate how much can be cut (and removed from the forest, which involves detailed logistics) so that, a few decades later, regeneration can take place. While this research was nascent in the 1990s, today it has matured and is being applied appropriately by several forest communities across Latin America in of projects developed by EMBRAPA (Santos *et al*. 2021), IMAZON, Instituto Floresta Tropical (IFT 2021), and others.

Evidence shows that forest policies in different countries need to be reassessed. The use of a few dozen species and current management norms (cycle length, harvest, intensity) prevent the recovery of wood stocks and, ultimately, the sustainability of the timber sector (Piponiot *et al*. 2019). Bioeconomic development in the wood sector involves *inter-alia* expanding the range of managed species, adapting management regulations, and modernizing industrial processes in order to allow the full regeneration of forests.

Given current declines in demand for wood from tropical forests (it is important to note plantations supply approximately 90% of the wood in Brazil, according to IBGE [Schmid 2019]), and the increase in technical knowledge, this sector could provide income and decent work on a considerable scale.

One main challenge that illegal harvesting can operate at far lower cost than more technically advanced units which respect environment and labor laws. In addition, the lack of defined property rights discourages long-term investment in sustainable projects. Poor management of illegal harvesting operations and the outdated technologies used also prevent selective removal and leads to large-scale destruction (Brancalion *et al.* 2018). The contrast between this and the more advanced contemporary forms of management (and whose costs tend to reduce in the future) is striking. Global initiatives such as the smart tree grid, which uses digital devices to scan millions of trees and detect key information to assess their resilience, are important in this aspect (Peskett 2020). In addition, our interviews with individuals from this sector show that complex procedures for obtaining logging authorizations discourage sustainable projects.

Finally, the added value of timber production in the Amazon has regressed over the past 20 years. The volume of raw sawn wood increased by 20% between 1998 and 2018, while products with higher added value (e.g., slabs, plywood) decreased by the same proportion (Lentini *et al.* 2020). It is also important to note that the wood species exploited today constitute a small fraction of the hundreds of species with potential in the region, resulting in underutilization of raw material and lost opportunities. Further research and investments are fundamental to realize the potential of new species in the market.

The adoption of technological innovations to increase efficiency in wood processing requires investment in fixed capital with a long maturity period. This only makes economic sense if there is a guaranteed long-term supply of wood in areas close to processing units, which is antagonistic with the predatory extraction model commonly practiced that quickly depletes local reserves. As a consequence, there is little investment in technological improvement, as sawmills and processing units need to be mobile and move along the deforestation frontier. For this reason, guaranteeing land property rights, including public areas and Indigenous peoples and local communities (IPLCs)' territories, is essential to ensuring long-term contracts for raw materials that make the investment in technological improvements, in addition to enabling forest certification, a necessary condition to reach buyer markets with greater added value (MacQueen *et al.* 2003).

Tropical forests have great potential to produce "noble wood", or high-quality, attractive wood for use in furniture, cabinetry, and other decorative uses. There are limited substitutions for such products, as neither plantations nor alternative materials offer similar quality and properties. There are two socially-constructive ways to realize this potential. The first is through collective management by forest dwellers, the main custodians of carbon stored in tropical forests. The opportunities for community forest management are vast in the Amazon, as approximately 50% of its area is occupied by a network of more than 6,000 ITs and PAs (see Chapter 16). IPLCs' surveillance over their territories is essential to preserve forest stocks and guarantee long-term management. Ensuring the legal land rights of these communities, including demarcation of territories (e.g., extractive reserves, Indigenous territories), is economically beneficial, as local communities take the best care of their own common goods using various forms of collective management (Romanelli and Boschi 2019).

Today, hundreds of communities generate income and jobs based on forest management. In some cases, their activities include the production of resins and other non-wood products, as well as tourism.

In Bolivia in 2013, 16 Communal Lands of Origin (TCOs) and 10 Indigenous lands held 111 approved management plans, covering approximately 1.8 million hectares and an annual allowable cut (AAC) of over 800,000 m^3. Approximately 300,000 m^3 (or 35%) of the AAC is harvested, generating approximately USD 7.5 million in gross income and benefiting approximately 6,000 Indigenous households (AFIN 2014; Del Gatto *et al.* 2018).

In addition to communal forest management, forest concessions are also an important path for the sustainable use of public areas, today threatened by illegal invasions and land grabbing. These mechanisms are applied especially in Peru and Brazil, although they are still far below their potential (Karsenty *et al.* 2008). In forest concessions in the Brazilian Amazon, in conservation units specifically designated for sustainable forest management (National Forests, State Forests for commercial exploitation, Extractive Reserves and Sustainable Development Reserves for communal exploitation), there is an annual extraction potential of 2–7 million m^3 of wood (Pereira *et al.* 2018).

There is an additional opportunity to develop a sustainable bioeconomy based on the beauty and diversity of tropical hardwoods in Amazon forests. The transition zone between the Andean and Amazon forest biomes in Colombia, Ecuador, Peru, and Bolivia (known as the "*piedemonte*" or "*ceja de selva*") contains a very large diversity of tropical hardwoods and timber species. Demand for tropical wood products is projected to increase in the coming decades (ITTO 2019); therefore, it is desirable to invest in large-scale AFS and forest enrichment systems to produce high-quality hardwoods in a relatively short time (20–25 years), which can be sustainably developed on existing deforested or degraded land, as extensively tested in the Colombian Amazon (Barrera *et al.* 2017). It is possible to combine sustainable, profitable timber production with ecological restoration, reduction of forest fragmentation, and recovery of ecosystem services, in addition to maintaining forest biodiversity and ecotourism potential.

The development of a strong forest socio-biodiversity economy based on the sustainable harvesting of wood faces four fundamental challenges. The first is linked to dominant, destructive forms of land use, with the opening of clandestine roads in Indigenous territories and protected areas. Efforts to contain illegality through strict legal and administrative rules have inhibited legal operations, by increasing costs and making them unable to compete against informal and criminal activities. The solution is obviously not the relinquishment of clear rules for logging, but the repression of illegal activities throughout the production chain and the formation of public and technical professional organizations capable of stimulating (and not restraining) legal activities.

The second challenge is to change wood management dynamics, which are currently concentrated on a few species with high-commercial value, aiming to maximize profits until their local populations become extinct (Richardson and Peres 2016). Mahogany (*Swietenia macrophylla*) and rosewood (*Aniba rosaeodora*) are emblematic examples of highly-valued species that became endangered and were then subject to trade regulations (IUCN 2021; CITES 2021; Salazar 2011; Grogran and Barreto 2005). Instead, the balanced use of hundreds of species needs to be encouraged; this requires investment and innovation in harnessing, processing, and adding value. Investments need to be channeled into the modernization of equipment, revenue, and production processes, as well as marketing for new species and products. The industrialization and commercialization of monocultures of native paricá (*Schizolobium amazonicum*) used for high-quality reconstituted wood panels (Medium Density Board, or MDF) in Paragominas, Pará, is an example (FLORAPLAC 2020). However, there are serious problems, both in terms of standardization in the cultivation of plants of this species (some individuals thicken, others remain stunted), and phytosanitary issues. Consequently, people involved in reforestation often prefer to use eucalyptus, an exotic species, over paricá, demonstrating the urgency for investments in the domestication of native species.

The third challenge is to connect logging with local demand (in the Amazon itself) through qualitative transformation. Various inputs for civil construction and the shipping industry, for example, can be replaced by wood from the Amazon, as shown by the Center for Management and Strategic Studies (CGEE 2009).

The fourth challenge is forestry legislation, which presents a fundamental contradiction. On the one hand, enforcement is deficient and fails to prevent illegal practices. On the other hand, as shown by Hirakuri (2003), still valid for the present times, the administrative procedures for legal logging are so complex that they discourage sustainable use.

30.4.2 Non-timber Forest Products

Currently, only a few non-timber forest products contribute to a forest socio-biodiversity economy and generate significant production, income, and jobs. While the role of non-timber forest products, such as medicinal plants, construction materials, and raw materials for handicrafts, is increasingly recognized, their commercialization is still in its early stage, as shown by Meinhold and Darr (2019).

This situation highlights one of the most important challenges for the emergence of a new bioeconomy of standing forests and flowing rivers. On the one hand, it is essential to preserve and strengthen forest and aquatic socio-biodiversity. At the same time, without the domestication and improvement of products such as cinchona (*Cinchona* sp.), cacao (*Theobroma cacao* L.), cupuaçu (*Theobroma grandiflorum*), bacuri (*Platonia insignis*), and uxi (*Endopleura uxi)*, the economic exploitation of biodiversity would be even smaller than it is today. Strengthening research aimed at domesticating economically-viable species within forest and aquatic systems (ecosystem services derived from their socio-biodiversity) is a critical need and could contribute to income generation and productive patterns adapted to the Amazon, supporting hundreds of thousands of farmers in the region.

What is at stake is the multifunctional nature of rural spaces on the lands of family farmers, Indigenous peoples, and local communities. Here, specialization rarely promotes monocultures, as is the case in other regions of the continent; rather, Amazonian traditional practices combine agricultural systems with extractivist management. In the Bailique Archipelago, located at the mouth of the Amazon River, for example, the açaí agroforestry production system was recognized as a good practice in Traditional Agricultural Systems (SAT), and received an award from the Brazilian Development Bank (BNDES) in 2019. In this system, common in the estuarine floodplain region of the Amazon River, *açaizais* and swiddens are mixed with a diversity of annual or permanent crops, forming a mosaic of high-value landscapes of agricultural, forest, and aquaculture heritage (Euler *et al*. 2019). In its 2018 and 2019 editions, the SAT BNDES Award recognized 53 good practice initiatives for the safeguarding and dynamic conservation of SATs in the Brazilian territory, of which 16 are communities in the Amazon.

The work of research institutions on expanding knowledge and improving diversified systems is essential. Agronomic research shows that systems are just as important as cultivars and, in a region such as the Amazon, the combination of scientific and traditional methods is especially important. Rather than produce a single commodity with high acceptance and market value, systems based on an immense variety of plants can have higher yields and returns. An interesting example is that of the Oiapoque Indigenous communities. They produce açaí (with EMBRAPA's support) using good practices, such as enriching their gardens with high-agronomic quality, pest-free banana and citrus seedlings. The result is an increase in production and supply to urban populations, both at markets and by direct sales, of diversified Indigenous products (flour, gum, tapioca, pepper, tucupi, chicory, manioc, banana, cane, piquiá, lime, tucumã, cupuaçu, taperabá), in addition to açaí.

According to vegetable and forestry production data (*Produção da Extração Vegetal e da Silvicultura*, PEVS) (IBGE 2019), Brazilian production is strongly concentrated in the Amazon, and a significant heterogeneity of contexts can be observed. Açaí stands out positively, with an increase in its production value from BRL 220.3 million in 2010 to BRL 539.8 million in 2016, indicating increased demand was compatible with growth in supply capacity. As previously highlighted, açaí has helped generate wealth and enrich the multifunctionality of spaces in many rural areas through cultivation that supports rich agricultural and forest diversity (Lopes *et al*. 2019).

The case of Brazil nuts (*Bertholletia excelsa*) goes in the opposite direction. The Brazil nut is one of the three most recognized food products derived from the Amazon. Its global value chain is worth almost USD 450 million annually. In Brazil, 60,000 extractivist families, organized in several small communal businesses, make the country the largest producer in the world, at 33,000 tons/year (TRIDGE 2020). Nevertheless, Brazil has been losing ground in international trade, currently dominated by informality (Brazil 2020a). In addition, the overwhelming majority of goods do not comply with basic technological and sanitary processes, which means that Brazil nuts are subject to special requirements for export to the European Union, due to the potential presence of aflatoxin. The consequence is that Brazil, unlike Bolivia and Peru, is unable to realize its full potential revenue.

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

In Bolivia, degrading forms of labor exploitation have marked the commercialization of nuts. The "*habilito*" (advanced payment for work, which promotes a cyclical system of indebtedness) and the "*enganche*" (a type of debt slavery) are still widespread in the country. These systems are similar to the "*aviamento*" explained above. Inadequate markets and degrading work are an "obstacle to improve and generate a positive social impact in the utilization of nuts" (Gonzales Rocabado and Terán Valenzuela 2012).

Guarana is an important symbol of the Amazon for Brazilians, and the source of one of the nation's most popular soft drinks. Although it is an Amazonian product, nowadays production is mostly in the State of Bahia. Two initiatives from research institutes in the State of Amazonas are worth mentioning. The first, from the Institute of Agricultural and Forestry Development of the State of Amazonas (IDAM), involves 200 communities in the municipality of Maués and 80 communities in the Saterê-Mawé Indigenous Reserve, using new technologies to increase production and productivity (IDAM 2019). The second comes from the Secretariat of Science and Technology of Amazonas, which, together with other research institutions, executes the Inova SocioBio project, aimed at reducing information asymmetry in the value chain in order to improve knowledge and strengthen the production chain. *Waranê* (native *guaraná*) and *waraná* bread (*guaraná* stick) received the first Geographical Indication (GI) granted to an Indigenous people in Brazil. Native *guaraná* contains active ingredients and *guaraína* (caffeine from *guaraná*) in much greater proportions than *guaraná* produced in Bahia (Algarve *et al.* 2019). These distinctions are part of what an industrial policy aimed at sustainable valuation of socio-biodiversity should consider.

The examples above show how fundamental it is to expand studies on Amazonian fruit trees (Shanley and Medina 2005). In 1972, a book by Paulo Cavalcante (2010), listed no less than 163 edible fruits found in the Amazon, of which half were native fruit trees. Alfredo Homma (2016) celebrates this diversity, but laments "the scarcity of survey data

Figure 30.4 Guaraná in Altamira, Pará. Photo: Ronaldo Rosa/Embrapa.

in relation to native and exotic fruit trees, vegetables and ornamental plants", and that "the apple is found even in the furthest corners of the Amazon and at a lower price than that of native fruits". Despite the region's immense biodiversity, three-quarters of wholesale fruit and vegetables traded in Belém come from other states in Brazil (Homma 2016b). Nevertheless, it is not simple to harness this potential; most of these fruits rot quickly, have dispersed distribution, and/or have multiple harvesting times and processing systems, which hinders their commercialization.

The extraction of natural rubber in the Amazon also shows a sharp decline; production fell by more than half between 2010 (4,000 tons/year) and 2016 (1,200 tons/year), and there was an even more substantial reduction in production value, falling from BRL 17.3 million to BRL 4.2 million in the same period (Pereira *et al.* 2018).

The market for vegetable oils derived from forest species (andiroba, babaçu, coconut, almond, copaiba, cumarú, murumuru, ucuúba, and tucumã) is booming. Although official data does not yet fully cover these products, which play an important role in the diversification of production and income, an estimated 45,751 extractivist families are engaged, generating approximately BRL 50 million in raw materials sales per year (IBGE 2019).

For the most part, oil production faces technical limitations, low added value (Villa Nova 2020), and compromised capacity to generate income because of the market structure in which they operate. As highlighted by Meinhold and Darr (2019), the value chains of these products rarely allow them to become the basis of a promising process of income generation. Their value chains are marked by "limited market information available, poor infrastructure and financial constraints", and also by the fact that "middlemen may sometimes be the only pathway for producers to access markets". Information asymmetry between buyers and sellers is the trademark of these value chains, often resulting in prices below production costs. An econometric study conducted by Angelo *et al.* (2018) demonstrated low price elasticity in relation to demand, which is a clear sign of incomplete and imperfect markets.

The predominance of certain market structures in the Amazon are longstanding, in which the sellers of extractive products historically depend on a single buyer, who is also the one responsible for selling them the goods necessary for their subsistence. The extra-economic components involved in this relationship are very strong, as clearly described by Gonzales Rocabaldo and Terán Valenzuela (2012) when referring to the "*habilito*". In the second half of the eighteenth century, an "Amazonian *caboclo* peasantry" already existed, which engaged in the trade structure led by *regatões* (mobile merchants) and large '*aviadores*' (suppliers, financiers), and which connected the Amazon to international drug market (Costa 2020).

The predominance of these market structures over time is impressive. Extensive work conducted by Meira (2008) in the northeastern Brazilian Amazon formulates an important concept in the understanding of market structures across the Amazon, namely the persistence of *aviamento* as an economic and social relationship based on violence and personalized dependence, which can even lead to slavery. This system has operated since the early colonization period and still persists, trapping a significant proportion of the local population, especially those who depend on the extraction of forest products, in an imbalanced economic system based on personal relationships, intergenerational debt, and modern slavery. Social and economic violence is at the base of this market structure.

In this context, the French geographer Pierre Gourou commented in 1948 that "the wealthiest families owe their fortune to the control of the Amazon trade; they dominate the concentration in Belém and the export of everything that the Amazon sells; they have a monopoly on introducing what the Amazon buys. These suppliers [*aviadores* in the original text] are often also colonels, that is, landowners, or more precisely, river owners". The commercialization of forest products in the first half of the twentieth century was sustained by non-competitive markets, in which buyers of local products also sold producers staples not available locally.

This finding is important because it shows that there is an economy of forest socio-biodiversity in the Amazon, but one characterized by personalized forms of domination that are obstacles, not only to competitive markets, but also to innovative initiatives aimed at adding local value to what is extracted from the forest.

This process has been extensively described in the literature, but few quantitative data are available, even in current practices. The best *aviamento* analysis was done by the Brazilian Federal Public Ministry (MPF) in the state of Amazonas, on the extraction and commercialization of piaçava and ornamental fish in the Rio Negro region. There, MPF found modern slavery and an *aviamento* market structure in which non-monetary exchange and indebtedness were widespread.

The result is that the "unfair distribution of income to extractivists and producers and their financial dependence on intermediaries and middlemen, the historical *aviadores*, have been part of local commercial relations for decades and constitute one of the most difficult paradigms to be broken" (Freitas and Schor 2020).

This market structure, as synthesized by Conexsus (2020), is an obstacle for countless cooperatives and associations to "identify the commercialization opportunities represented by the differentiated agricultural and extractive products that they produce". At the same time, companies interested in these products are unaware of their immense variety and end up missing promising opportunities for new products. Most of the time, as shown by Conexsus' work, companies interested in biodiversity products end up buying them from intermediaries within value chains that discourage the emergence of dynamic and competitive markets.

Both the work from Brondizio *et al.* (2021) and Conexsus (2020) show that non-timber forest products are extracted and commercialized by hundreds of individual producers and family networks, or groups organized in associations and small cooperatives. However, the functioning of these local organizations, in the overwhelming majority of cases, exhibits administrative and operational deficiencies (for example, to negotiate sales and export contracts, or to meet sanitary standards), and a lack of transportation, storage, and processing infrastructure. They are informal, do not possess an accounting record of their operations, and depend on incomplete and imperfect markets (Futemma *et al.* 2020; Brondizio 2008). Of the 374 communal enterprises analyzed by Conexsus (2020), only 20% go beyond planting to process their own products. In this context, it is clear that these initiatives do not have access to financing mechanisms capable of offering them the means to invest in improving their capacity.

30.4.3 Fishing and Pisciculture

The Amazon is a hotspot for aquatic biodiversity (Tedesco *et al.* 2017; Leroy *et al.* 2019), with Amazonian fish representing approximately 13% of all freshwater species described worldwide (see Chapter 3). Additionally, the Amazonian coast is part of the Amazon-Orinoco Influence Zone, considered an Ecologically or Biologically Significant Marine Area (EBSA) under CBD's criteria, including high biological productivity and biodiversity (CBD 2014).

Fisheries have a major impact on food security and local and regional economies in the rural Amazon (see Chapter 15; Tregidgo *et al*. 2020). In certain areas of the lower Solimões River and upper Amazon, it is the main source of protein for human populations, although in urban regions fish is far from the cheapest protein option.

In Brazil, fishing in the Amazon is classified into four subsectors discernable by different socioeconomic dynamics and sustainable management approaches. Subsistence fishing (for self-consumption) exploits a great diversity of species. It is a dispersed activity practiced by thousands of people; therefore, it is difficult to quantify its production.

Commercial fishing is carried out across the entire Amazon Basin and Amazonian coast and supplies local and international markets. However, reliable long-term statistics are unavailable (see Chapter 23). The composition of continental fisheries varies according to each specific region, with more than 90 species recorded on dockings, although approximately 80% of the production consists of only 6 to 12 species (or group of species; Batista *et al*. 2012; Pinaya *et al*. 2016; Lima *et al*. 2017). In general, Characiformes and Siluriformes are the most relevant orders of fish (Zacarkim *et al*. 2015; Garcez *et al.* 2017), and the main fishing resources include curimatã (*Prochilodus nigricans*), jaraquis (*Semaprochilodus insignis* and *S. taenirus*), tambaqui (*Colossoma macropomum*), dourada (*Brachyplatystoma rousseauxii*), filhote (*B. filamentosum*), mapará (*Hypophthalmus marginatus*), pacus (*Myleus* sp., *Metynnis* sp., and *Mylossoma* sp.) and surubins (*Pseudoplatystoma fasciatum* and *P. tigrinum)* (Batista *et al*. 2012; Ruffino 2014).

On the Amazon coast there are industrial and artisanal fisheries. Industrial fisheries target piramutaba (*Brachyplatystoma vaillantii*), pargo (*Lutjanus purpureus*), and pink shrimp (*Penaeus subtilis* and *P. brasiliensis*), while artisanal fishing targets many species, but mainly the Perciformes and Siluriformes, such as pescada amarela (*Cynoscion acoupa*), pescadinha gó (*Macrodon ancylodon*), gurijuba (*Sciades parkeri*), uritinga (*S. proops*) and bandeirado (*B. bagre*), in addition to the manual capture of uçá crab (*Ucides cordatus*) (Jimenez *et al.* 2020; Isaac *et al.* 2009; Almeida *et al*. 2011). Another important product for international trade is swim bladders (locally known as "grude"), a by-product highly valued in China. Brazil is one of the main suppliers of "grude" to the Chinese market (Sadovy de Mitchelson *et al*. 2019), and more than 97% of Brazilian production comes from the Amazon coast (MDIC 2021).

The main targets of sport fishing are the tucunarés (*Cichla* spp.), but other species are also caught, such as traíra (*Hoplias malabaricus*), pacus (genera *Mylossoma*, *Myleus* and *Metynnis*), piranhas (*Serrasalmus* spp.), Corvina (*Micropogonias furnieri*), pescada branca (*Plagioscion squamosissimus*) and pescada amarela (*Cynoscion acoupa*) (Ruffino 2014; Frédou *et al.* 2008).

In addition, small ornamental species are captured live for the aquarium trade. Brazil and Colombia are responsible for most exports of Amazonian ornamental fish, with the states of Pará and Amazonas (Brazil) primarily responsible (Tavares-Dias *et al.* 2009; Benzaken *et al*. 2015; Zehev *et al.* 2015). In 2014, Brazil exported USD 13.5 million in ornamental fish, with the states of Amazonas and Pará responsible for 88% (Faria *et al*. 2016; Araújo *et al*. 2017; Sousa *et al*. 2018). Targets include cardinal tetra (*Paracheirodon axelrodi*, the most exported fish), neon green (*Paracheirodon simulans* Géry), rodóstomos (*Hemigrammus bleheri* Géry & Mahnart), rosaceu (*Hyphessobrycon* spp.), butterfly-fish (*Carnegiella* spp. and *Apistogramma* spp.) and rays (*Potamotrygon* spp.). In the Xingu River (State of Pará), acari picota ouro (*Scobinancistrus aureatus*, the most valued species), acari amarelinho (*Baryancistrus xanthellus*), acari pão (*Hypancistrus* sp.), acari tigre de lista (*Peckoltia vittata*), and acari bola azul (*Spectra-*

canthicus punctatissimus) (Araújo et al. 2017) are exported mostly to international markets in the United States and Europe (Araújo et al. 2017).

The pirarucu, so called in Brazil and Colombia or paiche in Peru (*Arapaima gigas*), is one of the most emblematic Amazonian species. It is one of the largest freshwater fish in the world, commonly weighing 125–200 kg, and widely distributed in the Amazon Basin (Brazil, Peru, Colombia, and Bolivia). According to the Brazilian National Supply Company (CONAB 2020), there are 32 management areas in 19 municipalities in the state of Amazonas (Brazil), with fishing permits for 58,457 units/year, exhibiting a 164% increase in permits from 2011 to 2018. The gross income provided by the commercialization of pirarucu managed in these areas reached BRL 8 million a year in 2018, with a net income of approximately BRL 2,000/family. This is significant if we consider that the average HDI (Human Development Index) of municipalities in this area is 0.541 and per capita monthly incomes of the poor and extremely poor are below BRL 140 and BRL 70, respectively.

One of the main threats to the resource in this region is predatory fishing and high levels of bycatch. Fisherfolk discard tons of unwanted or untargeted fish to make room for high-value species 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 responsible for reduction of natural stocks and territorial conflicts between fisherfolk. Communal fishery agreements to define terms of common use or shared management of certain lakes are important. In the State of Amazonas, there are approximately 70 recognized fisheries agreements. The exemplary Mamirauá project has stimulated the development of similar initiatives in several regions (Queiroz and Peralta 2006; Viana *et al.* 2007; Amaral 2009).

Heavy metal contamination of water from illegal mining is also an alarming trend (see Chapters 20 and 21). A study by Fundação Owaldo Cruz (Fiocruz) in partnership with the World Wide Fund for Nature (WWF-Brasil) in the Tapajós River Basin showed mercury contamination in 100% of examined Munduruku people, mainly owing to the consumption of fish, an important protein source of Indigenous and riverside communities (WWF 2020). In an analysis of 88 fish specimens from 18 species, 100% of samples were contaminated with mercury. A similar study conducted by WWF-Brasil and ICMBio in Amapá state assessed the level of mercury contamination around the Tumucumaque National Park and the Amapá National Forest. Of the total animals sampled, 81% were contaminated with mercury (WWF and ICMBio 2017).

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, processing, and transport capacity forces fisherfolk who live far from consumer centers to sell to brokers at extremely low prices. This is aggravated by fragile social organization, which hinders the battle for fairer trade. A shortage of technical assistance and access to credit is also a challenge (Jimenez *et al.* 2020).

Reductions in natural fish stocks have driven increases in captive fish production in the Brazilian Amazon, which is also an important sector of the region's bioeconomy in terms of income and food security. Multiple forms of fish farming have been tested, including artificial tanks, damming springs, closing segments of streams, floating cages, and even restocking lakes and ponds. A species that receives much attention is the tambaqui (*Colossoma macropomum*), with an annual production of 73,181 tons in 2019 (72% of the national production, moving BRL 535 million), followed by the pirarucu with 1,679 tons (88% of the national production, and BRL 21 million).

Despite this growth, there are important bottlenecks. High feed costs make captive farming uncompetitive because extractive fishing is cheaper and many consumers prefer fish from the natural environment. High energy costs and unreliability of energy supplies compromise the propagation of juvenile fish, which depend on oxygenation of the water. According to Christian Jesús Méndez, the problems associated with fish farming in Peru (and by extension the region) include low levels of technology throughout the entire production chain, ranging from fish feed production to the sale of fish; poor business management processes; lack of collectives and associations; and lack of funding for applied research to overcome the aforesaid limitations or even for official time-series surveys (INPA 2018). Luiz Eugênio Conceição underlines some measures that could increase the potential of Amazonian fish farming; e.g., focusing on noble species with high nutritional value and good genetic load, increasing production volume to reduce transport costs, promoting integration and partnerships among fish farmers, and improving breeding, larvae production, water management, animal welfare, processing capacity, transport, meat quality, and marketing conditions. Another intervention is boosting the development of certification processes (INPA 2018). Promising results have been obtained with modern and more efficient salting, drying, and freezing techniques, as well as in adding value by producing burgers and products that are smoked, crushed, breaded, or marinated, and surimi (Jesus *et al.* 1991). Technological treatment has also been applied in the transformation of fish skin into several products, from clothing to bags and wallets; as well as using skins and bones in the production of collagen for foods, cosmetics, and nutraceuticals.

Fish processing waste can be used to produce biogas, bio-jewelry, handicrafts, animal feed, and food for human consumption (e.g., hamburgers, sausages, nuggets), reducing the environmental impact of waste and generating even more income (Jimenez *et al.* 2020).

30.5 Bioeconomy Services

In the previous section, we analyzed three biodiversity products and showed their importance for the subsistence and income of the Amazonian population. This cannot disregard the technological deficiencies that characterize exploitation and use of these products, as well as the incomplete and imperfect character of the markets in which they are commercialized. It is important to note that biodiversity also offers a range of services to humans that are fundamental to the emergence of a new bioeconomy of standing forests and flowing rivers. These services are not always expressed in markets that value their social relevance. The first one is forest regeneration, an urgency derived from the fact that most of the areas deforested in the last fifty years are abandoned or occupied by low productivity activities, particularly livestock. The second is tourism, and the third is payments corporations, public, and private organizations may make to conserve and expand standing forests and flowing rivers.

30.5.1 Synergies between the Bioeconomy and Forest Restoration

"Forest landscape restoration" encompasses a variety of strategies to increase tree cover, from tree planting and silviculture to ecological restoration (Mansourian *et al.* 2017; Chapter 28). Forest landscape restoration not only re-establishes a forest's ecological functions but also expands the supply of timber and NTFPs, restores ecosystem services, and helps recover biodiversity (Chapter 28). These landscapes then create new opportunities for increasing and diversifying supply chains, supporting innovation, creating jobs and income, and ultimately improving local peoples' well-being. This section discusses the synergies that might arise from undertaking forest restoration at scale and the bioeconomy, providing some examples of key on-the-ground experiences and pointing out some directions to the future.

Seedling planting and agroforestry are among the most common strategies for forest restoration in the Brazilian Amazon (Aliança para Restauração da Amazônia 2020; Chapter 28). Although agroforestry is found across all Amazonian countries, it is restricted to small areas, such as home gardens, whereas planned AFS are limited to local pilot projects mainly funded by international cooperation (Porro *et al*. 2012). Natural regeneration is a restoration strategy that can be widely adopted given the wide distribution of abandoned agricultural lands (Smith *et al*. 2020; Silva-Junior *et al.* 2020). This strategy is cost-effective, considering the low costs associated and high biodiversity and carbon returns (Ferreira *et al*. 2018; Lennox *et al.* 2018; Strassburg *et al*. 2020). However, it has still received little interest from the point of view of harnessing socio-biodiversity products.

Independent of the restoration strategy involved, business opportunities are often created across the restoration supply chain, involving for example seed collection, seedling production, nurseries, plantation management, and harvesting of forest products (Brancalion *et al.* 2017). In terms of seedling planting, perhaps the most prominent example is the Xingu Seed Network (Rede de Sementes do Xingu) in Brazil. This initiative, led by the non-governmental organization (NGO) Instituto Socioambiental (ISA), deals with seed exchange and commercialization. During the last 14 years, it has traded approximately 250 tons of seed from more than 220 species native to the Cerrado and Amazon, with a revenue of approximately US $782,000. The most prominent feature of the initiative is their engagement of over 500 people, including Indigenous groups, family farmers in agrarian reform settlements, and city residents, in collecting seeds and undertaking other activities in a cooperative model. The strong involvement of local communities across the restoration supply chain (Schmidt *et al.* 2019) might inspire other initiatives and potentially increase the scale of restoration across the region. In the Xingu Seed Network, innovation lies in linking together important actors, such as landowners, Indigenous people, government, and non-governmental organizations.

Agroforestry is often seen as the most promising restoration strategy as it can reach millions of family farmers living in the Amazon, and can align conservation and socioeconomic objectives (Porro *et al*. 2012). This approach relies on decades of experimentation by government institutions, NGOs, and farmers that culturally reproduce traditional systems across generations. The adoption of agroforestry and access to markets for bioproducts associated with forest restoration can benefit from many decades of successful experience in production, cooperativism, trading, and certification in different parts of the Amazon. Among emblematic examples led by family farmers in the Brazilian Amazon are the Mixed Agricultural Cooperative of Tomé-Açu (CAMTA) in Pará (Box 30.1) and the Agroforestry Program RECA in Rondônia, both focused on fruit pulp production, and 'Café Apuí' for coffee production in Amazonas.

It is true that in the context of ecosystem restoration, improvements in many agroforestry systems are necessary to achieve environmental objectives, such as increasing local biodiversity and structural attributes in ways that make them more similar to natural ecosystems.

30.5.1.1 Fruit Trees

Despite necessary adjustments to agroforestry systems for restoration, there is already a large amount of traditional and scientific knowledge on the cultivation of native Amazonian species in agroforestry, including açaí, Brazil nut, cocoa, cupuaçu, and pupunha (*Bactris gasipae*). Currently, economic revenue comes from selling the fruits *in natura*, i.e., producing fruit pulps individually or in cooperatives.

The implementation of extractive timber and NTFP activities in agroforestry plots (i.e., areas that are distant from large patches of primary forest) circumvents many of the limitations associated with extractive activities, widely discussed in section 30.4. Restoring areas with planted agroforestry allows farmers to have better control, such as increasing the presence and density of plant species of economic interest and planting at a distance that facilitates harvesting and processing. Managed agro-ecosystems can also enable or improve working conditions, as is the case for harvesting açaí, whose palms grow taller in natural *várzea* ecosystems.

Figure 30.5 Agroforestry system with banana, cupuaçu, taperebá, açaí, inga, mogno, andiroba, and paricá. Photo: Embrapa/Ronaldo Rosa.

Although agroforestry often includes a variety of plant species, the motivation for adopting systems is often based on a few individual species (e.g., aça) which can guarantee profitability. Açaí, one of the most desirable species at present, is especially suited to the restoration of riparian zones 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 also for industrial products with higher added value (e.g., medicine and production of panels, as discussed above).

Another key native species for agroforestry is cocoa, owing to favorable market prices and high demand in the national and international market. In the Brazilian Amazon, cocoa agroforestry plantations have been mostly restricted to areas with rich soils in the Transamazon region of Pará, but recently efforts are being made to increase production in other regions of Pará. Different initiatives have been successfully promoted to produce chocolate locally. One example is a family farm on Combu Island in Belém. The family, led by Mrs. Nena, produces up to 300 kg of cocoa each month and supports tourism, the main economic activity on the island. The family supplies high-end restaurants owned by celebrated chefs from Belém and São Paulo. Chocolate production also gathered 40 family farmers in the COOPATRANS cooperative (Cooperativa Agroindustrial da Trans-Amazônica) to build an agro-industrial plant and created the brand Cacauway, which sells their products in cities across the state.

Cocoa agroforestry to restore degraded pastures has been the focus of a socioenvironmental project led by the NGO The Nature Conservancy (TNC) in one of the most pressing agricultural frontiers of the Brazilian Amazon. The Cacau Floresta ("Forest Cocoa") project in the southern Amazon encourages small farmers and ranchers to recover defor-

Box 30.1 Agroforestry Systems

The need to reconcile productive land use with forest conservation and regeneration has stimulated the emergence of AFS. EMBRAPA conducts research and advisory activities in this area, and the practice has come a long way (EMBRAPA 2020). In Tomé-Açu, in the State of Pará (Brazil), agroforestry practices began at the end of the 1960s, when agrobiodiversity served as a solution to a serious crisis caused by disease and low prices for black pepper monocultures (Homma 2016). The region implemented adapted forms of traditional cultivation systems unique to the region, self-named the Tomé-Açu Agroforestry System (SAFTA) by promoters of these systems. The region has become not only an important export hub for products with higher added value (especially to Japan and the United States), but also an example of agroforestry innovation in Brazil and abroad.

In 1987, farmers implemented an agroindustry program to process fruit pulp produced in SAFTAs. In the 1930s they had already founded a cooperative that would later become the Mixed Agricultural Cooperative of Tomé-Açu (CAMTA) (Homma 2016). Today, the cooperative consists of more than 170 members and 1,800 family farmers registered to supply raw materials. Commercialized products include black pepper, cocoa bean, herbal oils, and regional fruit pulps. Members of the cooperative estimate that 10,000 jobs (direct and indirect) have been generated. Although many exotic commercial species are grown in SAFTAs, especially black pepper, Amazonian native plants such as cocoa (*Theobroma cacao*), cupuaçu (*Theobroma grandiflorum*), açaí (*Euterpe oleracea*), taperebá (*Spondias mombin*), and Brazil nuts (*Bertholletia excelsa*) are integrated in these systems. Native wood species are also frequently cultivated, such as ipês, cedar, and paricá (Barros *et al.* 2009).

Tomé-Açu farmers cultivate in integrated production systems with a greater diversity of products, guaranteed access to markets, and greater added value resulting from agro-industrial processing. This is considered a major success for the region. What can explain these examples of more sustainable agricultural systems in regions (such as the northeast of Pará) where mainstream forms of production degrade ecosystems and promote little socioeconomic development? Answers to this question are certainly important to boost the bioeconomy and bring large-scale transformation to the Amazon.

Tomé-Açu was founded by Japanese immigrants to the Amazon in 1929, as part of a cooperation treaty between Brazil and Japan (Homma 2016). While this unique story restricts many generalizations, some lessons emerge and may be applied to other contexts. Cooperativism and collective work have always characterized the region's production systems, regardless of culture (Saes *et al.* 2014; Tafner-Junior and da Silva 2011). Immigrants took a very innovative stance in the face of crises and experimented, based on technical support, both in the production system and with products.

Above all, technical and financial support from the Japanese government in various periods of crisis played an important role. This support was important not only as direct agricultural investment, but also to build essential infrastructure, overcoming deficiencies of the State, as in the case of rural electrification (Tafner-Junior and da Silva 2011). This example shows, among other aspects, how important it is to promote cooperation and symmetry among players (Futemma *et al*. 2020), in contrast to the exploitation and cliental relations that currently dominate the Amazon.

Finally, it is worth noting that many family farmers in the region (settlers) also reproduce AFS inspired by Japanese descendants (Futemma *et al.* 2020). It is important to encourage biodiverse agroforestry and expand markets for new products so that these niches can progress towards sustainable regional development.

ested or unproductive areas by planting cocoa and other forest species of high economic value. TNC has announced partnerships with two big internat ional chocolate companies, Olam (Singapore) and Mondelez (US).

30.5.1.2 Timber

The production of timber has received less attention than NTFPs in agroforestry or any other mixed-species restoration system. Despite its significant potential to improve vast areas of degraded pasture in the region, silvopastoral systems primarily rely on exotic species such as *Eucaliptus spp*. or Teca (*Tectona grandis*). This is, in part, due to limited market access for planted timber, scarcity of knowledge of silviculture of native species, and lack of financial support for tree crops that require longer time frames (and more financial risk). However, as previously mentioned, the market for planted timber is growing rapidly, following declines in the supply of timber from native species and consumer preference for more sustainable products (Veríssimo and Pereira 2014). The cultivation of timber species in restoration areas can boost the timber market, a relevant economic sector in the region. Fostering innovation is crucial in this sector, which is still dominated by largely unspecialized activities. According to Veríssimo and Pereira (2014), wood production in the Brazilian Amazon consists of 86% sawmills, 8% processed timber, 5% laminate industries, and 1% wood boards. Agro-industrial activities for producing medium-density fiberboard (MDF) are promising, as this sector requires large volumes of wood material. Paricá, naturally occurring in Brazil, Peru, and Colombia, is the only native species with the capacity to replace exotic *Eucaliptus* and *Pinus* species. Paricá is extremely fast-growing, has been widely planted both in monocultures and AFS in the region, and yields as high as or higher than *Eucaliptus* grown in 4–7-year cycles (Melo *et al.* 2014). Mahogany (*Swietenia macrophylla*) plantations also present high growth rates and commercial value (Veríssimo and Pereira 2014). Efforts are needed to identify a diversity of fast-growing native species, as well as to improve the efficiency of timber processing and related machinery. The Paragominas region (Brazil), once infamous as the largest source of illegal timber in the Amazon, has transformed to become a good example of industrialization in more specialized markets for planted timber. With eight companies distributed across six municipalities, it has been producing MDF boards through processing Paricá timber (ABIMCI 2019). Industrial demand for these products in the region was not met by production from ~38,000 hectares planted in recent years (Santos *et al.* 2018), indicating there is plenty of room for growth.

30.5.1.3 Other Products

Beyond timber products, it is important to emphasize that restoration systems can provide diversified NTPFs, including rubber, gum, wax, fibers for dyeing, aromatics, and medicines for several sectors, including chemical, pharmaceutical, automotive, and food (MAPA 2018). Examples of oil species already traded in the market (see above) include andiroba (*Carapa guianensis*), buriti (*Mauritia flexuosa*), copaíba (*Copaifera spp.*) and babassu (*Attalea spp.*).

In conclusion, we have presented several promising examples of partnerships between local communities, private companies, and NGOs for supplying Amazonian NTFPs to industry, such as Natura Cosmetics and Beraca, that trade in oils and other bioproducts. Such programs also benefit private companies by improving their socioenvironmental image. The relationship between private companies and local communities can have local benefits, but are full of complexities and caveats (Morsello 2006). It is paramount that these partnerships guarantee the empowerment and autonomy of the IPLCs involved (Ribeiro 2009).

Funding and partnerships linked to restoration activities are emerging in the region, with Belterra and Conexsus Sustainable Connection Institute mobilizing a large network of associations, cooperatives, and small- to medium-size companies to increase access to funding and markets for sustainable bioproducts. These innovative systems should complement strong public policies, such as credit for restoration and institutional programs for purchasing products from family farmers engaged in restoration. The Food Procurement Program (PAA) and the National School Meals Program (PNAE) in Brazil are good examples of initiatives that purchase socio-environmentally friendly produce from smallholders that could be scaled up (Resque *et al.* 2019).

Beyond the marketing of products, restoration using agroforestry 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 Chapter 28).

30.5.2 Tourism

Tourism is one of the fastest-growing economic activities in the world. Outstanding natural beauty, cultural diversity, and historical significance are among the most relevant factors for tourism demand (Cho 2010). The Amazon's immense sociobiodiversity puts it in a privileged position. Calderón (2015) highlights the biological, cultural, and geographical diversity of Ecuador as a great strength and opportunity for the development of tourism in that country, an argument that can be easily extended to other countries in the Andean Amazon region. Sinclair and Jayawardena (2003) point to a similar conclusion for Guyana. Castro *et al.* (2015) emphasize the importance of environmental quality for tourism in protected areas in Brazil. Tourism and environmental conservation are often intrinsically related; a study by the Escolhas Institute (2019) shows that, according to Amazonas Cluster Turismo, touristic areas are much less affected by fires and devastation than areas where tourism does not occur.

Nature is considered a decisive factor for travelers' choice of destination, for both foreign and domestic tourism. A study of the Comisión de Promocion del Peru para la Exportación y el Tourism (PromPeru 2019) found that 53% of domestic tourists consider "landscapes and nature" as a decisive factor. However, the Peruvian Amazon was not on the list of most-visited destinations, indicating the Amazon's potential is still limited. Similar trends can be observed in all countries of the region.

Rodrigues *et al.* (2018) estimated there were 16.8 million visitors to 209 Brazilian National and State Parks in 2016, with an economic impact of US $1–2 billion annually. However, less than 5% of those visits were in the Amazon. A similar result was presented in a study on ecotourism in Colombia, which showed that the Colombian Amazon is a relatively marginal destination compared with tourists in other parts of the country (Sánchez and Tsao 2015).

It is critical to understand the challenges for tourism in the region. Ochoa-Zuluaga (2019) argues that tourism in the Amazon is characterized by two distinct realities occupying the same space: commercial capitalism and local communities, which, although partly integrated into the market, maintain traditional forms of subsistence and social relations that are in conflict with conventional tourism. Capucci (2016), when analyzing the growth potential for tourism in Suriname's countryside, highlighted the problems that can originate owing to contact with foreigners if expansion is not properly controlled, both for nature and for communities that were previously isolated. Taking the Colombian Amazon as a reference, Ochoa-Zuluaga (2019) contrasts the substantial expansion of tourism around Leticia, with an increase in hotels and services for tourists, with the social conditions of local communities, which remain quite precarious despite the considerable increase of business and income. The challenge is to expand tourism while also improving the well-being of Amazonian populations and without significantly changing the spatial configuration of countryside towns and settlements, especially near isolated IPLCs.

For this reason, it is paramount to develop differentiated approaches in which the growth potential of tourism is not antagonistic to the principles of socio-biodiversity, which is ultimately its main drawcard. This means that it is not enough just to conserve the region's natural characteristics; it is also necessary to respect and value its historical and cultural legacy.

In an assessment of the potential of community-based tourism in Indigenous areas in the Colombian Amazon, Quintana Arias (2018) argues that by understanding art and territory as a social construct of the tourist reality, the importance of the symbols and myths that outline the social praxis resulting from the intersection between cultural and biological diversity increase. This appreciation of ancestral knowledge is also manifested in other cultural, artistic, and religious expressions that make the Amazon special. This includes popular festivals of religious origin, such as the *Círio de Nazaré* in Belém do Pará, as well as secular events, such as the *Boi de Parintins* in the Brazilian state of Amazonas. It is also necessary to explore the cultural mosaic of the diverse peoples who moved to the Amazon, as evident in the extraordinary ethnic diversity of Guyana, where the multiplicity of native languages reflects African, Asian, and European origins, resulting in one of the most culturally diverse populations on the planet, amid an equally diverse natural environment.

To this end, it is important to avoid myths such as the "return to El Dorado" or other fantastical constructions that identify forest dwellers as "good savages". As argued by Sinclair and Jayawardena (2003, p. 402), "The product in Indigenous tourism in Guyana and Surinam is often an equation that is as much myth as reality".

Following World Tourism Organization principles and based on experiences in the Ecuadorian Amazon, Arroyo and De Marchi (2017) 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 the touristic activity; and (vi) progressivity and planning.

Another important aspect is to encourage demand for tourists interested in a different type of tourism. Sinclair and Jayawardena (2010) highlight the potential to develop routes integrating the Amazon and Andes, possibly connecting Inca trails to the Guyanese Massif, and leveraging river routes throughout the entire region. Benevides *et al.* (2018), in a study of Roraima (Brazil), underline the importance of social innovation and creativity to increase the well-being of visitors. Insecurity, lack of transport, and lack of infrastructure are some of the barriers to be overcome to strengthen the tourism sector.

Arroyo and De Marchi (2017) draw attention to the principle that sustainable tourism is a means for development, but not an end in itself, and that tourism can be compared with an "iceberg", consisting of a small visible part (experienced by tourists) and a large non-visible component, composed of a mosaic of local initiatives, strategies, and investment coordinated by the public sector. Therefore, it is essential that this invisible part also benefit communities through better living conditions and generate positive citizenship effects. This requires coordination between market operators, development institutions, and local populations, respecting their heterogeneity and recognizing that, in community-based tourism, communities are the managers, producers, and administrators of their own tourism products and in control of the business. Tourism activity can significantly strengthen community organization, bonds, and identities, but also generates significant processes of appropriation, management, and organization of natural and cultural heritage. It is also worth mentioning tourism connected to Saint Daime Ayahuasca, and its impacts on cities such as Pauini (State of Amazonas, Brazil) (AMVCM 2021).

Recognition of this immense heterogeneity requires in-depth knowledge of resources, accessibility networks, and use of touristic resources so that an articulated tourism policy that respects the knowledge systems, cultures, religions, and local traditions that guarantee the conservation of sociobiodiversity can be developed for the Amazon.

30.5.3 Payment for Environmental Services

The Amazon is home to numerous terrestrial and aquatic ecosystems that provide invaluable environmental services (see Part I) to humanity. The most evident and debated are those provided by native vegetation, which represents a remarkable share of global biodiversity (see Chapters 2–4). The wealth is so great that it is possible to find more species of ant on a single Amazonian tree than can be found in the whole of the United Kingdom (Wilson 1987). In addition to being a repository of immense biological diversity, the Amazon stores more than 150 billion tons of carbon in its soils and vegetation (see Chapter 6). If this carbon is released into the atmosphere via deforestation and degradation, it would significantly aggravate global climate change. However, the importance of maintaining ecosystem services vital to human well-being has been little recognized, valorized, and compensated. In this sense, PES can potentially contribute to the large-scale protection of Amazonian ecosystems and their environmental services.

Compensation for ecosystem services are economic incentives to support the conservation or sustainable use of natural resources, aiming to induce behavioral change through the valuation of one (or more) services (e.g., climate regulation, water conservation) (Wunder 2015; Pagiola *et al.* 2016).

There are countless PES experiments in the Amazon involving the protection of water resources (Moreno-Sanchez *et al.* 2012; Montoya-Zumaeta *et al.* 2019; Young *et al.* 2019) and biodiversity (Machado et al. 2020). Castro *et al.* (2018) estimate that PES initiatives aimed at forest conservation in communities in the States of Acre (Certificate of Family Production Unities) and Amazonas (Forest Grant) benefited over 44,000 individuals between 2009 and 2015, and allocated over BRL 40 million.
Other initiatives involve compensation for GHG emission reduction owing 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+) under the United Nations Framework Convention on Climate Change (UNFCCC). In general, entities (jurisdictional or not) that can demonstrably reduce GHG emissions from deforestation are eligible to receive compensation through REDD+. Actions aimed at the conservation, management, and expansion of forests are also contemplated (the "+"). This mechanism has been debated for over a decade within the UNFCCC and several independent groups, but several bottlenecks still need to be overcome to advance the program (Angelsen *et al.* 2012; Duchelle *et al.* 2018; West *et al.* 2020). In the tropics, pilot REDD+ initiatives have been implemented, including in the Brazilian and Peruvian Amazon (e.g., Sunderlin *et al.* 2014; West *et al.* 2020). Although REDD+ initiatives demonstrate promising results (Simonet *et al.* 2019; Sunderlin *et al.* 2014), as well as a consolidation and profusion of REDD+ initiatives (Sunderlin *et al.* 2014), they still face several challenges. One is leakage, whereby the reduction deforestation and emissions in one area pushes deforesters into other areas. Another is double counting, i.e., when multiple entities claim responsibility and benefits for the same emission reductions. Finally, unequal distribution of benefits is another persistent issue (Gomes *et al.* 2010; Moutinho *et al.* 2014; Streck 2020). To address these, REDD+ is advancing jurisdictional modalities and involving subnational government entities (Nepstad *et al.* 2012). The Amazon, especially within Brazil, historically prospered from jurisdictional REDD+. The Brazilian State of Acre was a pioneer in this process, structuring governance mechanisms (Duchelle *et al.*

2014; Guerra and Moutinho 2020) propelled by the REDD+ Program for Early Movers (KFW 2021) of the German government. The same jurisdictional REDD+ construction process took place in nine states of the Brazilian Amazon, especially Mato Grosso, Roraima, and Maranhão (Guerra and Moutinho 2020). Besides Brazil, the impetus for proposing jurisdictional REDD+ among Amazonian countries, mainly Colombia and Peru, can be summarized by the Governors' Climate and Forests Task Force (GCF 2021), which involves governors of states and provinces, not only from the Amazon, but from several states (38 in total) that hold tropical forests throughout the world.

In summary, despite numerous bureaucratic obstacles, jurisdictional REDD+ programs are rapidly advancing across Amazonian countries, particularly Brazil and Peru. Among the obstacles faced are the lack of consolidated regulations for national REDD+ strategies, both technical and political (West *et al.* 2020; Wunder *et al.* 2020), and the growth of social movements against REDD+ (e.g., Grupo Carta de Belém 2009). Independent initiatives to qualify, monitor, and inform subnational REDD+ activities are multiplying, including the recent Architecture for REDD+ Transactions (ART), an initiative that aims to improve security for potential private investors in REDD+ actions.

Despite advances in PES initiatives, there are numerous bottlenecks to be overcome so that this bioeconomy approach can effectively grow and improve. On the 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 (ETS) and others in which charging for emissions surpluses is mandatory. On the supply side, it is necessary to advance the means for achieving socio-environmental safeguards (Pascual *et al.* 2014; Gardner *et al.* 2012), create procedures for the equal distribution of benefits (Moutinho *et al.* 2017), and guarantee that the positive effects of these initiatives are as comprehensive, effective, and lasting (Ezzine-de-Blas *et al.* 2016) as possible.

The full implementation of PES or its REDD+ variant will depend on progress in Amazonian countries' public policy. The most recent PES legislative initiative was Law 14.119 (1/13/2021), enacted by the Brazilian Congress, which created the National Policy for Payments for Environmental Services (PNPSA; Brazil 2021), paving the way for third sector institutions, companies, and individuals to receive compensation for environmental conservation activities. Numerous articles of this Law have been vetoed by the Brazilian federal government, compromising its effectiveness, transparency, and governance (Coalizão Brasil 2021). Later, these vetoes were overturned by the Brazilian Congress, enabling quicker progress in implementation of the policy. Furthermore, numerous PES initiatives are being implemented at the state level in Brazil and other countries, especially jurisdictional REDD+ (e.g., Simonet *et al.* 2019; Stickler *et al.* 2018; Palmer *et al.* 2017).

In the current large-scale deforestation scenario in the Amazon (Murad and Pearse 2018; Brito *et al.* 2019; Azevedo-Ramos and Moutinho 2020), PES and REDD+ mechanisms represent important allies in mitigating drastic changes in climatic patterns and promoting sustainable development and should not be disregarded.

30.6 An Emerging Transition

Strengthening the bioeconomy, following the ethical principles highlighted in this chapter, is an essential requirement for achieving the Sustainable Development Goals (SDGs) worldwide. However, the contributions from tropical forests, and particularly the Amazon, to products and services that improve not only to the welfare of local people but all of humankind is still negligible. So far, this chapter has explained the main reasons for the chasm between the Amazon and the scientific and technological frontier of the bioeconomy. In this section, we summarize the challenges and opportunities encountered in the transition from an economy based on exploitation to a new bioeconomy of healthy, standing forests and flowing rivers.

Social transitions (such as from an economy of destruction to a nature-based knowledge economy) are processes that depend on long-term factors, suffer unexpected shocks, and/or are influenced by individuals and organizations acting as political, institutional, or moral entrepreneurs. These individuals and organizations play a decisive role in the emergence of transformative social networks (Burt 2000), especially in times of turbulence. This is particularly true today, when deforestation, violence, and the invasion of protected areas might paradoxically catalyze the emergence of innovative solutions (Folke *et al.* 2020). The protagonists of these innovations establish bridges, alter agendas, and bring narratives aimed at the transformation that they aspire to achieve (Fligstein 2001a). The transition towards a nature-based knowledge economy is neither exclusively nor fundamentally technological, although science and technology have a crucial role. It also involves infrastructure, new markets, changing social preferences, dialogue between science and traditional knowledge, and other enabling conditions. It also involves cultural change in the social vision regarding forest socio-biodiversity and in educational processes themselves. As shown by Herrfahddt-Pähle *et al.* (2020), these cultural changes tend to value and expand proposals and alternatives that, until then, have remained confined to specialized niches and start to appear not only as necessary but as viable.

The transition is already underway. It was paradoxically accelerated by recent increases in deforestation, fire, invasions of Indigenous territories and protected areas, and the dire impacts of COVID-19. These events undermine the social legitimacy of current resource-use models.

When the landscape is profoundly transformed by a shock (e.g., those above), actors who developed models that until recently were in the niche stage gain prominence; new knowledge reaches a wider audience, gains legitimacy, and starts to occupy a decisive political–cultural space (Fligstein 2001b) in the organization of markets, opening a window of opportunity for unconventional innovations.

The emergence of a new, healthy, standing forests and flowing rivers bioeconomy cannot be limited to the products analyzed above, nor to the immense diversity of products that the Amazon produces. It also requires science and technology and a deep transformation of commodity production systems. The agricultural, livestock, and mining activities that currently account for most of the production value and exports in the region are systematically supported by socio-environmentally destructive practices (see Chapters 14–20). Concurrently, there is growing international and internal pressure on Amazonian countries to halt destruction. A truly regenerative economy must therefore emerge. In this sense, the aforementioned "Accord on the Amazon" includes the commodities sector as a bioeconomy component.

Imagining a healthy bioeconomy alongside predominantly destructive practices is a truly dystopian scenario. International and Latin American markets increasingly demand that soy, meat, cotton, and corn from the Amazon be produced with regenerative techniques that contribute to the strengthening of forest resilience and regional biodiversity. Scientific research in each country takes this beyond the theoretical, with many pilot programs. These production alternatives pave the way for a drastic and necessary reduction of damage from the agricultural sector. The experience of Paragominas and the Green Municipalities Program (da Costa and Fleury 2015), aimed at reducing deforestation and improving the livestock production, contributes to profitable and more environmentally sustainable agriculture. The agriculture and livestock commodities sector should have every interest in ensuring that all its production is certified not only as deforestation-free, but also as a vector for the enrichment and sustainable use of the forests within their properties.

In short, the emergence of a new bioeconomy of healthy, standing forests and flowing rivers is an urgent transition that can be compared with the global challenge of "deep decarbonization" as studied by Geels *et al.* (2017). It requires the transformation of consolidated productive systems (albeit of low productivity), whose inertia is broken both by the loss of social legitimacy and by the emer-gence of innovative activities that, given changing national, regional, and international contexts, gain new opportunities to assert themselves. It is clear that, similar to the urgency of deep decarbonize-tion, the mobilization of diverse actors and the application of public policies aimed at accelerating the transition are paramount.

30.6.1 The diversity of Actors

The acceleration of deforestation, forest fires, and illegal and criminal activities in the Amazon, especially from the beginning of 2019 (principally, but not only, in Brazil; Butler 2019) resulted in an intense mobilization, not only of activist organizations, but, in an unprecedented way, of businesses from the Amazon and other countries that until very recently did not actively participate in public discussions about the destiny of the Amazon. The return of the United States to the Paris Agreement, and the adoption of the Green New Deal with ambitious commitments to decarbonize the North American economy are cause for optimism. This is further supported by the adoption of the European Green Deal, and important commitments from major GHG-emitting countries, including China, India, and Japan. These developments have altered the international framework, making the immediate halt of the Amazonian destruction a global priority.

The social landscape within the Amazon itself has also changed significantly. Many prominent activist organizations are focused on strengthening entrepreneurship for the sustainable use of the forest. This is expressed not only in the search for business partners and the valuation of niche products produced within protected areas, but also in an effort to expand the products on offer and improve market conditions of socio-biodiversity products. Folke *et al.* (2020) show how large transnational companies are in the process of incorporating sustainability into their practices. NGOs that work on entrepreneurship (often in alliance with national research organizations, such as EMPRAPA are decisive actors for niche solutions to be incorporated into the practices of economic actors.

In addition to contributions by various NGOs and large corporations (financial and non-financial), it is important to highlight the mobilization of the scientific community and government stakeholders. In the Amazon, what Folke *et al.* (2020, p. 44) formulated as a premise for collaboration between human societies and the biosphere is taking place, namely that “Broad coalitions among citizens, businesses, nonprofits, and government agencies have the power to transform how we view and act on biosphere stewardship and build Earth resilience.”

The most emblematic examples come mainly from Brazil, but they are present in the Amazon as a whole. On June 2020, an open letter to the Brazilian government was published by global investment funds that collectively manage over US $4 trillion in assets, warning that the destruction of biodiversity represents a threat to their assets. Attacks to Indigenous peoples are also cited in the document (Pinto Cagliari 2020).

On July 14, 2020, 17 former finance ministers and presidents of the Brazilian Central Bank released a letter, entitled “For a low carbon economy”, in which they emphasized the risks derived from climate change and called for zero deforestation in the Amazon and the Cerrado, criticizing the invasion of conservation units and Indigenous territories (Chiaretti 2020a). A week later, in an unprecedented pre-competitive agreement, the three largest private banks in Brazil (Bradesco, Itaú, and Santander) launched an integrated plan for the sustainable development of the Amazon, in which the bioeconomy plays a strategic role, and called for halting invasions of public areas and Indigenous territories (Abramovay 2020b). The initiative’s originality lies not only in the pre-competitive agreement among the three banks, but also in its advisory board, composed of some of the most important scientists and socio-environmental activists in Brazil.

At the same time, food processing companies Marfrig and JBS released a report showing that, although they have control over the origin of the cattle they slaughter, it does not extend to the entire production chain, favoring destructive practices (Notícias Agrícolas 2020). At the same time, they announced goals to eliminate deforestation from their entire value chains.

There is no guarantee that these announcements will, in fact, 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. At the same time, it is important that investments made by these companies to strengthen biodiversity go through competitive processes and undergo rigorous, critical evaluations by specialists.

In 2014, in preparation for the Paris Conference, the Brazilian Coalition on Climate, Forests and Agriculture was established. It developed proposals that decisively influenced Brazilian positions at COP 2015. Comprising companies, activist organizations, and individuals linked to socio-environmental issues, the Coalition was important for the emergence of the previously mentioned "Accord on the Amazon" in 2020 (Chiaretti 2020b). The Accord (which has no defined legal character and is described as an informal, diversified network) aims to address topics ranging from public security and violence, to investment profiles for the sustainable development of the Amazon. The Accord organizes public discussions and requests documents from specialized consultants for each of these themes, enriching the discussions and seeking to expose the multiple points of view of the diverse players participating in this network.

A diversity of players was also essential for the establishment of a pact among state governments in the Brazilian Amazon (the Consortium of Governors of the Legal Amazon). The pact aimed not only to counter destructive practices, but also to create development plans for a new bioeconomy of standing forests and flowing rivers. Several of the authors of these plans actively participate in the Accord. The Accord also proposes to gather, process, and pave the way for the analysis of economic, political, cultural, and socio-environmental information on the Amazon through the Amazônia Legal em Dados ("Legal Amazon in Data") platform (Arapyau 2021), a request from the Consortium of Governors of the Legal Amazon.

Collaboration between scientists, IPLCs, socio-environmental activists, financial and non-financial companies, and state governments is recent and largely emerged as a reaction to the disruption of socio-environmental policies by the Brazilian government in relation to the Amazon. Many of the companies that have become protagonists of these initiatives have, until very recently, engaged in economic practices that have led to deforestation and disrespect for IPLCs' rights.

The transition to a healthy, standing forests and flowing rivers bioeconomy involves a broad and growing circle of forces that assume public commitments (backed by promising governance) to constructive practices. Among the Amazonian countries, this convergence of heterogeneous players is gaining the greatest relevance in Brazil. This is one of the most promising signs of the Amazon's transition towards sustainable development.

30.7 Navigating the New Bioeconomy: Challenges and Recommendations

The potential uses of the vast Amazon territory, the organizations that operate in it, and the institutions that govern the region's economy are so varied that specific approaches are required to propose pathways for the transition to a new bioeconomy. For example, strengthening niche markets

demands different interventions and logic than using forest socio-biodiversity products for animal feed. Supporting Amazonian cities as leaders on gastronomy based on forest socio-biodiversity products requires investment in cooking schools dedicated to forest products, while promoting the pharmaceutical and cosmetic industries will require investments in laboratories and education programs.
Despite this diversity, it is possible to list general objectives that will favor a strong and dynamic bioeconomy in the Amazon, based on the ethical-normative recognition of the value of healthy, standing forests and flowing rivers, as well as respect for the material and spiritual culture of Amazonian peoples.

Previous chapters showed that the most important objective is an immediate halt to destructive practices incompatible with the intelligent, fair, and promising use of forest socio-biodiversity. 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 borders (Abdenur 2019). In this sense, tracing the origin of illegal gold, widely exploited in the Amazon, is critical (Instituto Escolhas 2020).

With regard to the ambition for the establishment of a strong, competitive, and fair forest socio-biodiversity economy, a few fundamental objectives are described (without being exhaustive).

30.7.1 Cities, Infrastructure, and Internal Markets

A new bioeconomy of healthy, standing forests and flowing rivers cannot emerge as an enclave of scientific and technological advancement in a region so profoundly marked by poverty, inequality, violence, and lack of access to the conditions of basic citizenship, such as quality education and healthcare, basic sanitation, and participation in dynamic labor and product markets.

As discussed in previous chapters, the overwhelming majority of poverty and misery in the Amazon is concentrated in cities. In Brazil, the worst living conditions, according to the Social Progress Index (IPS 2021), are found in Amazonian cities. The current economy depends on cities, where products are sold and where most income is spent. Even families with strong ties to agriculture and forestry often maintain urban households for greater access to basic health and education services. Farmers' organizations are often based in cities. The use of forest socio-biodiversity products in the gastronomy of Amazonian cities has the potential to generate urban employment and income (Atala 2012).

Improving urban infrastructure, in cities large and small, is critical to fostering a dynamic bioeconomy. What geographer Bertha Becker called the "Consolidated Settlement Arc", referring to human occupations at the edge of the forest, has a decisive influence on the very development of the socio-biodiversity economy.

According to RAISG (2020), more than 60% of the Amazon's population is urban. It is important to highlight uncertainties in this statistic, not only due to the scarcity of demographic censuses in different countries in the region, but also to the varying definitions of the urban population in each of them. In Brazil, the definitions of municipal administrations may not reflect social realities; however, they guide classifications by the Brazilian Institute of Geography and Statistics (IBGE), which considers 72% of the Amazonian population to be urban. Veiga (2003) proposed a typology of three categories, used by Favareto *et al.* (2014) in the Amazonian context. According to this typology, one-third of the population of the Brazilian Amazon lives in unmistakably urban municipalities, 26% are in "intermediate" municipalities, and no less than 40% are in typically rural locations, even when they live in the center of these municipalities. These 40% live in municipalities with less than

50,000 inhabitants and a demographic density of fewer than 80 inhabitants per km^2. Inhabitants of these small municipalities' centers often have strong ties to agricultural and forestry activities and seek a second urban residence to access health or education facilities. This chapter will not detail this tripartition, but it is important to recognize it and its implications for infrastructure and the relationship with the bioeconomy, as it suggests a greater influence of the socio-biodiversity economy than would be expected in a highly urbanized region.

Current infrastructure in the pan-Amazon (Bebbington *et al.* 2020) guarantees the flow of mineral and agricultural commodities, and is frequently a vector of deforestation and invasion of protected areas. Alternatively, several low-cost investments can stimulate promising markets for socio-biodiversity products and reduce dependence on intermediaries that block economic dynamism. These include facilitating the mobility of rural populations and their access to urban services through information systems, accurate river transportation schedules, high-quality internet, and offering technical and university courses in small municipalities. It is also essential that cities contribute to strengthening the markets in which family farmers operate through cooperatives focused on the industrialization of what they already produce. Improving the industrial use of cassava, for example, is something that simultaneously strengthens the economy of the inhabitants of the interior and generates multiplier effects in cities. Two fundamental conditions are needed for this to happen; reducing information asymmetry and strengthening state support for rural economic activities.

30.7.2 Reduce Information Asymmetry

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. Government price guarantee policies are important but insufficient. It is critical that the production chains of socio-biodiversity products are mapped, fostering transparency to all participants and offering accessible information to producers. The grain stock exchange in Ethiopia, as described by Gabre-Madhin (2012), is an excellent example of an open and efficient system to share price information. Despite the particularities of Amazonian products, the Ethiopian case shows that producers themselves (either farmers or extractivists) can actively participate in information systems, no longer subject to intermediaries. Trade thus loses its personal nature and gains market transaction status.

As shown in previous sections, today buyers concentrate price information. In general, buyers control the price of what they sell to forest dwellers through *aviamento* and, frequently, through the debts linked to it. Information from institutionalized sources, such as a commodity stock exchange, is a fundamental component for the emergence of dynamic and competitive markets, according to a proposal elaborated by Freitas and Schor (2020). An initiative by the NGO Imazon, which for more than a decade has been collecting and disseminating the prices of NTFPs in the states of Pará and Amapá, stands out (Guimarães *et al.* 2019).

30.7.3 Seals of Quality, Scale, and Entrepreneurship

The Origens Brazil Seal operates in conservation units and Indigenous territories and has achieved significant results in incorporating products (rubber, Brazil nuts, peppers, herbal oils, and others) from these territories into the value chains of medium to large companies. Despite their importance, income generated by these products is necessarily limited due to the level of care required by a sustainable but fundamentally extractive economy, which is supported by the activities of populations living in sparsely populated areas and based on techniques that seek to avoid alteration of the environments in which they are located. Companies (e.g., Natura), and NGOs (e.g., ISA, IMAFLORA, ICV) pave the way for improvements, not only in production techniques, but also in the transparency of economic processes for the communities who are the real protagonists of these activities. The introduction of accounting to these communities, and efforts to link them to diversified markets, expand their capacities and autonomy.

These products are sold on a relatively small scale and in niche markets, representing a small fraction of the productive potential of the forest. Therefore, there are many initiatives that seek to scale such products and services. Most of these initiatives are not limited to the forest itself, seeking to encourage sustainable practices by family farmers, settlers, and large-scale farmers. Conexsus, for example, 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 communities that supply socio-biodiversity products. These transaction costs drive companies to use intermediaries, which prevents associations and cooperatives from further benefiting from dynamic and competitive markets. Conexsus leads the movement “Business for the Earth”, which aims to add “market intelligence to community enterprises.”

Belterra is an organization that is developing land-use models that combine forests, agriculture, and sometimes livestock (see Box 30.1). Within and outside the Amazon, these models have been successfully implemented, demonstrating that productive scale can be compatible with maintaining biodiversity and a varied set of ecosystem services.

Low-cost digital devices and software also allow for product and/or ingredient traceability, which can be a competitive asset of Amazonian products. Wickbold brand bread, which reaches thousands of consumers, uses Brazil nuts and is equipped with a QR code that reveals the origin of the product, who produced it, and the socio-environmental situation of the territory where it was produced. These devices could also demonstrate how products contribute to the regeneration of degraded environments or other benefits. Natura has extensive experience in this area.

Even products that currently contribute heavily to forest loss, such as beef and soy, can be transformed. The fundamental premise of tracing (as planned by Marfrig and JBS) is that consumers can easily access information about a product’s (and its components’) value chains. This can become an important competitive asset for Brazilian livestock, for example by showing that pastures are sustainably managed and methane emissions offset. The work of PECSA (a spin-off of ICV, an important NGO operating in the state of Mato Grosso, Brazil) is a successful example in this direction. If large importers of animal feed seek to replace these products with sustainable local alternatives, increased production in the Amazon can also conserve biodiversity in the environments in which feed is grown.

Production scale has historically been achieved through the simplification and homogenization of natural environments. One of the most critical challenges a new bioeconomy faces is precisely that of integrating gains of scale while simultaneously strengthening socio-biodiversity. In this sense, a Royal Swedish Academy document advocates for “strengthening resilience through investing in portfolios of ecosystem services for human well-being in diversity-rich social-ecological systems” (Folke *et al.* 2020).

These organizations currently depend on philanthropic contributions, while expressing ambitions to work with private capital and business organizations, and promote entrepreneurship itself. In this sense, one of the most important conclusions of this chapter is that activist organizations (in all their diversity) play a decisive role in increasing private participation in entrepreneurship aimed at a new, healthy, standing forests and flowing rivers bioeconomy. These organizations have the capacity to influence the world, language, objectives, and methods of private investors and introduce them to the realities of the Amazon, which is very different

Box 30.2 The case of Natura Cosmetics

Operating since 1999 in the Amazon region, today Natura Cosmetics is the 4th largest beauty company in the world. Their business model is based on the use of socio-biodiversity products and services, pioneering the combination of production at scale with the promotion of sustainable development.

Over many years, Natura established relationships with agro-extractivist communities, generating income and encouraging local training, field research (such as forest management and sustainable agricultural production), and technological innovation. The challenge of combining technological feasibility at scale, quality, and a vision of sustainable development led the company to stipulate a series of processes and, with the Natura Program Amazonia, to locally establish an “Ecoparque”, an Industrial Park in Benevides (Pará, Brazil) in 2011.

Natura invested in the research and development of ingredients and trained small producers in forest production and management techniques. They also supported institutional strengthening of communities and cooperatives, and established a policy for the sustainable use of products and services, based on the principles of the Convention on Biological Diversity (CBD) and a Brazilian provisional measure established in 2001 regarding the use of biodiversity. Some of the raw materials used by Natura are pre-processed in the communities, increasing added value.

The industrial park was built for local processing of raw materials and final products, with the objective of attracting other companies interested in a symbiotic industrial system. It also hosts the Natura Innovation Center in the Amazon and maintains partnerships on socio-biodiversity supply. So far, the German fragrance company Symrise has operations in the Ecoparque, and other suppliers, such as Beraca, have settled in the region.

To improve logistics and management, the company has been promoting local development through a strategy called sustainable territories. These territories are regions where there is a strong commercial relationship with socio-biodiversity value chains, and where intersectoral collectives are supported, bringing together communities, governments, NGOs, investors (e.g., GIZ, USAID, and Fundação Banco do Brasil), companies, and universities, for an expanded vision of standing forest economy hubs.

In total, the company has developed 38 bio-ingredients, produced by approximately 5,100 families, 33 agroextractive communities, 14 socio-biodiversity hubs (mainly in the Brazilian states of Pará, Amazonas, and Rondônia), and 11 community-based agroindustries.

Over the past 8 years, Natura reached a biodiversity business volume of approximately BRL 1.8 billion, which includes inputs, benefit sharing, and direct investments, while contributing to the conservation of 1.8 million hectares. They have offered professional courses to more than 3,000 people. In 2007, it supported the formation of the Union for Ethical Biotrade (UEBT) and the application of CBD practices and principles in input chains in different sectors of the economy.

Recently, UEBT practices were converted into a monitoring system (2014) and certification process (2018), both applied by Natura and other companies. UEBT certification ensures ethical biocommerce for the payment of fair prices, biodiversity conservation, and social development of Amazonian supply chains or any other supply chain of certified biodiversity (Natura 2019, 2020).

from those they are accustomed to. For instance, an early version of a document by three Brazilian banks explicitly mentioned promoting monocultures; after dialogue with activists, they came to understand that scaling up production in a tropical forest should not follow this model (Jankavski 2020).

Natura has been able to generate production on an industrial scale, while also strengthening forest socio-biodiversity, as shown in Box 30.2.

30.7.4 Government 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, stimulating evidence-based public policies. Furthermore, these policies encourage accurate calculation of production costs and highlight the competitive opportunities of these products. These programs already exist in Brazil, but their budgets are very low, and information does not reach the producers who need it most, exacerbated by lack of technical assistance and low levels of organization.

The Brazilian Government guarantees minimum prices for 17 extractivist products, of which nine exist in the Amazon region: açaí, andiroba, babassu, rubber, buriti, cocoa, Brazil nuts, murumuru, mangaba, baru, carnaúba, juçara, macaúba, pequi, piassava, pinhão, and umbu. In addition to minimum prices, other policies can play an important role in strengthening forest socio-biodiversity. In Brazil, the National School Meals Program strengthened family farming by requiring a that such farms supply a proportion of school meals. In the Brazilian Amazon, this has been an important opposing factor to the tendency for school lunches to be composed of ultra-processed, low nutrition foods. Other institutions, such as military barracks, public hospitals, and prisons can enact similar programs. Institutional markets are a way to offer security to producers, consolidating trade routes.

30.7.5 Science, Technology, and Innovation

Improving living conditions in Amazonian cities and strengthening markets for socio-biodiversity products is fundamental but insufficient to overcome the challenges for developing a strong economy of forest socio-biodiversity. For humanity to fully realize the potential of the most biodiverse forest in the world, it is essential to reduce the gap between the Amazon and the global scientific and technological innovation frontier. This ambition presupposes the expansion of public and private investments in science and technology in the region. The budgets of the most important and renowned research institutes in the Amazon are far from sufficient given the territorial, demographic, and ecological importance of the region, and the potential that it represents for the development of the countries in which it is located and for humanity as a whole. Tthe National Institute for Amazonian Research and the Emílio Goeldi Museum, two of the region's most prestigious institutions, systematically suffer budget cuts, and funds are often contingent (Silveira 2019). As a result, botanical, ethnobotanical, and parabotanical research lags behind, or is undertaken by better resourced institutions abroad. Strengthening Amazonian organizations is paramount; this could include courses on socio-biodiversity at different levels, from field studies for secondary students to postgraduate studies. In addition, the emergence of a strong bioeconomy presupposes the creation of new research centers that are committed to achieving relevant results vis-à-vis the use of these 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 in processes, techniques, brands, and patents, are needed.

In addition to government resources, international cooperation plays a decisive role, not only by financing research, but also through exchange programs on biodiversity knowledge and its utilization potential. Leveraging the confluence of academic and traditional knowledge and global experiences in bioeconomy innovation can attract significant venture capital investments.

It is paramount that investments in science and technology in the Amazon also strengthen an educational system that improves understanding and utilization of its socio-biodiversity. This involves clear protocols for ensuring that economic activities and land management practices will result in the strengthening (and not in the destruction) of the natural and social tissues responsible for maintaining the forest socio-biodiversity. It also requires new curricula for students and researchers. Today, courses focus on a small number of crops, mainly exotic, planted both for agriculture and logging. The recent creation of the Forest Social Business School in the state of Amazonas (Brazil), associated with the State University of Amazonas and the Institute of Advanced Studies of the University of São Paulo, is an important step in reconciling new education modalities and approaches on biodiversity with the strengthening of entrepreneurship (UEA 2020). This type of exchange is a very promising strategy.

It is critical to highlight the role of botanical gardens, herbariums, archeology museums, and living museums such as the Kuahi of the Oiapoque Indigenous peoples, among others. The Amazon is already home to a number of academic and research institutions, located both in as well as far from state capitals (Brazil 2020b), who invest in science, technology, and innovation. This community of scientists needs increased investment for expansion and strengthening. Some efforts have been made, such as the creation of the Amazon Biotechnology Center in Manaus, BIOTEC Amazônia, and Instituto Tecnológico Vale in Belém. In addition, organizations focused on workers' professional capacitation (e.g., the Brazilian National Service of Support to Industry) have resources, structures, and laboratories that can be employed to improve the performance of industrial transformation of biodiversity products. Sanitary challenges that hinder nut exportation, for example, could be overcome.

In 2013, the Science, Technology and Innovation Plan for the Amazon recommended the integration of initiatives from multiple governmental and non-governmental bodies focused on socio-biodiversity knowledge and technological applications that could be best adjusted to its sustainable use (CCGE 2013). Initiatives such as the Leticia Pact, signed by Brazil, Colombia, Peru, Bolivia, Ecuador, Guyana, and Suriname with the goal of protecting the Amazon (Heads of State and Heads of Delegation of the Plurinational State 2019), show that integration can and must go far beyond national borders, stimulating the exchange of information and experiences between researchers, technicians, and entrepreneurs. This is a critical component of biodiplomacy, as highlighted in a letter published by researchers from several countries asking Leticia Pact signatories to strengthen transnational cooperation for the protection and development of the Amazon (Prist *el al.* 2019). The importance of biodiplomacy is expressed even in international forums that do not mention it explicitly but advocate for the strengthening of socio-biodiversity as the most important pathway for sustainable development of the Amazon, such as the Synod of Bishops held at the Vatican in October 2019 (Vatican 2019).

30.7.6 Biodiversity Molecules and Shared Benefits

The Amazon is considered a medicinal treasure and the "largest drug dispensary in the world" by many (Skirycz *et al.* 2016); however, the pharmaceutical use of these materials falls far short of its potential. Over the past 40 years, several techniques have emerged (i.e., robotics, bioinformatics, high-throughput screening, combinatorial chemistry, molecular biotechnology, CRISPr), reducing the pharmaceutical industry's interest in natural components (McChesney *et al.* 2007). However, this substitution strategy in the search for molecules has not been successful (Skiryks *et al.* 2016), and interest in natural products has returned. New drugs derived from natural products made up 60% of all drugs approved by the US Food and Drug Administration agency (FDA) between 1981 and 2010. Research also shows that natural products have biochemical properties that make them superior. The title of an article by Harvey *et al.* (2015) is emblematic: "re-emergence of natural products for drug discovery in the age of genomics".

The presumed value of tropical forests' biodiversity for the pharmaceutical industry is predicated on the existence of cutting-edge technologies to identify and understand compounds and their potential uses. This requires strategic alliances involving public and private research organizations. Skirycz et al. (2016) 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 higher plants estimated to have medicinal properties, less than 200 are currently used in the pharmaceutical industry. Reducing this gap is a scientific task that can give rise to technological innovations. AstraZeneca's chemical library became available to a network of more than 130 research centers (Skirycz *et al.* 2016). The Joint European Compound Libraries also intends to share 500,000 compounds that belong to seven major companies (Besnard *et al.* 2015).

It is essential that Amazonian countries and French Guiana strengthen scientific research, information exchange, and cooperation, at the regional and international level, on biodiversity. It is crucial that mechanisms already established internationally are improved to ensure that populations living in the forest have a fair share in the benefits obtained by research and scientific discoveries (Joly and Santos 2019). Today, these mechanisms do not encourage research, hardly benefit the populations of tropical forests, and do not sufficiently advance scientific knowledge.

30.7.7 State and Local Information Systems

One of the most important premises for the emergence of a new bioeconomy of healthy, standing forests and flowing rivers is that public and private actors are able to count on quality information, not only on production and prices, but also on the social conditions of the territories in which they operate. 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, will play a fundamental role.

30.8 Conclusions

With the greatest socio-biodiversity on the planet, and the accumulated knowledge of at least 12,000 years of human history, the Amazon rainforest, over which eight governments and one overseas territory have sovereignty, has a unique material and spiritual culture, which is a natural patrimony and common good of humanity. The forest (as an ethical value) and the people who inhabit it and contribute to its conservation are the starting point of any project aimed at the emergence of a new bioeconomy in the Amazon.

Strengthening tropical forests' natural and social networks is not justified only for instrumental reasons. Despite the immense utility of its products and services, it is essential that the conservation and regeneration of the Amazon are not merely a means, but an end. However, the ethical value of protecting the forest and its peoples also has a decisive instrumental counterpart; given Latin America's deindustrialization in recent decades, the sustainable use of socio-biodiversity, supported by science and technology, represents one of the most promising ways to reduce the distance that currently separates the region from the scientific and technological frontier of contemporary innovation.

A second guiding approach of this chapter focuses on the knowledge of the socio-environmental reality on which the relationship between society and nature in the Amazon is based. A new bioeconomy of healthy, standing forests and flowing rivers will only emerge if it is part of a broad process of improving the living conditions of those who live in the Amazon. Without this, it would confine itself to an enclave, in a non-propitious environment, unable to offer the goods and services that can be expected of it.

Making tropical forests a vector for the development of life sciences' applications for the whole of humanity is a decisive aspiration. This presupposes that the bioeconomy paves the way not only to valuing the knowledge of those who directly exploit the forest, but also the social emancipation of those who are currently in vulnerable situations.

This dual objective (scientific guidance on the use of forest socio-biodiversity, and forest products and services as a means of combating poverty) needs to be addressed in an organically-articulated manner. Nobody has the recipe for this articulation, but it will surely result from the joint action of forest dwellers, the activists who defend them, organizations that foster entrepreneurship, and urban populations in the transformation of forest products, and social coalitions that may give rise to these transformations. Social change processes as ambitious as the emergence of a new bioeconomy of healthy, standing forests and flowing rivers depend on widespread change in the views of political and economic actors on the predominant forms of their activities.

This presupposes public policies that immediately interrupt the current prevalence of violence, illegality, and destruction in the region. These policies will have to integrate protection of the forest and the use of its products and services with the strengthening of environmentally-sensitive infrastructures aimed at improving the living conditions of the Amazon's inhabitants, and not only today's farming and mineral commodity production activities.

It is important to insist on an innovative methodological option. The great distance between the forest socio-biodiversity economy and what is currently identified as a bioeconomy globally, does not allow that the usual categories are used when tropical forests, and the Amazon in particular, are at stake. Establishing the bioeconomy as the domain par excellence of the life sciences (with an emphasis on the definitions in the introductory section of this chapter) means changing the paradigm that currently drives the overwhelming majority of tropical forest activities, products, and services. At the same time, replacing the current economy of destruction with an economy of knowledge of nature (which involves science and technology) is a fundamental ambition for a new economy of healthy, standing forests and flowing rivers. In other words, although the current forest socio-biodiversity still lacks an important vector for its use in science, this limitation must be overcome to guarantee the sustainable development—and ultimately the survival—of the invaluable Amazonian socioecological systems.

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