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WORKING PAPER

BIOECONOMY FOR THE AMAZON: CONCEPTS, LIMITS, AND TRENDS FOR A PROPER DEFINITION OF THE TROPICAL FOREST BIOME

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HIGHLIGHTS

- Bioeconomy is an emerging trend that has disputed and competing definitions. However, it stands out on scientific, political, and economic agendas and is assuming increasing importance.
- Existing bioeconomies should be evaluated more by their production process than by the product itself.
- The concept of the bioeconomy has emerged in industrialized countries as a solution for the mitigation of greenhouse gas emissions and energy transition, but not necessarily for conserving biodiversity.
- Amazonian bioeconomy should focus on strengthening local economies, maintaining a model that includes standing forests, flowing rivers, and a strong community component that emphasizes the values and knowledge of local populations.
- Amazonian cities play a key role in the development of a bio-ecology bioeconomy that aims to conserve the biome, since urban spaces are capable of mediating and transforming the relationship between society and nature.

CONTENT

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EXECUTIVE SUMMARY

This working paper seeks to compare what has been understood by the term *bioeconomy*; its connotations, limitations, and trends when applied to the Brazilian Legal Amazon. It also seeks to highlight the specific needs of the bioeconomy in the region—especially for the tropical forest biome—where the objective is to safeguard and value the biological, cultural, and social diversity present in the region.

Bioeconomy is an emerging term with several disputed definitions. Its first definitions and uses (e.g., OECD and EU) were aimed at clarifying the transition from fossil fuel-dependent economies to models based on biological inputs of agricultural origin but not necessarily biodiverse. These definitions were adopted by Brazilian institutions and economic sectors focused on the production of biofuels and biochemistry at scale and are more appropriate for consolidated agricultural areas.

Recently, the bioeconomy concept has been redefined as a productive and reproductive paradigm relating to biomes of high biological diversity, such as tropical forests, such as the Amazon. This "bio-ecology bioeconomy" diverges from a bioeconomy focused primarily on an energy transition, valuing social, cultural, and biological diversity.

Faced with this new frontier of economic thinking and with the need to preserve the planet's biotic and climate balance without sacrificing local development, it is understood that the bioeconomy in tropical forests such as the Amazon must integrate both into an economic system and a socio-ecological landscape, with an emphasis on the interaction with human societies and the forest. Above all, it must be based on the integral conservation of the biome, understood as a living, diverse, and deforestation-free system.

From a socio-ecological point of view, the idea of bioeconomy includes valuing the knowledge of traditional peoples, non-linearly coupled with scientific and technological knowledge. More than that—the creation of a partnership of alterity, trust, and mutual respect between the parties.

This paper reviews several definitions of bioeconomy and concludes that, among the formulations available in the literature, the most appropriate for a tropical forest such as the Amazon is primarily aligned with the concept of bio-ecology bioeconomy (Bugge, Hansen e Klitkou 2016). This concept is based on a paradigm expressed in local solutions grounded in diversity, circular use of materials and energy, ecological management of species and interspecies interactions, reduction of inputs and energy sources that are external to the system, and related strategies. It is, therefore, a concept centered on economic dynamics based on the flows of endogenously produced matter and energy, aimed at reducing as much as possible any type of external dependence. The creation of this dynamic involves urban spaces and the recognition of cities as a source of economic creation in the region, serving as a mediator in the interaction between society and nature.

Finally, certain *sine qua non* conditions are listed, which must be met when it comes to the most conserved areas of the Amazon. This paper recognizes that it is possible to implement different types of bioeconomy in certain areas (degraded land or areas with consolidated rural activities) in the Legal Amazon, but argues that in the forest, an innovative and primarily bio-ecology bioeconomy must prevail. This type of bioeconomy is different from the others because it promotes: zero-deforestation, forest conservation, land-use planning, legal enforcement, maintenance of Indigenous and traditional populations' rights, fair distribution of benefits, investments in science and technology, and technical assistance appropriate to its production. These conditions must be adopted by decision-makers and investors interested in encouraging the bioeconomy in the Amazon and be considered necessary requirements to develop an innovative and inclusive Amazonian bioeconomy.

1. INTRODUCTION

The concept of bioeconomy is still fluid and evolving. Without committing to a single definition, this working paper will analyze the term as it is understood in Brazil, including its connotations, limitations, and trends regarding the Brazilian Amazon. This paper seeks to highlight the specific needs of the bioeconomy in the Legal Amazon, mainly in its portion of the tropical forest biome. In addition, this paper will examine whether the definitions in use today are adequate for the Amazon, specifically concerning the goal of safeguarding the biological, cultural, and social diversities of the region, as well as preserving the integrity of the biome

Finally, this paper recognizes that the type of bioeconomy that should prevail in the region will be the one that follows the bio-ecology bioeconomy vision, as it is more adherent to the challenge of keeping the forest standing and the rivers flowing and points out constraints that decision-makers and investors should adopt.

Bioeconomy is an emerging trend that has disputed and competing definitions. However, it stands out on the scientific, political, and economic agenda, and has assumed increasing importance at the beginning of the 21st century.

Although the idea was proposed in the 1970s by Romanian economist Nicholas Georgescu-Roegen, the debate was recently revived. In 2017, at least one country on each continent had an approved bioeconomy strategy (not necessarily with convergent definitions), with the exceptions of Latin America and Australia. Among biodiverse countries,[1] only Malaysia, Thailand and South Africa had consolidated strategies. In Latin America, the first country to publish a national strategy dedicated to the bioeconomy was Costa Rica, in August 2020 (IACGB 2020). It is a debate that originated in developed countries and was only later adapted to the context of the global South.

International debates on the bioeconomy gained traction after the term began to appear in the economic development policies of European nations, within strategies that could help the continent migrate from an economy dependent on fossil fuels to an economy based on biological inputs. In this context, the bioeconomy would serve as an instrument for mitigating greenhouse gas emissions, while creating new jobs and technologies, and facilitating the opening of markets. However, this bioeconomy proposal would not necessarily be aimed at valuing or conserving biodiversity, or at creating a type of economy designed by and for biodiverse regions such as Brazil, particularly the Amazon.

2. CURRENT DEFINITIONS OF BIOECONOMY

2.1 Bioeconomy: Three Lines of Contemporary Debate

A comparison between the multiple definitions of bioeconomy adopted in Brazil and abroad by different sectors and regions reveals how the word bioeconomy can sometimes mean quite different things—such as, on the one hand, a monoculture or, on the other hand, sustainable management of native forests—for different interest groups and scientific strands. As already pointed out in the literature (Bugge, Hansen e Klitkou, 2016; Vivien et al., 2019), the prefix "bio" carries a lot of ambiguity.

A bibliometric study (Bugge, Hansen e Klitkou, 2016) established that the definitions of bioeconomy most frequently found between 2005 and 2014 could be classified into three approaches: bio-technology, bio-resource, and bio-ecology. The authors distinguish these three conceptual themes based on four criteria:

a) Adherence to the basic objectives of sustainability or economic growth

b) Main strategies for generating economic surplus

c) Main vectors and mediators of innovation

d) Spatial approach

Similarly, Vivien et al. (2019) also identify three types of visions or narratives about the bioeconomy, with similarities to the three types of Bugge, Hansen e Klitkou (2016). The first type considers the limits of the biosphere and is mainly based on the ideas of Georgescu-Roegen (ecological economics). The second type is based on the possibilities of scientific advancement, particularly in the development of bio-technology, having emerged in the 1990s and 2000s. The third type is guided by the idea that biomass will replace raw materials and fossil fuels with the adoption of production models with analogous processes or similar technology (biorefineries).

Even without adopting the formulation and approach proposed by these authors, the perspectives they raise allow for a broad analysis of the different bioeconomy agendas under discussion today, as detailed below.

The **bio-technological bioeconomy's** primary objectives are promoting economic growth and job creation while meeting sustainability is a secondary criterion (Bugge, Hansen e Klitkou 2016). The secondary condition of environmental criterion presented by the authors derives from the implicit hypothesis that the incorporation of science-intensive technologies (in the sense of the so-called linear model)[2] in the production process contributes to environmental efficiency. Being more intensive in high-tech scientific processes, it is assumed that these technologies and the economy that derives from them are environmentally more efficient and, consequently, sustainable.[3]

This fits the authors' argument which assumes a model of linear interaction between science, technology, and production (Bugge, Hansen e Klitkou 2016). The hypothesis also extends to productive efficiency, which would increase with technological intensification.

Thus, the application of technologies in production and their penetration in the trade and services sectors appears as the main source of dynamism and surplus creation. The success of the process depends on the existence of research and technological development associated with basic and applied science. Technical progress is assumed as a source of creating new processes and inputs, solving problems of resource availability and use and disposal of waste (Bugge, Hansen e Klitkou, 2016).

This aspect of the bioeconomy, proposed by Vivien et al. (2019), adopts a "weak sustainability" approach, that is, it does not have the integrity of ecosystems as a fundamental premise. It follows a technological and productive paradigm in which the control and degradation of the integrity of an ecosystem are acceptable for increasing the productivity and efficiency of an economic process.

The ***bio-resource bioeconomy*** is guided by the need to seek a greater balance in weighting the growth and the sustainability of products and processes (Bugge, Hansen e Klitkou 2016). It is based on the introduction of product innovations from nature, which are the main source of creating economic surpluses, as well as innovation in natural materials, management and good extractive practices, the reduction and use of residues, *cascade use*[4] of the same raw materials, and similar options. Like the bio-technological path, the bio-resource path is directly dependent on scientific research and development but assumes a more open and comprehensive perspective in terms of research fields. Interaction and collaboration between intermediary sectors, bringing together different competencies within the chains, becomes a fundamental element. There is a less linear view of the research-science-development-consumption process than in the case of bio-technology, but it is equally demanding in terms of costs and focused on the business and scientific universe.

Notably, the authors do not consider the diversity of resources and their potential ways of entering the market, specifically, the key aspect of the possibility of economic diversification based on biodiversity. In contrast, land use is presented as a central element in the bio-resource bioeconomy. The increase in productivity and intensification of land use and recovery of degraded areas in the production of biofuels are identified as drivers of innovation and growth (Bugge, Hansen e Klitkou 2016). These are processes that, at the limit, lead to a broader logic of homogenization rather than diversification.

In relation to this aspect of the bioeconomy that is based on biomass, Vivien et al. (2019) point out the possible increase of pressure on the use of natural resources. For this reason, they also associate it with a "weak sustainability" approach, as it is also linked to the standardization and scale requirements of a technological and productive paradigm in which productivity and efficiency must prevail over the conservation of the integrity of an ecosystem.

On the other hand, the ***bio-ecology bioeconomy***, in the classification of Bugge and coauthors, is characterized by economic systems in which the criterion of sustainability overlaps with the criterion of unilateral growth of the economy. Strictly speaking, this is an alternative paradigm to the one described in the two previous cases, since the creation of economic surpluses depends on processes that value "the promotion of biodiversity, conservation of ecosystems, the ability to provide ecosystem services, and prevention of soil degradation" (Bugge, Hansen e Klitkou 2016, 12). In these processes, the reduction of inputs external to each production system, and the reuse and recycling of waste are assumed as strategies to create systems with an intense internal circulation of matter, energy, and economic value (Bugge, Hansen e Klitkou 2016).

According to the authors, organic and ecological practices are the drivers of innovation, productivity gains, and cost reduction in the bio-ecology aspect, which implies seeking the reduction or abandonment of conventional, capital intensive, and high negative environmental impact techniques. Here too, research and innovation are key aspects. However, they are directed towards local solutions, *based on diversity*, reuse of matter and energy, ecological management of species, and their interactions. This is the case of agricultural systems that reduce (or eliminate) the use of agrochemical inputs and energy sources external to the system. The predominant *search* is for productive/reproductive solutions based on interactions between species and living systems, whose results partially or fully replace conventional physical, chemical, and mechanical processes, creating complete cycle systems with a strong component of circularity. The bio-ecology view would be convergent with the approach classified by Vivien et al. (2019) as "compatible with the limits of the biosphere", a "strong sustainability" approach, in which the economy is constrained by strict ecological restrictions.

Finally, these systems are characterized by the *search* for decision protocols and management and distribution of surpluses with social justice and inclusion (Bugge, Hansen e Klitkou 2016). Bastos Lima and Palme (2022), for example, advocate a **restorative bioeconomy**, with an emphasis not only on the conservation and restoration of ecosystems but also on improving social participation and the distribution of benefits among the different actors participating in value chains. Furthermore, it would involve an ethical transformation, something that is also mentioned as a factor of innovation in the bio-ecology vision by Bugge, Hansen e Klitkou (2016) and by Brazilian authors, as will be discussed below.

Nature-based Solutions

It is important to highlight that the bioeconomy is sometimes associated with another polysemic concept often mobilized to qualify principles, products, and services linked to the bioeconomy called Nature-based Solutions (NbS). Briefly, NbS are understood as economic principles and practices that, inspired by or copying natural processes, generate socio-environmental benefits. The portfolio of possibilities found in the literature is broad, including international and subnational agreements to offset carbon emissions by large corporations and polluting countries/regions; products and services aimed at reducing carbon emissions from agribusiness; green infrastructure in urban areas; and the creation of public and private conservation areas, among many other possibilities.

It is arguable whether an NbS concept applied to a bio-ecology bioeconomy would subordinate environmental processes compared to the industrial or financial needs of the technological and productive paradigm, which prioritizes productivity and efficiency over the integrity of the environment. Rather, it must be attentive to the promotion of biodiversity through solutions based on diversity referring to the socio-ecological specificities of the biome and to a broad policy of knowledge of these specificities.

Spatial Approach

It is important to highlight the fourth criterion used by Bugge, Hansen e Klitkou (2016) to distinguish the three conceptual visions of bioeconomy: the spatial approach.

Even though this criterion reveals different spatial implications of the bioeconomy proposals, none proves to be adequate for socio-biodiverse territories such as the Amazon.

The inclusion by Bugge, Hansen e Klitkou (2016) of the spatial distinction criterion allows for the discussion of the developments in the technological, agrarian, and urban fields of the three proposed types of bioeconomy. However, such a criterion has implicit links with the basic aspect of labor that is not explored by the authors. This aspect is still governed by the role of science and technology present in these forms of labor, which can directly impact the efficiency, productivity, and sustainability of the different bioeconomies under discussion. For example, the inclusion and appreciation of the knowledge and work of Indigenous peoples cannot be broadly analyzed within these bioeconomies without the inclusion of this aspect. Therefore, the spatial criterion allows for a discussion on the importance that social and technological components have in mediating between society and nature, which deserves greater attention in biomes populated by different cultures such as the Amazon.

In the treatment of the bio-technology vision, the authors highlight the protagonism of industrial plants with high technological content. The sectoral and technical segments that are protagonists in the process tend towards business and spatial concentration due to the demands of scale, technological capacity, and investment. Research and development of major innovations tend to be concentrated in specialized regions, around major players and agglomerations. Competition is international and takes place between major players, who play the leading role and exert influence over the markets they lead (Bugge, Hansen e Klitkou 2016).

Without resorting to concepts, the authors deal with problems known in the literature on regional economic development: economies of agglomeration, external economies, and, less explicitly, the role of urban life in economic dynamism. Literature is still investigating the role of these emerging[5] economic forces in urban productive agglomerations in the creation of innovations and technology, in the spatial distribution of different economic activities, and in economic growth itself.

Then, in the spatial discussion of the bio-resource and bio-ecology visions, the work classifies them as rural and peripheral economies but refrains from deepening the analysis.

This argument is presented by stating that the bio-technology bioeconomy has a pattern related to "concentrated growth in a limited number of regions", as opposed to rural and peripheral.

Therefore, the argument suggests that activities in the bio-resource and bio-ecology segments are not associated with spatially dense or concentrated economic phenomena. It also suggests that the creation of economies of scale, agglomeration, and urbanization is not typical or does not fit economies based on bio-resource or bio-ecology profiles.

The argument can also suggest a unidirectional relationship between intensive science and technology activities and urban agglomerations that are dynamic economies, with the former generating the latter, which is not necessarily true.

In the view of bio-ecology bioeconomy that this work adopts for the Amazon, the dynamism present in the urban agglomerations of the region is the result of a bidirectional relationship between rural and urban spaces, often rooted in the history of the urban economy of the region for at least two centuries, as shows Silva for the case of açaí (2017; 2021).

2.2 Bioeconomy: International Definitions in Dispute

The European Union (EU) was the main driving force behind the recent political use of the term *bioeconomy* as it saw a strategic opportunity to invest in technologies based on inputs of biological origin (EU 2007) in line with the growing demand for sustainable revisions in the current production paradigm considering the climate crisis. Economic policies and strategies have been developed by different European countries since the early 2000s with a greater or lesser focus on biotechnological innovation and renewable energies. In 2012, the EU presented its first strategy dedicated to the bioeconomy, whose motto was "Innovating for sustainable growth" and focused on developing new technologies and products, opening new markets and jobs, and maintaining European competitiveness, while considering the need to reduce dependence on fossil energy and face climate change (EC 2012).

However, as of 2009, the debate on prioritizing land use for food production over energy has led to a weakening of public support for investments in biofuels in Europe (Kaup and Selbmann 2013; Purkus et al. 2017). In 2018, a new strategy was published highlighting the sustainable and circular nature of the targeted bioeconomy, although the first version already brought the need for sustainability criteria (EC 2018). The products that currently account for the highest production values in the bioeconomy (in a broader sense, which includes primary production and food and beverages) in Europe are food and feed (€1.17 trillion),[6] industrial products based on biological resources (bio-based industry) (€780 billion)[7] that include wood-based products, plastics, chemicals, pharmaceuticals, pulp and paper, textiles, biofuels, and bioenergy. For comparison purposes, the EU's GDP in 2020 was €15.3 trillion (World Bank 2022).[8]

In the US, there was a similar debate and discussion of a *National Bioeconomy Blueprint* in 2012, which defined it as "economic activity that is fueled by research and innovation in the biological sciences" (White House, 2012), suggesting that the bioeconomy would lead to the discovery of new drugs and diagnostic methods to improve human health, high-yield agricultural varieties, biofuels to reduce dependence on oil, and products of the so-called green chemistry. Among the strategic objectives were: strengthening R&D, accelerating the entry of laboratory solutions to the market, reducing regulatory barriers, training the workforce, and promoting public-private partnerships.

The emergence of bioeconomy as a new field-shaping economic strategy in this century was also reinforced by the Organization for Economic Co-operation and Development (OECD), which recognizes the existence of different definitions of bioeconomy in use around the world and adopts that of "the set of economic activities in which biotechnology . . . contributes centrally to primary production and industry through the conversion of biomass into food, materials, chemicals, and fuels." (OECD 2019). The OECD also highlights the relevance of the bioeconomy for the transition of the energy, transport, and industrial production sectors to models that are less dependent on fossil fuels.

In its 2020 edition, the *Global Bioeconomy Summit* recognizes that the term is still evolving, with the scope and emphases varying according to the context and interests of each country. In Latin American and Caribbean countries, the report points out a trend towards associating the bioeconomy with an alternative model for sustainable development and green growth and already recognizes advances by the state of Amazonas in the development of a bioeconomy based on tropical forests (IACGB 2020). In 2021, another event that is an international reference in the area—the World Bioeconomy Forum—was held for the first time in a tropical country, in this case, Brazil. The final declaration of the event (WCBEF 2021) states that the bioeconomy is a process that encompasses many perspectives and echoes a message from the Science Panel for the Amazon (Abramovay et al. 2021), namely, that the bioeconomy is more than an economic

sector; it synthesizes a set of normative ethical values about the relationship between society and nature and its consequences.

In short, the global bioeconomy landscape is extremely dynamic. The intense debates that questioned the environmental and social sustainability of products derived from the use of biomass on a large scale led to the development of numerous initiatives and the revision of nationally defined concepts and strategies. In this sense, the Food and Agriculture Organization of the United Nations (FAO) has mobilized efforts to advance principles that ensure the sustainability of the bioeconomy. Such principles include the conservation of natural resources such as water and soil, food and nutrition security, as well as governance mechanisms to ensure consultation processes and risk management (FAO 2021). Similarly, the OECD warns that "great care needs to be taken that an unsustainable fossil economy is not replaced with an unsustainable bioeconomy" (OECD 2019, 70).

2.3 Bioeconomy: Disputed Brazilian Definitions

Although traditional sectors such as bioenergy have prompted the debate on bioeconomy in Brazil (IACGB 2020), the country did not have an official definition until recently. However, the term has already been used by the Brazilian federal government in different ministries, with the Ministry of Science, Technology, Innovation and Communications (MCTIC, from its initials in Portuguese) being the one that stands out the most for the recent efforts reflected both in the Action Plan on Science, Technology, and Innovation in Bioeconomy (PACTI Bioeconomy) (MCTIC 2018), and Bioeconomy: Opportunities and Challenges (ODBio), a project conducted with support from the Centre for Management and Strategic Studies (CGEE, from its initials in Portuguese) between 2020 and 2021 (CGEE 2021).

PACTI Bioeconomy defined the term as "the set of economic activities based on the sustainable and innovative use of renewable biological resources (biomass), replacing fossil raw materials for the production of food, feed, materials, chemicals, fuels, and energy produced through biological, chemical, thermochemical, or physical processes, promoting health, sustainable development, national growth, and the well-being of the population" (MCTIC 2018, 12). In the most recent definition of the ODBio, in which the "conceptual space" of the bioeconomy was explored, the emphasis changed from replacing fossil raw materials to "efficient solutions in the use of biological resources", including environmental services and protection, "which promote the transition to a new model of sustainable development and the well-being of society" (CGEE 2021, 63). Although it is a somewhat abstract definition, it already denotes the intention not to be restricted to a narrow objective (mitigation of greenhouse gas emissions) under which there is a risk of promoting actions that generate harmful (even if unintended) impacts on the welfare of society.

The Ministry of Foreign Affairs (MRE) has led the Biofuture Platform, whose mission is to accelerate the transition to a sustainable, low-carbon global bioeconomy. The partnership with the International Energy Agency (IEA) has already announced that the approach is strongly associated with bioenergy. The definition of the bioeconomy of this initiative comprises "a set of economic activities related to the invention, development, production, and use of biological products and/or processes for the production of renewable energy, materials, and chemicals." (Biofuture Platform 2018, 12). Such a definition is strongly associated with the bio-resource vision.

The Ministry of Agriculture, Livestock, and Food Supply (MAPA) has been running the Bioeconomy Brazil – Sociobiodiversity program since 2019 through the Secretariat of Family Agriculture and Cooperatives. The objective is to expand the participation of small farmers, family farmers, traditional peoples and communities, and their enterprises in productive and economic arrangements that involve the field of bioeconomy. Although the ordinance (MAPA 2019a) that creates the program does not present a definition, one of its objectives is to value Brazilian biological, social, and cultural diversity and to support the structuring of productive arrangements and integration roadmaps around sociobiodiversity products and activities to contribute to income generation and productive inclusion. In addition, it is a "bioeconomy that considers not only technological advances in chemical, industrial, and genetic engineering processes but also those resulting from traditional knowledge and the sustainable use of biodiversity" (MAPA 2019b). Despite an apparent approximation with the bio-ecology paradigm, it is notable that the initiative has a budget of only R$15 million[9] invested directly by MAPA (MAPA 2021a).

In the national debate, projects by relevant class entities are added to the government's initiatives. It is argued that the productive activities of agribusiness, as they commercialize biologically-sourced assets—plants, animals, organic matter, and their by-products—would be framed in the bioeconomy (Oliveira 2020).

An analogous conceptualization to this approach is the definition used by the National Confederation of Industry (CNI) in 2013, comprising "primary production, or agribusiness, which includes the raising of plants and animals and veterinary applications; production of biofuels; industrial biotechnology, involving the processing and production of chemicals, plastics and enzymes; environmental applications such as bioremediation, biosensors and other methods to reduce environmental impacts; and advances in human health (particularly medical biotechnology), encompassing new diagnostic and therapeutic procedures such as pharmacogenetics, functional foods, and medical equipment" (Silva, Pereira e Martins 2018, 287).

It must be recognized that important representations of social and popular movements in the Amazon disagree with the notions linked to the bio-technology and bio-resource bioeconomy mobilized by the national debate. In a document prepared by the National Council of Extractive Populations (CNS) and the Coordination of Indigenous Organizations of the Brazilian Amazon (COIAB), among others, during the Amazon Meeting of Sociobiodiversity, held in Belém do Pará in 2021, the criticisms and concerns were made explicit. Roughly speaking, they were aimed at innovation and financing processes linked to productive homogenization and deterritorializations.

The Letter from the Amazon (COIAB, 2021) defends a socio-bioeconomy "based on science and technology to improve the production of forestry and fishery products, enabling us to process, store, and market socio-biodiverse products while respecting our ways of life", against "innovative processes that result in technological packages and high-input production systems designed to replace the native forest with a monoculture of genetically uniform varieties" (CNS and COAIB 2021).

Other examples are definitions by governments and subnational institutions that also seek to differentiate the Amazon bioeconomy from the rest of the country. The Amazonas State Government stipulates its concept of bioeconomy as "the set of economic activities of production, promotion of production, distribution, and consumption of goods and services from resources of the Amazon socio-biodiversity in a sustainable and innovative way" (Amazonas 2016). Meanwhile, the definition of the Bio-Economy Priority Program (PPBio), an initiative of the Superintendency of the Manaus Free Zone (Suframa), is to "diversify and boost investments in the context of fiscal incentives policy, covering solutions for the sustainable economic exploitation of biodiversity" (Suframa 2018).

The state of Pará, in turn, has been developing its bioeconomy plan with a view to "the economic transition to matrices of low greenhouse gas emissions, resilient to the impacts of climate change, especially in a post-pandemic scenario, to generate social, environmental, and economic benefits and to overcome poverty through the socio-bioeconomy," based on three thematic axes: i) research, development, and innovation; ii) genetic heritage and associated traditional knowledge; and iii) productive chains and sustainable businesses (Pará 2021). The government emphasizes that this is not a "mere import of bioeconomy concepts", but rather an Amazonian construction that responds to the needs of the Amazonians themselves (Agência Pará 2022).

While the debates above seek to bring the concept of bio economy closer to the Amazon reality by introducing specifications and guiding activities for the conservation of the biome, they haven't had sufficient impact to go against the dominant technological and productive paradigm that contributes to the degradation of ecosystems and local cultures.

To that effect, federal subsidies for bioeconomy, when contrasted with federal subsidies for traditional agriculture, showcase this low impact. While the volume of the Harvest Plan corresponds to R$251 billion[10] (MAPA 2021b) in the Amazon, the National Program for Strengthening Family Agriculture (Pronaf) mobilizes around R$2 billion[11] per year, with only R$55 million[12] allocated to sustainable production activities in the biome in the 2019/20 harvest (Pimenta, 2021). Suframa, for example, created the Center for Biotechnology of the Amazon (CBA) 20 years ago to develop the scientific and technological basis for the bio-technology bioeconomy, but currently struggles to produce something truly innovative, facing problems that go from the lack of maintenance of the equipment to the lack of a definition of a management model. In addition, although the creation of the PPBio is commendable, it is worth noting that the resources mobilized in this program still constitute a very low percentage of the total volume of financial contributions established by the Informatics Law for Investments in Science, Technology, and Innovation. Between 2020 and 2021, 11 companies invested R$9.8 million[13] vis-a-vis approximately R$700 million[14] (IDESAM 2021a).

2.4 Comparative Matrix

To assist in understanding the different theoretical trends predicted in the literature and their alignment with the main trends in the world debate on the subject, the document proposes an analysis matrix that seeks to organize a graphic representation of the alignments between the main actors and the main characteristics of the three main strands of the bioeconomy concept, as described in Bugge, Hansen e Klitkou (2016).

The matrix uses the definitions by the Amazonas State Department for Economic Development, Science, Technology and Innovation (SEDECTI–AM); Science Panel for the Amazon; Amazônia 4.0; MRE; Secretariat of Family Farming and Cooperativism of the Ministry of Agriculture, Livestock and Food Supply (SAF/MAPA); MCTIC; CNI; European Commission, U.S. Government, OECD; and Food and Agriculture Organization (FAO).

In addition to the geographic aspect, the matrix contains summarized versions of the work definition of each of these institutions, the sources consulted, the main objective of each initiative to which the definition is linked, the territorial focus from which it originates, the importance of technological innovation for its consolidation, its relationship with the different approaches to the sustainability theme, and the correspondence with the different typologies brought by the literature.

The goal of this exercise is to observe how the development profile approximates certain groups to the concepts and the prioritizations brought by them, and the differences between the priorities of the different interest groups involved in this debate.

Among the international references, it is noted that few, if any, address issues that are essential in the context of a tropical forest like the Amazon, with its biological and sociocultural diversity. At the national level, it is possible to identify a recent trend of approximation of the concept to the Amazonian reality, although there are doubts, or even contradictions, regarding its implementation, as described in the previous section.

ENTITY	FAO	OECD	EUROPEAN COMMISSION	WHITE HOUSE	MRE	SAF/MAPA	MCTI	CNI	SEDECTI - AM	SEMAS - PA	AMAZÔNIA 4.0	SCIENCE PANEL FOR THE AMAZON	NEW ECONOMY FOR THE AMAZON (NEA-BR)
SCOPE	INTERNATIONAL	INTERNATIONAL (DEVELOPED COUNTRIES)	REGIONAL	NATIONAL (USA)	NATIONAL (BRAZIL)				STATE - AMAZONAS	STATE - PARÁ	AMAZON BIOME	AMAZON BIOME	AMAZON BIOME (BRAZIL)
Bioeconomy definition	Production, use, conservation, and regeneration of biological resources—including related knowledge, science, technology, and innovation—to provide sustainable solutions (information, products, processes, and services) within and across all economic areas, enabling transformation to a sustainable economy (IACGB 2020).	Set of economic activities in which: i) biotechnology and life sciences (including chemistry and biochemestry) contribute centrally to primary production; and ii) industry contributing to the constriction of the bioeconomy through the conversion of biomass into food, materials, chemicals, and fuels.	All sectors and systems depend on biological resources (animals, plants, microorganisms, and derived biomass, including organic waste), their functions and principles. It includes and interconnects terrestrial and marine ecosystems and the services they provide. Thus, the concept of bioeconomy is related to all primary production sectors that use and produce biological resources (agriculture, forestry, fishery, and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, bio-based products, energy, and services.	Infrastructure, innovation, products, technology, and data derived from biologically related processes that drives economic growth, improve public health, agriculture, and generate security benefits.	Set of economic activities related to the invention, development, production, and use of products and/or processes for the production of renewable energy, materials, and chemicals.	Although the ordinance that defines the program "Bioeconomy Brazil – Sociobiodiversity" does not present the concept, one of its objectives is to value Brazilian biological, social and cultural diversity and to support the organization of productive arrangements and integration routes around sociobiodiversity products and activities in order to contribute to income generation and productive inclusion. It considers not only technological advances in chemical, industrial and genetic engineering processes, but also those resulting from traditional knowledge and the sustainable use of biodiversity.	All economic activity derived from bioprocesses and bioproducts that contribute to efficient solutions in the use of biological resources—in the face of challenges in food, chemicals, materials, energy production, health, environmental services, and environmental protection - and that promote the transition to a new model of sustainable development and the well-being of society.	"Activities that employ new technologies to generate a wide range of products. It encompasses the processing and service industries and relates to the development and production of pharmaceuticals, vaccines, industrial enzymes, new plant and animal varieties, bioplastics and composite materials, biofuels, bio-based chemicals, cosmetics, food, and fibers. The entire value chain is guided by advanced scientific knowledge and the search for technological innovations in the application of biological and renewable resources in industrial processes to generate circular economic activity and collective social and environmental benefits (ABBI)."	Set of economic activities, promotion of production, distribution, and consumption of goods and services from socio-biodiversity resources, and market structures (productive knowledge networks) based on products and processes that are grounded on four guiding principles: 1) conservation of biodiversity; 2) science and technology aimed at the sustainable use of sociobiodiversity; 3) reduction of social and territorial inequalities and; 4) expansion of biodiverse and sustainable forested areas.	There is no specific definition. The decree that establishes the strategy for the elaboration of the state bioeconomy plan has the following themes: I - research, development, and innovation; II - genetic heritage and associated traditional knowledge; and III - productive chains and sustainable businesses.	It is based on seven fundamentals: 1) accumulated knowledge represented by Amazonian biodiversity; 2) ability to understand the intrinsic knowledge of the forest; 3) application of this accumulated knowledge to improve human life; 4) production of goods and services from biodiversity; 5) building a bioeconomy that is both local and global; 6) equitable distribution of socio-economic benefits; and 7) intrinsic valuation of the Amazon biome.	It refers to a bioeconomy of standing forests and flowing rivers, which is based on ethical and normative precepts for the transformation of the relationship between society and nature, with the support of science, technology, and innovation. It is summed up in the motto: "more than a sector, an ethical imperative".	The project focuses on a bioeconomy of standing forests and flowing rivers. In this sense, the concept of bioeconomy is related to the productive and reproductive paradigm (way of doing), focused not on the product itself (açaí, bacaba, or Brazil nut, for example), but the production process (respecting parameters of sociobiodiversity).
Primary objective	Scope of the Sustainable Development Goals (SDGs), including those related to sustainable production and consumption, food and nutrition security, climate change, biodiversity, and the environment. It is possible to generate economic value while improving environmental and social outcomes.	Economic growth, based on the transition to a low carbon economy.	Replacement of fossil fuels and raw materials. This would occur through the reduction of associated greenhouse gas emissions, while creating a technological competitive advantage.	Development of economic activities linked to biotechnology and the use of biomass produced internally (cf. The Billion Ton Biomass report (2016), which evaluated the potential for production and use of one billion tons of renewable biomass per year in the USA).	Promotion of renewable energies and other products from biomass.	Development of family farming and extractivism.	Innovation and sustainable use of biological diversity resources in Brazil.	Development of a new industry that appropriates the solutions developed by nature for the production of fuels, chemical commodities, and molecules of high added value, using both timber and non-timber resources.	Internalization of technological and productive development, benefiting social groups at the different levels of the production chains.	Encouragement of the "economic transition to matrices of low greenhouse gas emissions, resilient to the impacts of climate change . . . to generate social, environmental, and economic benefits and overcome poverty through the sociobioeconomy."	Biome conservation, while allowing Brazil to become a global leader in the circular economy, combining knowledge of biodiversity with the possibilities of Industry 4.0.	Maintenance of the integrity of the biome and the peoples who inhabit the Amazon.	Integrity of ecosystems (conservation and restoration of degraded areas), as well as respect and appreciation of traditional knowledge are central objectives. In this sense, the possibilities of economic diversification must be based on the diversity of existing resources, and not on their homogenization.
Territorial approach	Activities linked to the forestry and agriculture sectors in both developed and developing countries.	Global clusters and urban core regions with industrial and scientific research activities.	Integration of activities in the primary sector (rural environment) and industry (urban environment), mainly targeting energy and materials markets.	Global clusters and urban core regions with industrial and scientific research activities.	Integration of activities in the primary sector (rural environment) and industry (urban environment), mainly targeting energy and materials markets.	Rural areas occupied by family farming.	It includes cities, peri-urban areas, forests, and rural areas, as it covers the entire national territory.	National clusters with industrial and scientific research activities.	Integration of activities in the forestry sector (extractivism) and STI, through "productive knowledge networks", in which cities play a relevant role.	Undefined.	Integration of activities in the forestry sector (extractivism) and STI without necessarily involving urban centers. One of the fundamentals is the "construction of a bioeconomy that is both local and global."	Integration of urban areas and forests. Urban infrastructure, both in large centers and in rural municipalities, is critical to boosting the bioeconomy.	Cities as an element of mediation of the relationship between society and nature, aiming to contain its fragmentation, and as an element of generation and diffusion of technologies, acting as a source of economic creation.
Technology relevance	Not central.	Central. Bio-technology and life sciences are fundamental determinants of international competitiveness.	Central. Design focused on the cultivation and processing of biomass. The definition of the 2018 strategy excludes biomedicines and biotechnology applications in healthcare.	Central. There are concerns related to cyber security (data) and national defense and the four vectors of technological development: 1) life sciences (biology, botany, agronomy, microbiology, etc.); 2) biotechnology; 3) engineering; and 4) computer science and informatics.	Central. Design focused on the cultivation and processing of biomass.	Not central. Traditional knowledge is the focal point of this conception.	Central. The issue of technological innovation is fundamental to the concept.	Central. The document focuses on issues such as the regulation of access to genetic resources, the relationship between ICT (Institute of Science and Technology) companies, intellectual property, and the granting of patents.	Central. Reflected in the guiding principles and in the concept of "productive knowledge networks" that integrate traditional knowledge and STI, according to the specific characteristics of each territory.	Central. The importance is reflected in the first two thematic axes, with emphasis on traditional knowledge associated with genetic resources.	Central. The "interactive fusion of traditional, scientific, and technological knowledge" is proposed. One of the fundamentals is the intrinsic knowledge of the forest.	Central. However, knowledge to innovate is more important than the technology itself. Innovations can be social in nature.	Central. But in combination with traditional knowledge.
Relationship with sustainability aspects	Integrative vision guided by the SDGs.	Focus on the climate issue, without explicitly observing biodiversity.	The sustainability criteria and circular nature of the bioeconomy became more relevant with the 2018 review.	Mitigation of climate change is one of the goals to be achieved. Sustainability is assumed.	Focus on the objective of decarbonizing economies and on sustainability criteria for products based on biomass.	Sustainability is important. Biodiversity conservation is a priority in relation to climate change.	From PACTI to ODBio there seems to have been a strengthening of the concern with biodiversity conservation, in addition to mitigation, completing the spectrum of sustainability.	The document deals with biodiversity as an asset for the fourth industrial revolution. However, there is no focus on sustainability.	Sustainability is important for this aspect, as it relates to the principles of the Amazonian bioeconomy listed above.	Still undefined but potentially important. The decree refers to State Law nº 9048/2020, on climate change, whose guidelines include, among others, "conservation of the original plant cover and combating the destruction of areas of remaining natural vegetation, to guarantee the conservation of biodiversity and the high biomass and carbon stock". The participatory nature of the elaboration of the plan is also highlighted.	Sustainability is important for this aspect. In addition to ecological integrity, it aims at social inclusion and respect for traditional Amazonian peoples.	Sustainability is important for this aspect. In addition to ecological integrity, it aims at social inclusion and respect for traditional Amazonian peoples, in addition to cultural appreciation.	Sustainability is important for this aspect. Economic diversification is supported and driven by biome-specific natural and social diversity. In addition to having the maintenance of its integrity as a primary objective, this vision adopts as prerequisites: territorial planning; respect and appreciation of traditional cultures and knowledge, combined with science and technological innovations; and fair distribution of benefits, among others.
Association with typologies by Bugge et al. (2016)	Bio-resource vision with elements of bio-ecology.	Bio-technology vision	Bio-resource vision, focused on the multiple uses of biomass.	A combination of elements of the bio-technology and bio-resource visions.	Predominance of the bio-resource vision, focused on the multiple uses of biomass, with aspects of bio-technology.	Bio-ecology vision.	Combination of elements from the three visions.	Bio-tecnology vision.	Bio-ecology vision.	Still undefined, but the reference to "socio-bioeconomy" suggests an approximation with the bio-ecology vision.	Bio-ecology vision.	Bio-ecology vision.	Primarily bio-ecology vision.
Sources	Bioeconomy for a sustainable future (FAO, 2021) https://www.fao.org/publications/card/en/c/CB6564EN	Innovation systems in the Bioeconomy (OECD, 2019) https://www.oecd-ilibrary.org/docserver/e2e3d8a1-en.pdf?expires=1645193516&id=id&accname=guest&checksum=056E653DCC077E6CF941DCD23EC3500A	A sustainable bioeconomy for Europe (EC, 2018) https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-149755478	Summary White House Summit on America's Bioeconomy (White House, 2019). https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/10/Summary-of-White-House-Summit-on-Americas-Bioeconomy-October-2019.pdf	Biofuture Platform. http://www.biofuturepla-tform.org/	https://www.gov.br/agricultura/pt-br/assuntos/camaras-setoriais-tema-ticas/documentos/camaras-setoriais/hortalicas/2019/58a-ro/bioecono-mia-dep-saf-mapa.pdf.	Oportunidades e Desafios da Bioe-conomia - Relatório ODBio Integrado (CGEE, 2021) https://www.cgee.org.br/documents/10195/6917123/CGEE_ODBio_Rel_Int.pdf	Bioeconomia e a indústria brasileira (CNI, 2020) https://www.portaldaindustria.com.br/publicacoes/2020/10/bioeconomia-e-industria-brasileira/	Diretrizes para a Construção Conceitual da Bioeconomia no Amazonas (SEDECTI, 2021) http://www.sedecti.am.gov.br/wp-content/uploads/2021/07/NT_Bioeconomia_0_SECTI-SEDECTI-AM_Bioeconomia_no_Amazonas.pdf.	Decree nº 1.943, October 21, 2021. https://leisestaduais.com.br/pa/decreto-n-1943-2021-para-instrui-a-estrategia-estadual-de-bioeconomia-do-para-reconhece-o-grupo-de-trabalho-interinstitucional--para-estrategia-estadual-de-bioeconomia-gteeb--e-da-outras-providencias-leia.	Projeto "Amazônia 4.0" (Nobre & Nobre, 2019) http://www.plataformademocratica.org/Arquivos/Futuribles2_FuturibleS_2_ProjetoAmaz%C3%B4nia4.0.pdf	Science Panel for the Amazon (2021). Amazon Assessment Report 2021. https://www.theamazonwewant.org/wp-content/uploads/2021/11/211112-Amazon-Assessment-Report-2021-Part-III-reduced.pdf	This Working Paper.

3. SPECIFIC NEEDS OF AN AMAZON BIOECONOMY

To better define the bioeconomy in the Amazon, several virtual events were held, alongside analyses of relevant literature. These public events convened various interest groups capable of influencing the bioeconomy agenda, including public and private institutions, organizations engaged in public policymaking, lobbying, and applied research, as well as interest groups of different natures.

Through the analysis of these privileged moments of dialogue, it is noted that three themes are constant in the debate on the bioeconomy in the Amazon: the preservation of forest assets through the sustainable exploitation of forest products (mainly non-timber); territorial planning with law enforcement, including against land grabbing; and the recognition of the contributions of Indigenous, traditional, and *quilombola*[15] communities in making this forest-based economy viable in the Amazon biome and the fair distribution of its benefits.

3.1 Preservation and Regeneration of Forest Assets Through Sustainable Exploitation

These debates make clear that the preservation of forest assets must be a priority within any model of local economic growth linked to biodiversity, but it requires investments in sustainable infrastructure. Most of the non-timber forest production is in remote forest areas, with difficulties related to logistics, connectivity, and even the availability of basic services such as energy, water, and telecommunications. The distribution of essential services in the Amazon does not overlap with the productive hubs at the end of the forest chains, and even the most basic business support services, such as accounting, are hard to access in forest massifs.[16] Reducing this gap is essential for the management of forestry businesses to reach the depths of the Amazon in a sustainable way. Among the main points mentioned are the need for connectivity and decentralized electricity (mini-grids).

In addition to this fundamental condition, the demands of industrial technology and technical assistance are among the main needs of local enterprises for the preservation of forest assets through sustainable exploitation. Only 15 percent of municipalities in the Brazilian Amazon have the industrial infrastructure to produce raw materials such as fats, oils, and pulp (Brandão et al. 2021).

The Forest Cities project, developed by the Institute for the Conservation and Sustainable Development of the Amazon (IDESAM), is an example of how science, technology, and technical assistance can change reality. Actions to support production, management, and marketing, with 10 social organizations (associations and cooperatives) in several municipalities in Amazonas, include the provision of infrastructure, equipment, and technical assistance for the installation and operation of non-timber forest products processing plants, and promoting community-based timber management. Industrial machinery has increased the ability of community organizations to add value to primary products and market products such as andiroba oil (Carapa spp) and *breu* (Protium spp), among others. In addition to the construction of mini plants, the project invested in environmental licensing procedures, occupational safety, forest certification, waste treatment, renovations, management tools, accounting services, and satellite internet installation. (Walendorff 2020; IDESAM 2021b, 2022).

It is important to emphasize that the valorization of forest assets not only is based on the use of goods and services offered by the standing forest, but also on the rehabilitation of forest landscapes through natural regeneration, assisted natural regeneration, and management of areas of low vegetation such as *capoeiras* and *juquiras* through the development of agroforestry systems (SAFs). Data from the 2017 agricultural census allow us to assess that the Gross Value of Production (GVP) of standing forest products in the Legal Amazon already represents almost half of the GVP of deforestation, reaching R$971 million[17] in 2017 against R$2.2 billion.[18] The role of family farming is evident in this process of valuing the forest. Family farmers hold 19 percent of the forests contained in rural establishments in the Amazon, but they are responsible for no less than 87 percent of the GVP from the extraction of products from the standing forest. The data does not allow evaluating the GVP from the AFS, but WRI Brasil estimated, using spatial regressions (SAR/SEM models), that each hectare of SAF among family farmers significantly increases the GVP of extractive products by R$506.04,[19] while for nonfamily producers the marginal GVP is R$68.77 [20] (IBGE 2019).

Finally, the preservation of forest assets through the sustainable exploitation of forest products does not exclude timber production via forest concessions or the recovery of degraded lands (Brienza Júnior et al. 2008). However, forest concessions need to undergo a profound reform so that they can meet the needs of local populations and not reinforce predatory and wasteful exploitation (Brasil 2006).

3.2 Territorial Planning and Law Enforcement

The issue of land use, land change and forestry (LULUCF) in the Amazon region has always been a matter of dispute, especially among private individuals. In the logic of logging, illegality does not occur in parallel with the established system, but because of it. The predatory extraction model is compatible with illegal logging since the timber inspection and certification system was designed so that regularity is costly and difficult to achieve, and irregularity is ineffectively fought. Additionally, the successive changes in the Forest Code, that postpone the final date for beneficiaries of possessions to regularize their occupation, encourage new invasions and new waves of land speculation (IPAM 2021).

The fact that local communities have repeatedly sought to develop solutions to contribute to territorial planning and law enforcement demonstrates the relevance of this topic. The struggle for the demarcation of Extractive Reserves (RESEXs), and the very creation of the RESEX concept by the rubber tappers movement in Acre (Cunha 2010), is an example of a solution to dilemmas that arises from socio-environmental emergencies and from the agency of the communities affected (Oliveira 2016). Through the creation of the concept of RESEXs and Conservation Units for Sustainable Use, social movements, scientists, and organized civil society have contributed to creating and consolidating territorial planning mechanisms that respond to complex issues such as collective land ownership, diffuse generational rights, and forest and biodiversity protection. These achievements can be further strengthened by other governmental actions. Recently, the state of Amazonas offered Concessions of Real Rights of Use (CDRUs), including to communities that live outside protected areas, bringing light to the concept of Territories of Common Use (TUC) (IEB 2022).

In the absence of state command and control mechanisms, specifically environmental inspection in Protected Areas, riverside communities also took the lead in defining the protection of local nature, especially fish, which is the main source of income and food for these communities. This is the case of the Fisheries Agreements carried out at the community level in the floodplains of the Amazon River (Oviedo et al. 2015; McGrath et al. 1999), where riverside communities, partners of non-governmental organizations, and other civil society institutions mobilized to create alternatives for fish and water management in their territories. Solutions that were born in the civil sphere were in some cases incorporated into solutions linked to the public power, as is the case of specific zoning of certain regions (D'Almeida 2006).

3.3 Recognition of the Contributions of Indigenous and Traditional Communities to the Forest-based Economy, Ecosystem Services, and the Fair Distribution of Benefits

Although the terms "Amazon bioeconomy" and "Indigenous bioeconomy" are relatively new, there are already relevant productive processes conducted by the communities themselves with the support of public and private partners. These processes feed the local, national, and international economy with agricultural and forestry products, superfoods, and cultural experiences with strong roots in traditional forms of community organization. And they promote ecosystem services such as regulation of rainfall, carbon removal through the regeneration of degraded areas, and the maintenance of the primary forest.

An example is the Baniwa jiquitaia pepper, produced by communities in the Upper Rio Negro, including the Baniwa people, and sold as a luxury culinary item in Brazil and abroad. For such a local product to become a commercial delicacy, there was a journey that involved the work of community-based Indigenous associations, especially the Indigenous Organization of the Içana River Basin (OIBI, from its initials in Portuguese), which has been working for two decades to guarantee the rights of the peoples of the region, and the Federation of Indigenous Organizations of the Rio Negro (FOIRN), with three decades of experience on behalf of the 23 communities on the Rio Negro. For this articulation, the Traditional Agricultural System of Rio Negro was recognized as a Brazilian Intangible Heritage by the National Institute of Historic and Artistic Heritage (Iphan) in 2010, motivating the valorization, efforts, and continuation of the commercialization and dissemination of Baniwa jiquitaia pepper in national and international markets.

The production units of Baniwa jiquitaia pepper as a commercialized agro-industrial good are small agro-industries called "Casas de Pimenta" (Pepper Houses), led by OIBI's community-based structures. The products are packaged and marketed in the communities themselves along the banks of the Içana River, opting for low-scale production. It is important to note that, even though the partners play a relevant role in the viability of the peppers, the decision to commercialize is based on the priorities defined by the community itself. In the words of Franklin Baniwa, "the communities remain intact in environmental, cultural and traditional terms, but they are developed from an economic, political, and social point of view ... the political, social, and economic autonomy of the Baniwa People occurred and occurs by their own will and fight" (Baniwa 2016).

Another example is the Central Cooperative for Extractive Commercialization of Acre (COOPERACRE), headquartered in the state capital of Acre, Rio Branco, and with three factories in operation that process the production of 25 cooperatives and associations (Fonseca et al. 2018) distributed in 12 municipalities. According to 2015 data, COOPERACRE processed 1,300 tons/year of Brazil nuts (*Bertholletia excelsa*) and 400,000 tons/year of fruit pulp, also selling the traditional latex from native rubber trees (Oliveira 2016). Its foundation is directly linked to the resistance movement against the invasion of São Paulo farmers in forested areas in the state, which promoted deforestation and eviction of rubber-tapping families, forcing them to move to the outskirts of cities. The social and political processes driven by the rubber tappers' resistance gave birth to innovations such as Extractive Reserves and the structuring of non-timber forest production chains, such as those of cooperatives associated with COOPERACRE (Oliveira 2016).

4. A BIOECONOMY CONCEPT APPROPRIATE FOR THE RAINFOREST BIOME, BASED ON THE BRAZILIAN AMAZON

Although there are different types of bioeconomies, only in the bio-ecology bioeconomy and the restorative bioeconomy approaches does the sustainability criterion overlap with the unilateral growth of the economy.

A bioeconomy in the Amazon represents, in a way, a new frontier for economic thinking if its implementation is premised on the conservation of the biotic and climatic balance of the planet without harming the socio-economic development and the well-being of the populations that live in these biomes. Here the concept of production scale collides with that of ecosystem scale, where the balance of the biome depends on the preservation of terrestrial and aquatic biodiversity of vast areas.

It is proposed that the bioeconomy in a tropical forest such as the Amazon must be an economic system whose foundation is the concrete existence of the biome, considered as a living, diverse and deforestation-free system; and marked by positive, respectful, and sustainable interaction with human societies. This includes valuing and inserting the knowledge of traditional peoples into the development of this bioeconomy and its science.

Additionally, it is understood that Amazonian cities play a key role in promoting this bioeconomy due to their ability to mediate between society and nature. Urban areas have the attribute of articulating, intensifying, expanding, and creating trends in economic diversification, which is strategic for maintaining and enabling a bio-ecology bioeconomy in the Amazon.

Before self-regulated markets, industries, and the modern state emerged, cities and urban settlements provided the platform for social and economic creation that allowed local societies to establish a stable relationship with nature. The emergence of the industry-market interaction, with its enormous increase in productivity and the intensification of the transformation of space, matter, and energy, displaced the city from this condition of privileged mediation.

In this sense, it is important to question whether mediation by industry (and its corresponding infrastructure), which traditionally implies large scale and high homogeneity, among other characteristics, is compatible, in the medium or long term, with economic diversification based on biodiversity, especially in peripheral economies such as the Amazon.

As seen in section 2, the distinction made by Bugge, Hansen e Klitkou (2016) among the three bioeconomy visions includes the regional and urban developments associated with each modality. However, the authors do not explore how the various spatial and technical devices of mediation between society and nature allow cities to assume different integrative configurations in each of these modalities.

It should be noted that one of the foundations of social, technical, and economic creation in the Amazon is always the diversity of the natural world.[21] Historical records show that urban life in the region traditionally articulates and expands the social, technical, and economic possibilities of the relationship between society and nature. This is the point of considering an urban mediation between society and nature as a source of economic creation in the region. In other words, the richness and flexibility of urban structures and practices are at the origin of the very formation of markets as structures of recurrent, decentralized, and diverse exchanges.

This paper does not refute that in the Brazilian Legal Amazon it is possible to have the implementation of different bioeconomy approaches as a regional development strategy if they follow certain common principles widely agreed upon and debated. However,

the importance of bio-ecology bioeconomy is highlighted as the predominant approach in tropical forest areas, especially where there are standing biodiverse forests and healthy rivers flowing, to not impact terrestrial and aquatic ecosystems. A bioeconomy must be evaluated mainly by its productive and reproductive process, more than by the product itself (*açaí* or Brazil nut, for example).

In the Amazon, the existing economic systems must strengthen, expand, and diversify from an enriching connection with the diversity of the biome, and not in opposition to it. The challenge is to establish a pattern and a development model in which economic diversification is supported and driven by the natural and social diversity present in a specific way in the Amazon biome. It is not just about bringing knowledge from the outside but incorporating, in an innovative way, the traditional knowledge, which is multi-diverse and full, with the one brought by modern science and technology.

The need for grassroots communities, cooperatives, and their leaders to be at the forefront in consolidating the bioeconomy is a constant topic of discussion in the sector. Social technologies for community empowerment can be developed by the communities themselves, partnering with technical assistance organizations, non-governmental organizations, acceleration processes, or innovative public policies.[22] Therefore, once again, the bioeconomy in the Amazon must exist and be stimulated as an endogenous process, driven by its own reality, privileging knowledge, contributions, and technologies developed from the region itself.

Among the strategic economic activities for this bioeconomy are agroecological or agroforestry rural development materialized in trajectories based on agroforestry systems (SAFs) (Costa et al. 2021); the sustainable exploitation of non-timber forest products with added value; the prospection, discovery, and valorization of pharmaceutical actives with benefit-sharing, following the Nagoya Protocol; sustainable ecotourism; and other non-invasive modalities that coexist with forest dynamics.

Conclusively, the last sections have sought to show that, when it comes to the Amazon, the term bioeconomy needs to observe eight *sine qua non* conditions:

- The integrity of ecosystems, zero deforestation, and forest degradation, reconciling conservation and the restoration of degraded areas
- Respect and appreciation of Indigenous peoples and local communities, whose cultures and traditional knowledge contribute to the sustainable use of biological resources
- Respect for traditional knowledge as a guiding element of science and technological innovations
- Territorial planning, including the allocation of public lands and guaranteeing the land rights of Indigenous peoples and traditional and local communities (Azevedo-Ramos et al. 2020; Moutinho et al. 2022)
- Fair distribution of the benefits generated from the commercialization of forest products and the valorization of ecosystem services (which are not limited to income)
- Support Indigenous peoples and local rural and urban communities with the consolidation of their local economies through the valorization of their different forms of production and economic integration. This includes the strengthening of the strategy of verticalization of the productive activity to generate the highest level of value aggregation for the various products of Amazonian biodiversity and the well-being of the communities
- Creation of economic opportunities that make it possible to counter illegal activities that destroy ecosystems and increase violence. Specifically, land grabbing and the illegal exploitation of wood and gold (Soares et al. 2021; Waisbich et al. 2022)
- Implementation of a sustainable transport, energy, and telecommunication infrastructure compatible with the conservation of terrestrial and aquatic ecosystems of the forest and which respects territoriality and meets the priority interests and needs of the substantive economies of Indigenous peoples, *quilombolas*, traditional communities, and family farmers.

5. CONCLUSION

Meeting these criteria, through public and private initiatives, is vital to developing an effective Amazon bioeconomy. These goals must become the standards for decision-makers and investors seeking to encourage the bioeconomy in the Amazon. Solutions based on a technology and production paradigm, with a focus on the integrity of the biome and preserving sociobiodiversity should be the primary focus of their actions.

Actions to make these demands viable, through public and private initiatives, are critical to develop an effective Amazon bioeconomy. That is why they must become determinants for decision-makers and investors interested in encouraging the bioeconomy in the Amazon, with solutions based on a technology and production paradigm that place the integrity of the biome, including its sociobiodiversity, as a primary object of their activities.

Social organization is a central element for solidifying an Amazonian bioeconomy. It requires varied and multidisciplinary knowledge and tools to plan and manage forest product companies, associations, and cooperatives. It is important to consider the costs of social organization in bio-ecology bioeconomy proposals, considering that the State will not guarantee them all. Investments linked to an innovative social organization in the Amazon will gain relevance in the political agenda of regional development and expand the autonomy of local populations in the management of their territories

Unlike other economic models in developing countries—almost always copied from models that worked in developed countries—this new bioeconomy for the largest tropical forest on the planet must be creatively implemented, especially since no other country with a tropical forest has developed one. Amazonian cities can and should help to mediate this innovation process between society and nature. It is a unique opportunity for Brazil to endogenously create a bioeconomy that can contribute to saving tropical forests, fighting climate change, hunger, inequality and valuing indigenous peoples and local communities.

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NOTES

1. These are countries that harbor a wide variety of living organisms of all origins, including, among others, terrestrial, marine, and other aquatic ecosystems. Brazil occupies the top of this list, as the country with the greatest biological diversity in the world.
2. The linear model assumes that innovation processes begin with scientific research, from which products and the production process itself are developed, followed by commercialization.
3. Note that the association between technological efficiency and sustainability is a chain of logical arguments, not an articulation of empirical events.
4. Wood industry example: Veneered wood products, after a life cycle, become particle-based products, which then become fiber-based products, which then become bio-based chemicals, which then become energy for electricity and heat. See Liu et al. (2019).Exemplo da indústria da madeira: produtos de madeira folheada, após um ciclo de vida, tornam-se produtos à base de partículas que, então, tornam-se produtos à base de fibra que, então, tornam-se produtos químicos de base biológica que, então, tornam-se energia para eletricidade e calor. Ver Liu *et al.* (2019).
5. The concept of emergence comes from research in biology, and has been incorporated by other sciences, including social sciences. According to Pessoa Jr. (2013, p. 22), the concept refers to a state of affairs in which the properties of a certain domain are not completely reduced to the properties of another domain (they would be "autonomous"), despite being, in some sense, produced by this other domain (or being "dependent" on it).
6. US$1.26 trillion (April, 2022).
7. US$841 billion (April, 2022).
8. US$15,89 trillion (April, 2022).
9. US$2.92 million (May 2022).
10. US$50 billion (May, 2022).
11. US$400 million (May, 2022).
12. US$11 million (May 2022).
13. US$1,9 million (May, 2022).
14. US$137 million (May, 2022).
15. Quilombolas are residents of quilombos (settlements originally established by fugitive slaves in Brazil).
16. Based on the speech of Leonardo Letelier (Sitawi) in the 7th Panel of F2iBAM.
17. US$206,5 million (April 2022).
18. US$468 million (April 2022).
19. US$107,62 (April 2022).
20. US$14,63 (April 2022).
21. This question is at the heart of Jacobs' (1969) proposition in her hypothesis of the precedence of urban life in relation to the countryside, which is one of the sources of our argument, alongside Lefebvre (2014) and Polanyi (2012), among others.
22. Based on the speech of Amiraldo Picanço, (Projeto Bailique), in the 7th Panel of F2iBAM.

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ABOUT THE NEW ECONOMY OF THE BRAZILIAN AMAZON

The New Economy for the Brazilian Amazon (NEA-BR) is an initiative developed by WRI Brasil, New Climate Economy and more than 50 Brazilian researchers from partner organizations, including the Federal University of Pará (UFPA), University of São Paulo (USP), Federal University of Rio de Janeiro (UFRJ), Federal University of Minas Gerais (UFMG), Institute for Environmental Research in the Amazon (IPAM), Center for Climate Crime Analysis (CCCA), Concertation for the Amazon and Instituto Contas Abertas.

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ABOUT WRI BRASIL

WRI Brasil is a research institute that transforms great ideas into actions to promote environmental protection, economic opportunity and human well-being. It works in the development of studies and implementation of sustainable solutions in climate, forests and cities. It combines technical excellence with political articulation and works in partnership with governments, companies, academia and civil society.

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The Global Commission on Economics and Climate and its flagship project The New Climate Economy were created to help governments, businesses and society make more informed decisions about how to achieve prosperity and economic development while addressing climate change.

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