



A KNOWLEDGE BASE
for the NATIONAL
BIOECONOMIES
STRATEGY

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A KNOWLEDGE BASE
for the NATIONAL
BIOECONOMIES STRATEGY

CONSENSUS STUDY AND PRIORITIZATION



GT Bioeconomia
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PRESIDENT'S MESSAGE

It is with great pleasure that I present to you the publication “A Knowledge Base for the National Bioeconomy Strategy.” Resulting from the National Bioeconomy Working Group (WG) of the Institute of Engineering, and the actions of the administrations of the former presidents, Eduardo Lafraia, who awarded Carlos Nobre as Eminent Engineer of the Year 2020, and Paulo Ferreira, who created the aforementioned WG in 2021.

This project was motivated by the challenge launched by engineer Carlos Nobre, in his award speech, when he emphasized the need for Brazil to develop a national bioeconomy strategy and become the first tropical power.

The Institute of Engineering embraced this challenge and took the first step to create a knowledge base, forming the WG, which began to organize data and useful information for a national bioeconomy strategy, with participatory dialogues, facilitated by open meetings, workshops and events and involved professionals and academics in the sector.

Also, during the administration of the president Paulo Ferreira, the group promoted expeditions to the Amazon with a scholarship program for students and newly graduated engineers, encouraging sustainability in a transversal way in Engineering training.

Upon assuming the presidency in 2023, I continued support of this important work that now culminates in this publication.

To carry out this project, a committee composed of 25 leaders in the sector, focused itself on the aspirations, capabilities, objectives, and fundamental recommendations for a transformative bioeconomy strategy.

Among the main aspirations, Brazil's position as a global leader in the bioeconomy stands out, which promotes development of social inclusion and concomitantly acts to achieve balance between human activity and nature.

The bioeconomy is a huge opportunity for Brazil, with the potential to drive a new model of sustainable development. Engineering is fundamental from research and the advancement of technologies to industrialization and the formulation of public policies based on the technique for the sector.

Our main goal is to collaborate with the improvement and implementation of the National Bioeconomy Strategy. The vision of continuity between administrations and the professionalism employed in this project, over three administrations of the Institute of Engineering, was key to this result that we present. This long-term commitment shows our vision of the importance of the bioeconomy for the future of Brazil.

This publication is another milestone in the history of the Institute of Engineering, which once again fulfills its mission of promoting Engineering for the benefit of the development and quality of life of society.

We invite everyone to engage in this collective effort, contributing their knowledge and experiences to put Brazil at the forefront of the global bioeconomy.

José Eduardo Frascá Poyares Jardim
President of the Institute of Engineering



“We embrace the challenge posed by Carlos Nobre, as we believe that Brazil has everything required to be a world power in Bioeconomy, and the Institute of Engineering has the mission of acting to transform this potential into reality.”

Eduardo Lafraia (2017-2018 | 2019-2020)



“As it stands, the Institute of Engineering offers a valuable contribution to the challenges of the Bioeconomy. By the fortuitous initiative of our National Bioeconomy WG, which had the collaboration of great experts in the field, this fundamental work is delivered to Brazil, with the hope that it can support the expansion and implementation of a national Bioeconomy strategy. Brazil’s natural protagonism in the subject imposes non-transferable responsibilities and, certainly, the country will prove to be up to this tremendous challenge.”

Paulo Ferreira (2021-2022)



“The vision of continuity and the professionalism employed in this project that has persevered over three administrations of the Institute of Engineering, was key to this result that we presented. This long-term commitment demonstrates our vision of the importance of the bioeconomy for the future of Brazil.”

José Eduardo Frascá Poyares Jardim (2023-present)

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PRESENTATION

“Strategy is the process of transforming aspirations into capabilities.”

Eng. Silvio Meira

The development of a national bioeconomy strategy is essential to guide the development of public policies and ensure the efficient use of resources. In this context, the Leaders Committee formed by the National Bioeconomy WG of the Institute of Engineering began the construction of a knowledge base to support the construction and implementation of the National Bioeconomy Strategy, structured in nine key elements (opportunities, challenges, risks, aspirations, capacities to be developed, national and Amazon strategic objectives, governance, sources of financing and the role of engineering).

Based on the dialogue between leaders chosen for their extensive work experience on topics directly related to the bioeconomy, a structured group communication technique was used, developed to obtain consensus among experts on future forecasts or complex issues. The main benefits of this method, known as Delphi, are the reduction of group bias, the promotion of independent thinking, the integration of diverse specialized perspectives, and the ability to address complex or uncertain problems in a structured and systematic way.

In an iterative process, participants answer questionnaires in successive rounds, receiving anonymous feedback on the group’s responses after each step. This allows experts to refine their opinions based on the perspectives of others, without the influence of factors such as status or dominant personality that may occur in face-to-face discussions. In all, there were more than 2,300 responses and 143 comments, which brought reflections with multiple points of view.

The questionnaires were initially developed with the technical collaboration of representatives from the initiative **A Concertation for the Amazon** and based on a set of publications such as bioeconomy strategies from other countries, as well as the “Strategic Plan of the National Council of the Legal Amazon 2020-2030” and the work of the Center for Management and Strategic Studies (CGEE) “Opportunities and Challenges of the Bioeconomy” to address the objectives, challenges and opportunities for development. The discussion on

governance, policy instruments and physical infrastructure necessary for the development of the Brazilian bioeconomy was based on the documents “Bioeconomy in the Amazon: Conceptual, Regulatory and Institutional Analysis” of the Climate Policy Initiative (CPI) and “Proposal for a governance model for the Brazilian bioeconomy of the CGEE”. Infrastructure ideas brought by the work of the Amazon 4.0 Institute, the publications “Infrastructure for the Sustainable Development of the Amazon” and “Safeguarding Bioeconomy” were also incorporated.

We are deeply grateful to each of the leaders involved for their commitment and collaboration in answering the questionnaires, providing great learning to the project team. With humility, we hope to have recorded and transmitted in this report the richness of the contributions received. We reiterate our gratitude for the generosity, dedication, and understanding shown throughout this process.

This publication is the result of the dialogue and exchange of knowledge and presents a set of recommendations to support the development of a comprehensive, inclusive, and transformative national bioeconomy strategy.

BIOECONOMY, THE ECONOMY OF LIFE

Ricardo Abramovay*

The International Resource Panel¹, of the United Nations Environment Program, has been publishing reports on contemporary social metabolism for almost twenty years. In living beings, metabolism is the set of chemical reactions that convert the energy contained in food into energy available for different cellular processes. In social life, it is about understanding how the materials that support the reproduction of human groups are extracted, transformed, consumed, and discarded.

Faced with infinite products and services that make up social wealth, experts calculate this metabolism based on the weight (in tons) of four basic materials: biomass, fossil fuels, metallic minerals (iron, aluminum, copper) and non-metallic minerals (sand, gravel, clay, which are products basically aimed at civil construction). The main goal of these studies is to evaluate whether population increase, economic growth and expanded access to the consumption of goods and services can be achieved with less and less use of these materials, in accordance with Sustainable Development Goal 8.4 (improve efficiency in the use of resources for production and consumption).

Regarding biomass, it corresponded to 40% of the materials that make up social wealth in 1970 and this proportion drops to 26% in 2020. Non-metallic minerals, which were 31% of the weight of social production in 1970, reach 48% of the total in 2020. Fossil fuels have fallen from 20% to 16% and metallic minerals remain at 10% of the total over the last fifty years.

From 1970 to present, the global GDP has increased more than five times and annual consumption of the four materials mentioned above rose from 31 billion to 95 billion tons, that is, it has been multiplied by a little more than three. This means that there was a decrease in the proportion of materials used for each unit of wealth obtained, which signals an important gain in efficiency.

The problem is that this **relative decrease** (more wealth per unit of materials consumed) hides an **absolute increase** in the use of these materials. In the case of biomass (the basic part of the bioeconomy), for example, although global GDP depends less and less on it, its production has expanded tremendously, from 12.6 to 24.8 billion tons between 1970 and 2020. Among the components of the increase in the weight of biomass, the two most important items are wood (fundamental for construction and infrastructure), and, above all, products aimed at animal feed.

This background information is essential to understand the foundation from which this publication is based and the very meaning of the bioeconomy. It is clear that biomass (its collection, its cultivation, its harvesting, its transformation, its use, its disposal, but also – what cannot be ignored – its waste that is not reused and its destruction by deforestation and pollution) is the basic material of the bioeconomy.

But to make this observation without going into the merits of the quality of this use, its real social utility and its capacity to erode or regenerate the environmental services is, however,

an intellectual attitude that undermines the ambition aroused by the increasingly frequent use of the term bioeconomy. Agnostic definitions, by which the bioeconomy consists of different forms of biomass use, suffer from this vice.

The agri-food system, for example, handles a third of global greenhouse gas emissions and is classified by the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Environmental Services) as the most important vector of biodiversity erosion in the world. In addition, as the Food System Economics Commission² shows, it embeds a set of hidden costs in pollution, destruction of biodiversity, and health expenditures resulting from the global obesity pandemic, which exceed the market value of all food sold in the world. The recently released Thematic Report on Agriculture, Biodiversity and Ecosystem Services (from the Brazilian Platform on Biodiversity and Ecosystem Services)³ shows that, in Brazil, the conversion of natural areas for agricultural production has reduced biodiversity and environmental services, to the point of constituting a threat to territories that today account for a decisive part of the country's agricultural growth. The same occurs, in the Amazon⁴, with the formation of monotonous landscapes formed by the cultivation of local products (açai, for example), which depend much more on chemical inputs than on the rich biodiversity contained in the original ways of procuring the product.

It is true that biomass also plays a fundamental role in the supply of modern renewable energies and a good example of this is second-generation ethanol. However, consider from a bioeconomic perspective, large agricultural tracts of homogenous crops require the use of pesticides and chemical fertilizers that destroy soil biodiversity, even if their products are intended to replace fossil fuels, this compound act nullifies the literal meaning of the expression itself. The financial economy is fundamentally structured in opposition to the inherent nature of bioeconomy and thus complicates full integration of bioeconomic values into financial systems.

Recent work by the World Economic Forum⁵ examines promising paths of the “tech driven bioeconomy”. The achievements already made and promised in medicine, in the fight against pollution, in decarbonization and in food itself are remarkable and should be incorporated into policies to support the bioeconomy. But for a country like Brazil, where agriculture and the food industry are so important, the basic premise of any support for the bioeconomy lies in its ability to contribute to the resolution of its three greatest challenges: the fight against poverty and inequalities, the valorization of the knowledge of forest and riverine communities, and, at the same time, the protection and regeneration of environmental services that economic growth has so far systematically destroyed. The good news is that this triple concern is at the heart of the recently approved National Bioeconomy Strategy⁶.

Engineering, a discipline that focuses on solving the most varied problems, can certainly make a relevant contribution so that the National Bioeconomy Strategy contributes to the sustainable development of Brazil. This publication endeavors to enrich the debate and improve practices aimed at this objective.

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BIOECONOMIES IN THE PLURAL AND THE BIO-IMPACT VISION

George Paulus Dias*

The definition of bioeconomy is a topic of ongoing debate and dispute. Different sectors of the economy compete to position their interests as central to the narrative around the bioeconomy. While certain sectors seek to be considered as part of the bioeconomy, other movements look to determine what should not be considered as bioeconomy.

Our perspective goes in the opposite direction, we look to identify all activities that have some relationship, even if indirect, with the bioeconomy. We try to fit even those activities that, by traditional definitions, are not classified as bioeconomic. In this sense, we propose that bioeconomy activities need to be differentiated and treated appropriately by public policies, investors, and bioeconomy actors. For example, extensive agriculture has demands and challenges to be overcome that are different from extractive activities and it would be inappropriate for both to be treated equally by the National Bioeconomy Strategy.

We believe that every bioeconomy needs to have a surname: the bioeconomy of sociobiodiversity or socio-bioeconomy, the creative bioeconomy, agribusiness, livestock, fishing, health, medicines, native peoples, family farming, cooperatives, cosmetics, extractivism, construction materials, tourism, decarbonization, biogenetics, biofuels, and even the bioeconomy of biopiracy, illegal timber, land theft, and all others, each with its characteristics, peculiarities and demands, need to be foreseen and adequately addressed by the regulatory framework of the bioeconomy and the allocation of financial resources.

In the strict sense, the bioeconomy refers to the production, use, and conservation of biological resources, including related knowledge, science, technology, and innovation to provide information, products, processes, and services across all economic sectors. This concept covers various sectors, including health, agriculture, forestry, extractivism, and the chemical industry, among others. As will be explored in greater depth later, contrary to what would be desired, bioeconomy activities are not necessarily sustainable. Therefore, an approach to the **impact** of each bioeconomy on ecosystems and biodiversity is imperative.

Bioeconomy visions

We value the direction taken by the approach proposed by Bugge et al, 2016, who propose, in a broad literature review, three visions of the bioeconomy: the bio-technology visions, the bio-resource visions and the bio-ecology visions. The analytical model developed by the authors is based on four dimensions or key factors to characterize and differentiate these views, offering a conceptual framework to understand the competing perspectives on the development of the bioeconomy:

- “Objectives and goals”, which captures the ultimate purposes and desired results. This factor reveals the underlying priorities and values, whether it is maximizing economic growth and job creation, balancing economic development and sustainability, or ecological preservation over financial gain.

- “Value creation” refers to the sources and processes by which each vision proposes to generate wealth, such as the application of advanced biotechnologies, optimization of biomass production chains, or the development of locally adapted systems.
- “Drivers and mediators of innovation”, which covers the actors, processes and approaches considered essential to catalyze advances in each vision. This includes the linear model of R&D and patenting, interdisciplinary science-industry collaborations, or the identification of agroecological practices and favorable ecological interactions.
- “Spatial focus” shows the expected geographic distribution of innovations and benefits, whether concentrated in cutting-edge technological hubs, dispersed in biomass-producing regions, or more centralized in local economies.

By proposing these four dimensions of analysis, the study by Bugge and colleagues provides a valuable tool for mapping and contrasting the different visions and discourses present in the scientific, political, and regulatory debate on the future of the bioeconomy. More than a simple classification, this analytical model invites us to explore the nuances, tensions, and potential synergies between these perspectives.

- **Bio-technology vision:** sees the bioeconomy primarily through the prism of applying advanced genetic engineering and synthetic biology techniques to create innovative products and processes. Its central goal is to boost economic growth and generate jobs through the commercialization of biotechnologies, sometimes disregarding possible environmental impacts. Innovation is conceived as a linear process, starting from scientific research to the patenting and development of commercial applications. Benefits are expected to be concentrated in high-tech hubs and globally connected metropolitan regions. A key example is the use of genetic engineering to develop crop varieties with increased resistance to pests and diseases to increase agricultural productivity and reduce reliance on chemical pesticides.

- **Bio-resources vision:** focuses on the sustainable and optimized use of renewable biological raw materials, such as plants, animals, and microorganisms, to produce food, energy, and bioproducts. It looks to balance economic development and sustainability, betting on the processing and full use of biomass along value chains. Innovation involves incremental improvements in processes and products, interdisciplinary collaborations, and a strong interaction between academia and the productive sector. The benefits tend to spread to regions rich in biological resources, especially rural areas. For example, the use of biomass such as sugarcane, grasses, or fast-growing algae for bioenergy production.

- **Bio-ecology vision:** prioritizes ecological sustainability, proposing a regenerative and distributive development model based on principles of agroecology, circular economy, and regional resilience. Its focus is on maintaining the health of ecosystems by closing cycles of nutrients, materials, and energy. To promote biodiversity, its innovation is guided by the valorization of traditional knowledge, ecologically-based agricultural practices and locally adapted solutions. For example, bioecological engineering techniques are used to design agricultural systems that rely on ecological interactions to increase soil fertility and crop yields while reducing the need for agrochemicals and energy inputs.

Bio-impact vision

Our perspective for bioeconomy introduces a fourth theoretical vision, which we will call the bio-impact visions. This vision of bioeconomy expands the traditional scope to include economic sectors that, although they do not deal directly with biological resources, “interfere with the

conservation and use of biological resources”, and therefore should also be considered in the bioeconomy. This vision recognizes that industries such as mining, energy, infrastructure, and tourism, while not biologically based, interact with the bioeconomy through their effects on natural habitats, biogeochemical cycles, and ecosystem functioning.

Bio-impact differs from existing visions of the bioeconomy by focusing on the comprehensive management of the effects of human activities on biological resources, regardless of the sector of origin.

In the bio-impact view, the main focus should be on the assessment, mitigation, and remediation of the impacts that productive activities have on biological resources and ecosystems, encouraging business practices that minimize negative externalities and generate net benefits for the biosphere. This includes efforts to minimize damage to the environment, efforts to restore damaged ecosystems, and initiatives to implement lower-impact practices.

Unlike the other visions, the value creation aspect of this vision is strongly linked to harm reduction and restorative processes, in addition to traditional economic growth. The drivers of innovation for this vision are technologies and practices that reduce negative environmental impacts and increase positive ones. The spatial focus within this vision can be dispersed globally, depending on where industries are affecting biological resources. However, there may be a special focus on areas where economic activities are causing significant environmental damage.

It is important to note that this is a theoretical proposition and any practical application of it needs carefully constructed guidelines to prevent it from becoming merely a justification for harmful practices, rather than genuinely promoting a shift toward diminishing the impact of economic activities on ecosystems.

Goals and objectives

The main goal is to monitor, mitigate and remediate the biological and ecological impacts of various industries, including those such as oil, which are not traditionally associated with the bioeconomy. This may involve efforts to decrease impact risks, reduce environmental damage, and restore damaged ecosystems. Economic growth and job creation are also aims of this vision, as they would be achieved through the implementation of modulated impact practices and technologies.

Bio-impact vision objectives framework

1. Assess and monitor the impacts of various productive activities on biological resources and ecosystems.
2. Mitigate the negative impacts of human activities on ecosystems.
3. Remediate and restore degraded ecosystems.

Value creation

Value creation is based on business models and production chains that internalize their positive and negative impacts on nature. This would involve, for example, valuing and remunerating environmental services, incorporating environmental externalities into prices, and creating markets for products and services that contribute to ecosystem regeneration. The value would also be generated from technological and organizational innovations that allow monitoring, evaluating, and mitigating the impacts of productive activities on biodiversity.

The assumption that this value creation can more effectively capture the positive and negative externalities in market prices is something that we recognize is easy to propose, but the implementation challenges are enormous, as we have seen with carbon credit markets. But in this context, by reducing environmental damage or restoring damaged ecosystems, important contributions to value creation will be generated.

Drivers and mediators of innovation

Innovation in the bio-impact vision is driven by the need to develop tools, methods, approaches, and regulatory policies to measure and manage the impacts of economic activities on biological resources. It involves advances in areas such as accounting and environmental law, participatory-transparent-agile-flexible governance, life cycle analysis, supply chain traceability, sustainability certification, and remote monitoring technologies. Innovation mediation takes place through international, intersectoral collaborations and public-private partnerships that bring together expertise from different fields, such as ecology, economics, business management, social sciences, life sciences, engineering, and information and communication technology.

Space focus

The spatial focus is multiscalar, recognizing that the impacts of economic activities on biological resources manifest themselves at different levels, from the local to the global. It involves mapping and managing impacts on specific ecosystems, as well as the aggregate and transboundary effects of productive and consumption activities.

The relevance of the bio-impact vision does not derive from conceptual innovation, but from its integrative function, offering a concrete and objective framework for assessing and managing the impacts of economic activities on biological resources. From a communication perspective, it can serve as a more tangible and measurable alternative narrative to that of vague and overused "sustainability."

To implement the bio-impact vision, it is necessary to create methods to measure environmental externalities, to develop policies that integrate these costs into economic models, and to develop markets that remunerate low-impact practices and burden high-impact ones. It will take collaboration between universities, companies, and governments for applied research, development of monitoring technologies, and pilot projects in various sectors. Training professionals in bio-impact assessment and management will also be crucial. These actions aim to turn the concept into practice, making bio-impact a functional approach to economics.

Several conceptual and market initiatives already incorporate, to some extent, the vision of bio-impact. Each professional must seek standards and certifications in their area of expertise, but we can mention the Life Cycle Assessment (LCA)^{1,2}, for example, which allows the environmental impacts of products and services to be evaluated considering multiple indicators, such as carbon footprint, land use, water consumption, and biodiversity loss. Sustainability certifications and

standards, such as seals for organic³, forestry (FSC⁴), agricultural (RTRS for soy⁵), construction (LEED⁶, BREEAM⁷, Envision⁸, ISO 50001⁹, and LBC¹⁰), fashion (BCI¹¹, GOTS¹² and C2C¹³) and greenhouse gas (GHG¹⁴, ISO-14064-3¹⁵) also include bio-impact metrics in their protocols, but which are often voluntary or poorly recognized by the market.

In this context, the recommendations of the Taskforce on Nature-related Financial Disclosures (TNFD)¹⁶, stand out, which provide a framework for companies and financial institutions to identify, assess, respond to and disclose their nature-related issues. The TNFD disclosure framework consists of conceptual foundations, a set of general requirements, and a set of recommended disclosures structured around four pillars: governance, strategy, risk and impact management, and metrics and targets.

TNFD's proposed metrics include a small set of core metrics, which apply to all sectors and sectoral metrics for each sector. The framework of metrics and systematic disclosures provides a basis for comprehensively and objectively assessing and reporting on the bio-impacts of business activities. TNFD appears as an important initiative to promote transparency, accountability, and action by organizations in relation to their dependencies, impacts, risks, and opportunities.

**George Paulus Dias is Coordinator of the National Bioeconomy WG and advisor to the Institute of Engineering.*

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INTRODUCTION

The bioeconomy appears as a necessary approach to face current and future challenges, integrating biological, technological, economic, and political aspects to promote sustainable development. Brazil with its rich biodiversity in its 6 biomes (Amazon, Cerrado, Caatinga, Atlantic Forest, Pampa and Pantanal), has great potential for development in the bioeconomy.

The country has advanced in the development of policies and strategies related to the bioeconomy, seeking to reconcile economic development with environmental conservation. The National Strategy for Economic and Social Development (ENDES) highlights the bioeconomy as a strategic area for the sustainable development of Brazil (ENDES, 2020). The document emphasizes the importance of innovation, sustainability, and social inclusion, recognizing the role of the bioeconomy in generating jobs, adding value to natural resources, and promoting a greener economy.

In addition, the National Biodiversity Strategy and Action Plan (EPANB) sets up guidelines for the conservation and sustainable use of Brazilian biodiversity, highlighting its importance for people's livelihoods and for the resilience of social and economic systems (MMA, 2016). It recognizes the direct relationship of bioeconomy with the Sustainable Development Goals (SDGs) and its potential for the sustainable development of the country.

The study "Brasil 2035: cenários para o desenvolvimento" (IPEA, 2017) presents a comprehensive analysis of Brazil's economic development strategy, projecting scenarios for the country until 2035. The study identifies trends and uncertainties related to the development of the bioeconomy in Brazil, highlighting the importance of investments in science, technology and innovation, the need for a favorable regulatory environment and the relevance of business strategies and investments in bioindustries.

In June 2024, after this research was already completed, the first version of the National Bioeconomy Strategy in Brazil was published, an important milestone, with the aim of coordinating and implementing public policies for the development of the bioeconomy. The document sets up guidelines and objectives for the National Bioeconomy Strategy. However, it does not specify in detail how these guidelines and aims will be achieved, leaving it up to the National Bioeconomy Development Plan, to be prepared by the National Bioeconomy Commission, to define resources, actions, responsibilities, goals, and indicators. In addition, the decree does not decide deadlines for the implementation of the proposed measures. The

results presented here serve as a contribution, in the short term, to the National Plan and, in the medium and long term, to the revisions of the Strategy that will most likely take as an example the pioneering countries in the sector that have already published updates of their bioeconomy strategies.

The bioeconomy scenario in Brazil presents several opportunities, such as the potential of biodiversity for the generation of new products and services, the contribution to the generation of jobs and income, especially in rural areas and traditional communities, and the promotion of social inclusion and regional development. However, there are also challenges to be faced, such as the need for investments in research, development, and innovation, the lack of adequate infrastructure, the lack of technical training, and the need for a favorable and effectively enforced regulatory environment. To address these challenges and seize opportunities, it is necessary to build capacities in key areas, establish effective governance, and promote integration between public policies and private initiatives. In addition, the role of engineering is essential for the advancement of the bioeconomy in Brazil, contributing to the development of innovative technologies, the optimization of production processes, the implementation of sustainable solutions, and the training of qualified human resources.



ASPIRATIONS AND CAPABILITIES

According to Silvio Meira (2021), strategy is a dynamic and integrated process that aims to turn **aspirations** into reality, through the development and application of specific **capabilities**. At the core of this process is the transition of aspirations—goals and desires that have not yet been realized—to a state where we have the skills, abilities, and resources necessary to realize them. This process is not static; it constantly evolves, adapting to internal and external changes, requiring careful management of aspirations and capacities. They can change over time, requiring periodic review to ensure that strategic direction remains aligned with the end objectives.

To realize these aspirations, we develop capabilities, which are a set of competencies (theoretical and practical knowledge, learning potential, behaviors, principles, and values), skills (the practical aptitude to apply competencies), and resources (the means needed to perform tasks). These capabilities are developed and enhanced both in the planning phase and during strategy implementation, adapting to meet the demands of an ever-changing environment. Dynamically managing these capabilities is crucial, as it allows the organization to adjust and respond effectively to new opportunities and challenges that arise over time.

At the center of any strategy are people. It is the people who matter. They are the ones who give life to aspirations, develop, and apply skills, and respond to the context in which they are inserted. Therefore, a successful strategic approach is one that puts people at the center, recognizing and valuing their potential, their needs, and their contributions. In doing so, the strategy combines itself as the culminating process of transforming aspirations into capacities in which individuals and collectivities **are empowered** to reach their full potential (Meira, 2021).

We need to collectively decide what dream unites us as a nation, where we want to go and what our ambition is for the bioeconomy in the long term. These provocations were made to our Leaders Committee based on the following questions:

- 1. Which **ASPIRATION** should guide the Brazilian national bioeconomy strategy?**
- 2. When the **ASPIRATION** you wrote down has been achieved, what **CAPACITIES** will have been developed on the path?**

Based on the answers, we were able to apprehend and understand a rich configuration of visions and aspirations that, despite being distinct, share several points of contact and complementarity. Below, we will detail the main themes, points of convergence and divergence, as well as the nuances that permeate these perspectives.

Dreaming of Brazil. – Logic alone does not move: the creation of the new requires a dream. The tenor of the tension between logic and dream is essential. A Brazil worthy of our dreams cannot be the daydream of a capricious imagination. The symbolic construction of the desired and desirable nation will always be a collective task: the result of the patient purification of time; the construction of the mysterious link between successive generations, coming and going; and an infinity of trials, setbacks, negotiations, and victories. A Brazil worthy of a dream must be conceived from what we effectively and collectively are; of the accidents and conditioning factors as well as of the vices and virtues that are intertwined in our common destiny. It must be based on the lucid intelligence of things that have happened, not to fixate on them, but so that we can support a conscious and fruitful relationship with them. It is by sifting through the dirt of our bets, achievements, and failures that we will reach the pentacle of our knowledge and potential. The secret of utopia lies in the art of unraveling the light in darkness. There is a luminous future – epic remittance in the vision of a poet – wanting to awaken from the shadows of the present. – Brazil is mestizo; genetically and culturally fused – this is the trait that best defines us. Through tortuous and sometimes cruel paths, without this being part of any clerical or governmental intention, the presence of pre-modern attributes, sensibilities and values, of African and Amerindian extraction, was established among us, and which, to our luck, proved capable of offering tenacious resistance to the invasion of the narrowly utilitarian and competitive values of the Western subculture. Hence the spontaneity and the unique ability to vividly enjoy the moment; the warmth and intensity of affections in personal relationships, including in the sphere of work and common tasks. Hence the predominance of the “sweet feeling of existence”, independent of rationalizations or logical pretexts; the unmotivated joy that gives an intensely poetic, cordial, and playful quality to ordinary life, despite the poverty and violence that exists. Hence the anachronism-promise called Brazil. – When I think of the ideal Brazil that populates and animates my dreams, I do not see us as conquerors, owners of the truth or manufacturers of empires. I don’t see ourselves exchanging our soul for the golden calf or giving up our playful and amiable understanding of life in the fight for a pole position in the metric of GDP per capita and in the disregard for all values, starting with environmental values, which do not lend themselves to monetary calculation. If the civilization of the machine, of fierce competition, and of time measured in drips has any reason to exist, then it exists to free men from servitude of economic monopoly, and not to entangle them in a perpetual and ever-renewed arms race of consumption and accumulation. – A utopian Brazil can make us believe that we can be more – much

more! – what supporting actors serve an obsolete world with ethnographic material for the amusement of tourists and anthropologists? It speaks to us of an ideal of life based on the tranquility of being what one is. It speaks to us of the natural existence of what is beautiful and of the search for perfection through the purification of everything that distances us from the essential. It speaks to us of another Brazil, neither more true nor more false than the existing one – only reconciled with itself. Of a proud Brazil open to the world, finally cured of the infantile-colonial disease of masquerading progressivism and its opposite – ardent nationalism. Of a Brazil in which racial democracy is no longer a myth to be covered up to become a form of life to be revealed. Of a Brazil that works (enough), but does not stop exuding *joie de vivre* and sensuality from every pore. Of a Brazil capable of refining the form of coexistence without losing the fire of affections. A nation that educates and refines but preserves the flame of Yoruba vitality filtered by Portuguese tenderness. A nation that saves, invests in its future, and takes care of social security, but does not give up the Tupi availability for joy and merriment. Does the idea of a Brazilian civilization make sense? An affirmative answer does not have to imply any kind of xenophobic outburst or cultural hubris. What it implies is the identification of our values and an effective adherence to them. What it implies is the rejection of the belief that we cannot be original – that we must resign ourselves to the condition of clumsy imitation or flawed copy of the model instilled in us by the “rich world”. The biodiversity of our geography and the social diversity of our history are the main Brazilian assets in the face of a civilization in crisis. – May the hardship and brevity of the present times neither depress nor deceive or discourage us. The future is constantly redefined - it responds to the strength and boldness of our will. From the pitch black of the thick night comes the dawn of the morning.*

**Trópicos utópicos: uma perspectiva brasileira da crise civilizatória / Eduardo Giannetti. – 1ª ed. São Paulo: Companhia das Letras, 2016*

PRESENTATION

Brazil positioned as a **global leader** in the bioeconomy via **innovation** focused on **knowledge, products and services** with higher **added value** for **tangible, resilient, regionalized** economic development, **reconciled** with the **valorization of socio-biodiversity** and particularly recognized by the **social inclusion and poverty reduction.**

Based on the answers offered by the Leaders Committee, we can affirm that the aspiration for the national bioeconomy strategy looks to harmonize relevant and tangible economic development with environmental conservation and social inclusion, evidencing an ambitious and innovative trajectory for the country. This vision aims to transform Brazil into a global bioeconomy leader, recognizing and valuing both its potential for biomass and food production, as well as its unique biodiversity, a strategic economic asset, and a pillar for sustainable development.

The central axis of this aspiration shows the strengthening and expanding of the bioeconomy segment in the Brazilian GDP, through modern bioindustrialization, which involves the development of new sectors, technologies associated with Industry 4.0, innovative products, processes, and services. The strategy encompasses the creation of an economy that is resilient and adaptable, characterized by high productivity, knowledge generation and local value aggregation, distributing wealth and promoting quality of life.

The ambition is to stimulate a bioeconomy that minimizes the impact on natural resources and incorporates circular economy practices, which promotes socially inclusive economic activities. This involves the development of social technologies, the promotion of biodiverse and sustainable agricultural systems. In addition, the aim is to create infrastructures and technologies that reduce production costs, increase competitiveness, and attract investments, contributing to socioeconomic development in all biomes in the country.

As a priority, the reinvention and valorization of local economies must occur, especially the economy of the Amazon. The national aspiration for the Brazilian bioeconomy goes beyond cultural identity and environmental conservation. It emphasizes tangible and lasting economic development goals. A desirable transformation balances in an innovative way

the sustainable use of natural resources with economic growth, social inclusion, and the appreciation of biodiversity.

This combined picture is by no means exhaustive. It provides a step towards translating the diverse aspirations of the leaders consulted into a National Bioeconomy Strategy for Brazil.

CAPABILITIES

The capabilities listed here reflect not only the immediate but mainly the long-term needs of bioeconomy. Below, we present the capacities identified by the Leaders Committee in the context of the aspirations for the national bioeconomy.

- **Interdisciplinary Knowledge Production and Application:** Ability to generate new knowledge by combining indigenous and non-indigenous knowledge and apply it in innovative ways in areas such as conservation, technology, and economic development. This involves promoting an interdisciplinary approach to the bioeconomy.
- **Education for Sociobioeconomy:** Development of educational and training programs focused on the bioeconomy, preparing professionals with an integrated understanding of science, technology, and innovation (ST&I), who are ready to face the challenges and opportunities of the socio-bioeconomy. Skills developed by training professionals in critical areas such as engineers in modalities related to life sciences, production engineers, administrators, economists, anthropologists, sociologists, and political scientists.
- **Environmental Impact Management:** Strengthening skills to assess the impacts of economic activity on ecosystems, particularly in relation to biomass production and land use. It includes the ability to implement production practices that minimize the risks of deforestation and environmental degradation.
- **Multisectoral Coordination and Collaboration:** Ability to integrate and coordinate efforts between different sectors – government, private sector, academia, indigenous and local communities, and non-governmental organizations – for the formulation and implementation of bioeconomy strategies.
- **Fostering Innovation and Investment in RD&I:** Establishing an environment conducive to innovation, with substantial investments in research, development, and innovation, focused on sustainable solutions for the bioeconomy. This includes supporting applied research that looks to minimize negative environmental impacts.
- **Review, Adaptation and Implementation of Public Policies:** Ability to review, adapt and implement regulatory frameworks and public policies that encourage sustainable bioeconomy practices, including specific legislation that promotes the conservation and sustainable use of biodiversity.

- **Infrastructure and Financing:** Resources such as technology centers, university campuses and public financing mechanisms that support education, research, and innovation in bioeconomy. Inclusion of tax and credit incentives for socio-biodiversity products and sustainable practices.
- **Development and Implementation of Sustainable Technologies:** Technical capacity to create, adapt and implement technologies that support the bioeconomy, including regenerative agriculture practices, low-impact production systems and the valorization of socio-biodiversity products.
- **Promotion of Social Inclusion and Equitable Distribution:** Development of strategies and mechanisms that ensure social inclusion and a fair distribution of the economic benefits derived from the bioeconomy, contributing to the reduction of inequalities and the promotion of quality of life.

This list focuses on the essential capabilities that must be developed during the implementation of the bioeconomy strategy. Each point highlights a critical aspect necessary for the transformation of aspirations into concrete results, promoting an integrated and sustainable approach to economic development, environmental conservation, and social inclusion.

The successful execution of the aspirations indicated by the Leaders Committee will have as a natural consequence the development of this complex set of capabilities. The development of these capacities represents the real vanishing point in the perspective of building the Brazilian bioeconomy. The construction of these capacities is decisive to transform the living conditions of people inserted in the bioeconomy.

These aspirations and capacities form the basis for a national bioeconomies strategy. However, to translate them into effective actions, it is essential to understand the current context in which this strategy will be implemented, considering the opportunities, challenges, and existing risks.



CONSENSUS AND PRIORITIES

In this chapter, the main consensuses and priorities identified throughout the research process will be presented and organized into five major blocks: Opportunities, Challenges and Risks; strategic objectives for the national bioeconomy; the economics of the bioeconomy; governance and the role of the State; and engineering, education and work in the bioeconomy. Each block explores critical dimensions for the strategic planning of the Brazilian bioeconomy, highlighting the points of convergence and priority areas for action.

To obtain these results, a dialogue was established between leaders selected for their experience in topics related to the bioeconomy. The Delphi method was used, a structured group communication technique that seeks to obtain consensus among experts on complex issues and future forecasts. This method reduces group bias, promotes independent thinking, and allows for the integration of diverse specialized perspectives, addressing complex problems in a systematic way.

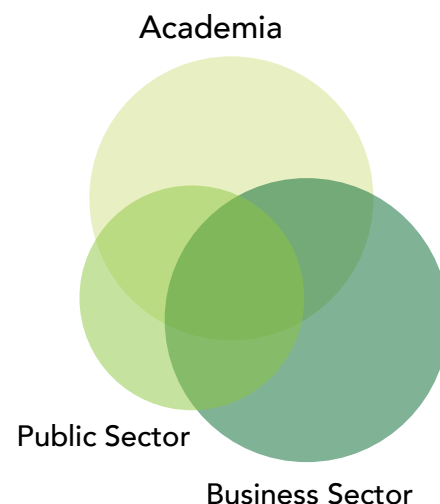
The iterative process of the Delphi method involved the application of questionnaires in two successive rounds, with participants receiving anonymized results on the group's responses. This allowed experts to refine their opinions based on the perspectives of others, avoiding the influence of factors such as status or dominant personality that can occur in face-to-face discussions. With the same objective, the sources of information used to prepare the questionnaires, and which will be presented below, were also not identified to the participants during the research. The engagement of the participants resulted in more than 2,300 responses and 143 comments, bringing reflections with multiple points of view.

The Leaders Committee was structured to bring diverse views including renowned scientists, researchers, professionals with experience in the government sector, business leaders, social entrepreneurs, representatives of non-governmental organizations and a representative of the indigenous community, as well as professionals with experience in financial and development institutions.

This diversity of backgrounds, experiences, and areas of activity reflects the complexity inherent in the development of a national bioeconomy strategy, seeking to build a comprehensive and balanced vision capable of guiding policies and actions that reconcile the different perspectives for the national bioeconomy. The final composition with 25 people, which can be consulted in ANNEX I, resulted in a distribution of experiences of 39% from the university, 23% from the government and 38% from companies, estimated by the years of professional experience of the participants.

The Leaders Committee was involved in the research process in two main phases. The first aimed to build a **consensus** on diagnoses and proposals formulated by different institutions of Brazilian society. In the second phase, the objective was to seek **prioritizations** made by these leaders.

The results discussed here reflect the richness of the contributions received and offer a set of recommendations to support the creation and implementation of a comprehensive, inclusive, and transformative national bioeconomy strategy in favor of a development model that reconciles economic, social and environmental objectives.



OPPORTUNITIES, CHALLENGES AND RISKS

Successful strategic planning requires careful analysis of the opportunities, challenges, and risks involved, to identify the most promising paths and actions with a quick return. In this way, it is possible to anticipate potential obstacles, mitigate threats, and direct efforts and resources to put the odds in favor of the objectives aspired to. The Strategic Plan of the National Council of the Legal Amazon 2020-2030 (CNAL) and the document “Visions on bioeconomy in the Amazon: Opportunities and challenges for Embrapa’s performance” address these factors.

The CNAL plan highlights the importance of the convergence of efforts to achieve sustainable development, preserving the ecosystem and promoting economic and social growth. It proposes a sustainability agenda that emphasizes dialogue, education, legality, and commitment to sustainable development, establishing general and sectoral strategic objectives. The Embrapa study identifies opportunities for improving the quality of life, regional development, valuing biodiversity, and productive inclusion, in addition to recognizing challenges such as *greenwashing*, potential social injustices, and risks related to the increase in demand for products from the Amazon.

The publication resulting from the week of events “Brazil and the Future of Bioeconomy”, promoted by the Institute of Engineering, in turn, explores the opportunities and challenges of Brazil in bioeconomy, highlighting the importance of cooperation between public institutions, academia and private initiative. The document addresses topics such as **bioeconomy and ethics, agriculture, energy, health, and public policies**, emphasizing the need for investments in science and technology, the promotion of a stable and competitive business environment, and the appreciation of Brazilian biodiversity as a differential for a development path.

OPPORTUNITIES

In the context of the creation of a National Strategy, **OPPORTUNITY** is a favorable situation or set of circumstances, which can be used to achieve strategic goals or objectives. The identification of opportunities occurs through a comprehensive analysis, which considers both internal strengths and external environmental factors, present and predicted for the future. Ideally, an opportunity should be aligned with national priorities, have significant potential for positive impact, and be feasible within available or attainable resources and capabilities.

This stage of the research was animated by the report “Opportunities and Challenges of the Bioeconomy” by the Center for Management and Strategic Studies (CGEE), prepared in April 2020, which presents a broad view of the expectations of the bioeconomy in Brazil, consolidating the opinion of various sectors on the potentialities and difficulties of this new development model. The document is the result of the joint work of the CGEE and the Ministry of Science, Technology and Innovation (MCTI). The questions related to the opportunities and challenges of the Brazilian bioeconomy present in the Delphi questionnaire were based on the definitions and information presented in this study.

The following questions were presented to the participants in two distinct phases of the research: in Phase I, they were asked to evaluate the opportunities for the development of the bioeconomy on a five-point scale of agreement, while in Phase II, they were asked to prioritize these same opportunities in terms of their importance to Brazil, using a three-level scale.

Phase I - Assess opportunities for bioeconomy development

STRONGLY
DISAGREE

DISAGREE

NEUTRAL

AGREE

STRONGLY AGREE

Phase II - Prioritize the opportunities for bioeconomy development for Brazil

AVERAGE

HIGH

VERY HIGH

As can be seen in Table 1, in only one round of the questionnaire (Phase I) it was possible to verify a high degree of consensus among the leaders consulted regarding the opportunities presented in the CGEE study (2020) for the development of the Brazilian bioeconomy.

Also in Phase I, in addition to verifying the elevated level of consensus, groupings were created based on the incorporation of 33 opportunities listed for the Brazilian bioeconomy by the Committee of Leaders and in the works consulted, they are:

Sustainable development and environmental conservation

Opportunity to leverage Brazil's rich biodiversity for sustainable development. With a focus on biodiversity conservation, environmental services, sustainable use of socio-biodiversity products, and promotion of forest genetic resources, Brazil can position itself as a global leader in environmental management. These opportunities not only support the preservation of natural heritage but also open avenues for innovative and sustainable products and services that can drive economic growth.

Science, Technology and Innovation for a new market

Opportunity for Brazil to diversify its economy and position itself as a leader in sustainable development, exploring new market niches in high value-added sectors. The transition to a development model based on sustainability responds to the growing global demand for green products and processes, placing the country in an advantageous position in the international market. Bioeconomy emerges as a promising field, with the potential to transform traditional sectors such as agribusiness, energy, and pharmaceuticals through the introduction of innovative, more efficient, and sustainable materials and products.



Social inclusion and cultural enhancement

Opportunities for Brazil to leverage its cultural and natural heritage to promote social inclusion and regional development. Valuing this heritage opens avenues for sustainable tourism and education, while broader social and political participation ensures that everyone has a voice in decisions that affect them. The inclusion of rural families in productive activities and the appreciation of traditional knowledge contribute to sustainable development and social justice. Develop inclusive public policies that focus on the biodiversity economy that promotes benefits for all communities, especially those that are currently in the most vulnerable conditions and promoting development that respects the country's cultural and natural diversity.

Climate change mitigation and energy transition

Opportunities associated with the mitigation of greenhouse gas emissions and progress in the energy transition. Faster adoption of renewable energy sources, sustainable systems and mechanisms such as REDD+ can reinforce Brazil's position as a key player in the global effort against climate change. This not only contributes to global environmental goals, but also opens new markets and investment opportunities in green technologies.

Employment, income generation and regional development

Opportunities for job and income generation, reduction of regional inequalities and improvement of territorial and environmental management. They aim to leverage the Brazilian bioeconomy as an engine for job creation, increased food security, and the promotion of equitable development in different regions.

Health and well-being

The economy of the future holds numerous opportunities for the promotion of health and well-being through the bioeconomy. It focuses on the interconnectedness of human, animal, and environmental health, advocating for an integrated approach to health promotion and disease prevention.

International positioning

The strengthening of the national production of inputs, aiming to reduce dependence on imports and promote economic autonomy. Through the formation of support networks and articulation between sociobiodiversity actors, with the stimulus to collaboration, knowledge exchange and innovation. In addition, by improving its international image with a focus on sustainable development, the country can attract investments and open new markets.

Table 1

OPPORTUNITIES OF THE BIOECONOMY	SOURCE	Phase I ¹ Agreement	Phase II ² Prioritization
A new, sustainable, model for the country's development and growth with the potential to generate high value-added products and services.	CGEE	95%	1
World market trend for sustainable products and processes, addressing the desires of a more conscious society.	CGEE	90%	2
Increased production capacity of inputs in Brazil, reducing dependence on imported products.	CGEE	65%	
Development of new products from renewable sources to replace non-renewable and increasingly scarce inputs.	CGEE	95%	
Brazil can be placed on another level of competitiveness with bioeconomy products.	CGEE	100%	
Positive impacts on production chains and environmental conservation³	CGEE		3
Prospects for developing innovative materials and products that are more efficient and better than existing ones.	CGEE	100%	
Agribusiness, energy and pharmaceuticals, as possible leading sectors for the advancement of the bioeconomy in Brazil.	CGEE	40%	
Development of value production chains, focusing on the entrepreneurship and innovation ecosystem, encouraging bioplants and biorefineries in the Amazon region.	CGEE	80%	

In **Phase II**, the following items were evaluated as the highest priority:

- 1.** New, sustainable, model of development and growth in the country with the potential to generate products and services with high added value;
- 2.** World market trend for sustainable products and processes, addressing the desires of a more conscious society; and
- 3.** Positive impacts on production chains and environmental conservation.

- 1** Sum of the percentages of the answers "Agree" and "Strongly agree".
- 2** Weighted average of the "Very High (10)", "High (4)" and "Medium (1)" prioritizations.
- 3** Question included in PHASE II of the research.

CHALLENGES

In the context of creating a National Strategy, a **CHALLENGE** is a significant obstacle, issue, or problem that needs to be addressed to achieve strategic objectives. Challenges can arise from economic, social, environmental, and political sectors, requiring focused attention and resources to overcome. They often involve complexities that require innovative solutions and collaboration across different industries.

To assess the challenges related to the advancement of the bioeconomy, we decided on points presented by the Strategic Plan of the National Council of the Legal Amazon 2020-2030 (**CNAL**) and by the CGEE document: **ODBio** - Subsidies for the Brazilian STI strategy in bioeconomy. Participants were asked: in Phase I, to assess the degree of agreement with these challenges using a five-point scale, and in Phase II, to prioritize the importance of overcoming them using a three-level scale.

Phase I - Assess the challenges that must be overcome for the development of the bioeconomy

STRONGLY
DISAGREE

DISAGREE

NEUTRAL

AGREE

STRONGLY AGREE

Phase II - Prioritize the challenges that must be overcome for the development of the bioeconomy

AVERAGE

HIGH

VERY HIGH

Again, the evaluation showed an important level of agreement in relation to the challenges pointed out in the publications, as shown in Table 2. However, despite the agreement of the majority, there was divergence regarding the importance of the item “Adapting geological, biological and renewable resources in an innovative and sustainable way in favor of production systems”.

In addition to the objective answers, another 32 challenges for the Brazilian bioeconomy were identified by the Committee of Leaders in Phase I and in the consulted works. They were organized by thematic and semantic similarities into 7 groupings.

Regulatory and infrastructure barriers

Physical and regulatory challenges that hinder the development of the bioeconomy. The lack of infrastructure, compounded by a complex regulatory environment, creates barriers to growth. Addressing these challenges requires an efficient legislative framework capable of promoting legal certainty, as well as significant investments in infrastructure, especially in critical areas such as the Amazon, to create a safer and more conducive environment for bioeconomic activities. The development of the bioeconomy depends on a stable legal and political framework.

Financial and economic challenges

Financial constraints and an unattractive business environment present critical challenges to the advancement of the bioeconomy. Limited access to finance, together with the need for better value for bioeconomy initiatives, stifles innovation and investment. Solutions include creating financial mechanisms that support bioeconomy ventures, especially for small-scale farmers and family farmers, and improving the overall business environment to attract investment.

Education, training and cultural change

Overcoming educational gaps and ensuring that the bioeconomy benefits everyone, especially family farmers, indigenous and traditional communities, are crucial challenges. This involves not only improving education and training, but also promoting a cultural shift towards sustainable practices in relation to the environment and the processing of raw materials locally to directly benefit the region. Addressing these challenges requires a multidimensional approach that combines policy reform, infrastructure investment, engagement with local communities, promoting innovation, and formalizing business.



Social and community engagement

The importance of community engagement in the bioeconomy, especially indigenous and traditional peoples, is highlighted here. The challenge lies in establishing effective communication and collaboration between the public and private sectors, and these communities. Emphasizing participatory regulation and leveraging social technologies driven by local knowledge are necessary steps towards inclusive and sustainable bioeconomic development.

Innovation and strategic vision

One of the main challenges is the low level of innovation and the absence of a cohesive strategic vision for the Brazilian bioeconomy. Overcoming this requires the promotion of an environment that encourages research and innovation, the increase in the intellectual capital of research centers, and the development of clear and actionable strategies that align with the country's bioeconomic potential.



Environmental and climate concerns

The vulnerability of bioeconomy to climate change, together with the need for sustainable environmental practices such as river transport, underscores the need to integrate climate resilience into bioeconomic planning. Recognizing the role of forests and biodiversity as central to the bioeconomy is vital for aligning efforts.

Table 2

CHALLENGES OF THE BIOECONOMY	SOURCE	Agreement ⁴ Phase I	Prioritization ⁵ Phase II
Adapt geological, biological and renewable resources in an innovative and sustainable way in favor of production systems	CNAL	61%	
To use natural resources responsibly, which meet the needs of current and future generations	CNAL	100%	
To value intellectual capital in research centers and academia	CNAL	95%	1
Increase the volume of research on biodiversity, with emphasis on the search for results that contribute, in the medium and long term, to the conservation of biodiversity and the expansion and densification of the region's production chains	CNAL	95%	2
To foster the expansion and dissemination, throughout the Legal Amazon, of technological research centers supported by an efficient ST&I system	CNAL	86%	
Establish bioeconomy research systems for the Legal Amazon, aligning with market demands and technology transfer mechanisms	CNAL	90%	3
Consolidate the formation and dissemination of a portfolio of marketable products from the Amazon bioeconomy, in addition to promoting the "Amazon Brand"	CNAL	90%	
Regulatory environment	ODBio	95%	
Lack of vision and clear strategies for the bioeconomy in Brazil	ODBio	95%	
Valuation of bioeconomy initiatives	ODBio	95%	
Unsafe environment and lack of infrastructure for activities in the Amazon region	ODBio	95%	

In **Phase II** of prioritization of challenges, the three items that obtained the highest priority in the evaluation of the Leaders Committee were:

- 1.** To value intellectual capital in research centers and academia;
- 2.** Increase the volume of research on biodiversity, with emphasis on the search for results that contribute, in the medium and long term, to the conservation of biodiversity and the expansion and densification of the region's production chains; and
- 3.** Establish Bioeconomy Research Systems for the Legal Amazon, aligning with market demands and technology transfer mechanisms.

⁴ Sum of the percentages of the answers "Agree" and "Strongly Agree".

⁵ Weighted average of the "Very High (10)", "High (4)" and "Medium (1)" prioritizations

RISKS

In the context of the creation of a National Strategy, a **RISK** is any event, obstacle or potential condition that may affect the objectives of the strategy or the implementation of its initiatives, positively or negatively. These risks can originate from economic, environmental, social, technological and geopolitical factors. Identifying and monitoring these risks is crucial to ensure the resilience and adaptability of the strategy.

The risk of the outdated incorporation of technological advances from Information and Communication Technologies (ICT), Industry 4.0 and Bioeconomy is highlighted by the National Strategy for Economic and Social Development (ENDES) as critical. This risk is particularly relevant in the global perspective, in light of the rapid and profound technological and industrial transformations currently underway. Brazil's delayed technological progress represents a critical risk to its productivity and competitiveness. In this mapping stage, the risks that were part of the research questionnaire were defined by a group of five professionals who work in this discipline.

The research addressed the risks associated with the non-development of the Brazilian bioeconomy in two stages: in Phase I, participants assessed their level of agreement with the risks presented using a five-point scale, while in Phase II, they rated the potential impact of these risks for Brazil on a three-level scale of priority.

Phase I - Assess the risks of non-development of the Brazilian bioeconomy

STRONGLY
DISAGREE

DISAGREE

NEUTRAL

AGREE

STRONGLY AGREE

Phase II - Prioritize the risks with the greatest impact on Brazil resulting from the non-development of the bioeconomy

AVERAGE

HIGH

VERY HIGH

As can be seen in table 3, the result of the survey with the Leaders Committee once again showed consensus on the importance of the mapped risks, except for the risk of retaliation by the international market. In addition, another 51 risks were indicated by the Leaders Committee and were organized into the following groupings:

Ecosystem collapse, depletion of vital resources and climate change

Risks associated with the environmental challenges faced by the Brazilian bioeconomy, emphasizing the critical need for sustainable strategies for resource management and conservation. Risks range from biodiversity loss, deforestation and depletion of essential resources, to broader impacts on ecosystems that underpin quality of life and economic activities. Addressing these risks requires a comprehensive approach that integrates environmental conservation with economic development, adaptation and climate change mitigation actions.

Deepening inequalities and escalation of socio-environmental conflicts

Risks associated with socioeconomic disparities, governance challenges, and erosion of cultural identity within the bioeconomy. These risks highlight the potential for increased social inequality, the marginalization of vulnerable communities, and the erosion of traditional knowledge and cultural heritage. Effective governance, inclusive policies, and active participation of all stakeholders, especially indigenous and local communities, are vital to avoid this scenario and ensure the most equitable distribution of benefits and the promotion of social justice within the bioeconomy.

Regulatory obstacles

The specific regulatory challenges of the Brazilian bioeconomy are highlighted here, especially in the effective implementation of the regulation that already exists. The risks identified in this grouping point to the need for coherent public policies that facilitate the development of the bioeconomy. Addressing these challenges requires a concerted effort to harmonize regulations, promote inter-agency coordination, and ensure that policies are conducive to innovation and growth in the bioeconomy.

Economic instability and excessive external dependence

Economic vulnerabilities and market dependencies can undermine the potential of the Brazilian bioeconomy. Risks such as dependence on external markets, land speculation, and increased demand for Amazonian products highlight the need for diversified markets and sustainable land management practices. Developing strategies to mitigate these risks involves fostering a competitive business environment, encouraging investment in higher-value-added businesses, and ensuring diversified supply chains.



Technological stagnation and unsustainable production practices

The technological and innovation barriers that can stifle the growth of the Brazilian bioeconomy. The critical need for governance in agroforestry production is emphasized, addressing pesticide contamination and overcoming challenges related to investments in science, technology and innovation (ST&I). Strengthening the technological base of the bioeconomy requires significant investment in research and development, fostering partnerships between the productive sector and academia and developing a skilled workforce to drive business legalization, innovation, and sustainable production practices.

Illicit appropriation of genetic and cultural heritage

Risks of irregular use of natural resources and traditional knowledge, especially biopiracy and misappropriation of cultural heritage, with negative impacts on the preservation of biodiversity, development of the bioeconomy, and the fair and equitable sharing of benefits with traditional peoples. Addressing these risks is essential to protect Brazil's rich biodiversity and the rights of indigenous and local communities. Strategies to combat these challenges include strengthening legal protections, promoting equitable benefit-sharing models, and strengthening enforcement against illegal activities.

Risks of socioeconomic disruption, emerging biological threats, and geopolitical disputes in the bioeconomy era

Complex and interconnected risks that the Brazilian bioeconomy may face in a global context of rapid technological and geopolitical change. These risks range from the intensification of social conflicts and rural exodus due to advances in automation to the emergence of new biological threats resulting from genetic manipulation and the military use of pathogens. It also includes the intense competition between powers for strategic resources essential to new technologies and the risk that Brazil will lose the opportunities presented by the bioeconomy revolution if it is unable to position itself competitively in this new scenario.

Table 3

BIOECONOMY RISKS	SOURCE	Agreement ⁶ Phase I	Prioritization ⁷ Phase II
Limited wealth generation and the potential reduction of Brazilian biodiversity	Committee	95%	2
Long-term damage to the economy from the effects of climate change on hydrological cycles	Committee	95%	3
Losing the economic potential of Brazilian biodiversity to companies from abroad	Committee	79%	
Increased social inequality. Risk of biodiversity capital accumulation by large companies	Committee	94%	1
Retaliation by the international market	Committee	50%	

In **Phase II** when it came to prioritizing risks, the results that indicated the three items of highest priority were:

1. Increased social inequality. Risk of biodiversity capital accumulation by large companies;
2. Limited wealth generation and the potential reduction of Brazilian biodiversity; and
3. Long-term losses in the economy with the effects of climate change on hydrological cycles.

⁶ Sum of the percentages of the answers “Agree” and “Strongly agree”.

⁷ Weighted average of the “Very High (10)”, “High (4)” and “Medium (1)” prioritizations.

The Committee pointed out exacerbating social inequality as a risk, since the economic benefits of biodiversity can be concentrated in large companies, to the detriment of local communities and traditional peoples. This concern is shared by the leaders and has been the emphasis of the work of several institutions. *Amazônia 4.0*, for example, arises with the motivation to mitigate this risk. The fundamental principle of the project is to scale up the bioeconomy market through the processing of production chains, ensuring that the added value is realized and used by local communities, with the use of state-of-the-art technology adapted to local conditions (Nobre and Nobre, 2019).

The probability of this risk increases as Brazil (State and society) does not invest in scientific, technological and entrepreneurial development to take advantage of its bioeconomic potential. When analyzing the history of the economic development of Brazil – a supplier of raw materials – it can be said that this is the expected (or most likely) development, unless a strategy to develop specific capacities is elaborated and implemented in the sector.

Regarding the possibility of “retaliation by the international market” imposed on the Brazilian bioeconomy, half of the leaders attributed significant importance to this risk, which stands out because it is the only one among five risks they assessed as being of little relevance. Regarding concerns related to the adoption of sustainable practices in the management of

biodiversity in Brazil, especially in the production of commodities in deforested areas, this stance suggests the need for a careful assessment of the situation. The leaders recognized the need to balance economic development with environmental protection, opting for an approach that weighs economic demands with the urgency of adapting to more sustainable environmental practices.

In the specific case of the Amazon Rainforest, its vast vegetation cover plays a crucial role in the hydrological cycle through transpiration, where trees absorb water from the soil and release part of it in the form of water vapor into the atmosphere, contributing to the formation of “flying rivers”. These rivers carry moisture to various parts of the continent, including agricultural regions of utmost importance.

In addition to the concerns already identified, the possibility of lasting damage to the economy due to climate change in rainfall patterns and the availability of water resources becomes a critical element to be considered. The leaders pointed out the importance of preventive and adaptation measures to mitigate such impacts and ensure the resilience of the economic system in the face of these climate variables that are increasingly unstable and unpredictable. It is also noteworthy **that the most significant economic effects can occur in regions outside the Amazon, which depend crucially on the water ‘pumped’ by the forest.**

It should be noted that all the risks emphasized by the Leaders Committee focus on the economic aspect, signaling possible losses to the Brazilian economy, whether due to issues related to international relations, income inequality or the impacts resulting from the change in hydrological regimes for agriculture.

The analysis of this complex scenario, with its potentials and threats, is essential to define clear and realistic strategic objectives for the development of the bioeconomy in Brazil. These objectives should seek to take advantage of the identified opportunities, overcome the mapped challenges, and mitigate the projected risks.



STRATEGIC OBJECTIVES FOR THE NATIONAL BIOECONOMY



The analysis of national bioeconomy strategies in other countries shows not only the presence, but also the centrality of the determination of concise and well-defined objectives, which serve as a lever for planning and implementation actions.

To begin the dialogue with the Leaders Committee on the objectives to strive in the development of the Brazilian bioeconomy, focus turned to international strategies as examples. The European Union’s Bioeconomy Strategy (EUBE) and its 2018 Action Plan served as a reference for the evaluation of objectives.

Once again, the results of the survey showed a high degree of consensus among leaders around the objectives outlined for the national bioeconomy, as can be seen in table 4.

Table 4

OBJECTIVES OF THE NATIONAL BIOECONOMY	SOURCE	Agreement⁸ Phase I
Managing natural resources sustainably	EUBE	96%
Ensuring food security	EUBE	81%
Reduce dependence on non-renewable resources	EUBE	91%
Mitigating and adapting to climate change	EUBE	91%
Promote the sustainable use of Brazilian biodiversity in a sustainable way to generate wealth	Committee	91%

⁸ Sum of the percentages of the answers “Agree” and “Strongly agree”.

Despite the elevated level of agreement with the objectives presented, another 42 objectives more specifically related to the Brazilian reality, were indicated by the Leaders Committee and are organized into seven large groups below.

Bioeconomy based on socio-biodiversity

Promote a new model of economic development for Brazil based on the use of biological resources and traditional knowledge to foster the bioeconomy, with an emphasis on the development of value and wealth chains free of deforestation, which value the deep interdependence between biological diversity and sociocultural diversity. To achieve these objectives, investing in research, development, and innovation as well as seeking solutions based on nature and the circular economy becomes paramount. In addition, it proposes to develop the bioeconomy based on concepts such as "good living", which reflect the cultural values of indigenous peoples.

Conservation and enhancement of biodiversity

Preserve natural resources and promote Brazilian biodiversity, not only as a natural heritage, but also as a strategic pillar for the country's sustainable development. The integrated approach of conservation with sustainable development is essential, and it is proposed to deepen the synergy between sustainable agricultural practices and the economic valorization of biodiversity. In this way, policies that promote the research and development of products from biodiversity and inserting them in an innovative way in the national and global economy will result in creating employment and income opportunities that respect the balance of ecosystems.

Valuing traditional knowledge

To realize a successful bioeconomy requires incorporation of traditional knowledge. Recognizing the ancestral wisdom and sustainability of indigenous and community practices, this objective seeks to protect and promote this knowledge, providing legal certainty and adequate territorial preservation. It is essential to recognize, value and learn from the capacities of these communities to live in balance with biodiversity, integrating their knowledge into the development of a bioeconomy that is based on cultural and biological diversity.



Trademarks, intellectual and territorial property

The development of collective trademarks and geographical indications will strengthen the identity and competitiveness of Brazilian products. The strategy includes improving territorial governance, ensuring that the management of territories is aligned with the principles of the bioeconomy. Thus, it is proposed to promote greater protection and appreciation of regional specificities.

Economic inclusion with technological innovation

Simplifying regulations for family agribusinesses and small producers will enhance economic and social inclusion, also encouraging innovation and sustainable technological development. The promotion of a solidarity economy and investment in science and technology are fundamental.

Public policies and social development

Public policies on job creation, income generation and the promotion of food security, with an approach that integrates environmental, economic and social issues will serve as tools for equitable and sustainable social development. It is essential that policies are designed to promote citizenship education and the reduction of inequalities, ensuring that the benefits of the bioeconomy are widely shared. Public policies must be developed in order to promote the convergence of industrial development, environment, climate and innovation policies.

Social empowerment and food sovereignty

Empower civil society organizations and support the management of community enterprises, increasing participation and social protagonism. As a precondition for these objectives, democratic access to land is essential. This ambition also highlights that the generation of wealth must be a means to promote human rights, value cultures, reduce inequalities and ensure access to basic resources, such as sanitation. These actions converge on a development model centered on social well-being and the autonomy of communities.

Table 5

OBJECTIVES OF THE BIOECONOMY	SOURCE	Prioritization ² Phase II
Stimulate the solidarity economy and strengthen civil society organizations, community enterprises and collective brands.	Phase I	
To add value and technologies to the national biodiversity product chains.	Phase I	1
Incorporate biodiversity products and services into Brazil's productive matrix.	Phase I	
Establish the bioeconomy based on sociobiodiversity, with a focus on the conservation of standing forests and rivers.	Phase I	2
Promote the well-being and ensure the development of indigenous populations and traditional communities.	Phase I	
Managing natural resources sustainably	EUBE	
Mitigating and adapting to climate change	EUBE	
Reduce dependence on non-renewable resources from domestic and foreign sources	EUBE	
Ensuring food security	EUBE	
Promote the use of Brazilian biodiversity in a sustainable way to generate wealth	Committee	3

In **Phase II** when it came to prioritizing objectives, the committee prioritized:

- 1.** To add value and technologies to the national biodiversity product chains;
- 2.** Establish the bioeconomy based on sociobiodiversity, with a focus on the conservation of standing forests and rivers; and
- 3.** P3. Promote the use of Brazilian biodiversity in a sustainable way to generate wealth.

⁹ Weighted average of the "Very High (10)", "High (4)" and "Medium (1)" prioritizations.

The Leaders Committee established as priorities in Phase II to boost the bioeconomy, strengthen the value chains of Brazilian biodiversity and promote its sustainable use to generate wealth. By integrating biodiversity products and services into the country's economy, Brazil can strategically take advantage of natural resources. Seeking a bioeconomy based on socio-biodiversity, reconciling economic development and environmental conservation benefits all communities involved.

The specific objectives for the Amazon Bioeconomy will be detailed below, considering the enormous potential of this region to leverage Brazil's sustainable economic growth.

Strategic objective for the Amazon bioeconomy

The Strategic Plan of the National Council of the Legal Amazon 2020-2030, released in December 2022, presents in the section related to the Sustainable Strategic Objective the following description of the desired end state:

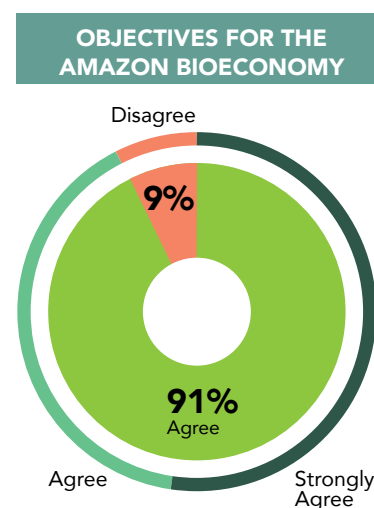
“An adequate business environment where the bioeconomy is established in order to promote sustainable development in the region, with the expansion of local production chains and with greater retention of value by the communities inserted in the process”

Resolution No. 5/2022 - Strategic Plan of the National Council of the Legal Amazon 2020-2030

The Leaders Committee was invited to assess whether the strategic objective was aligned with the expected objectives for the development of the bioeconomy in the Amazon. More than 90% of the leaders consulted agreed that this phrase summarizes the Strategic Objectives for the Amazon bioeconomy.

Despite the consensus, the strategic objective statement has generated discussions that propose a broader approach to the Amazon bioeconomy, not limited to extractivism. It is necessary to create value chains that keep the forest standing, incorporating activities that add value through knowledge and technology. This includes using biodiversity to develop products in the pharmaceutical, cosmetic and fine chemical sectors, among others.

It is also important to support agroforestry systems managed by traditional communities, which combine conservation with production. In economic terms, it is necessary to move beyond sustainable development, seeking an economic model that promotes environmental recovery and social inclusion, in line with the Sustainable Development Goals (SDGs). This involves improving the quality of life of local communities, respecting indigenous rights, ensuring territorial autonomy, and strengthening governance. To do so, investments in infrastructure, especially in energy and technology, will be necessary, in addition to overcoming logistical and regulatory challenges.



A possible revised strategic objective statement for Amazon bioeconomy that incorporates the criticisms and suggestions of the Leaders Committee is:

A business environment with diversified socio-biodiversity value chains generates wealth from the standing forest and the restoration of degraded areas. An environment supported by activities of greater added value, intensive in knowledge and technology also empowers local communities by demonstrating value of their traditional knowledge through the fair distribution of the benefits generated with the communities included in the process.

After the strategic vision for the Amazon bioeconomy, the general objectives for its implementation were examined.

General objectives for the Amazon bioeconomy

The results of phases I and II of the consultation with leaders, presented in table 6, revealed a consensus around a bioeconomy that generates wealth with forest conservation and restoration, promoting social justice and valuing the knowledge of traditional peoples. In Phase I of the search for consensus there was unanimity in promoting the generation of wealth with forest conservation and reducing social inequality by fostering the economy of local communities. The restoration of deforested forests and the empowerment of traditional culture and knowledge also received broad support. The expansion of the participation of foreign companies was questioned.

Table 6

OBJECTIVES FOR THE AMAZON BIOECONOMY	Agreement ¹⁰	Prioritization ¹²
	Phase I ¹¹	Phase II
To empower national companies so that they can be inserted in the bioeconomic innovation ecosystem, aiming to scale up production	-	
Develop a value addition to the products of terrestrial and aquatic ecosystems through modern bioindustrialization	-	
Involve foreign companies for access to markets and cooperation for export, prioritizing national enterprises	-	
Visualize long-term strategies for the Amazon, considering the time of consolidation of community enterprises in the region	-	
Establish mechanisms for the fair and equitable sharing of benefits from the bioeconomy	-	3
Foster the innovation ecosystem related to the development of bioeconomy products and processes, expanding the participation of start-ups, accelerators, national and foreign companies	-	
Stimulate the production of biomass in deforested and degraded areas, aiming at environmental recovery	-	
Promote the generation of wealth with forest conservation	100%	2
Restoring the already deforested forest	95%	1
Empower existing local culture and traditional knowledge	95%	
Reduce social inequality by fostering the economy of traditional communities, native peoples, quilombolas and family farmers	100%	
Scale up production (expanding the participation of foreign companies) ¹³	45%	

¹⁰ Sum of the percentages of the answers "Agree" and "Strongly agree".

¹¹ Part of the questions were inserted only in PHASE II of the research.

¹² Weighted average of the "Very High (10)", "High (4)" and "Medium (1)" prioritizations.

¹³ In Phase II of the survey, this question was changed to just "Scale production".

In **Phase II**, of prioritization, the relatively most valued objectives were:

- 1. Restore the deforested forest;**
- 2. Promote the generation of wealth with forest conservation; and**
- 3. Establish mechanisms for the fair and equitable sharing of benefits from the bioeconomy.**

The comments and objectives highlighted by the Leaders Committee for the Amazon bioeconomy reflect the search for economic development that values the particularities and potential of the region, without neglecting sustainability. A central point is the aggregation of value to the products of Amazonian ecosystems, both terrestrial and aquatic, through a modern bioindustrialization sustained by innovation. To this point, reiterating the concern of ensuring that this development benefits local populations, especially traditional communities, indigenous peoples and quilombolas – with the valorization of their knowledge and culture, the fair sharing of the benefits of the bioeconomy and their preparation to actively participate in this new economic model.

Another important aspect is the long-term vision. It is recognized that community enterprises in the Amazon take 10 to 20 years to consolidate, requiring strategies appropriate to this reality. The attraction of robust investments and the promotion of an innovation ecosystem that involves everything from startups to large companies, national and foreign, is another point highlighted. International cooperation is seen as a way to access new markets and export the products of the Amazon bioeconomy. Finally, and with the highest priority among leaders, there is an emphasis on the recovery of already degraded areas, using them for biomass production, and taking advantage of existing conservation legislation.



THE ECONOMICS OF THE BIOECONOMY

When considering the broader definition of **bioeconomy**, the specific sector that encompasses the production and conversion of renewable biological resources into value-added goods and services has been gaining increasing relevance in Brazil. Recent estimates indicate that it already accounts for about **20% of the Brazilian GDP**, with emphasis on the weight of bioindustry (54% of the total), followed by primary activities of plant origin (25%), animal (8%) and extractive (3%) (LIMA; PINTO, 2022). These figures show that, **despite the enormous potential of Brazilian biodiversity**, most of the value added by the bioeconomy in the country is associated with biological resources derived mainly from agribusiness and traditional commodities.

In fact, when analyzing Brazil's export basket, it is observed that of the US\$ 40.2 billion in exports of bioeconomy products in 2016, more than half corresponded to soybeans, cane sugar, and cellulose (SILVA; PEAR TREE; MARTINS, 2018). Although these sectors are competitive and generate foreign exchange, their economic model has less potential to add value and take advantage of the richness of biodiversity.

On the other hand, new segments of the bioindustry, such as advanced biofuels, biochemicals, biopharmaceuticals, cosmetics, and bio-based materials, represent promising opportunities to combine technological innovation, environmental conservation, and socioeconomic development. Brazil has made advances in areas such as vaccines, cell therapies, biological control, and industrial enzymes, but the scale is still restricted (DIAS; CARVALHO, 2017).

For these emerging segments to fully develop and become vectors of a new, more diversified and sustainable bioeconomy, it will be necessary to overcome a series of challenges. Among them, the need to mobilize adequate financial resources stands out, which enables not only the increase in the productive scale, but also the generation and dissemination of innovations.

Financial solutions for this new bioeconomy paradigm require a differentiated look, which goes beyond the traditional models applied to agribusiness and commodities. It is necessary to consider the specificities and risks involved in biodiversity-based activities, often involving traditional knowledge, local communities and biological assets not well known or valued by the markets.

At the same time, the creation of new financing mechanisms aimed at the bioeconomy represents an opportunity for the financial sector to incorporate and price in a more systematic way the positive and negative socio-environmental externalities associated with economic activities. This can contribute to directing capital flows to sectors and companies with better practices and a greater commitment to sustainability.

The agenda of financial solutions for the bioeconomy cannot be restricted to the creation and regulation of new markets, no matter how well designed and governed they may be. It must be articulated with a deep critique of the dogmas and contradictions of contemporary economic systems, based on a dialogue of knowledge between science, ethics, spirituality and traditional knowledge. The importance of indigenous peoples and local communities in the conservation of biodiversity and ecosystems must be recognized and valued through their effective participation in environmental governance, at its different levels and institutional arrangements. It is necessary to strengthen the solidarity economy, agroecology, community management of common goods and other relational paradigms of economic organization, which recognize the intrinsic values of nature and the ecodependence of social processes.

Financial solutions for a new paradigm

The study *Financial Solutions for Nature Conservation* (CAMPOS, DALLASTA and LETELIER, 2023) proposes a comprehensive framework for the analysis of sources of financing applicable to nature conservation, a sector of growing importance in the Bioeconomy Economy. The report considers multiple dimensions of financial solutions, such as the origin of resources, the type and category of intervention, the most appropriate financial instruments, the sectors involved, the environmental assets covered, the strategies to be followed and the expected results.

The study highlights three key strategies that can enhance the impact of financial solutions aimed at biodiversity conservation: multisectoral collaboration, blended finance, and nature-based solutions. Multisectoral collaboration recognizes the need to mobilize skills and resources dispersed among different actors in society, such as governments, companies, investors, NGOs, universities, and local communities. Blended finance seeks to direct various sources and types of capital to enable investments with a positive impact on biodiversity, sharing risks and improving conditions of attractiveness for investors. Nature-based solutions, on the other hand, combine conservation objectives with the generation of broader social, economic, and environmental benefits, internalizing the positive externalities associated with ecosystems in investment decisions.

The potential outcomes of conservation financing strategies and mechanisms can be organized into four categories: mobilization of additional capital, increased allocative efficiency, realignment of spending and investments, and avoidance of future costs. To achieve these outcomes consistently and at a scale commensurate with the magnitude of the challenges of biodiversity loss, the financial sector as a whole needs to undergo a profound cultural and operational transformation, embedding conservation risks and opportunities at the heart of business models and decision-making processes at all levels. This is a complex and long-term process, which depends on changes not only in the financial sector, but in society as a whole, involving advances in legislation, public policies, consumer awareness, company behavior, and the generation and dissemination of knowledge.

Complementing the analysis, NatureFinance (2023) published a significant study on the valuation of the bioeconomy, entitled “Enabling Nature’s Markets”. The report explores how more accurate pricing of natural capital can generate economic incentives for its conservation and sustainable use, arguing that explicitly valuing nature in economic transactions is a necessary condition for building a prosperous and resilient global bioeconomy. This requires the development of new markets for environmental assets, such as carbon credits, fishing quotas, rights over water and genetic resources, among others. However, the document warns that the creation of markets to trade elements of nature is not a panacea and can generate negative impacts if it is not accompanied by adequate governance structures, with socio-environmental safeguards, scale limits, stakeholder participation and fair benefit-sharing mechanisms.

A taxonomy is proposed to classify the various forms that nature markets can take, dividing them into four broad types: Asset Markets, Intrinsic Markets, Credit Markets, and Derivative Markets (NatureFinance, 2022). This taxonomy seeks to encompass the breadth and diversity of emerging nature markets, offering a framework for understanding their different forms and characteristics while also informing the debate on how to harness the potential of these instruments to mobilize resources and incentives for the conservation and sustainable use of nature and seeking to avoid risks such as the excessive commoditization of natural assets and the exclusion of vulnerable groups.

Economic potential of the Amazon

The bioeconomy comprises all economic activity derived from bioprocesses and bioproducts that contribute to efficient and sustainable solutions in the use of biological resources, promoting the transition to a new development model focused on the well-being of society (CGEE, 2020). “The Amazonia Third Way,” the movement that underpins the Amazon 4.0 Project, builds on the enormous untapped potential of Amazonian biodiversity to generate a new sustainable bioeconomy based on research and taking advantage of the advances in technologies of the 4th Industrial Revolution. Rather than relying solely on the exploitation of agricultural and mineral commodities, the Amazon can develop value chains based on non-timber forest products. The new Amazonian bioeconomy could generate much more wealth and distribute it more fairly, benefiting local populations. To this end, they propose the creation of “innovation ecosystems” that unite traditional knowledge, cutting-edge laboratories, startups and companies to develop new bioproducts – cosmetics and medicines made from oils and plant extracts; functional foods and nutraceuticals derived from fruits and seeds; advanced materials inspired by biomimicry; among others (Nobre and Nobre, 2018).

The diversified, high-value-added Amazonian bioeconomy based on biological and biomimetic assets can be a sustainable and profitable alternative to the current development model focused on primary commodities. To do so, a conceptual, educational, and entrepreneurial revolution will be needed that unites the different actors in decentralized innovation ecosystems across the region. It represents an opportunity for Brazil to become a world leader in this bio-based economy, combining its megabiodiversity with scientific knowledge and the possibilities of industry 4.0 (Nobre and Nobre, 2019).

In the period from 2017 to 2019, exports of products from Amazon-based enterprises, derived from non-timber forest extractivism, agroforestry systems, fishing, tropical fish farming, and tropical horticulture, resulted in an annual revenue of US\$ 298 million. This amount is of great relevance, as it remunerates practices aligned with the preservation of the forest. However, a deeper analysis reveals that this value represents only 0.17% of the global market of US\$ 176.6 billion for these same products, highlighting the vast untapped potential (Coslovsky, 2021).

The socio-bioeconomy of the state of Pará, for example, has the capacity to generate significant revenue, estimated at more than R\$ 170 (US\$ 34) billion by 2040 (Costa et al., 2021). The economic analysis conducted by this study included 10 key products: açaí, cocoa-almond, Brazil nut, heart of palm, rubber, tucumã, cupuaçu-almond, cumaru, murumuru and Brazil nut oil. These products accounted for more than 96% of the total income generated, which is equivalent to a significant amount of R\$ 5.2 (US\$ 1) billion. One of the scenarios analyzed in this study considers carbon credits as an instrument for valuing the bioeconomy. As an example, the profitability per hectare of a biodiverse area with managed açaí cultivation is estimated at around US\$ 1500, against about US\$ 200 for a hectare of soybeans, without considering the issues of job creation and related environmental services (Nobre and Nobre, 2019).

Strategies for valuing the bioeconomy

Table 7 presents the results of the consultation with leaders on strategic measures to enhance the Brazilian bioeconomy. In Phase I, three measures stood out with 95% agreement on their efficiency: promotion of national Payment for Environmental Services (PES) and Carbon Credit markets, and the position of the Brazilian government at UN international meetings on climate finance. This consensus reflects the importance attributed to international coordination to attract resources and provide financial sustainability to bioeconomy projects.

Table 7

STRATEGIC MEASURES FOR VALUING THE BIOECONOMY	Agreement ¹⁴ Phase I ¹⁵	Prioritization ¹⁶ Phase II
To foster the National Payment for Environmental Services (PES) market	95%	
Foster the National Carbon Credit market	95%	
Prioritization of projects associated with the bioeconomy by national funds	90%	3
The Brazilian government's position on the UN international meetings on climate finance	95%	
Bioeconomy of sociobiodiversity: Invest in the bioeconomy of sociobiodiversity, promoting community products and enterprises, such as meliponiculture, açai, cupuaçu, guaraná, pirarucu, piaçava, among others, and offering mentoring, incubation, and specific funding lines for research in this area.	-	1
Physical and digital infrastructure: Invest in building and improving the infrastructure needed for the development of the bioeconomy, including roads, energy, communications, and digital connectivity.	-	2
Coordinate research and develop modern technologies to improve the monitoring systems of Brazilian biomes.	-	

In **Phase II**, leaders prioritized, primarily, investment in the socio-biodiversity bioeconomy, with a focus on community-based products and enterprises. This measure reflects the view that the bioeconomy should be a vector of social inclusion and appreciation of the knowledge and practices of forest peoples. The second priority was investment in physical and digital infrastructure, recognizing that improved basic logistics, energy, and communications conditions is essential to enable the development of bioeconomy production chains, especially in remote regions. The third measure prioritized, in line with the results of Phase I, was the allocation of resources from national funds to bioeconomy projects. This action has the potential to leverage investments and scale up sustainable enterprises.

Analyzing the interconnections between the responses, the prioritized measures are mutually reinforcing. Investment in the bioeconomy, socio-biodiversity and infrastructure creates the basis for the development of inclusive and high value-added production chains.

- ¹⁴ Sum of the percentages of the answers "Efficient" and "Very Efficient".
- ¹⁵ Part of the questions were inserted only in PHASE II of the research.
- ¹⁶ Weighted average of the "Very High (10)", "High (4)" and "Medium (1)" prioritizations.

In turn, the allocation of resources from national funds and the attraction of investments via PES and carbon credits can boost these ventures and generate revenue streams to remunerate environmental services.

In addition, the government's active position in international forums on climate finance is essential to attract external resources and give visibility to investment opportunities in the Brazilian bioeconomy. This international articulation, combined with the prioritized economic instruments, can create a favorable environment for attracting capital and structuring partnerships.

Funding sources

The Leaders Committee conducted an exercise of suggestions on sources of financing for the development of the bioeconomy in the Amazon. In response, a range of possibilities was presented to attract capital, generate wealth and create value for the bioeconomy in the Amazon. The committee's suggestions range from raising funds from international funds to the creation of new innovative financial mechanisms, including the combination of various sources of financing and the use of public development policies.

A pivotal point is the need to go beyond the traditional mechanisms for financing forest conservation, seeking instruments that can directly boost the bioeconomy sector. In this sense, partnering with impact businesses and business programs emerges as an opportunity to align the interests of investors with the sustainable development goals of the region.

The combination of resources from diverse sources, such as philanthropy, patient capital, public funds, and private investments, is pointed out as a promising strategy to offer the flexibility and scale necessary for bioeconomy projects. This blended finance model can be especially relevant for initiatives that involve research and development, requiring a long-term commitment from investors.

Another highlight in the suggestions is the creation of new mechanisms for pricing and remuneration of the environmental services provided by the forest, going beyond the carbon market. Services such as pollination, water regulation, and biodiversity conservation can generate significant revenue streams, if markets are structured and methods for valuation and remuneration are developed. In this context, the tokenization of these environmental services and the creation of green cryptocurrencies emerge as innovative possibilities, but they require careful development to ensure their environmental and social integrity.

The importance of using existing instruments to promote sustainable productive activity was also highlighted, such as the ABC Plan, the National Program for the Strengthening of Family Agriculture (PRONAF), the Constitutional Fund for Financing the North (FNO) and the lines of the National Bank for Economic and Social Development (BNDES).

These mechanisms can be adapted and directed to boost bioeconomy production chains, taking advantage of their capillarity and experience in promoting economic activities in the region.

A critical aspect pointed out is the need for a stable regulatory and political environment favorable to the development of the bioeconomy. This involves a long-term commitment to funding research, development, and innovation, as well as creating a context of trust and credibility to attract investors. The reduction of deforestation and the implementation of effective socio-environmental safeguards are pointed out as essential conditions for the success of this development model.

Finally, the leaders also mention the importance of ensuring that bioeconomy products are competitive in the market, either through gains in scale or by implementing appropriate incentive policies.

Table 8 lists the suggestions presented in two categories: government funds and other sources of financing.

Table 8 - Financing Mechanisms

GOVERNMENT RESOURCES	
FINANCING FACILITY	DESCRIPTION
Biodiversity Fund FNO (Constitutional Financing Fund of the North) BNDES (National Bank for Economic and Social Development), Climate Fund, Amazon Fund	Government funds and programs dedicated to financing environmental conservation, sustainable development, and bioeconomy projects in the Amazon region. These sources offer resources with different conditions for initiatives aligned with their specific objectives.
ABC Program (Low Carbon Agriculture) PRONAF (National Program for the Strengthening of Family Farming)	Public development policies aimed at promoting sustainable agricultural practices and strengthening family farming. These programs can be directed to boost bioeconomy production chains, offering technical assistance, training, and access to differentiated credit for rural producers involved in sustainable activities.
<p>Challenges and Opportunities</p> <ul style="list-style-type: none"> • Need to adapt and target the instruments to the specificities of bioeconomy projects • Opportunity to take advantage of the capillarity, expertise and resources already available in these mechanisms to leverage the development of the bioeconomy in the region • Challenge of promoting articulation and coordination between the different funds and programs to optimize their application and avoid overlaps • Potential to leverage significant volumes of resources, given the scale and variety of existing government mechanisms 	
OTHER SOURCES OF FUNDS	
FINANCING FACILITY	DESCRIPTION
International Funds <ul style="list-style-type: none"> • GCF (Green Climate Fund) • GEF (Global Environment Facility) • COP15 (Fundo da Biodiversidade) 	Fundraising funds dedicated to environmental conservation and sustainable development at a global level. These funds offer financing opportunities for bioeconomy projects aligned with their specific criteria and priorities, allowing them to leverage external resources for the region.
Association with Impact Business and ESG	Partnerships with companies and investors interested in promoting positive social and environmental impact through their businesses and investments.
Blended finance	Combining resources from various sources (philanthropy, patient capital, public funds, private investments) to finance long-term projects. This model allows the structuring of financial mechanisms tailored to the specific needs of bioeconomy projects, bringing together the advantages of each type of capital involved.

OUTRAS FONTES DE RECURSOS

FINANCING FACILITY	DESCRIPTION
Payment for Environmental Services	Creation of mechanisms to price and remunerate environmental services provided by the forest in addition to carbon, such as pollination, water regulation, and biodiversity conservation. The development of effective valuation methods and the structuring of efficient payment systems are essential to enable recurring revenue streams for bioeconomy projects from these services.
Innovative Financial Instruments	Tokenization of environmental services and creation of green cryptocurrencies to attract investors and generate liquidity for bioeconomy projects. These instruments have the potential to create new markets and expand financing possibilities, but they also bring challenges related to ensuring their environmental and social integrity.

Challenges and Opportunities

- Alignment with the criteria and priorities of international funds and the need to develop competitive proposals to access these resources
- Opportunity to attract private capital aligned with sustainability, but challenge of establishing social and environmental impact metrics and reports
- Complexity in the articulation between different actors and sources of funds in the blended finance model
- Need to develop and negotiate valuation methods for environmental services beyond carbon
- Potential of innovative financial instruments to attract new investors and generate liquidity, but challenge of ensuring their environmental and social integrity
- Opportunity to diversify funding sources and leverage significant resources for bioeconomy projects

Recommendations for bioeconomy financing

The Leaders Committee’s recommendations to boost the bioeconomy in Brazil cover a wide range of strategies, from creating and strengthening specific markets to attracting national and international investment. Table 9 summarizes the main recommendations and ideas presented. The table provides an overview of the suggestions, ranking them according to the type of instrument proposed, the stakeholders involved and the thematic category to which they refer.

Table 9 - Recommendations of the Leaders Committee

TITLE	DESCRIPTION	CATEGORY	INSTRUMENT TYPE	STAKEHOLDERS
PSA Nacional	Promotion of the Payment for Environmental Services (PES) market at the national level, already supported by Law No. 14,119/2021 (PNPSA)	Intrinsic Markets	Public Policy / Legislation	Government, Environmental Service Providers, Users of Environmental Services
Diversification of Environmental Services	Scaling up priceable environmental services, such as pollination, beyond carbon	Intrinsic Markets	Market Innovation	Environmental Service Providers, Users of Environmental Services, Research Institutes
Tokenization and Green Cryptocurrencies	PES tokenization and generation of cryptocurrencies with environmental value, using blockchain technologies	Derivatives Markets	Financial Innovation / Technology	Environmental Service Providers, Investors, Technology Companies
National Carbon Credit	Stimulus to the National Carbon Credit market, with regulation in progress (PL 182/2024)	Credit Markets	Public Policy / Regulation	Government, Companies, Environmental Service Providers
Social and Environmental Certification	Inclusion of socio-environmental and benefit-sharing criteria in the evaluation methods of carbon credit certifiers	Credit Markets	Standards and Certification	Certifiers, Indigenous Peoples, Local Communities, Environmental Service Providers
Impact Business and ESG	Linking bioeconomy financing to impact businesses and corporate and financial sector ESG programs	Sustainable Investments	Business Strategy / Investments	Companies, Investors, Financial Sector, Environmental Service Providers
Combined Finance (Blended Finance)	Combining various sources of funds (philanthropy, patient capital, public and private funds) for long-term financing in the bioeconomy	Sustainable Investments	Financial Innovation / Partnerships	Government, Private Sector, Investors, Philanthropists, Financial Institutions
International Funds	Fundraising from international funds, such as the Biodiversity Fund (COP-15) and climate funds (GCF)	International cooperation	Fundraising / Partnerships	Government, International Institutions, Donor Countries, Environmental Service Providers
Brazil's International Positioning	Brazil's active participation in international negotiations on climate finance and biodiversity, seeking to structure compulsory markets for environmental services, leadership, and investment attraction	International cooperation	Diplomacy / Public Policy	Government, International Institutions, Partner Countries
National Strategic Funds	Prioritization of projects associated with the bioeconomy in existing national funds (e.g., FNO, BNDES)	National Investments	Public Policy / Resource Allocation	Government, Public Financial Institutions, Environmental Service Providers, Corporations

TITLE	DESCRIPTION	CATEGORY	INSTRUMENT TYPE	STAKEHOLDERS
Long-Term Funding for R&D	Long-term credit lines to support research and development in the bioeconomy, enabling innovations and new bio-based products and services	Investments in Innovation	Public Policy / Financing	Government, Research Institutions, Universities, Companies, Investors
Incentive and Regulation Policies	Establishment of clear incentive and regulatory policies to ensure the competitiveness of bioeconomy products, promoting trust, credibility, and scale	Regulatory Environment	Public Policy / Regulation	Government, Regulatory Agencies, Companies, Investors
Action Plan and Monitoring	Creating a detailed action plan, with defined goals, deadlines, and responsibilities, to direct efforts and monitor progress in implementing recommendations	Governance and Public Policy	Strategic Planning / Monitoring	Government, Private Sector, Academia, Civil Society
Technical Training and Participation	Investment in technical capacity building, especially in regions rich in natural resources, to enable the effective participation of local communities and indigenous peoples in nature markets	Local Development and Social Inclusion	Public Policy / Training	Government, Educational and Research Institutions, Civil Society Organizations, Indigenous Peoples, Local Communities
Valuing Traditional Knowledge	Valuing traditional knowledge and fair sharing of the benefits generated by the bioeconomy, ensuring that indigenous peoples and local communities are direct beneficiaries of nature markets	Equity and Benefit Sharing	Public Policy / Human Rights	Government, Indigenous Peoples, Local Communities, Companies, Investors
Aligning with Global Challenges	Alignment of the development of the Brazilian bioeconomy with the global challenges related to biodiversity loss and climate change, seeking a regenerative economy compatible with planetary boundaries	Sustainability and Global Responsibility	International Cooperation / Public Policies	Government, International Institutions, Partner Countries, Private Sector, Academia, Civil Society

These suggestions are in line with the growing global trend of valuing environmental services and biodiversity. One of the central pillars of the recommendations is the promotion of the Payment for Environmental Services (PES) market at the national level. The PES already has a legal framework in Brazil, instituted by Law No. 14,119/2021, which establishes the National PES Policy (PNPSA) and its instruments. However, it is important to emphasize that, although PES is an important mechanism for valuing the environment, it is not a source of financing, but only an instrument for directing and applying existing resources from other sources. Therefore, PES by itself does not generate new resources, but it can enhance the application of resources available for conservation. In addition, especially when based on voluntary markets, PES may face difficulties in mobilizing the volumes of resources needed to promote significant changes at the required scale. Thus, it is essential that PES be complemented by other policies and instruments, to ensure the resources and scale necessary for an effective protection of environmental services and biodiversity in the country.

It should be noted that PES cannot be directly compared with the carbon market, which is a regulated market with a clear demand and specific targets for reducing greenhouse gas emissions. The carbon market was structured based on international commitments, such as the Kyoto Protocol and the Paris Agreement, which established emission limits for signatory countries. This has created a demand for carbon credits, which can be generated by projects that reduce or remove emissions from the atmosphere. On the other hand, another indication of the Committee is that markets for other environmental services, such as biodiversity conservation, regulation of the hydrological cycle, pollination, and erosion control, still need to be created and structured properly. For these PES markets to function effectively, it is necessary to establish clear goals and commitments, develop methodologies to quantify and value environmental services, create monitoring and verification systems, and establish rules and standards for the generation and commercialization of environmental credits. In addition, it is essential to engage the different actors involved, such as environmental service providers, beneficiaries, governments, and investors, to create a consistent demand for these services and ensure the long-term sustainability of the markets.

In this context, another innovative recommendation is the tokenization of PES and the generation of cryptocurrencies with environmental value. The stimulus to the National Carbon Credit market was also pointed out as strategic by the leaders.

A crucial point raised is the need for carbon credit certifiers to consider socio-environmental commitments to local communities and indigenous peoples in their assessment methods. In addition to specific markets, the importance of associating bioeconomy financing with impact businesses and ESG (*Environmental, Social and Governance*) programs in the business and financial sector was emphasized. The combination of various sources of funds, such as philanthropy, patient capital, and public and private funds (*blended finance*), is also mentioned as a promising strategy. This approach allows the structuring of long-term financing, essential to support research, development, and innovation in the bioeconomy.

Another point of convergence between the recommendations and global trends is the importance of international cooperation and attracting foreign investment. The potential for raising funds from international funds, such as the Biodiversity Fund, launched at COP-15, and climate funds, such as the Green Climate Fund (GCF), was highlighted. The need for greater articulation and coherence between international agreements and institutions related to climate, biodiversity, trade, and finance was highlighted, to support the development of nature markets. In this context, Brazil's active position in international negotiations on climate finance and biodiversity is considered crucial. The country should seek to establish itself as a relevant and responsible actor in these forums, promoting policies aligned with global sustainability goals. This action is essential to attract investments, strengthen cooperation and ensure the competitiveness of the Brazilian bioeconomy in the international scenario.

In addition to the recommendations aimed at attracting external resources, the importance of prioritizing projects associated with the bioeconomy in existing national funds, such as FNO and BNDES, was also emphasized.

The need to create specific funds for the payment of non-carbon environmental services was also indicated, with the potential to move significant resources especially to the Amazon. These funds could be fed by philanthropic and private resources, anchored in organizations with expertise in the field. This recommendation is in line with the trend of expanding nature markets beyond carbon, encompassing a variety of environmental services, as highlighted earlier.

To ensure the competitiveness of bioeconomy products, the need for incentive policies was pointed out, in addition to the scale of supply. The regulatory issue was considered key, as was Brazil's ability to promote trust, credibility, and the ability to deliver at scale.

Finally, it is important to emphasize that the development of the Brazilian bioeconomy cannot be dissociated from the global challenges related to biodiversity loss and climate change. In this sense, we emphasize that the recommendations of the leaders are aligned with the urgency of building a regenerative economy that is compatible with planetary limits.

For this economic potential of the bioeconomy to be effectively realized, however, it is essential to establish a robust and participatory governance structure. The role of the State, in articulation with the other actors, is central to ensuring the institutional, political, and regulatory conditions necessary for the flourishing of a sustainable and inclusive bioeconomy.

The triple illusion. – Time decants the past. What is clear today, was barely glimpsed yesterday. The modern world was born and evolved under three powerful illusions: that scientific thought would gradually banish the mystery of the world and thus elucidate the human condition and the meaning of life; that the project of exploiting and subjecting nature to the control of technology could continue indefinitely without stirring up its opposite – the threat of a terrible lack of control of the natural balance of life; and that the advancement of civilization would promote the ethical and intellectual improvement of humanity, making our lives happier, fuller and more worthy of being lived. If it is true that an era ends when its founding illusions are exhausted, then the verdict is clear: the modern era has expired. Criticism or resignation? Are we, Brazilians, recalcitrantly “condemned to civilization”, will we stand for this? Will we one day be able to propose an alternative in the face of the crisis of civilization?

**Trópicos utópicos: uma perspectiva brasileira da crise civilizatória / Eduardo Giannetti. – 1ª ed. São Paulo: Companhia das Letras, 2016*



GOVERNANCE AND THE ROLE OF THE STATE

The importance of Governance?

Governance is crucial to create conditions for economic progress, social cohesion, and environmental resilience. It defines who makes decisions, how they are made, ensures accountability, and determines the distribution of resources, policy implementation, and conflict resolution. This directly impacts the economy, society, and the environment, translating into better outcomes for individuals and communities. Ineffective governance leads to a waste of resources, corruption, social instability, and general dissatisfaction.

Governance is a key pillar for the development and successful implementation of a national bioeconomy strategy. It establishes the structures, processes, and mechanisms for decision-making, resource allocation, and coordinated actions. In the context of the bioeconomy, governance faces unique challenges due to the complexity and interconnectedness of the biological, economic, and social systems involved. The bioeconomy encompasses a wide range of sectors, actors, and interests, from research and innovation to the production, distribution, and consumption of bio-based goods and services. This complexity requires a governance approach that is adaptive, collaborative, and capable of dealing with changing scenarios, risks, and uncertainties.

In addition, the bioeconomy has the potential to contribute to broader social and environmental objectives, such as climate change mitigation, biodiversity conservation, food security and sustainable rural development. Therefore, in view of the objectives defined for the bioeconomy, its governance must be guided by principles of innovation, sustainability, equity, and inclusion, ensuring that benefits are shared fairly and that the negative impacts of productive activities are minimized.

The challenges for the construction of a governance model for the bioeconomy in Brazil will be analyzed based on the recommendations of the Committee of Leaders and the proposal for institutional arrangements prepared by the Center for Management and Strategic Studies (CGEE) (CGEE, 2020b).

Sustainability governance in the bioeconomy

The biggest “elephant in the room” of bioeconomy governance is the relationship between bioeconomy and sustainability. There is a broad misconception that the bioeconomy is innately sustainable however this is not the case. Pfau, C. et al. (2014), in a systematic review of the literature, identified four distinct views on this relationship, ranging from sustainability as an inherent characteristic of the bioeconomy to a negative impact of the bioeconomy on sustainability. While most publications consider the relationship to be positive, the vast majority also acknowledge potential problems.

The most important problems mentioned are the competition for land caused by the growing demand for biomass resources. This problem exemplifies the well-known “food vs. fuel” debate. It is argued that agricultural production of biomass for bioeconomy products (mainly biofuels) can compete with food production. The study concludes that the bioeconomy cannot be considered inherently sustainable, and that sustainability should be a central goal in its development.

Contemporary challenges of bioeconomy governance

The fundamental direction for the creation and development of governance for the bioeconomy must be based on three basic vectors: a) Ensure the effective implementation of regulatory and capacity-building policy measures to promote transitions towards a sustainable bioeconomy; b) Continuously monitor its gaps (in the governance of the national bioeconomy) with international governance; and c) Act to reduce these gaps (Dietz et al., 2023).

Table 10 summarizes the main challenges facing the global bioeconomy, along with the proposed solutions, as identified in the literature and in a consultation conducted with 282 experts from around the world in 2020 at the 3rd German Bioeconomy Council. The challenges range from the lack of capital for start-ups to the need for more effective international laws and regulations. Solutions include improvements in financing schemes, increased policy coordination at various levels of government and strengthening institutional capacities in several countries. These measures are vital to turn bio-based innovations into sustainable economic successes and to ensure a balanced and sustainable development of the global bioeconomy.

Still in the international context, the report “Global Bioeconomy Policy Report (IV)” published in 2020 and updated in 2024 by the International Advisory Council on Global Bioeconomy (IACGB), identifies several lessons learned and proposed for bioeconomy governance, highlighting the importance of coordination mechanisms, stakeholder participation, international collaboration, and continuous monitoring. One of the most common mistakes pointed out is the **lack of concrete action plans** to translate strategic visions into practical measures. Many countries **lack clear targets, milestones, and responsibilities**, which can seriously jeopardize the effective implementation of their bioeconomy strategies. To overcome this challenge, it is necessary to establish **intergovernmental coordination mechanisms**, such as interministerial working groups **or advisory councils**, with special attention to the adoption of participatory processes that **involve science, the productive sector, and civil society** in the formulation and implementation of strategies. International **collaboration** is also seen as crucial, given the global character of many of the challenges that the bioeconomy seeks to address. The need for monitoring and evaluation mechanisms is also emphasized, **with indicators** that cover not only the economic dimension, but also the **social and environmental aspects of the bioeconomy**.

The creation of a **favorable environment for innovation and investment** is a key point. This may involve reviewing **regulatory frameworks** to remove barriers and create incentives. Replicating funding mechanisms, such as the Malaysian Biotechnology Commercialization Fund and the European Circular Bioeconomy Fund, are also important to support **research, development, and commercialization**.

Table 10 - Challenges and Solutions for Bioeconomy Governance

PROBLEMS	SOLUTIONS
Lack of capital for nascent companies in the bioeconomy	Improving private sector and government-funded schemes, developing public-private partnerships focused on the bioeconomy, use of targeted taxes to support the bioeconomy
Slow growth of the sustainable bioeconomy	Promote support for commercialization, direct investments by the States and an improvement in the economic order of the sector
Lack of coordination and harmonization of policies at national level	Better stakeholder engagement, alignment of inter-ministerial policy processes, better communication, cooperation and integration processes between all stakeholders and groups involved
Lack of binding international laws and regulations	Development of stronger international standards, regulation of potential conflicts of objectives, better coordinated international policies on trade and development issues
Uneven distribution of institutional capacities among different countries	Establishment of a network of bilateral and trilateral international activities for knowledge transfer, institution building, promotion of green international financing schemes
Unfavorable market conditions for trading success	Coherence of policy incentives; Support for phases beyond initial technology development
National policies do not adequately address social, economic and ecological objectives	Global and intersectoral policy coordination; More effective regulatory guidance
Governance gaps at the international level	Creation of internationally binding laws and regulations; Increased intergovernmental cooperation and coordination
Unequal distribution of knowledge and access to technology	Better distribution of knowledge and access to technology across regions and countries
Regional imbalances in institutional capacities	Strengthening institutional capacities in less developed regions

Source: based on (Dietz et al., 2023)

The role of **education** is central, both in **training** and in **public awareness**. Countries such as France, Italy, Ireland, and the United Kingdom are investing in educational programs at all levels and promoting partnerships between academia and the productive sector to develop the skills needed for the bioeconomy. Public engagement initiatives, such as the Year of Science on Bioeconomy in Germany, are also valuable for communicating the benefits and opportunities of the bioeconomy and building societal support. The creation of **bioeconomy hubs that bring together companies, research institutions and government**, is another promising strategy. Examples such as “Biopolis” in Thailand illustrate how these arrangements can promote collaboration, resource sharing, and the development of integrated value chains.

Social **and ethical** considerations are also key in bioeconomy governance. As noted in every section of this report, it is necessary to ensure a **fair distribution of benefits** and to carefully assess the **impacts on local communities and ecosystems**. Costa Rica, Japan and the EU highlight the importance of inclusive and transparent governance mechanisms to address these issues. The **alignment and coherence between** bioeconomy policies and areas such as agriculture, environment, energy, and innovation is another point of attention. Austria, Germany, and the United Kingdom are mentioned as examples of countries that are adopting integrated approaches to promote synergies and minimize conflicts between different sectors.

Flexibility and adaptability are pointed out as important attributes for bioeconomy strategies, allowing adjustments in the face of new opportunities and challenges. Japan, Italy and the EU have established regular review and update mechanisms, while Finland and France have explored experimental approaches and pilot projects emphasizing the value of **international cooperation** and **the exchange of good practices**. Countries such as Germany, the United States, France, and Japan have played an active role in promoting dialogue and collaboration in global forums, contributing to the advancement of the bioeconomy on a global scale.

Effective bioeconomy governance requires a combination of **political leadership, cross-sectoral collaboration, stakeholder engagement**, innovation capacity, and **effective monitoring and adaptation mechanisms**. By adopting good practices and addressing the mapped challenges, countries increase their chances of creating the necessary conditions for the development of sustainable and prosperous bioeconomies that generate lasting economic, social, and environmental benefits (IACGB, 2020; 2024).

Table 11 presents a comprehensive overview of the main aspects related to bioeconomy governance, highlighting the key governance categories, the good practices and recommendations identified, the challenges and lessons learned, and the objectives and indicators relevant to each area.

Table 11- Summary of good practices of bioeconomy governance policies

CATEGORY	GOOD PRACTICES AND RECOMMENDATIONS	CHALLENGES AND LESSONS LEARNED	OBJECTIVES AND INDICATORS
Action Plans	Establish clear goals, milestones, and responsibilities	Lack of translation of policy objectives into concrete and implementable measures; Absence of action plans with goals, milestones, deadlines and indication of the responsible bodies	Indicators of progress and impact of bioeconomy policies (economic, social, environmental)
Coordination	Establish intergovernmental coordination mechanisms (working groups, advisory councils)	Difficulty in coordinating the wide range of bioeconomy actors and their different interests; Need to align priorities and demands from different sectors	Establishment of interministerial coordination bodies; Number of meetings and decisions taken by these bodies
Participation	Adopt participatory processes involving science, the productive sector, agribusiness, the traditional community and civil society	Challenge of ensuring the effective and balanced participation of different stakeholders in the policy-making process	Number and diversity of stakeholders involved; Incorporation of contributions into decision-making processes
Monitoring and Evaluation	Develop comprehensive indicator systems (economic, social, environmental)	Lack of adequate monitoring and evaluation mechanisms to track progress and inform decision-making; Need for indicators covering different dimensions of the bioeconomy	Economic (GDP, jobs, productivity), social (inclusion, well-being) and environmental (GHG emissions, biodiversity) indicators
Regulatory Environment	Assess effective implementation and review regulatory frameworks to remove barriers and create incentives	Existence of regulatory barriers that hinder the introduction of new bio-based products and services; Need to create a favorable environment for innovation and investment	Time and cost to approve new products and processes; Number of patents and startups in bioeconomy
Financing	Establish appropriate funding mechanisms for research, development, and commercialization	Insufficient high-risk, long-term investments in the bioeconomy; Importance of mobilizing private capital and creating innovative financial instruments	Indicators of investment (public and private) in R&D and commercialization in the bioeconomy
Education and Training	Invest in educational programs at all levels and promote academia-productive sector partnerships	Need to develop interdisciplinary skills and competencies to meet the demands of the bioeconomy; Challenge of aligning educational curricula with market needs	Education and training indicators (number of programs, students, and qualified professionals)
Public Awareness	Promote public engagement initiatives to communicate benefits and opportunities of the bioeconomy	Importance of increasing societal awareness and support for the bioeconomy; Challenge of communicating the concepts and applications of the bioeconomy in a clear and accessible way	Indicators of public awareness and acceptance (opinion polls, media, participation in events)

CATEGORY	GOOD PRACTICES AND RECOMMENDATIONS	CHALLENGES AND LESSONS LEARNED	OBJECTIVES AND INDICATORS
Bioeconomy Hubs	Create arrangements that bring together companies, research institutions, traditional populations, and government for collaboration and resource sharing	The challenge of promoting effective collaboration and resource sharing between different actors in regional bioeconomy clusters or hubs, especially with riverside populations, small farmers, and traditional peoples.	Cluster performance indicators (number of companies, jobs, patents, collaborative projects)
Social and Ethical Considerations	Ensure fair distribution of benefits and assess impacts on communities and ecosystems	Need to address issues of equity, inclusion and socio-environmental impacts of the bioeconomy; Importance of establishing transparent and participatory governance mechanisms	Indicators of social impact (income distribution, access to resources) and environmental impact (environmental services, carbon footprint)
Policy Alignment	Adopt integrated approaches to promote synergies and minimize conflicts between different objectives	Challenge of ensuring coherence and complementarity between bioeconomy policies and other areas (agriculture, environment, energy, innovation)	Degree of integration and coherence between sectoral policies related to the bioeconomy; Existence of intersectoral coordination mechanisms
Flexibility and Adaptability	Establish regular review, update mechanisms, and explore experimental approaches	Importance of adapting bioeconomy strategies to technological, economic, and social changes over time; Need to learn from experience and adjust policies according to lessons learned	Innovation indicators (new products, processes and services) and adaptation indicators (policy reviews, pilot projects)
Challenges and Trade-offs	-	Existence of potential tensions and conflicts between economic, social and environmental objectives in the bioeconomy; The need to promote dialogue and negotiation to find balanced solutions	-
Local Specificities	-	The importance of adapting bioeconomy strategies to the specific conditions and priorities of each region; Lack of a single governance model applicable to all contexts	-
International Collaboration and Cooperation	Promote dialogue, knowledge exchange, and common approaches, as well as collaboration on platforms, international and global forums	Need to strengthen international cooperation and coordination to address global challenges such as climate change, food security, and seize opportunities in the global bioeconomy; Importance of sharing good practices and lessons learned	Participation in initiatives, joint projects, and global networks; Alignment of policies and practices with international partners; Exchange of experience and knowledge with other countries and regions

Source: adapted from IACGB, 2020, 2024.

An example of maturation in the process of building and implementing governance for the bioeconomy comes from the case of Ireland, which has a bioeconomic complexity that is not comparable to Brazil, but whose evolution and maturity of actions and governance can serve as a reference.

In 2015 the country invested in BioÉire, a two-year project, which was part of the Irish national agri-food strategy and focused on the development of a sustainable and low-carbon bioeconomy in Ireland. This project served as the foundation for the publication of the National Bioeconomy Policy in 2018. In 2019, the government published the first progress monitoring report on the implementation of the bioeconomy policy and, in 2023, it published the Bioeconomy Action Plan (2023-2025). This document exemplifies a well-structured national strategy model, reflecting a coordinated and comprehensive approach to objectively advancing the field of bioeconomy. The plan's structure is organized around seven main pillars: governance and awareness, research, development and innovation, nature, climate, energy, and circular economy. Each pillar is detailed with specific objectives, practical measures, and targets that align the country's natural biological resources with its competitive advantages.

The process of drafting the plan involved significant collaboration between public bodies, research institutions, the productive sector, and the public, ensuring that all stakeholders had a voice in policy making. This collaborative method ensures the integration of the bioeconomy into all relevant areas of governance, strengthening the connection between environmental sustainability, technological innovation and economic development.

The document not only clearly outlines the areas for action, but also establishes a framework for the effective implementation of these actions, underlining the importance of a regenerative and circular economy. It is divided into several sections that guide the implementation of the policies. For example, for the "Research, Development and Innovation" pillar, the plan details actions such as "Developing new biomaterials from local resources", followed by the steps for delivery, which include partnering with universities and the productive sector and a deadline that extends until the end of 2024. Each action has a designated owner, ensuring that there is a clear chain of command and accountability in execution. With the plan, Ireland aims to position itself as an industry leader by 2025 (Ireland Department of the Environment, Climate and Communications; Department of Agriculture, Food and the Marine, 2023).

Conceptual, Regulatory and Institutional Analysis – CPI | PUC-Rio

In 2022, the Climate Policy Initiative – PUC-Rio, which historically monitors the implementation of the Brazilian Forest Code (LOPES; CHIAVARI, 2022b), published a review on the organization of knowledge of Brazilian governance for bioeconomy with a focus on the Amazon, “Bioeconomy in the Amazon: Conceptual, Regulatory, and Institutional Analysis”.

The study examines the regulatory and governance framework that shapes the Brazilian bioeconomy (with special attention to the Amazon region). By scrutinizing current legislation and policies, the document analyzes the challenges and opportunities within the Brazilian legal framework, considering the bioeconomy as an interdisciplinary field that encompasses both technological innovation and the sustainable use of biological resources. The main regulatory frameworks that directly affect the bioeconomy are identified, such as the Biodiversity Law and the Forest Code, and discuss their implications for sustainable development. The complexity inherent in the regulation of bioeconomic activities in the balance of environmental protection and economic growth is highlighted.

The following table presents an overview of the main legislation and public policies related to the bioeconomy in Brazil, organized by thematic area and classified according to the three visions of bioeconomy proposed by Bugge et al. (2016): biotechnology, bioresources and bioecological, representing their different approaches and priorities. Biotech focuses more on the commercial application of biotechnology, aiming at economic growth. The bioresources section emphasizes the use of biological raw materials to replace fossil resources, with a focus on technological and economic development. Bioecological, on the other hand, prioritizes sustainability, biodiversity conservation, and ecological processes.

The biotechnological vision is contemplated in laws and policies focused on intellectual property, science, technology and innovation, biodiversity and genetically modified organisms. The vision of bioresources is addressed in policies related to biofuels, agriculture, planted and native forests. Finally, the bioecological vision is represented by family and organic farming policies, socio-biodiversity products, aquaculture and fishing, as well as legal frameworks for the protection of indigenous peoples and traditional communities. It is important to note that some laws and policies fit into more than one view, evidencing the interconnection between the different perspectives of the bioeconomy. In addition, the legal frameworks for land regularization, which cover tenure on public lands, quilombola territories, indigenous lands, conservation units, and agrarian reform settlements, are fundamental to the three visions, since legal certainty about land tenure is essential for the development of any and all activities related to the bioeconomy. Table 12 offers a comprehensive overview of the legal and political framework that sustained, in 2022, the bioeconomy in Brazil, allowing an integrated analysis of the different visions and seeking to promote a broad discussion on the regulatory framework of the bioeconomy.

Table 12 - Main regulatory frameworks of the bioeconomy

LAW/POLICY	AREA	VISION
Industrial Property Law (LPI)	Intellectual property	Biotechnology
Plant Variety Incentive Law	Intellectual property	Biotechnology
Science, Technology and Innovation Law	Science, Technology and Innovation	Biotechnology
Law of "Bem"	Science, Technology and Innovation	Biotechnology
Startups Law	Science, Technology and Innovation	Biotechnology
National Innovation Policy	Science, Technology and Innovation	Biotechnology
National Biodiversity Policy (PNB)	Biodiversity	Biotech, Bioecological
Law on Access to Genetic Heritage, Protection and Access to Associated Traditional Knowledge and Benefit Sharing (Biodiversity Law)	Biodiversity	Biotech, Bioecological
Biosafety Law	Genetically Modified Organism (GMO)	Biotech, Bioresources
National Biofuel Policy (RenovaBio)	Biofuel	Bioresources
"Social Biofuel" Seal	Biofuel	Bioresources
Agroecological Zoning of Sugarcane*	Biofuel	Bioresources
Agroecological Zoning of Palm Oil	Biofuel	Bioresources
Agricultural policy	Agriculture and Planted Forestry	Bioresources
National Integration Policy-Crop-Livestock-Forest	Agriculture and Planted Forestry	Bioresources
Agricultural Policy for Planted Forest	Agriculture and Planted Forestry	Bioresources
National Plan for the Development of Planted Forests (PlantarFlorestas)	Agriculture and Planted Forestry	Bioresources
National Program of Biomaterials	Agriculture and Planted Forestry	Bioresources
National System of Nature Conservation Units (SNUC)	Native Forest	Bioresources, Bioecological
Public Forest Management Law	Native Forest	Bioresources, Bioecological
Native Vegetation Protection Law/Forest Code	Native Forest	Bioresources, Bioecological
National Policy and Plan for the Recovery of Native Vegetation (Proveg/ Planaveg)	Native Forest	Bioresources, Bioecological
National Plan for Environmental Regularization of Rural Properties (RegularizaAgro)	Native Forest	Bioresources, Bioecological
Program for the Strengthening of Family Agriculture (Pronaf)	Family/organic farming	Bioecological
National Policy on Family Farming	Family/organic farming	Bioecological
Organic Farming Act	Family/organic farming	Bioecological
National Policy on Agroecology and Organic Production (Pnapo)	Family/organic farming	Bioecological
Minimum Price Guarantee Policy for Sociobiodiversity Products (PGPMBIO)	Sociobiodiversity Products	Bioecological

LAW/POLICY	AREA	VISION
National Plan for the Promotion of Sociobiodiversity Product Chains (PNPSB)	Sociobiodiversity Products	Bioecological
National Policy for the Sustainable Development of Aquaculture and Fisheries	Aquaculture and Fisheries	Bioecological
Legal Frameworks for the Protection of Indigenous Peoples	Traditional Peoples and Communities	Bioecological
National Policy for Territorial and Environmental Management of Indigenous Lands (PNGATI)	Traditional Peoples and Communities	Bioecological
National Policy for the Sustainable Development of Traditional Peoples and Communities	Traditional Peoples and Communities	Bioecological
ILO Convention 169: Free, Prior and Informed Consultation	Traditional Peoples and Communities	Bioecological
Tenure over Public Lands	Land Regularization	Biotech, Bioresources, Bioecological
Quilombola Territories	Land Regularization	Biotech, Bioresources, Bioecological
Indigenous Lands	Land Regularization	Biotech, Bioresources, Bioecological
Conservation Units (UC)	Land Regularization	Biotech, Bioresources, Bioecological
Agrarian Reform Settlements	Land Regularization	Biotech, Bioresources, Bioecological

Source: LOPES; CHIAVARI, 2022a

The existence of this set of laws does not guarantee a necessary environment for the development of the bioeconomy, the role of governance is emphasized as fundamental to the success of the bioeconomy in the Amazon. It is suggested that effective governance should be multidimensional and inclusive, engaging stakeholders at all levels, from local communities to government institutions, to ensure that the bioeconomy meets regional development needs without compromising ecological integrity.

As for federal governance, the study argues that the complex and multisectoral nature of the bioeconomy demands a governance arrangement that promotes commitment, cooperation, and coordination among the various ministries, agencies, and government institutions involved. However, what is still observed is a fragmented governance, with the uncoordinated action of multiple actors.

In recent years, the Ministry of Science, Technology and Innovation (MCTI) has taken a leading role in the construction of a national bioeconomy agenda, focusing on the biotechnological vision. The Ministry of Agriculture, Livestock and Supply (MAPA), through the Secretariat of Innovation, Sustainable Development and Irrigation (SDI) and the Brazilian Agricultural Research Corporation (Embrapa), works on the vision of bioresources, promoting the

sustainable use of genetic resources and the development of bioproducts. The Ministry of the Environment (MMA), essential for the bioecological vision, is responsible for the management of genetic heritage, associated traditional knowledge and conservation units, but in 2022, it was absent from discussions on bioeconomy. The Ministry of Mines and Energy (MME), in turn, has a strategic role in the vision of bioresources, acting as an inducer and regulator of the production of biofuels. Despite the relevance of these and other ministries, there is currently no unified strategy or effective coordination mechanisms that insert them into governance.

The sustainable development of the bioeconomy requires a governance model that integrates the visions and expertise of the different ministries. The active participation of the ministries responsible for the environment and indigenous peoples is essential to value the biodiversity and knowledge of the Amazonian peoples. In addition, the ministries responsible for justice and public security, women, and human rights are crucial to implement the bioecological vision, to empower indigenous peoples, traditional communities, and family farmers. Fragmented and uncoordinated governance, which does not consider the socio-environmental diversity of the region, can lead to an unbalanced development of the bioeconomy, with damage to environmental conservation and socioeconomic inclusion.

Governance of the Brazilian bioeconomy – CGEE

A comprehensive study conducted by the Center for Management and Strategic Studies (CGEE), under the supervision of the Ministry of Science, Technology, and Innovation and Communications (MCTIC), was carried out in 2020 with the aim of developing an effective governance model for the Brazilian bioeconomy. The proposed governance model was based on technical aspects, learnings from national and international experiences, and opinions from different public and private actors. This CGEE/MCTIC initiative represents a significant contribution to accelerating the maturation of a national bioeconomy strategy. The model aims to coordinate efforts in four domains: between different areas of government; between various levels of government; between the State, society and market actors; for different socio-spatial realities.



The structure combines consultative and deliberative spaces at the national level. The National Bioeconomy Panel, an advisory body linked to the High-Level Interministerial Council, will have the function of channeling the demands and propositions of the different segments of society involved with the bioeconomy. Composed of representatives of the government, the business sector, civil society organizations, science and technology institutions and ordinary citizens, the Panel will produce documents and annual reports to support the decisions of the Interministerial Council.

The High-Level Interministerial Council for Bioeconomy will be responsible for defining the guidelines of the Brazilian Bioeconomy Strategy, coordinating and monitoring actions aimed at its implementation. Composed of Ministers of State from the relevant areas and with minority participation of representatives of civil society and the business sector appointed by the Panel, the Council will adopt a multi-year document that will establish the vision of the future, the diagnosis of bottlenecks and the actions necessary to promote the bioeconomy in the country.

The execution of the actions defined by the Interministerial Council will be the responsibility of the Technical Management Committee, formed by managers of the ministries, autarchies and other State agencies involved. The Committee will have the support of an Executive Secretariat, responsible for monitoring the Strategy Monitoring Plan and coordinating the functioning of the thematic or sectoral Chambers and Working Groups. These spaces of articulation will bring together relevant actors to address strategic themes or specific segments of the bioeconomy, producing diagnoses, subsidies, and proposals for actions for the Steering Committee (CGEE, 2020b).

The model seeks a balance between complexity and efficiency, placing itself at an intermediate level of complexity. It is suggested to read the study in full for a broader and more detailed understanding of the bases on which the proposal is based.

The Leaders Committee was invited to think about the coordination necessary for success in the development of the bioeconomy. The recommendations were made freely during the first phase and were later validated. The recommendations brought by the leaders addressed issues related to governance and institutions that can play a relevant role in the bioeconomy.

Government and society

The first results of the Phase I survey on the role of government agencies, which are consolidated in table 13, indicate a high level (58%) of consensus among leaders on the need for government agencies to develop, adopt and regularly update a strategy with goals to sustain and grow the bioeconomy. However, when it comes to awareness of the bioeconomy, the survey results reveal a divide in opinion among leaders. While 54% agree that government agencies should identify and raise awareness of how the government can promote the bioeconomy, 38% disagree with this belief.

Another point that draws attention is the neutral position adopted by 65% of leaders in relation to the coordination and control of political activities related to the bioeconomy by government agencies. This result may indicate a perception that the governance of the bioeconomy should be shared between the government and other actors, such as the private sector, academia and civil society, through spaces for dialogue and participatory decision-making mechanisms.

On the other hand, most leaders (89%) disagree that government agencies should continuously conduct data collection and analysis of innovation in the bioeconomy for the creation of reports and indicators. This result suggests attributing the responsibility to other specialized institutions, such as observatories and research centers, ensuring that government agencies use these data and indicators as subsidies for decision-making and for the improvement of public policies.

Table 13 - Responsibility of Government Agencies

RESPONSIBILITIES	Disagree	Neutral	Agree
Develop, adopt and regularly update a living strategy with goals to sustain and grow the Brazilian bioeconomy.	26%	16%	58%
Identify and raise awareness of the means by which the government can promote the Brazilian bioeconomy	38%	8%	54%
Plan, organize, direct, coordinate and control activities regarding the orientation of political actions	0%	65%	35%
Produce, research and develop studies on the Brazilian bioeconomy	43%	7%	50%
Continuously conduct data collection and analysis of innovation in the bioeconomy for the creation of reports and Science and Engineering Indicators, in order to better characterize and capture the depth and breadth of the bioeconomy, with emphasis on the identification of indicators that provide information on Brazilian leadership and competitiveness	89%	6%	5%
To gather, systematize and communicate information about the Brazilian bioeconomy	38%	12%	50%

Finally, regarding the systematization and communication of information about the Brazilian bioeconomy, there were also divergences among the leaders, with half of the participants agreeing that this is an attribution of government agencies and 38% disagreeing. This result may reflect different understandings of the role of the State in transparency and accountability to society, indicating the need to find a balance between the responsibility of government agencies and the participation of other actors in the dissemination of information.

In summary, the results of the survey with the Leaders Committee highlight the complexity of defining the skills and responsibilities of government agencies in the development of the bioeconomy. While there is a consensus on the importance of a living and adaptive strategy, there are divergences about the degree of government protagonism in aspects such as awareness, political coordination, production of studies, data collection and communication of information. These divergences point to the need for a governance model that can

articulate the different visions and distributing responsibilities in a balanced way between government agencies and other actors in the bioeconomy ecosystem.

Participatory and decentralized governance

As for governance, the leaders' responses, summarized in tables 14 and 15, point to the need for a participatory governance model, decentralized and capable of articulating the different dimensions, valuing the participation of states, municipalities and local actors. The holding of state, regional, and national bioeconomy forums, as well as the creation of sectoral chambers, are relevant mechanisms to promote dialogue, the integration of different perspectives, and the construction of consensus. These spaces for participation must be institutionalized and have effective power to influence the formulation and implementation of public policies.

Another point highlighted is the need for governance that promotes intersectoral articulation and the harmonization of policies related to the bioeconomy. This requires mapping existing initiatives, identifying synergies and gaps, and seeking greater integration between actions in different areas, such as the environment, agriculture, science and technology, industry, and commerce. The approval of a National Bioeconomy Policy, built in a participatory way, can be an instrument to establish general guidelines and guide this articulation.

The governance of the bioeconomy must also be guided by transparency, access to information, and accountability to society. It is necessary to establish monitoring and evaluation mechanisms, with effective indicators and systematization of data collection. Conducting a Bioeconomic Census, as suggested by one of the leaders, can contribute to the production of strategic information and support decision-making. In addition, it is essential to ensure the participation of civil society in the processes of formulation, implementation, and control of public policies related to the bioeconomy.

A critical aspect of governance is the training and institutional strengthening of the actors involved, especially traditional communities, indigenous peoples, and small producers. It is necessary to promote the empowerment of these groups, value their knowledge and ensure their effective participation in decision-making spaces. This requires investments in training programs, technical assistance and strengthening of local organizations.

One of the proposals presented is the creation of a national coordination body, a climate authority linked to the presidency of the republic. This body would be responsible for leading integrated planning, harmonizing public policies and promoting articulation between sectors. However, it is essential that this national coordination does not translate into an excessively centralizing and bureaucratic approach, respecting regional specificities and the autonomy of the federative entities.

Table 14

ESTABLISHING A GOVERNING BODY FOR THE BIOECONOMY	Phase II Prioritization¹⁷
Creation of continued policies for each area, through a national bioeconomy policy and its capillarization in state policies.	1
Develop a national bioeconomy strategy that addresses the various themes.	2
Establish a leadership in the Federal Government that can address the demands of the business sector and academia in an organized way.	3
Approve a National Bioeconomy Policy that establishes a participatory and decentralized governance model.	4
Coordinate and build a national plan that harmonizes and integrates existing actions.	5
Formation of Sectoral Chambers for each of the areas.	-
Hold biannual State, Regional and National Bioeconomy Forums.	-
Use the National Authority model adopted for data protection law.	-
It is necessary to have a climate authority linked to the presidency of the republic that coordinates the ministries in transversal tasks.	-
Creation of a Bioeconomic Census within the scope of the IBGE Agricultural Census.	-
Centralize related activities, considering the bioeconomy as an ecosystem with several determinants of efficiency and quality.	-
The bioeconomy in the Amazon can be coordinated from an appropriately structured special secretariat in the Ministry of Economy.	-

Finally, bioeconomy governance must be able to mobilize and coordinate the financial resources necessary for the implementation of policies and initiatives. This involves the creation of innovative financing mechanisms, which combine public and private, national and international resources. Governance should also seek to attract investments for bioeconomy projects, through incentive policies, differentiated credit lines and strategic partnerships.

¹⁷ Weighted average of the "Very High (10)", "High (4)" and "Medium (1)" prioritizations.

Table 15 - Propositions for bioeconomy governance

THEME	PROPOSALS
National Coordination	<ul style="list-style-type: none"> • Creation of a climate authority linked to the presidency of the republic to lead integrated planning and articulation between sectors through effective coordination of ministries in transversal tasks.
Decentralized Governance	<ul style="list-style-type: none"> • Governance model that values the participation of states, municipalities and local actors. • Holding state, regional and national bioeconomy forums. • Creation of sectoral chambers to promote dialogue and integration of different perspectives.
Intersectoral Articulation	<ul style="list-style-type: none"> • Mapping existing initiatives and identifying synergies and gaps between bioeconomy-related policies. • Search for greater integration between actions from different areas (environment, agriculture, science and technology, industry and commerce).
National Policy	<ul style="list-style-type: none"> • Approval of a National Bioeconomy Policy, built in a participatory manner, to establish general guidelines and guide the articulation between the sectors integrating existing actions.
Monitoring and Evaluation	<ul style="list-style-type: none"> • Establishment of monitoring and evaluation mechanisms, with valid indicators and systematization of data collection. • Conducting a Bioeconomic Census to produce strategic information and support decision-making
Social participation	<ul style="list-style-type: none"> • Guarantee of civil society participation in the processes of formulation, implementation and control of public policies related to the bioeconomy
Capacity Building and Institutional Strengthening	<ul style="list-style-type: none"> • Promotion of the empowerment of traditional communities, indigenous peoples and small producers. • Valuing traditional knowledge and ensuring effective participation in decision-making spaces. • Investments in training programs, technical assistance and strengthening of local organizations.
Financing	<ul style="list-style-type: none"> • Creation of innovative financing mechanisms, combining public and private, national and international resources. • Attracting investments for sustainable bioeconomy projects through incentive policies, differentiated credit lines and strategic partnerships.

Institutions for the bioeconomy

The Leaders Committee prepared a series of recommendations on the importance and prioritization of instruments and institutions, as can be seen in table 16, for the development of the bioeconomy in Brazil. The results obtained in the two phases of the research reveal a high degree of consensus on the relevance of initiatives that promote intersectoral collaboration, capacity development, and knowledge generation and dissemination.

In Phase I, which assessed the importance attributed to a predetermined list of instruments and institutions, all items received a high percentage of “important” and “very important” responses, ranging from 63% to 85%. This result highlights the recognition, on the part of leaders, of the need for a comprehensive and integrated approach to boost the bioeconomy in the country.

Table 16

INSTRUMENTS AND INSTITUTIONS FOR BIOECONOMY	SOURCE	Agreement ¹⁸ Phase I	Prioritization ¹⁹ Phase II
National Bioeconomy Information System (SNIB)	Committee	71%	14%
National Bioeconomy Agency	Committee	63%	50%
Local committees to promote dialogue between civil society, private initiative and academia	Committee	85%	22%
Brazilian Government Bioeconomy Strategy Intelligence Center - Identify trends, attraction and direction of international and national investments	Committee	80%	57%
Institute of Technology for the Amazon (AmIT) - Research, education and knowledge center	Committee	70%	66% 3
Observatory of development and infrastructures aimed at the sustainable use of the biodiversity of Brazilian biomes	Committee	70%	62%
SEBRAE of the Forest with the objective of forming capacities for the challenges of the forest socio-biodiversity economy	Committee	85%	85% 1
Bioeconomy Knowledge Centre (CCB) – provide data, information and analysis to help build evidence-based and coherent policies across sectors	Committee	80%	83% 2

Among the highlights of the first phase, the local committees to promote dialogue between civil society, private initiative and academia, together with SEBRAE of the forest, obtained 85% of the responses, emphasizing the importance of intersectoral collaboration and capacity development to face the challenges of the forest socio-biodiversity economy. In addition, the Brazilian Government’s Bioeconomy Strategy Intelligence Center and the Bioeconomy Knowledge Center (CCB) also stood out, with 80% of responses each, indicating the need for structures dedicated to identifying trends, attracting investments, and providing data and analysis to support coherent policies.

¹⁸ Sum of the percentages of the answers “Agree” and “Strongly agree”.

¹⁹ Percentages of “Very High” responses.

In Phase II, in which the leaders were asked to order the institutions by priority, the SEBRAE of the forest and the CCB maintained their prominent position, with 85% and 83% of the responses, respectively, considering them to be of “very high” priority. This result reinforces the perception that capacity building and the provision of information are key elements for building evidence-based policies and advancing the bioeconomy.

Another relevant point of the second stage was the high priority given to the Institute of Technology for the Amazon (AmIT) and the Observatory of Development and Infrastructures Aimed at the Sustainable Use of the Biodiversity of Brazilian Biomes, with 66% and 62% of the responses, respectively. These results highlight the importance of research, education and knowledge centers, as well as mechanisms for monitoring the sustainable use of biodiversity, for the success of the bioeconomy.

It is interesting to note that, although the National Bioeconomy Information System (SNIB) was considered important or very important by 71% of the leaders in the first stage, only 14% classified it as a “very high” priority in the second stage. This apparent discrepancy may suggest that, despite their relevance, other initiatives are perceived as more urgent or of greater immediate impact. On the other hand, the National Bioeconomy Agency gained prominence in the second stage, with 50% of leaders considering it a “very high” priority, compared to 63% who considered it important or very important in the first stage. This result indicates that a structure dedicated to the coordination and promotion of the bioeconomy is seen as crucial for its development, which is in line with previous discussions on the importance of effective and articulated governance.

In the specific case of AmIT, the importance of a Pan-Amazonian public-private institution focused on the production of sustainable technologies to solve bottlenecks in existing value chains, observing the culture and conservation of Amazonian environments, was highlighted. It was suggested, alternatively, that it be studied whether EMBRAPA’s decentralized public company format could be more efficient than an institute.

Another point strongly emphasized by the leaders was the need to optimize and value existing science and technology institutions (ICTs), which often face budgetary challenges to maintain and expand their technical staff and infrastructure. In this sense, the importance of a national policy that offers incentives for the development of platforms and projects that meet the demands for information for decision-making in the public and private sectors was highlighted. In addition, proposals were mentioned, such as support for other existing knowledge units, such as universities and EMBRAPA units, to convert knowledge into solutions for value chains; the promotion of technology transfer actions; the structuring of ATER (Technical Assistance and Rural Extension) agents prepared for the promotion of sustainable production technologies; and the preparation of key ministries, such as the Ministry of Finance, Development, Industry, Trade and Services, and Environment and Climate Change, to lead the bioeconomy agenda and the areas of sustainable production.

In the specific case of the Amazon, the need to increase incentives for the development of the bioeconomy and socio-biodiversity value chains, especially the forest, was highlighted, while gradually reducing incentives for livestock and grain production chains.

These results and additional comments highlight the complexity and scope of the challenges involved in the development of the bioeconomy in Brazil. The implementation of an effective National Bioeconomy Strategy requires not only the creation of new structures and instruments, but also the strengthening and articulation of existing institutions, the promotion of intersectoral collaboration, and the review of incentive policies.

In this context, the importance of governance capable of coordinating the efforts of the different actors and sectors involved in the bioeconomy becomes evident. The creation of a National Bioeconomy Agency, as highlighted by the leaders, can be a fundamental step in this direction, acting as a link between the various initiatives and promoting the necessary articulation to advance the agenda. Nevertheless, it is essential that this governance be accompanied by the proper allocation of resources and a long-term vision.

Effective governance of the bioeconomy is not restricted to the political-institutional sphere. It also requires the active engagement of academia, research, and the productive sector. In this context, engineering, education and human resource training play a key role in generating the knowledge, technologies and skills needed to drive innovation and the transition to a bio-based economy.

SEBRAE OF THE FOREST TO THE BIOECONOMY OF THE AMAZON

The sustainable development of the bioeconomy in the Amazon requires an innovative and inclusive approach, which values the biological and cultural diversity of the region. In this context, SEBRAE (Brazilian Service of Support to Micro and Small Enterprises) emerges as a fundamental actor to boost this new development model, focusing on small producers and entrepreneurs, in need of legalization and formalization of their enterprises. The creation of a “SEBRAE of the Forest”, a proposal widely supported by the Leaders Committee and presented by Abramovay (2022), is a crucial step to face the challenges of the forest sociobiodiversity economy. By leveraging its expertise in training and promoting the competitiveness of micro and small enterprises, SEBRAE can play a profoundly transformative role in the Amazon region.

For the sustainable development of the Amazon bioeconomy, the logistical and business feasibility challenges in the Amazon depend on scale. But not the scale of commodities that we are accustomed to in Brazil, but a scale that is sustained by the sociobiological diversity that still exists in the region (Dias, 2021). This innovation in the development model based on hundreds of thousands of small businesses will be one of the greatest achievements in the fight against poverty and sustainable development when and if realized. It depends on an active, effective SEBRAE of the Forest that has been operating for decades.

This vision aligns perfectly with SEBRAE’s mission and competencies. By taking the lead in the creation of “SEBRAE of the Forest”, the entity can function as a catalyst for the emergence and strengthening of these small businesses, providing training, technical assistance and access to markets. SEBRAE can contribute to the construction of a highly integrated and proactive network of forest entrepreneurs, which values the biological and cultural diversity of the region. In addition, SEBRAE can play a crucial role in the articulation between the various actors involved in the development of the Amazonian bioeconomy. By promoting collaboration between government, private initiative, universities, technology and innovation centers, and civil society, SEBRAE can create a favorable environment for these small businesses to flourish, overcoming bureaucratic and regulatory barriers and facilitating access to resources and knowledge.

Another fundamental aspect is the need for investments in education and preparation of small producers to undertake. SEBRAE, with its extensive experience in training entrepreneurs, is in a privileged position to lead these efforts together with other actors. By offering training, mentoring, and technical support, SEBRAE can contribute to the formation of a new generation of forest entrepreneurs, equipped with the skills and



knowledge necessary to thrive in the bioeconomy. In addition, SEBRAE can act as a facilitator in the promotion of technological innovations, such as the “Amazon 4.0”, by supporting the installation of biofactories and manufactures that use sophisticated technologies of industry 4.0, SEBRAE can contribute to the generation of income sustained in quality jobs and the sustainable economic development of the region, without compromising biological and cultural diversity.

In short, the “SEBRAE of the Forest” represents a significant opportunity to boost the Amazon bioeconomy, but its success will depend on a realistic and collaborative approach. Although SEBRAE has valuable expertise in supporting small businesses, the peculiarities of the Amazon region - such as the vast territorial extension, cultural diversity and logistical challenges - will require substantial adaptations in its methodologies. The impact of this initiative could be evaluated through indicators such as the increase in the formalization of local enterprises, the diversification of the regional economy and the reduction of activities that are harmful to the environment. However, it is important to recognize that SEBRAE, by itself, will do little. The effectiveness of “SEBRAE of the Forest” will be intrinsically linked to its ability to integrate into a broader ecosystem of bioeconomy governance, involving public, private and third sector institutions. This multisectoral collaboration is essential to overcome regulatory barriers, ensure sustainable investments, and align initiatives with environmental conservation policies.

The next steps, from the perspective of the governance of the Amazon bioeconomy, should focus primarily on the clear and strategic definition of the mandate for the “SEBRAE of the Forest”. This process involves:

- **Articulation between the various actors of the bioeconomy (public and private sector, academia and civil society) to establish consensus on the specific role of SEBRAE in this ecosystem.**
- **Alignment of SEBRAE’s competencies with the needs and opportunities identified in the region, avoiding overlaps with other institutions and maximizing their potential impact.**
- **Definition of governance mechanisms that guarantee the autonomy necessary for the effective performance of the “SEBRAE of the Forest”, while ensuring its harmonious integration with the sustainable development policies of the Amazon.**
- **Establishment of criteria and indicators for continuous monitoring and evaluation of the performance of ‘SEBRAE of the Forest’, allowing adjustments and improvements in its mission over time.**

The implementation of these steps by the governance of the bioeconomy will be fundamental to create the necessary conditions for the ‘SEBRAE of the Forest’ to fulfill its role as a catalyst in the sustainable development of the Amazon region.”



ENGINEERING, EDUCATION AND WORK IN THE BIOECONOMY

Engineering plays a fundamental role in the development of the bioeconomy in Brazil, acting on several fronts, such as the transition of the energy matrix in large urban centers, the minimization of the environmental impact of bioeconomy business activities, the development of infrastructures for sustainable development in all biomes and in particular in the Amazon.

Our bioeconomy needs to engage in the reindustrialization movement based on biodiversity, aiming at the development of a diversified, advanced, competitive industry on a global scale and with greater added value in products and services. The presence and performance of engineering are essential to achieve these goals. However, it is essential that engineering acts not only in its physical and technical dimension, but also considers the perspectives of what sociologist Gilberto Freyre called human engineering and social engineering (Freyre, 1987). In “Men, Engineering and Social Directions” Freyre places engineering at the center of his reflections on the occupation and development of the Amazon. He argues that the development of engineering solutions is paramount and must consider the needs and characteristics of the people who will interact with these technologies (human engineering), as well as the impacts and adequacy of these innovations to the sociocultural context of each region (social engineering). This vision is especially relevant for the bioeconomy, which has the Amazon as one of its main frontiers. With this more comprehensive and human-centered approach, engineering will avoid historical errors of unbalanced solutions, the result of partial and hasty definitions of the problem.

In this context, the Leaders Committee was invited to answer the following question: “How can Engineering and engineering entities help Brazil become a bioeconomy power?”

The responses were analyzed and grouped into four sets, each representing a strategic dimension for the participation of engineering in the advancement of the bioeconomy in the country. These groupings include:

- 1.** Training of human resources to boost the bioeconomy;
- 2.** Industrialization and scaling of bioeconomy products and processes;
- 3.** Development of knowledge, technologies and innovations for the bioeconomy;
- 4.** Influence and strategic articulation for the advancement of the bioeconomy.

Each grouping brings together a set of ideas, proposals and directions that, together, offer a comprehensive and integrated vision of how Engineering can contribute to Brazil realizing its potential for the bioeconomy.

Human capital formation for the bioeconomy

Engineering and the entities that represent it can play a fundamental role in the formation of qualified human capital to boost the bioeconomy in Brazil. The importance of training new professionals with specific knowledge and skills to face the challenges and take advantage of the opportunities of the bioeconomy is highlighted. This can be achieved by recommending curricular content related to bioeconomy to schools and colleges of engineering and agronomy, as well as by conducting strategic studies that guide the implementation of agendas in this field. In addition, giving visibility to successful initiatives that reconcile environmental, social, economic, and cultural aspects in the bioeconomy can inspire and motivate new professionals to engage in this area. The involvement of engineers and entities

that represent engineering in the creation of a fund to support the bioeconomy can also be a way to enable the training and development of talent in the sector.

“Recommendations: (...) 6. Introduce specific training in engineering schools focused on nature-based solutions and stimulate research for the application of these solutions to problems of management of forest, rural and urban territories, especially in the Amazon.”
(Abramovay, 2022, p.90)

To effectively boost the bioeconomy in Brazil, it would be productive if the training of human capital in engineering fully integrated the principles of interdisciplinarity and innovation, as outlined in the “World Declaration on Higher Education in the 21st Century” (UNESCO, 1998). This involves adapting curricula to include not only traditional engineering, but also aspects of life sciences, natural resource management, and sustainable development.

In this regard, the “Engineering for One Planet” (EOP) framework provides essential guidelines for transforming engineering education, ensuring that all engineers are equipped with the skills, knowledge, mindsets, and understandings necessary to protect and improve our planet and our lives (The Lemelson Foundation, 2022). EOP emphasizes the importance of **systems thinking, social responsibility, environmental impact, sustainable material selection, and conscious design**. By integrating these principles into engineering curricula, we will prepare future professionals with skills for continuous learning, able to address complex societal challenges and operate in an environment characterized by rapid change and uncertainty.

In addition, international collaboration and knowledge exchange must be fostered to enrich the training of these professionals, ensuring that they can contribute not only locally, but in the global scenario of the bioeconomy. In this context, it is essential that **engineers are prepared to face complex and interdisciplinary challenges, acquire and apply new knowledge continuously, and consider the environmental and social impacts of their work**, principles that are aligned with the engineering challenges proposed by the National Academy of Engineering (NAE, 2008). Higher education institutions must therefore function as catalysts for development, preparing students not only for the job market but also to be responsible and innovative global citizens committed to promoting sustainability and equity.

In addition to engineering, it is essential that an analogous process of human capital formation focused on the bioeconomy occurs in other areas related to the sector, such as agronomy, forestry, biological sciences, biotechnology, and environmental management. These areas play a key role in the development and implementation of nature-based solutions, the sustainable management of natural resources and the promotion of regenerative agricultural and forestry practices. In addition, the bioeconomy requires a truly interdisciplinary approach, demanding the contribution of professionals from diverse fields, such as law, economics, administration, design, social sciences, communication, public management, among others. These areas of knowledge are essential for the creation of solutions that favor

the bioeconomy. Therefore, a coordinated and comprehensive human capital training effort is essential, integrating multiple disciplines and fields of knowledge, to build a solid base of knowledge and skills that can drive the advancement of bioeconomies in Brazil.

Finally, a crucial challenge that has not yet been fully addressed is the issue of valuing and incorporating traditional knowledge in the formation of human capital for the bioeconomy. While there is a growing recognition of the importance of this knowledge, effective institutionalized mechanisms to promote a fair and equitable exchange between traditional knowledge and formal scientific knowledge need to be improved in practice. Often, when this exchange occurs, it is to the detriment of those who hold traditional knowledge, resulting in cases of judicialization and disputes over intellectual property and the sharing of benefits derived from the exploitation of this knowledge. Therefore, it is essential that, within the scope of human capital formation for the bioeconomy, innovative strategies and solutions are implemented to deal with this challenge, ensuring that traditional knowledge is valued, protected and incorporated in an ethical and fair way, for the benefit of traditional communities and society as a whole.

Scalability and value addition in the bioeconomy

For Brazil to realize its bioeconomic potential, it is essential to promote scalability and add value to the products and processes developed in the bioeconomy. The need to establish a bridge between research conducted in laboratories and application on an industrial scale is emphasized, taking innovations from benches to the market. Engineering must contribute to the design of scalability strategies, considering technical, economic and logistical aspects. In addition, the industrialization of socio-biodiversity products is pointed out as a promising way to add value and generate wealth from natural resources. For this, it is essential that private companies in the industrial sector, of all scales, invest massively in advanced Research, Development and Innovation laboratories. In addition, it is of paramount importance to include indigenous peoples and traditional communities in all stages of the process, valuing their knowledge of the “engineering” of forests, land and waters.

Research, technology and innovation for the bioeconomy

As already observed in the previous research topics, the development of the bioeconomy in Brazil requires a strong investment in research, technology and innovation. Engineering must play a leadership role in this process, coordinating research and developing modern technologies that contribute to the preservation, protection and enable the sustainable development of the country’s bioeconomic potential.

The processing and analysis of geographic information can help identify the vocations and potentialities of different regions, guiding the definition of strategic areas for pilot projects in partnership with local actors and specialists. These projects should be guided by the

search for solutions appropriate to the specificities of each biome and contribute to the improvement of regionalized systems for monitoring and management of natural resources.

In this context, the Amazon in particular, due to its immense potential for the bioeconomy, is the largest space for the development of research, technologies and innovations aimed at the sustainable use of its wealth. Adequate investments can significantly boost the bioeconomy in the region. Initiatives such as AmIT (Amazon Institute of Technology) can become references in education, science, technology, innovation and entrepreneurship for the promotion of a more sustainable and socially inclusive bioeconomy, not only in the Amazon, but throughout the national territory.

To help students and researchers better understand challenges of each region and engage them in the development of innovative solutions for the bioeconomy, send them into the field as part of the curriculum.

Articulation and influence for the promotion of the bioeconomy

The scenario of growing competition and international investment in bioeconomy requires measures to be taken to accelerate this process in Brazil. An effort of articulation and influence with different actors, such as decision-makers, academia, companies and productive sectors, is necessary so that the plans are prepared and the investments made viable. The importance of basing this influence on **technical and scientific information** that highlights the **potential and urgency** of investments in the bioeconomy is emphasized. Engineering and the entities that represent it can play a reference role in the articulation of institutions (academic and technological, public and private) and people for technological development appropriate to the demands of the bioeconomies of the 21st century.

In addition, the inclusion of compensatory activities for engineering works, with an amount dedicated to the promotion of the bioeconomy in places of impact, especially in rural areas and in the Amazon, is pointed out as a concrete way to direct resources to this agenda. The realization and promotion of research, development and innovation activities were again mentioned by the Committee of Leaders, but here as strategies to influence and mobilize different actors around the bioeconomy.

In Phase II, of prioritization of actions, the results of which can be consulted in the following table, the Committee of Leaders was called upon to prioritize Engineering actions to leverage the Brazilian bioeconomy.

The prioritized actions reveal a comprehensive and systemic vision, which goes beyond the traditional technical contributions of the area. More than developing technologies and designing processes, Engineering is called upon to assume a leading role in the promotion of a new development model, based on the valorization of biodiversity and traditional knowledge.

Table 17

PRIORITY ACTIONS FOR ENGINEERING TO LEVERAGE THE BRAZILIAN BIOECONOMY	Phase II Prioritization ²⁰
Influencing decision-makers based on technical and scientific information	1
To give visibility to successful initiatives that reconcile the environmental, social, economic and cultural aspects of the bioeconomy	2
Recommend bioeconomy-related curriculum content to schools and colleges	3
Encourage the approval of a National Bioeconomy Policy with a participatory and decentralized governance model	4
Contribute to bringing information obtained in laboratories to the shop floor and scale up small-scale findings or information for new products and processes	5
Design strategies for the scalability of new products and processes	6
To be a reference in the articulation of institutions and people for the technological development appropriate to the bioeconomy in the Amazon	-
Development of modern technologies to improve monitoring systems for activities that impact the preservation, protection and development of Brazilian biomes	-
Conduct strategic studies to accelerate the implementation of bioeconomy agendas	-
Engage members to create a bioeconomy support fund	-
Train new staff to respond to the challenges and priorities of the bioeconomy	-
Coordinate and articulate actions between academic, technological and planning institutions	-
Include indigenous peoples and traditional communities at every stage of the process	-
Creation of financing in compensation for engineering works	-

²⁰ Weighted average of the “Very High (10)”, “High (4)” and “Medium (1)” prioritizations.

By placing influence on decision-makers and the visibility of successful initiatives as the most priority actions, leaders signal that Engineering should function as a bridge between technical-scientific knowledge and the formulation of public policies. This requires a proactive stance of translating evidence into concrete recommendations and promoting success stories that can inspire new practices.

This vision aligns with the need, pointed out in other parts of the research, to create a regulatory and institutional environment favorable to the bioeconomy. The prioritization of encouraging the approval of a National Bioeconomy Policy with participatory and decentralized governance reinforces this point and signals that Engineering can and should contribute to the construction of a legal framework that promotes coordination between different actors and values regional specificities.

Actions related to the scale and practical application of technological innovations, such as taking information from laboratories to businesses and designing scalability strategies, reflect the challenge of translating scientific knowledge into concrete solutions. Similarly, to strengthen bioeconomy value chains and promote technological innovation for the development of high value-added socio-biodiversity products theory must transfer to actionable tasks.

Finally, it is interesting to note that, even in more specific actions, such as the development of technologies for monitoring biomes or the creation of a fund to support the bioeconomy, the view that Engineering should act in an articulated manner with other areas of knowledge and sectors of society is evident. The inclusion of indigenous peoples and traditional communities in all stages of the process reinforces the importance of social participation and dialogue of knowledge for the construction of an inclusive and sustainable bioeconomy.

By implementing these measures, we can transform engineering practice and education to empower a new generation of professionals with the skills, knowledge, and values needed to lead the transition to a truly sustainable bioeconomy.

CONCLUSIONS AND NEXT STEPS

This study was developed with the objective of building a knowledge base to support the elaboration and implementation of a national bioeconomy strategy in Brazil. The research involved a literature review, analysis of international experiences and consultation with a Committee of Leaders from various sectors related to the bioeconomy. This process was completed before the publication of Decree No. 12,044, of June 5, 2024, which instituted the National Bioeconomy Strategy.

The final report of the study, however, was prepared after the publication of the decree. It should be noted that, at the time of the conclusion of this report, the acts that will define the composition and functioning of the National Bioeconomy Commission and the National Bioeconomy Development Plan, provided for in the decree as central instruments for the implementation of the strategy, had not yet been published. In this context, it is expected that the subsidies generated by this research can contribute both to the formation of the diverse and representative National Bioeconomy Commission, to the construction of a comprehensive and effective National Bioeconomy Development Plan, and to the continuous improvement of the National Bioeconomy Strategy itself. After all, the bioeconomy is a field in constant evolution, both in Brazil and in the world, and the pioneering countries through the elaboration of national strategies have adopted the good practice of reviewing and updating them periodically.

Limitations

Before considering our conclusions, it is important to acknowledge the limitations of this study. Although we are concerned with the formation of a diverse Leaders Committee, the consultation with leaders does not exhaust all the perspectives and interests involved in bioeconomies. In addition, the research does not delve into the definition of measurement indicators or the detailing of strategies for implementing the proposed objectives. These gaps point to the need for future work that expands the participation of actors, develops appropriate metrics and develops specific action plans.

Another limitation refers to the complexity and magnitude of the challenges inherent to the bioeconomy, which will require a coordinated and persistent effort from different sectors of society. In this sense, a critical reflection on the research process revealed the importance of continuously improving the mechanisms of engagement and articulation between government, the private sector, academia and civil society.

It is also important to recognize that the foundation of the research began in 2021 under the name of **the Amazon and Bioeconomy WG of the Institute of Engineering** and changed in 2023 to **the National Bioeconomy WG of the Institute of Engineering**. This change reflects the group's perception that the bioeconomy of the Amazon is an element of a broader

context, with opportunities, challenges, risks, ambitions and capacities that extend beyond the Amazon and must be developed at the national level. However, despite this finding, the work was significantly influenced by the wave of interest in the Amazon during the COVID-19 pandemic, which, in our assessment, also affected the movements that today influence the federal government. This effect may have resulted in a disproportionate emphasis on the Amazon region, to the detriment of a more comprehensive view of bioeconomies in Brazil.

Throughout the research process, the WG identified several areas that need further study to create a knowledge base for the national bioeconomy strategy. These areas were identified with the valuable participation of professionals listed in **ANNEX II - Technical collaborators in events, lectures and open classes**, whose contributions can be explored through the lectures available on TV Engenharia. The mapped themes cover agriculture, energy, health, extractivism, livestock, public policies, science and technology, governance, industry 4.0, traditional knowledge, environmental services and ecosystem valuation, financing, tourism, biomimicry, transportation, global bioeconomy, sustainable cities, sanitation, and education. The necessary expansion of study in these fields will allow a more complete and integrated understanding of Brazilian bioeconomies, subsidizing the formulation of strategies and policies that enhance the vocations and strengths of each region and bioeconomic sector of the country.

Bioeconomies

Bioeconomies (used in the plural): highlights that there is no single or homogeneous model of bioeconomy, but rather a variety of sectors with specific characteristics and needs. This perspective is based on the conception that the bioeconomy ranges from large-scale commodity production to small-scale initiatives, including local productive arrangements, socio-biodiversity value chains, innovation networks, and environmental services markets. This concept allows the design of public policies, development instruments and business models, which consider the particularities of each bioeconomic context.

It is important to emphasize that the bioeconomy of sociobiodiversity, although fundamental, does not cover all the complexity and diversity of bioeconomies in Brazil. For an effective National Bioeconomy Strategy, it is necessary to recognize and treat the particularities of each type of bioeconomy differently. In this sense, the concept of “bioeconomies”, in the plural, becomes more appropriate, allowing the development of public policies that consider the specificities and needs of each sector, as well as the allocation of resources. In agriculture, for example, there is everything from large-scale commodity production to small family farming, including Integrated Crop-Livestock-Forest (ICLF) production systems. In bioenergy, there are both large biofuel plants and local waste use initiatives. Biotechnology ranges from innovative research to the development of appropriate solutions for smaller-scale contexts. This diversity is also reflected in biochemistry and resource management for emerging markets for environmental services, with projects of varied sizes and focuses of action.

Recognizing and understanding this diversity of bioeconomies is crucial for the development of a comprehensive, fair, and effective National Bioeconomies Strategy. By considering the particularities of each sector, it becomes possible to develop appropriate policies and instruments to foster the potential of each bioeconomy. In addition, the structuring of environmental services markets, with the creation of new mechanisms for valuing, negotiating and effectively attracting resources, presents itself as an opportunity to boost innovation and the adoption of practices with lower bio-impact in all bioeconomies in the country.

Bio-impact A term that refers to the direct and indirect effects that economic activities have on biological resources, biodiversity, and the functioning of ecosystems. Bio-impact includes everything from the extraction of raw materials and the modification of habitats to the generation of waste and the emission of pollutants. It can be positive, when activities contribute to the conservation and regeneration of natural systems, or negative, when they lead to degradation and loss of environmental services. The concept of bio-impact is based on the recognition that all economic activities, including those related to bioeconomies, interact and affect in some way the biological basis that sustains life on the planet. Therefore, bio-impact management becomes a crucial component for sustainable development, requiring tools to measure, monitor, mitigate and remedy these effects in an integrated and systematic way.

The analysis of the opportunities, challenges and risks pointed out by the Committee of Leaders revealed that Brazil has strategic assets to boost an innovative and sustainable bioeconomy, such as the richness of biodiversity, the installed capacity of the agricultural and forestry sector. However, to realize this potential, it will be necessary to overcome critical bottlenecks, such as the effective implementation and maturation of the regulatory framework, infrastructure gaps, and the insufficiency of adequate financing mechanisms for different bioeconomies. It is also necessary to mitigate risks such as the concentration of benefits, the increase in inequalities and the impacts of climate change on the biological asset base.

A configuration of different visions and aspirations led to the definition of the aspiration for Brazil positioned as *a global leader in the bioeconomy via innovation focused on knowledge, products and services with greater added value for tangible, resilient, regionalized economic development, reconciled with the valorization of socio-biodiversity and particularly recognized for social inclusion and poverty reduction.*

To achieve this aspiration, facing the challenges and seizing the opportunities, the Leaders Committee listed a set of enabling capabilities that need to be developed during the implementation of the strategy. These include the Production and Application of Interdisciplinary Knowledge, Education for the Socio-bioeconomy, Environmental Impact Management, Multisectoral Coordination and Collaboration, Fostering Innovation and Investment in RD&I, Reviewing, Adapting and Implementing Public Policies, Infrastructure and Financing, Development and Implementation of Sustainable Technologies, and

Promoting Social Inclusion and Equitable Distribution. These capacities should underpin the strategic objectives of the Brazilian bioeconomy centered on adding value, conserving and using biodiversity, minimizing negative bio-impact and fair sharing of the benefits generated.

The results also highlight the committee's vision for the potential of the Amazon as our most significant biome for the future of many bioeconomies. The region has the greatest biodiversity on the planet and an immense stock of forest carbon, in addition to a wealth of traditional knowledge. At the same time, it is under increasing pressure from deforestation and environmental degradation. Directing efforts and investments to the construction of Amazonian bioeconomies with low (negative) bio-impact, based on the multiple use of the forest, the valorization of socio-biodiversity and the protagonism of local populations, should be priorities for the region.

In this context, the mobilization of financial resources emerges as a critical component. An approach that combines public and private, national and international sources will be needed. Mechanisms such as green funds, impact bonds, payments for environmental services, and carbon markets can leverage the necessary investments. At the same time, it is necessary to direct existing development instruments, such as those of the BNDES, regional agencies, royalties, and constitutional funds to prioritize initiatives aligned with the objectives of bioeconomies.

In the field of governance, the results point to the importance of a participatory, decentralized model capable of articulating the different policies and relevant actors. This involves the establishment of clear leadership in the federal government, with adequate mandate and resources, the construction of instances of dialogue and consultation, such as forums and sectoral chambers, and the dialogued formulation of a long-term state strategy. It is also essential to strengthen key institutions, such as a Bioeconomy Reference Center, an observatory of sustainable infrastructures, and a "SEBRAE of the Forest" to support community-based businesses.

To accelerate this process, it is necessary to engage universities, public companies in the sector, and engineering, among other disciplines, in the development of skills and technological solutions for bioeconomies. This involves the modernization of training curricula, the promotion of interdisciplinary research oriented to concrete problems, and acting at the interface between academia, government, and the productive sector.

Based on these analyses and focusing on the capacities to be developed to achieve what we aspire to, a set of priority actions is recommended to advance in the construction and implementation of a transformative strategy for bioeconomies in Brazil, organized into 7 dimensions:

1 Research, development and innovation (RD&I)

- **Implement a bold program of public and private investments in RD&I for the technological densification of bioeconomy production chains, with an emphasis on innovative biodiversity products and processes.** This program is key to developing the capacities of Production and Application of Interdisciplinary Knowledge and Fostering Innovation and Investment in RD&I. It contributes directly to the aspiration to make Brazil a world leader in bioeconomy with high added value.
- **Create a network of centers for excellence in research and innovation bioeconomies, anchored in universities and ICTs spread across the country.** These centers must act in close connection with the productive sector and local communities, developing technological solutions adapted to different contexts. They are at the heart of the capacity for the Production and Application of Interdisciplinary Knowledge. They are key to the aspiration of knowledge- and innovation-intensive bioeconomies.
- **Establish effective mechanisms for technology transfer and scaling up bioeconomy innovations, to “take science from the laboratory to the factory floor”.** This action is critical to materialize the economic potential of biodiversity research. It fosters the capacities of Knowledge Production and Implementation of Sustainable Technologies. It paves the way for the aspiration to add value and technologies to biodiversity product chains.
- **Conclude the implementation of a highly integrated network of National Institutes of Science and Technology (INCTs) and Applied Research Centers dedicated to bioeconomies, with units distributed in the regions with the greatest potential, especially the Amazon.** This infrastructure is vital for the capacities of Production and Application of Interdisciplinary Knowledge and Fostering Innovation. It supports the aspiration of a Brazilian leadership in tropical bioeconomy. These centers should incorporate the concept of bio-impact into their research, developing methodologies to assess and minimize the negative impacts, and maximize the positive ones, of bioeconomic innovations on ecosystems and biodiversity.

2 Education and skills training

- **Promote a broad reformulation of school curricula, at all levels of education, to incorporate competencies and skills related to bioeconomies.** This action is a pillar to develop the capacity of Education for Socio-bioeconomy, training citizens and professionals prepared for the challenges of sustainability and enabling students to critically evaluate the effects of economic activities on biological resources and ecosystems. It contributes to the aspiration of valuing socio-biodiversity as a strategic asset of the country.

- **Create technological extension and continuous training programs for communities, workers and entrepreneurs in bioeconomies, with a focus on the dissemination of social technologies and the solution of concrete problems.** This initiative is central to the capacities of Education for the Socio-bioeconomy and the Development and Implementation of Sustainable Technologies. It promotes the aspiration of social inclusion and poverty reduction through knowledge.
- **Implement a network of technical vocational institutes in bioeconomies in the different Brazilian biomes, with curricula adapted to local productive vocations.** These institutes are vital to train technical skills aligned with the demands of sociobiodiversity productive arrangements and thus strengthen the capacity of Education for Sociobioeconomy and the aspiration for regionalized development.

3 Strengthening value chains and institutional arrangements

- **Implement a set of policies to strengthen small businesses and community enterprises based on the sustainable use of biodiversity.** These policies are essential to promote the capacity to promote Social Inclusion and Equitable Distribution and to enable the aspiration of bioeconomies based on conservation and income generation for local populations.
- **Create the “SEBRAE of the Forest”, with capillary operations in all states of the Legal Amazon, to bring training and technical assistance to bioeconomy entrepreneurs in the region.** This institution is strategic to develop the capacities of Multisectoral Coordination and Collaboration, Education for the Socio-bioeconomy, Promotion of Innovation and Investments in RD&I, Development and Implementation of Sustainable Technologies and especially in the capacities of Promotion of Social Inclusion. It leverages the aspirations of valuing the local economies of the Amazon, with greater added value for tangible and resilient economic development with social inclusion and poverty reduction.
- **Stimulate the creation of Local Productive Arrangements (LPAs) and Bioeconomy Territories in regions of high potential, with priority for the Amazon.** These arrangements materialize the capacities of Multisectoral Coordination and Collaboration and Promotion of Social Inclusion. They give life to the aspiration of bioeconomies that generate wealth and well-being from regional vocations. They should be structured prioritizing activities that minimize negative effects on local ecosystems and maximize benefits to biodiversity.
- **Structure reference value chains of Amazonian sociobiodiversity, such as those of nuts, açai, fish and rubber, with attention to all links and the fair sharing of benefits.** This action strengthens the capacities of Environmental Impact Management, Multisectoral Coordination and Collaboration, and Promotion of Social Inclusion. It materializes the aspiration to generate wealth from the standing forest and rivers.

4 Valuing bioeconomies and sources of financing

- **Create a specific fund to finance the structuring actions of the National Bioeconomy Policy, with diversified sources and innovative mechanisms.** This fund needs to enable the capacities of Infrastructure and Financing and Promotion of Innovation and Investment in RD&I, fulfilling the aspiration of a new development model based on bioeconomies. Given the magnitude of the investments required, it will be necessary to build a strategy that combines multiple sources, including: public resources from the budgets of the Union, states and municipalities; public funds such as the Amazon Fund and the National Fund on Climate Change; credit lines from official banks such as BNDES, Banco do Brasil, BASA and BNB; bilateral and multilateral international cooperation; private impact investment funds; market instruments such as green bonds and cryptocurrencies backed by environmental assets; among others.
- **Attract private and international investments for the constitution of investment funds dedicated to bioeconomy businesses in Brazil.** These external resources are complementary to domestic Infrastructure and Financing capabilities. They signal the country's potential to become a world leader in this sector, attracting capital to a sustainability agenda.
- **Strengthening Payments for Environmental Services (PES) and Diversification of Environmental Services.** Reinforce the use of PES as an instrument for directing and applying existing resources from various sources. To this end, it is essential to develop and structure markets for a variety of environmental services and bio-impacts, in addition to carbon, such as biodiversity conservation, regulation of the hydrological cycle, pollination and erosion control. This diversification will contribute to the valorization of environmental services, the burden of (negative) bio-impact and the creation of new economic opportunities. It is essential to establish clear goals, robust methodologies for quantification and valuation, monitoring and verification systems, as well as rules and standards for the generation and commercialization of different environmental credits.

5 Regulatory framework

- **Improve the regulatory environment for bioeconomies, ensuring legal certainty.** The promotion of bioeconomies in Brazil depends on a good regulatory framework, capable of promoting the development of the sector with legal certainty. There is a perception that the regulatory environment is complex and bureaucratic. Any improvements to legal frameworks must be made based on evidence and data and in a way that considers the different sectors, actors and aspirations.

- **Establish a participatory national bioeconomy policy.** The establishment of a national bioeconomy policy in Brazil, built with the participation of society, is a key step towards the promotion of bioeconomies in the country. This framework should define concepts, principles, objectives, instruments and governance model for the development of the sector. It is a central piece for the alignment of existing regulations and the capacity for Review, Adaptation and Implementation of Public Policies.
- **Regulate financial mechanisms capable of fostering investment markets in bioeconomies, such as payments for environmental services, forest carbon credits, and green bonds.** These instruments support the capacities of Infrastructure and Financing and Management of Environmental Impacts. It enables the aspiration of a development model reconciled with the valorization of socio-biodiversity. In addition to the regulation of the mechanisms, the problem of the source of funds needs to be addressed. One possible path is through the creation of metrics to evaluate the bio-impact of economic activities in all sectors.

6 Participatory and transparent governance

- **Create a National Bioeconomies Council, as an instance of governance and articulation, linked to the Presidency of the Republic.** This council is essential to strengthen the capacities of Multisectoral Coordination and Collaboration and of Review, Adaptation and Implementation of Public Policies. It is a strategic space to agree on the aspiration to lead an entrepreneurial revolution that is supported by businesses capable of producing knowledge, products and services with greater added value while promoting social inclusion and poverty reduction.
- **Implement advanced systems of strategic intelligence, information management and monitoring of the impacts of bioeconomy policies, supported by institutions of excellence.** These systems are vital to develop capacities for Environmental Impact Management and for the Review, Adaptation and Implementation of Public Policies. They allow you to keep up with the advances towards the established aspirations.
- **Hold the National Bioeconomy Conference every two years, preceded by regional preparatory meetings.** This process is a privileged moment to strengthen the capacity for Multisectoral Coordination and Collaboration and to engage the various social segments. It consolidates the aspiration of a bioeconomy built in a participatory way and with social legitimacy.

- **Produce, with broad engagement of the various social segments, the Strategic Map of Brazilian Bioeconomies, on a national and regional scale.** From a reading of the vocations and assets of each biome and macro-regions, establish the priority technological routes, the productive arrangements to be strengthened, the ST&I poles to be supported and the main infrastructure gaps to be filled. The short, medium and long-term goals must be agreed upon, as well as the potential socio-environmental impacts expected.
- **Promote the creation of a “Brazilian Coalition for Bioeconomies”, bringing together leaders committed to this agenda.** This coalition would be a key player in advancing the capacity for Multisectoral Coordination and Collaboration. It would work as a platform for action in favor of the aspiration to make bioeconomies an engine of sustainable development for the country.
- **Create the collaborative digital platform, with the objective of connecting actors, facilitating business and disseminating knowledge of bioeconomies.** In addition to a georeferenced map of bioeconomy initiatives in the country (companies, ICTs, communities, NGOs, etc.), the platform should have an observatory of public notices and funding opportunities, a showcase of technologies and products, a catalog of training offerings, a panel of bioeconomy indicators and a hub of content on the subject.

As for the National Bioeconomy Strategy instituted by Decree No. 12,044, of June 5, 2024, which, by proposing the creation of the National Bioeconomy Commission, takes a major step towards the governance of the sector. However, the restricted composition of the commission, limited to the Ministries of Environment and Climate Change (MMA), Development, Industry, Commerce and Services (MDIC) and Finance (MF), if on the one hand objectively and unequivocally points to the relevance and priority that the topic needed to have in federal governance, on the other hand, it is not consistent with the transversality of bioeconomies.

It is alarming to note that the Ministry of Science, Technology and Innovation (MCTI) is absent as a central actor in this commission, with innovation being the core for Brazil to become a global leader in the bioeconomy. The MCTI had been leading the national bioeconomy agenda and has internal and associated bodies operating in the sector, such as the General Coordination of Science for Bioeconomy and the Center for Management of Strategic Studies, with relevant initiatives and aggregated knowledge in the field of Bioeconomy.

In addition to the MCTI, other ministries are essential in the governance of the bioeconomy. The Ministry of Regional Integration and Development (MI) for coordination of inter-regional policies and resources, support of local communities and articulation with other government entities. The Ministry of Agriculture and Livestock (MAPA) is central to the bioeconomies of agriculture and livestock, the sustainable use of genetic resources and the development of bioproducts, with the outstanding performance of the Brazilian Agricultural Research Corporation (EMBRAPA). The Ministry of Mines and Energy (MME) is key in the production of biofuels. In addition to the MMA, the Ministries of Justice and Public Security (MJSP), the Ministry of Women (MMULHERES), the Ministry of Indigenous Peoples (MPI) and the Ministry of Human Rights and Citizenship (MMFDH) are vital to the bioecological vision, empowering indigenous peoples, traditional communities and family farmers. Without these ministries, the bioeconomy will hardly promote robust, resilient, regionalized economic development aligned with the valorization of socio-biodiversity.

The Ministry of Education (MEC) must play a crucial role in integrating education, research and technological development, strategically aligning with the needs of Brazilian bioeconomies. Partnerships with the MCTI and Embrapii should be strengthened and expanded, as well as success stories such as the Professionals of the Future Project - Competencies in Green Economy of the Secretariat of Professional and Technological Education (SETEC/MEC).

For the bioeconomy to drive social inclusion and poverty reduction, its governance must consider the multiple diversities of Brazil and particularly of the Amazon. A diverse commission, which incorporates the ministries relevant to each theme and integrates their perspectives and expertise, is essential to achieve our aspirations for the bioeconomy.

7 Infrastructure for Amazonian bioeconomies

- **Develop an Infrastructure Master Plan for Brazilian bioeconomies, with a long-term vision and investment priorities in transport modes that integrate value chains.**
- **Implement Export Processing Zones (EPZs) with a focus on bioproducts and the expansion of bioindustrial districts to leverage business.**

Infrastructure Runways for the Amazon

For the Amazon, it is necessary to implement a new infrastructure paradigm for the development of the region. The development of the region requires an innovative approach, which goes beyond the traditional framework focused on large physical works. In this sense, we highlight the four avenues for rethinking infrastructure from Abramovay (2022) to propose an expanded and systemic vision of infrastructure in the Amazon: 1) Nature as infrastructure, recognizing the environmental services of the forest and rivers as strategic assets; 2) The care economy, prioritizing health, education, sanitation and waste management equipment and services adapted to the needs of local populations; 3) Appropriate technical devices, fostering technologies and systems appropriate to the valorization of socio-biodiversity; and 4) Quality institutions, organizations, and brands, strengthening intangible infrastructures, such as institutional arrangements, knowledge networks, certification systems, and collective brands to differentiate products and services from Amazonian bioeconomies. This expanded approach to infrastructure should guide the implementation of an observatory dedicated to systematizing and disseminating experiences and learning about sustainable technologies and arrangements in the region.

Despite the time lost, the implementation of these recommendations can place Brazil at the forefront of the global bioeconomy, generating significant gains in terms of economic growth, environmental conservation, and social inclusion. But, for this, it will be necessary to have leaders with a strategic vision and a State committed to the long term.

VANISHING POINT

On the horizon of development, the bioeconomy emerges as a transformative vanishing point. Just as visionary entrepreneurs turn impossible dreams into aspirations and aspirations into real capabilities, our nation can convert its vast biodiversity into a strategic asset for a new cycle of prosperity. We invite Engineering to the new paradigm in which the convergence between traditional knowledge and cutting-edge technology creates an innovative perspective with solutions from nature. It proposes challenging the status quo and reimagining our relationship with nature, not as an obstacle, but as the key to a desired future. It is time to look at our forests and all nature with the eyes of the future. To value our genetic heritage and the intelligence of traditional communities with the tools of innovative science. To transform biodiversity into innovation and innovation into quality of life for the population.

The bioeconomy can inaugurate a new cycle of development for Brazil. Implementing it is a gigantic challenge, which will require State capacities, engagement of the private sector, attentive listening to society, active diplomacy and a great pact around the future we want to build. But it is also an unprecedented opportunity to experiment with a regenerative and life-centered growth model. It is an opportunity to (re)unite the Brazilian people around a shared dream of a nation.

The world needs a new nature economy. Brazil has everything to occupy a relevant space in this revolution. The challenge is launched. The bioeconomy is more than a concept: it is a call to collective action to realize our purpose and be who we are. As Giannetti (2016) well defines it, a nation that preserves the flame of Yoruba vitality filtered by Portuguese tenderness, that works enough to educate and civilize itself without losing the fire of affections, that saves and invests in its future without giving up joy and merriment. The richness of our geography and the diversity of our history are our main assets in the face of a civilization in crisis. May the present not discourage us, because the future responds to the strength and boldness of our will.





“Let’s transform Brazil
into the first power
of the sustainable
socio-bioeconomy”

Carlos Nobre

The question unanswered. - “Tupi, or not tupi that is the question” - proposes the well-known anthropophagic formula. “Tupi and not tupi” - this is the possible answer.

**Trópicos utópicos: uma perspectiva brasileira da crise civilizatória / Eduardo Giannetti. – 1ª ed. São Paulo: Companhia das Letras, 2016*

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LEADERS COMMITTEE

Adalberto Luis Val: Biologist, postdoctoral fellow at the University of British Columbia (Canada), studies biological adaptations to environmental changes in the Amazon. He has been a researcher at INPA since 1981, he has published more than 210 papers and supervised more than 120 students. He served as the general director of INPA (2006-2014), full member of the Brazilian Academy of Sciences and the World Academy of Sciences (TWAS). He received the National Order of Scientific Merit and other awards.

Ana Margarida Castro Euler: Forest Engineer from UFRRJ, Master and PhD in Environmental and Forestry Sciences (Yokohama National University, Japan), with postdoctoral studies on Traditional Populations, Biodiversity Governance and Traditional Agricultural Systems (CIRAD and IRD, France). She has been working in the Amazon for 20 years, including a period working in Africa. She was coordinator at WWF-Brazil, researcher at Embrapa Amapá and director-president of the State Institute of Forests of Amapá. Currently, she serves as the Executive Director of Business at Embrapa - Brazilian Agricultural Research Corporation. Research areas: community forest management, governance, sociobiodiversity value chains, and public policies.

André Fernando Baniwa: Baniwa indigenous leader, General Coordinator for the Promotion of Citizenship at the Ministry of Indigenous Peoples. He was president of the Indigenous Association of the Içana Basin, deputy mayor of São Gabriel da Cachoeira and vice-president director of FOIRN - Federation of Indigenous Organizations of the Rio Negro. He studied Agrozootechnics, Environmental Management and a master's degree in Sustainability. He promotes well-being, traditional indigenous knowledge in sustainability projects and the fight against violence and racism.

Andréa Azevedo: Executive director of the JBS Fund for the Amazon, with a PhD in Sustainable Development (UnB) and a period at the Woodwell

Climate Research Center. She has worked at IPAM, CONEXSUS and serves on several councils related to socio-environmental impact businesses such as CI, Concertation for the Amazon, among others. Experience in public policies, climate change and land use in the Amazon.

Antonio Hamilton Martins Mourão: Retired Army General and 25th Vice President of Brazil. Graduated from AMAN, with advanced courses and higher studies. He held command and advisory positions in the Army, including UN military liaison in Angola. He commanded military units in RS and AM. Senator elected by RS.

Camille Bendahan Bemerguy: Economist from UFPA, master's degree from the Center for Higher Amazonian Studies / UFPA and PhD from UFF/ American University, with extensive experience in public policy related to the Amazon region. She served as Director at MMA, Secretariat of the Environment of Pará and BioTec-Amazônia. She worked at Instituto Unibanco and Fundación Capital. Specialist in environmental and social policies, microfinance, impact projects and bioeconomy.

Carlos Afonso Nobre: Brazilian engineer, researcher and scientist, a reference in defense of the Amazon and sustainable development. PhD from MIT. He worked at INPA, INPE and CAPES. Member of the Brazilian Academy of Sciences, NAS (USA) and Royal Society. Creator of the AmIT project (Amazon Institute of Technology). Author of the Amazon 4.0 Project, he seeks sustainable development through biofactories and local bioindustries. He has received several awards and distinctions, including the Conrado Wessel Foundation Award for the environment and the Nobel Peace Prize in 2007.

Carlos Gabriel Koury: Forest engineer from ESALQ/USP, with a career dedicated to the sustainability and development of the Amazon. He has been working for more than 17 years at Idesam, where he is Director of Innovation in Bioeconomy.

He held leadership positions at Idesam, such as technical coordinator, executive director and technical director. Previously, he was a researcher at Imazon and course coordinator at IFAM.

Cristina Leme Lopes: Chemical engineer and lawyer, with a master's degree in environmental law (Sorbonne) and multidisciplinary practice. Senior Research Manager at CPI/PUC-Rio, he develops research on land use, Forest Code, biodiversity and environmental governance. Co-leader of the Land Regularization Task Force of the Brazil Coalition on Climate, Forests and Agriculture. She teaches in the specialization course in Environmental Law at PUC-Rio.

Denis Minev Bemol: Business leader and social entrepreneur, CEO of Bemol. Co-founder and advisor to the Amazonas Sustainable Foundation (FAS), the Museum of the Amazon and the Partners for the Amazon Platform (PPA). He holds a degree in Economics (Stanford), a master's degree in Latin American Studies and an MBA (Wharton). He was Secretary of State for Planning and Economic Development of Amazonas. He was named Young Global Leader by the World Economic Forum in 2012.

Diego Ken Osoegawa: Multidisciplinary professional with a degree in Ecology (UNESP), master's and PhD in progress in Environmental Sciences and Sustainability (UFAM). He works as a Collaborating Professor at UFAM on topics such as Indigenous Rights, Sociobiodiversity Value Chains, Social Technologies, Sustainability and Territory Management and Meliponiculture. He worked as a Socio-Environmental Consultant in projects with GIZ, PIATAM, Mamirauá Institute, UNICEF and Fundación Vive con Esperanza (Colombia). He is co-founder of the Amazonas Meliponiculture Network and the Amazonian Bee Impact Enterprise.

Estevão Vicente Cavalcanti Monteiro de Paula: Civil engineer, full professor at UEA and retired full researcher at INPA. He holds a master's degree from USP and a doctorate from the University of Tennessee in structural engineering. He has held leadership positions at INPA, SIPAM and the government of Amazonas. Member of the ABNT

wood structures standard review committee. He coordinates research projects on the use and technology of wood.

Fernando Campos: Forest engineer (UFPR) with master's degrees in agriculture and forestry (Finland) and Ecology and Forest Management (Germany). With more than 10 years of experience in biodiversity conservation and natural capital management, he works as Conservation and Climate Finance Manager at Sitawi, developing financial and economic solutions for the sustainable management of biodiversity and the fight against climate change. He worked at the Boticário Group Foundation with biodiversity economics, impact investing and sustainable business models. He has developed research on conservation, forest policies and REDD+ strategies in Brazil.

Francisco de Assis Costa: Economist, full professor at UFPA, with a master's degree (UFRRJ) and doctorate (Freie Universität Berlin) in agricultural economics and development. Researcher at RedeSist (UFRJ) and visiting fellow at the Centre for Brazilian Studies (Oxford). Member of the Science Panel for the Amazon and of the board of CISAM/UFPA. He worked at IPEA and develops research on innovations for the sustainable development of the Amazon.

Izabella Mônica Vieira Teixeira: Biologist, environmentalist and former Minister of the Environment (2010-2016). Graduated from UnB, with specialization (FGV) and master's/doctorate (COPPE - UFRJ). She led international negotiations and received awards such as the Champions of the Earth (UN). She is currently co-chair of the International Resource Panel - UN, environmental analyst at IBAMA/MMA and Advisor at institutions such as CEBRI, IFHC, Inhotim Institute and BNDES and Fellow at the Arapyau Institute.

Jacques Marcovitch: Professor Emeritus at USP and FEA/USP. He is currently a Senior Professor at FEA and at the Institute of International Relations at USP, of which he was dean (1997-2001). PhD from USP and postdoctoral fellow at IMI (Switzerland). He is the author of books and articles on strategy, innovation and sustainability of the Amazon. Member of national and international academies,

with awards such as Jabuti and National Order of Scientific Merit. He currently coordinates research projects on the bioeconomy in the Amazon and the institutional performance of universities and their impacts. He is a member of the Deliberative Council of the Biblioteca Brasileira Guita e José Mindlin and the Superior Council of the Graduate Institute of International and Development Studies (IHEID), in Geneva.

João Carlos de Souza Meirelles Filho: Writer, socio-environmental activist and general director of the Peabiru Institute since 1998. Author of 18 books on the Amazon, with 32 years of experience in the region. Former vice-president of the SOS Mata Atlântica Foundation and the Ecotourism Institute of Brazil. Graduated in business administration from FGV-SP, twice winner of the Samuel Benchimol Award.

João Tezza Neto: Entrepreneur and economist, director of Original Trade and founder of DARVORE Cosméticos da Amazônia and Academia Amazônia Ensina. PhD in Environmental Sciences and Sustainability (UFAM), with research at Washington and Lee University (USA). Graduated in economics (UFAC and UnB) and Executive MBA (FGV). He works in the conciliation between economic development and environmental preservation in the Amazon.

Juliana Simões: Deputy Manager of Indigenous Peoples and Traditional Communities at TNC, with 19 years of experience in government institutions. She worked at IBAMA and MMA, leading policies for sustainable extractivism, rural development and combating deforestation. She graduated in Educational Science. She promotes the participation of indigenous and traditional peoples in biodiversity conservation and sustainable development.

Leonardo Letelier: Specialist in social finance and impact investing, CEO of Sitawi Finanças do Bem and executive director of Endowments do Brasil. An engineer (USP) and an MBA (Harvard), he founded Sitawi to generate socio-environmental impact. He was co-director of the Social Finance Task Force in Brazil and received awards such as Social Entrepreneur of the Year (2021).

Luciano Cunha de Sousa: Coordinator of Planning and Institutional Relations at EMBRAPPII, with a PhD in Administration (UnB/GWU), a master's degree in economics (UnB) and a degree in Electronic Engineering (UFU). He served as Undersecretary in the Federal District, Director at the Ministry of Economy and MDIC, and Foreign Trade Analyst for 16 years. He contributes to innovation and technological development policies.

Marcello Brito: Advisor in ESG, international trade and sustainability, with experience in national and international markets. Food Engineer, MBA (FIA) and master's degree (Grenoble IAE). Executive Secretary of the Legal Amazon Consortium, member of councils and technical coordinator at FDC in the Global Agro-Environmental Center and in the Global Agribusiness Academy.

Maritta Koch-Weser: Anthropologist, environmentalist and social entrepreneur, with more than 40 years of experience in international development, especially in the Brazilian Amazon. She led the "Amazon in Transformation" program at IEA/USP and the Amazon 4.0 initiative. She has worked at the World Bank, was director general of IUCN and founded Earth3000. PhD from the universities of Bonn and Cologne (Germany).

Ricardo Abramovay: Full Professor of the Josué de Castro Chair at the Faculty of Public Health at USP, with 30 years of experience at FEA/USP. He holds a degree in Philosophy (Paris), a master's degree in political science (USP) and a PhD in Human Sciences (UNICAMP). Author of books on sustainable development, green economy and Infrastructure for the development of the Amazon. He researches topics such as territorial development, economic sociology, natural resource management and innovation.

Salo Vinocur Coslovsky: Associate Professor at NYU, with a PhD in Urban Studies and Planning (MIT). He researches regulation, development and organizational behavior in Latin America, especially in Brazil. He studies how to apply regulations in competitive business environments. He engages in public sector reform projects, accountability, and export opportunities for sustainable forest products in the Amazon.

ANEXX II

TECHNICAL COLLABORATORS IN EVENTS, LECTURES AND OPEN CLASSES

NAME AND INSTITUTION	TITLE	DATE	LINK
Adalberto Luis Val (INPA)	Presentation of the pre-feasibility study for the Amazon Institute of Technology (AMIT)	10/04/22	https://www.institutodeengenharia.org.br/site/2022/10/04/apresentacao-do-pre-estudo-de-viabilidade-para-o-instituto-de-tecnologia-da-amazonia-amit/
	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Adriana Marwell (Farmabrazil Group)	Brazil and the Future of the Bioeconomy - Health of Tomorrow Event Series	03/17/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
Adriano Venturieri (Embrapa)	Open Meeting WG Amazon and Bioeconomy with Adriano Venturieri	05/03/22	https://www.institutodeengenharia.org.br/site/2022/05/17/encontro-aberto-gt-amazonia-e-bioeconomia/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
Alexandre Alonso (Embrapa)	Brazil and the Future of the Bioeconomy Event Series - Energy of Tomorrow	03/16/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
Alexandre Saraiva (Federal Police)	Past, Present and Future of the Amazon - 105 years of IE	10/13/21	https://www.institutodeengenharia.org.br/site/2021/10/22/passado-presente-e-futuro-da-amazonia-105-anos-do-ie/
Ana Margarida Castro Euler (Embrapa)	Launch of the special booklet: Amazon and Bioeconomy	03/23/21	https://www.institutodeengenharia.org.br/site/2021/03/23/lancamento-caderno-especial-amazonia-e-bioeconomia-2/
	Sociobiodiversity Amazon in search of international markets	05/09/23	https://www.institutodeengenharia.org.br/site/2023/05/31/a-sociobiodiversidade-amazonica-em-busca-de-mercados-internacionais/
	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Andrea Waichman (UFAM)	Training Cycle: An Amazon for the Future - Sustainability: Concepts and their Complexity	03/25/22	https://www.institutodeengenharia.org.br/site/2022/03/25/ciclo-de-formacao-uma-amazonia-para-o-futuro-sustentabilidade-conceitos-e-sua-complexidade/

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Bruna Ciasca (TNC)	Open Meeting of the Amazon and Bioeconomy WG - Bioeconomy of Sociobiodiversity in the State of Pará	06/21/22	https://www.institutodeengenharia.org.br/site/2022/07/01/encontro-aberto-gt-amazonia-e-bioeconomia-bioeconomia-da-socio-biodiversidade-no-estado-do-para/
Bruno Nunes (MCTI)	Launch of the publication "The opportunities of the Brazilian bioeconomy" of the Amazon and National Bioeconomy WG	10/24/22	https://www.institutodeengenharia.org.br/site/2022/10/24/assista-a-gravacao-do-lancamento-da-publicacao-as-oportunidades-da-bioeconomia-brasileira-do-gt-amazonia-e-bioeconomia-nacional/
Camille Bendahan Bemerguy (SEMAS)	Brazil and the Future of the Bioeconomy Event Series - Public Policies	03/18/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
Carlos Brito Cruz (Elsevier Research Networks)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Carlos Afonso Nobre (Amazônia 4.0)	Launch of the special booklet: Amazon and Bioeconomy	03/23/21	https://www.institutodeengenharia.org.br/site/2021/03/23/lancamento-caderno-especial-amazonia-e-bioeconomia-2/
	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
	Past, Present and Future of the Amazon - 105 years of IE	10/13/21	https://www.institutodeengenharia.org.br/site/2021/10/22/passado-presente-e-futuro-da-amazonia-105-anos-do-ie/
	Training Cycle - An Amazon for the Future: The Need for a New Standing Forest Bioeconomy	05/16/22	https://www.institutodeengenharia.org.br/site/2022/05/30/ciclo-de-formacao-a-necessidade-urgente-de-uma-nova-bioeconomia-de-floresta-em-pe/
Cristina Leme Lopes (CPI/PUC-Rio)	Bioeconomy in the Amazon and the Forest Code	02/07/23	https://www.institutodeengenharia.org.br/site/2023/03/07/assista-abaixo-a-gravacao-do-encontro-bioeconomia-na-amazonia-e-codigo-florestal/
Denis Minev Bemol (Bemol)	Training cycle: An Amazon for the Future - Bioeconomy and Sustainable Entrepreneurship	06/07/22	https://www.institutodeengenharia.org.br/site/2022/06/29/ciclo-de-formacao-uma-amazonia-para-o-futuro-bioeconomia-e-empreendedorismo-sustentavel/
Eduardo Giannetti (ABL)	Books: - The Ring of Gyges: An Ethical Fantasy - Utopian Tropics: A Brazilian Perspective on the Crisis of Civilization by Eduardo Gianetti	04/25/22	https://www.institutodeengenharia.org.br/site/2022/04/30/livro-o-anel-de-giges-uma-fantasia-etica-por-eduardo-giannetti/
Eduardo Roxo (ATINA)	Why doesn't this abundance translate into prosperity?	11/22/22	https://www.institutodeengenharia.org.br/site/2022/11/22/por-que-essa-abundancia-nao-se-traduz-em-prosperidade/

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Eugênio Pantoja (IPAM)	Brazil and the Future of the Bioeconomy Series - Public Policies	03/18/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
Guilherme Ary Plonski (IEA-USP)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Inaiê Santos (Instituto Arapyáú)	Open Meeting WG Amazon and Bioeconomy with Inaiê Takaes Santos	06/07/22	https://www.institutodeengenharia.org.br/site/2022/08/08/encontro-aberto-gt-amazonia-e-bioeconomia-2/
Iris Ferreira Rodrigues (CONAFER)	Open Meeting WG Amazon and Bioeconomy - Bioeconomy at CONAFER	11/08/22	https://www.institutodeengenharia.org.br/site/2022/11/08/bioeconomia-na-conafer/
João Tezza Neto (Academy Amazônia Ensina)	Amazon and Bioeconomy WG Open Meeting - Amazon Expeditions 2021	11/11/21	https://www.institutodeengenharia.org.br/site/2021/11/19/expedicoes-amazonia-2021/
	Training Cycle: An Amazon for the Future - Economic History of the Amazon	02/22/22	https://www.institutodeengenharia.org.br/site/2022/02/22/ciclo-de-formacao-uma-amazonia-para-o-futuro-historia-economica-da-amazonia/
Laura Lamonica (Coalition)	Brazilian Coalition on Climate, Forest and Agriculture	01/24/23	https://www.institutodeengenharia.org.br/site/2023/03/09/coalizao-clima-flor-esta-e-agricultura/
Márcio Souza (Amazonian Academy of Letters)	Past, Present and Future of the Amazon - 105 years of IE	10/13/21	https://www.institutodeengenharia.org.br/site/2021/10/22/passado-presente-e-futuro-da-amazonia-105-anos-do-ie/
Marco Pellegatti (Hypertext)	Open Meeting WG Amazon and Bioeconomy with Marco Pellegatti	05/17/22	-
Maria Eugenia Tezza (Academy Amazônia Ensina)	Amazon and Bioeconomy WG Open Meeting - Amazon Expeditions 2021	11/11/21	https://www.institutodeengenharia.org.br/site/2021/11/19/expedicoes-amazonia-2021/
Mario Ernesto Humberg (PNBE)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	-
Maurício Bastos (Consultant)	Open class: good practices in the application of the Delphi Method		
Ricardo Abramovay (USP)	Brazil and the Future of the Bioeconomy - Bioeconomy and Ethics Series	03/14/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
	Reading Group - Book "Infrastructure for the Sustainable Development of the Amazon", by Ricardo Abramovay	03/08/23 to 03/29/23	https://www.institutodeengenharia.org.br/site/2023/04/14/grupo-de-leitura-livro-infraestrutura-para-o-desenvolvimento-sustentavel-da-amazonia-de-ricardo-abramovay/

NAME AND INSTITUTION	TITLE	DATE	LINK
Ricardo Kenzo (Institute of Engineering)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Roberto Rodrigues (FGV)	Brazil and the Future of the Bioeconomy - Agriculture of Tomorrow Series	03/15/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	
Tatiana Schor (SEDECTI/AM)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Vahan Agopyan (USP)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Victor Brecheret Filho (Institute of Engineering)	Amazon and Bioeconomy Sustained in Science, Technology and Innovation	03/23/21	
Victor Phanebecker (Engineers Without Borders)	Consolidation of a knowledge base for the national Bioeconomy strategy – ESF (Engineers Without Borders)	03/30/22	https://www.institutodeengenharia.org.br/site/2022/04/07/consolidacao-de-uma-base-de-conhecimento-para-es-strategia-nacional-de-bioeconomia-esf/
Walkymário Lemos (EMBRAPA)	Brazil and the Future of the Bioeconomy - Agriculture of Tomorrow Series	03/15/22	https://www.institutodeengenharia.org.br/site/2022/03/30/serie-de-eventos-brasil-e-o-futuro-da-bioeconomia-2/
	The Opportunities of the Brazilian Bioeconomy	10/24/22	



This research was animated by the provocations made by Eduardo Giannetti in **Utopian Tropics: A Brazilian perspective of the civilizational crisis**, which kindly allowed the transcription of three of the 124 sections of the work in this publication. Three aphorisms that bring reflections and fundamental findings to be on the radar of all professionals, but especially engineers. At a time of serious challenges and uncertainties such as the one we are experiencing; it is vital that those responsible for thinking about and building the material infrastructure for development are fully aware of the broader civilizational context in which they operate. Specific technical competence is not enough: it is necessary to understand the assumptions, values and limitations of the paradigm that has been dominant until now, as well as the possibilities for transformation that open. Giannetti's provocations are an invitation for professionals in general (and engineers, in particular) to broaden their horizons and train themselves to play a leading role in the construction of new models, aligned with our singularities as a people and nation.

Trópicos utópicos: uma perspectiva brasileira da crise civilizatória / Eduardo Giannetti. – 1ª ed. São Paulo: Companhia das Letras, 2016



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