


PlanBio:  
A Comparative Analysis and Benchmarking  
Report on the Bioeconomy of Pará, Brazil

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## ***Bioeconomy – a comparative analysis and case study of the Brazilian State of Pará***

### **Introduction**

The notion of bioeconomy deserves a dedicated section that elucidates its technical intricacies and the diverse definitions that emanate from distinct geographic, cultural, economic, and social contexts. Nonetheless, a preliminary analysis of this concept reveals that the realm of bioeconomy is preoccupied with devising economic systems that honor the integrity of nature. The prefix "bio" pertains to life, therefore, progressing towards an economy that factors in both the environment and human well-being is a formidable undertaking that several nations are contemplating tackling, particularly amidst the climate and biodiversity emergencies and the necessity to restructure, or recreate, development paradigms.

The prefix 'bio' also pertains, perhaps more obviously, to biodiversity, a theme that is often discussed in conjunction with climate change in global environmental debates, forming a part of the mosaic of crises we face in the Anthropocene. The approach taken by the bioeconomy to address the issue of biodiversity loss is by adopting a holistic perspective that blends the need for conservation with the goal of creating economic prosperity and meeting basic human needs, all while taking nature into account as a critical input. Thus, by finding a middle ground between strict conservation and massive extractivism, promoting a bioeconomy can be viewed as a promising alternative to incentivize the preservation of ecosystems as a means of generating economic value and supporting local livelihoods.

Diverse territories may have varying motivations for embarking on the task of establishing a new economic rationale. For instance, countries that possess significant biodiversity, also known as "megadiverse countries" - such as Brazil, Costa Rica, and the United States - are motivated by the immense untapped potential of utilizing a wide range of plants, fruits, herbs, fungi, and animal species. Additionally, these countries face social pressures to recognize and support the communities that depend on the natural resources of these biodiverse areas. These communities demand the



implementation of public policies that would facilitate the expansion of sustainable economic models that are less harmful to nature, an approach they have mastered better than anyone else.

Another driving force behind the increasing focus on the bioeconomy is the international community's emphasis on this issue in debates and formal agreements. For instance, the 2015 Paris Agreement, which calls for Nationally Determined Contributions to reduce emissions, urges countries to develop mitigation plans based on proposals that promote changes in their production methods. Additionally, the 15th Conference of Parties of the Biodiversity Convention, held in Montreal, Canada, in December 2022, resulted in the creation of a Global Biodiversity Framework, following two years of negotiations among UN Member States. Such developments serve as a source of inspiration and guidance for the development of local policies.

Therefore, discussions on bioeconomy are essential and cannot be carried out without examining issues that are intrinsically linked to the topic, encompassing the main challenges of our time. Nonetheless, professionals in the fields of environment and international affairs must be aware of the dilemmas generated by this field. Some of the key questions driving this work are: how have states formalized their bioeconomy strategies, and how do public policies regarding nature address the creation of economic alternatives for local communities? Additionally, it is important to consider how these same communities are included in the process. Furthermore, it is essential to examine when a bioeconomy strategy can result in more harm than benefit to an ecosystem, or when a state's historical debts to local communities may impede their confidence in progressive and well-intentioned policies.

This research, conducted in the context of the School of International and Public Affairs (SIPA), aims to contribute to the contemporary debate on biodiversity at Columbia University. We recognize that the issue goes beyond the mere protection of species, and that biodiversity and nature must be increasingly integrated into the decision-making processes of states, the private sector, and the third sector. In our effort to identify regions that could provide relevant inputs for the analysis of these

issues, we have identified three countries that stand out due to their mega-diverse ecosystems, their pioneering policies on bioeconomy, and the complexities they present.

In this sense, the current research investigates the approaches adopted by Brazil, Costa Rica, and the United States, gathering data and analyzing how these countries conceptualize and implement bioeconomy strategies. The research investigates how megadiverse countries that are not like-minded address biodiversity conservation and how this translates into political-economic strategies. As a result of that first screening, it examines the current plans in each of these territories, their weaknesses and strengths, and how policymakers have conducted dialogue and ensured benefit-sharing with the populations involved, considering both multilateral goals and national commitments.

In order to closely observe the phenomena that give rise to the research questions, it was fundamental to approach a territory where one of the bioeconomy plans is currently being elaborated. The State of Pará, the second largest in Brazil and abundant with the Amazon Forest, was identified as a relevant context for the analysis. The State of Pará is currently building the newest Bioeconomy Strategy in the Brazilian Amazon Forest territory, the "PlanBio" policy. The elaboration and subsequent implementation of PlanBio requires convergence of interests from different stakeholders, such as the private sector (heavily present in the mining and agriculture areas in the state), academia and research centers, as well as indigenous peoples and local forest communities. Building a common vision for a new nature-positive economy amidst such a complex scenario is not an easy task, especially considering the challenge of high deforestation rates in that state.

Finally, the opportunity to engage in a hands-on project alongside SIPA's Energy and Environment specialization opened the door to a closer collaboration with the government of the State of Pará. Officials from the State's Environment Secretariat (SEMAS) kindly shared their time, intelligence, and valuable insights into the challenges faced by policymakers working in the environmental sphere. Through SEMAS, the State of Pará was interested in conducting a benchmarking study to compare their policies

with those of Costa Rica and the United States. This study aimed to understand how the Brazilian State has innovated and how it can learn from the experiences of other places that are referenced in this field. Therefore, the benchmarking study is the main output of our Practicum and will be explored throughout this report.

Representatives of groups involved in the construction of the plan, including the National Council of Extractive Populations (CNS), the Associations of Remnant Communities of Quilombos in Pará (Malungu), the Amazon Environmental Research Institute (IPAM), and the Foundation for Research Support of the State of Pará (FAPESPA), were kind enough to share their knowledge with us, without which this research would not have been possible. Thanks to the conversations we had with them, which took place in research institutes, on boats traveling up the river, and in the middle of the forest, this experience was transformative for us as professionals.

### **Discussing the concepts of bioeconomy**

The notion of bioeconomy (or "bioeconomics") was established in the academy by the Romanian Nicholas Georgescu-Roegen between the 1970s and 1980s. While describing Georgescu-Roegen's work, Martinez-Alier says that "he was not an 'environmental and resource economist' but rather something new, an 'ecological economist' or as he called himself, a bioeconomist." (Martinez-Alier, 1997, p. 235).

Adding the prefix "bio" to the word "economy" suggests the emergence of a new field that aims to integrate economics and ecology to promote development, and there might be different ways of pursuing this goal. To Georgescu-Roegen, as a precursor of the "greening" of economics and as one of the founding pillars of Ecological Economics, it made sense that the concept of bioeconomy comes tied to "de-growth." As a result, the usage of bioeconomy is tied to the specific problem of survival that the human species faces. Markedly, his first narrative about bioeconomy acknowledges the significant material and energy restrictions that growth would ultimately encounter (Vivien et al., 2019, p. 189-191).

However, scholars claim that the contemporary use of the term bioeconomy can diverge from its first use, and it has gained increasing relevance over the beginning of the 21<sup>st</sup> century, revived in a different context three decades after Georgescu-Roegen first coined its idea (Vivien et al., 2019, p. 189). As of today, the word "bioeconomy" can sometimes indicate quite different things because the prefix "bio" contains much ambiguity, as shown by a comparison between the various definitions of the term adopted by different sectors and locations (de Assis Costa et al., 2022, p. 3).

Combining the publications of Viven and Bugge and their co-authors, the following sections describe the three most common definitions of bioeconomy — **biotechnology**, **bio-resources**, and **bio-ecology**, which will later be crucial for an analysis of the dominating approaches in Brazil, Costa Rica, and the United States.

#### Biotechnological approach to bioeconomy

The first definition focuses on achieving economic growth with sustainability as a secondary benefit or criterion. Rather than placing sustainability and ecosystem integrity at the center, it revolves around efficiency and productivity within the economic process. Overall, this approach assumes that the mere adoption of science-intensive technologies leads to environmental gains of efficiency. It hypothesizes that a model of linear interaction between science, technology, and production contributes to technical progress and dynamism in such a way that the process per se solves issues related to resource availability and treatment of waste (Bugge, Hansen, et al., 2016 apud de Assis Costa et al., 2022, p. 3-4).

This approach was influenced by the "biotechnology revolution" that progressively arose during the 1990s and 2000s. This expansion was soon portrayed as both a paradigmatic revolution based on new knowledge and an industrial revolution for chemistry, pharmacy, medicine, and other scientific fields, thanks to the development of biotechnologies as all-purpose technologies. Since scientific breakthroughs in biotech can shape new fields, such as genomes and bioinformatics, they can also generate a "life science-based industrial revolution" (Vivien et al., 2019, p. 191).



In order to make this reality feasible, this approach also requires a specific institutional architecture in which startups are encouraged to make groundbreaking discoveries or "techno-scientific promises," a motive that justifies the attraction of private and public funding. Complementing this capacity, improving knowledge is an additional imperative that can be reached through partnerships with existing firms in the sector and academia (Vivien et al., 2019, p. 191). Therefore, this vision relies on a technical and scientific perspective as the main power that boosts a bioeconomy setting.

### Bio-resources or biomass-based approach to bioeconomy

The second definition, "bio-resource bioeconomy," pursues a healthier balance between growth and sustainability aims through economic processes. It is based on the introduction of naturally occurring product innovations, which are the primary driver of economic surpluses, as well as innovation in natural resources, management, and ethical extraction methods, such as the reduction and utilization of residues and cascading uses of the same raw materials. In general, it is also a demanding path regarding costs and similarly focuses on productivity's business and scientific aspects. However, it is less infected by the linear logic that characterizes the biotechnology perspective (de Assis Costa et al., 2022, p. 4).

This approach is also viewed as a "biomass-based" bioeconomy, as it is not technology-driven but instead geared toward ensuring the transition to biomass use that is economically feasible. As Bugge explains, "whereas the biotechnology vision takes a point of departure in the potential applicability of science, the bio-resource vision emphasizes the potentials in upgrading and conversion of the biological raw materials" (Bugge et al., 2016, p. 9). For instance, the European Commission has used it since 2010 to encompass the agriculture, forestry, fishing, chemistry, biotechnology, and energy sectors, the raw materials of which the Commission advocates should be transformed into "biorefineries" (EC, 2012, apud Vivien et al., 2019, p. 192). According to their definition, biorefineries are sophisticated systems that process diverse forms of biomass in a way that is both profitable and environmentally responsible (wood, agricultural products, waste, and algae). A term called "biorefining" was created to help

define the shift to using biomass instead of fossil fuels. The issue is that one cannot guarantee that this transition will be ecologically sustainable (Vivien et al., 2019, p. 192).

In none of the above, the diversity of resources and potential sustainable ways of using them is considered an essential aspect of its capacity to advance economic diversification. For instance, in a bio-resource bioeconomy model, the production of biofuels through the intensification of land use and recovery of degraded zones is viewed as a significant driver of innovation and growth, disregarding the nuance of how it can lead to homogenization instead of diversification based on biodiversity (Bugge, Hansen and Klitkou, Bugge, Hansen, et al., 2016 apud de Assis Costa et al., 2022, p. 4).

#### Taking the limits of the biosphere into account or the bio-ecology approach to bioeconomy

In the "bio-ecology bioeconomy," the goal of unilateral growth of the economy overlaps with the principle of sustainability. This approach suggests that traditional, capital-intensive, and highly environmentally damaging approaches should be minimized or abandoned. Research and innovation are also essential components here, but they respect regional issues and are focused on variety, resource conservation, ecological management of species, and interactions between them (de Assis Costa et al., 2022, p. 4). Also, this perspective emphasizes technological risks over the rewards of these innovations (Martinez-Alier, 1997, p. 237).

Therefore, aligned with the Ecological Economy perspective per se, it does not focus primarily on economic expansion and growth. Instead, it investigates the ecological viability of the economy, paying attention to the many biochemical and economic cycles, and it recognizes the necessity of reducing the rate at which energy and material inputs are channeled into the economy (Martinez-Alier, 1997, p. 237).

Georgescu-Roegen became known for his studies offering a comparison between thermodynamics and economics. For the bioeconomist, technology extends a human's biological body, allowing new possibilities and actions. However, as he explains, if

humans are to develop and prosper, the economy must be careful enough to maintain the matter and energy flows required for the operations of the technical objects surrounding humans. That practice includes "caution by saving finite stocks of fossil resources as much as possible, using them to meet only the most urgent needs — particularly those of populations living in the South" (Vivien et al., 2019, p. 191).

Therefore, the bio-ecology vision emphasizes the significance of ecological processes that maximize the utilization of nutrients and energy, foster biodiversity, prevent monocultures, and prevent soil degradation. This vision emphasizes the possibility of regionally centered circular and interconnected processes and systems, as opposed to the previous two visions that are technology-focused and place a significant emphasis on RD & D in globalized systems (Bugge et al., 2016, p. 9).

Overall, before concluding the summary of the perspectives presented above, it is valuable to make two observations. First, it is toward highlighting that this is a brief theoretical framework to explain how and why certain states have opted to follow one or a combination of these paths in their national strategies. Nonetheless, the concept of bioeconomy is not exhaustive to the visions illustrated above, and it is under constant construction and scrutiny, especially in the present. The second observation is about how indigenous peoples and local extractivist communities have their notion of what a bioeconomy is and could be, which will be explored later in this paper within the analysis of the Bioeconomy Plan of the Brazilian State of Pará.

### **Brazil's approach to Bioeconomy**

The Brazilian civil society, primarily through a group of engaged third-sector organizations, has been advancing the debate about bioeconomy by first highlighting that conceptualizing the term is crucial for its addressing through the construction of public policies. By the time this analysis is written, Brazil has not adopted a shared, official vision of Bioeconomy. Instead, different Ministries, such as the Ministry of External Relations (MRE), the Ministry of Science, Technology, Innovation, and Communications (in the Portuguese acronym, MCTIC), and the Ministry of Agriculture, Livestock, and Food Supply (MAPA) have advanced on diffuse policies, following

different visions, throughout unconnected timings, and governments. The period analyzed ranges from 2016 to the first bimester of 2023.

Brazil's Ministry of External Relations' most direct engagement with the theme dates to 2016, during the Conference of the Parties (COP22), when the country proposed the creation of the "Platform for the Biofuture." This initiative was joined by 19 other countries, especially those relevant in the biofuels and biomaterials markets. In this area, the group focused on accelerating the development of advanced biofuels in various sectors, replacing fossil fuels (MRE, 2016). The platform's launch took place in partnership with the International Energy Agency (IEA) and had an approach associated with bioenergy, bringing it closer to the vision of the bioeconomy of bioresources (de Assis Costa et al., 2022, p. 7).

The Brazilian Ministry of Science, Technology, Innovation, and Communications launched an Action Plan on Science, Technology, and Innovation in Bioeconomy (translated by the authors, in Portuguese "*Plano de Ação em Ciência, Tecnologia e Inovação em Bioeconomia*"). According to its content, the document's objective was to initiate debates in a coordinated way about the bioeconomy in Brazil since the perception of that ministry was that Brazil already has several actions in the bioeconomy underway but performed in a disjointed manner. Furthermore, in the view of the MCTIC, "several countries focus on the exploitation of biological resources (biomass) and the development and use of scientific and technological knowledge, such as biotechnology, as axes of promotion of sustainable development." Therefore, innovating little, MCTIC internalized the conceptualization of the term bioeconomy in Brazil through similar optics, adopting the same international parameters (MCTIC, 2018, p. 12).

For the MCTIC, fostering a bioeconomy means replacing fossil raw materials with economic activities anchored in the sustainable and innovative use of biomass. This transition would improve health, national growth, and the population's well-being and sustainable development. In this way, the Plan created objectives and targets to be achieved by 2022, focusing on scientific and technological development, prioritizing the

sustainable production of biomass, and references to biorefineries to increase the efficiency and improvement of production processes, aiming at the less environmental impact. This approach fits squarely with the biotechnological and bioresource approaches reviewed in the previous section.

More notably, the Brazilian Ministry of Science proposed the creation of the National Bioeconomy Committee, intending to coordinate and debate the progress of the bioeconomy in the country in a transversal way, with the federal government leading the dialogue between the most relevant ministries for the agenda (MCTIC, 2018, p. 33). This project never came to fruition in the transition from the Michel Temer government (2016-2019) to the Bolsonaro government (2019-2022).

During the past four years, the administration of President Jair Bolsonaro did not advance the construction of a central Bioeconomy strategy. However, in this period, the federal government recognized the increasing strategic importance of the subject and Brazil's potential to become an international protagonist in the field. In this sense, Brazil's Ministry of Agriculture (MAPA) took leadership of the subject under Minister Tereza Cristina Corrêa da Costa Dias. Since 2019, the government has implemented the "Bioeconomy Brazil - Sociobiodiversity" program as a notable initiative to increase the involvement of small farmers, family farmers, traditional communities, and their businesses in economic activities related to the bioeconomy (de Assis Costa et al., 2022, p. 7).

### **Subnationals take the lead: Pará State's approach to bioeconomy**

#### The process of structuring PlanBio

The State Bioeconomy Plan for the State of Pará was elaborated by the State Secretariat for the Environment (SEMAS), with technical coordination from The Nature Conservancy. In addition to these, the plan emerges from the efforts of a working group composed of 25 organizations, among which are associations of extractive peoples, quilombolas, and indigenous peoples, in addition to non-governmental organizations, research institutes, foundations, universities, and the secretariats of other areas of the

State (science and technology, mining and energy, economic development and planning, agriculture). The plan also had the help of consultants from the *Centro Brasil no Clima*, an organization that supports Brazilian subnational governments in building their strategies to face the climate crisis (PlanBio Pará, 2022, p. 1).

At the beginning, the document emphasizes the State's economic, social, cultural, and environmental capabilities. Notably, it is a Brazilian state with a considerable extension of the Amazon rainforest, which is why the possibility of promoting productive chains based on the forest and "socio-biodiversity" becomes attractive. For the Secretariat for the Environment, moving the economy is a pillar of sustainable development – fair and inclusive – anchored in regional qualities and to share benefits with the local society. From the start, it is also possible to identify that the security of the genetic heritage and the appreciation of the knowledge and culture of traditional peoples are at the center of the vision of bioeconomy of the State of Pará (PlanBio Pará, 2022, p. 1).

The Bioeconomy Plan of the State of Pará was launched in 2022 and is a step following the policies that the State had already institutionalized. Therefore, it comes after the Pará State Policy on Climate Change (PEMC), instituted in 2020, with the aim of promoting measures that achieve the necessary conditions for adapting and mitigating the impacts derived from climate change. Also, the State already had the Amazônia Agora State Plan (PEAA), also launched in 2020, through which the State established a series of goals aimed at zero emissions, and the State Bioeconomy Strategy (2021), which precedes the PlanBio in establishing its programmatic strategic bases, seeking to reorient the socio-economic development of the State. Also, the document cites international references for the construction of the plan, such as the UN Sustainable Development Goals (PlanBio Pará, 2022, p. 2).

In this way, forming the basis of PlanBio, the State Bioeconomy Strategy is based on three guiding axes. The first, "Research, Development and Innovation", has the objective of "Promoting and applying scientific knowledge and technological research for the valorization and production of innovations, in an inclusive way and with



integrated social, economic and environmental benefits," in addition to "Identify and map knowledge about the bioeconomy of Pará" (PlanBio Pará, 2022, p. 4).

The second axis is "Cultural Heritage and Genetic Knowledge." This one seeks to "Recognize traditional practices, protect and value them, integrating them into the low-emission socio-economic development policy of the state of Pará, with socio-environmental safeguards and guarantees for the genetic heritage associated with cultural knowledge and biodiversity," in addition to "Guaranteeing the rights of local populations, providing sustainable alternatives for development, training and socio-environmental integrity" (PlanBio Pará, 2022, p. 4).

The third structuring pillar is "Sustainable Productive Chains and Businesses." This section addresses the need to "value the products of the territory's biodiversity, in order to add specificities of the region to local products, through certifications, protection of cultivars, geographic identification, among other strategies." Also, it considers promoting "production chains and new socio-biodiversity businesses, strengthening and verticalizing production, generating local development, employment, and income and equitably distributing benefits." Therefore, the three pillars effectively evolved into a public policy implementation plan (PlanBio Pará, 2022, p. 4-5).

Also, PlanBio had as a fundamental part of the multisectoral workshops, together with bilateral meetings with government institutions in four central municipalities of the State: Altamira, Belém, Santarém, and Marabá. According to the Government of Pará, these sessions were held to listen to and promote the participation of different groups to accommodate sectoral expectations and demands. Soon, the 89 actions that make up PlanBio emerged from this qualitative listening process. Then, the document with the actions was submitted to a public consultation process, which collected contributions from 143 research, science, and technology institutions; 8 associations and cooperatives linked to indigenous peoples and traditional communities; 78 companies and consultancies; 32 third-sector organizations; 132 public institutions; 8 benches; and 20 individuals. All this robust framework allowed the State to state that "the Plan in its

current version has a set of concrete actions that are adequate to the different realities and specificities of the state of Pará" (PlanBio Pará, 2022, p. 6).

### Conceptualizing and characterizing Pará's bioeconomy

According to the state of Pará's plan, the bioeconomy must play an active role in transitioning to an economic model that not only safeguards socio-biodiversity but also ensures a fair and inclusive construction and implementation process. Additionally, bioeconomy should address two problems affecting the state - high greenhouse gas emissions that make it the country's top emitter due to deforestation, and a low Human Development Index (PlanBio Pará, 2022, p. 7).

Therefore, the concept of bioeconomy is defined by "an opportunity to advance a socioeconomic development that includes low carbon production, with the aim of promoting the transition to a diversified, fair and inclusive economy; able to create and/or improve local production processes and socio-biodiversity, based on the alignment of science, technology and innovation to the local economy. The bioeconomy must guarantee the safety of the genetic heritage, appreciation of traditional knowledge and culture of indigenous peoples, quilombolas and local communities, in addition to social, economic and environmental benefits for the local population" (PlanBio Pará, 2022, p. 7).

To promote a bioeconomy that leverages the forest sector, biodiversity, and local comparative advantages in the state of Pará, policymakers have designed an agenda focusing on priority territories. It is important to consider the following socio-economic data: Pará's social and economic indicators are generally below the national average, with the state ranking 24th out of 27 Brazilian states. Pará's average monthly household income in 2021 ranks 21st among Brazilian states, which highlights the state's high level of social vulnerability. Additionally, Pará falls short of the Brazilian average for access to essential services, with only 47.5% of households having access to water networks and 7.7% having access to sewage collection, both of which are below the national averages of 84% and 55%, respectively. Furthermore, only 10% of households in Pará

have access to sewage treatment, which is significantly lower than the Brazilian average of 51% (PlanBio Pará, 2022, p. 8).

Pará's economy is noteworthy in comparison to other Amazonian states, as it has the highest GDP in the region, ranking 11th among Brazilian states. The mining sector is a significant contributor, generating 19.7% of the added value, particularly through the exportation of iron and copper ores. Conversely, forest-based activities, fishing, and aquaculture only represent a small percentage (1%) of the state's economy, while the manufacturing industry's contribution is also limited (4%). Nonetheless, it is the extractive activities related to biodiversity and forest resources, along with the transformation and improvement of bioproducts, that are essential to the bioeconomy model currently being developed (PlanBio Pará, 2022, p. 10).

According to the Pará state government report (2022, p. 11), the remaining native vegetation covers a significant portion of the state's land area, with 78.2% or 973,689 km<sup>2</sup> out of 1,245,870 km<sup>2</sup>. A significant proportion of this area, around 850,000 km<sup>2</sup> or 68.1%, is located in the collective territories of Indigenous Peoples, Quilombolas, and Traditional Communities (PIQCTs), as well as in conservation units. This distribution of preserved areas supports the UN report that indigenous peoples and traditional communities have been good guardians of nature in Latin America and the Caribbean, despite the threats they face (FAO and FILAC, 2022). The state of Pará has 77 regularized indigenous lands (TIs) (FEPIPA, 2016 apud PlanBio Pará, 2022, p. 13), which contribute to the conservation of 30.2 million hectares of native vegetation, representing 24% of the state's territory (PlanBio Pará, 2022, p. 13).

The topic of the role of indigenous peoples in forest governance is significant because, according to the same UN report, there are 826 distinct indigenous groups in the region, and the majority of them, 305, reside in Brazil. These peoples share common concerns that form the basis of their global and regional agendas, including various aspects of the right to self-determination, such as the right to own an economic development model, and the right to Free, Prior and Informed Consent, or the right to consultation (FAO and FILAC, 2022, p. 7). Together with this, it is also worth noting the focus that PlanBio

gives to the potential of the state's cultural and genetic heritage (PlanBio Pará, 2022, p. 20).

### **Comparative analysis**

This benchmarking report uses a comparative approach to establish environmental, economic, and social measures by which to evaluate the proposed bioeconomy strategy in the Brazilian subnational state of Pará. We construct these measures by researching and analyzing the current bioeconomy strategies in the United States and Costa Rica. We selected these two strategies because they greatly differ in their sociopolitical contexts, their approaches, and their ultimate ambitions. In the following section, we lay out the details of each strategy, if and how their governments have implemented them thus far, and the critical points that we will utilize for our analysis.

### **The United States approach to bioeconomy**

#### Summary

On September 12, 2022, U.S. President Joe Biden signed the Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy, establishing a new bioeconomy plan for the country. As an executive order, the plan does not constitute legislation that has moved through the congressional approval process and regulates individuals and private businesses, but rather manages operations of various federal government agencies (American Bar Association, 2021). Without far-reaching legislative power, the order focuses on information gathering, investment in research and development, and setting legislative recommendations. This extends to every major U.S. federal agency, including the Department of Commerce, Department of Defense, Department of Health and Human Services, Department of Agriculture, Department of Homeland Security, Department of Energy, Department of Education, Department of Labor, the Environmental Protection Agency, and the Department of State (Biden, 2022).

The order identified the U.S. bioeconomy to be worth around \$1 trillion and predicted that it will grow to over \$30 trillion over the next two decades. It also further injected \$2 billion into the country's bioeconomy, including \$270 million from the Department of Defense to "incentivize" the expansion of domestic industrial biomanufacturing for materials and products for the military supply chain, \$40 million from the Department of Health and Human Services to expand biomanufacturing for pharmaceutical ingredients, antibiotics, and starting materials, and \$178 million from the Department of Energy to support biorefineries in research and commercialization for renewable chemicals and fuels (Cumbers, 2022).

As a whole, the bioeconomy plan concentrates on the stated goals of growing domestic biomanufacturing capacity and expanding market opportunities for bio-based products. To do this, it is split into 14 sections: policy, coordination, harnessing biotechnology and biomanufacturing R&D to further societal goals, data for the bioeconomy, building a vibrant domestic biomanufacturing ecosystem, biobased products procurement, biotechnology and biomanufacturing workforce, biotechnology regulation clarity and efficiency, reducing risk by advancing biosafety and biosecurity, measuring the bioeconomy, assessing threats to the United States bioeconomy, international engagement, definitions, and general provisions. The order's policy section frames the plan around the "policy" of the Biden administration "to coordinate a whole-of-government approach to advance biotechnology and biomanufacturing towards innovative solutions in health, climate change, energy, food security, agriculture, supply chain resilience, and national and economic security" with an emphasis on equity, ethics, safety, and security. Similarly, the order's coordination section mandates the Assistant to the President for National Security Affairs in consultation with the Assistant to the President for Economic Policy and the Director of the Office of Science and Technology Policy (OSTP) to coordinate the executive branch to implement the order and the heads of agencies to consult outside stakeholders, including those in industry, academia, nongovernmental organizations, communities, labor unions, and state, local, and tribal governments.

Centering around these policy and coordination mandates, the order sets out eleven major components. The first, harnessing biotechnology and biomanufacturing research and development, orders the agencies to submit reports on biotechnology and biomanufacturing to further goals related to health, climate change and energy, food and agricultural innovation, resilient supply chains, and scientific advances. These reports will need to identify research and technology development needs as well as public-private collaboration opportunities, which will in turn be used to develop a plan to implement recommendations. The following component, data for the bioeconomy, requires the administration to establish a Data for the Bioeconomy Initiative that ensures high-quality and secure biological data sets and the director of OSTP to issue a report that identifies the most critical data types and sources, sets forth a plan to fill any data gaps, identifies security and privacy risks, and outlines the existing federal resources. The building of a domestic biomanufacturing ecosystem component orders the various federal agencies and the Administration to develop a strategy that identifies policy recommendations to expand domestic biomanufacturing capacity and connect relevant infrastructure and to direct resources towards the creation or expansion of related programs. Subsequently, the biobased products procurement component mandates procuring agencies to establish a biobased procurement program and to enhance procurement reporting.

As the component with the largest focus on social equity, the biotechnology and biomanufacturing workforce section mandates the federal government to expand training and education opportunities in biotechnology and biomanufacturing, with a promotion of Historically Black Colleges and Universities, Tribal Colleges and Universities, and Minority Serving Institutions and emphasis on racial and gender equity and support for underserved communities. Next, the biotechnology regulation clarity and efficiency component is centered around clarifying and making more efficient the regulatory process for biotechnology products. Following this, the order aims to advance biosafety and biosecurity by requiring the government to launch a biosafety and biosecurity innovation initiative, which seeks to reduce biological risks associated with advancing the bioeconomy. Through this initiative, the various agencies will support



investments in biosafety research, use investments to enhance biosafety practices, and produce plans for biosafety and biosecurity recommendations. Additionally, the order includes a component on measuring the bioeconomy, ordering the Secretary of Commerce to create a lexicon for the bioeconomy and the chief statistician to improve federal statistical data collection designed to characterize the economic value of the U.S. bioeconomy.

The final components of the bioeconomy plan are focused on the country's international relationships and foreign threats. This includes one on assessing threats to the U.S. bioeconomy, which orders the Director of National Intelligence to lead an interagency assessment of threats to national security against the bioeconomy, including the stealing of U.S. technologies, and data. Finally, the international engagement component orders the Department of State to enhance cooperation, encourage the adoption of best practices, develop joint training arrangements, and work to promote the open sharing of scientific data with foreign partners. It further stated that such cooperation should be done with a focus on developing countries, international organizations, and nongovernmental organizations (Biden, 2022).

Overall, as the U.S.'s first order solely dedicated to the bioeconomy, the plan lays a base for the country's bioeconomy, but because of its broad mandates and lack of legislative power lacks teeth in enforcing progressive bioeconomy policies. Furthermore, following a broad definition of the bioeconomy, the order pushes themes of biotechnology and innovation, with few mentions of ecology or sustainability. Combining the lack of governing power and the wide technology-focus, the U.S. remains lagging in the international bioeconomy landscape.

### Conceptualization

The United States' bioeconomy plan establishes several definitions for the related terms, including biotechnology, biomanufacturing, and bioeconomy. As the overarching themes of the order, biotechnology is defined as "technology that applies to or is

enabled by life sciences innovation or product development,” while biomanufacturing is defined as “the use of biological systems to develop products, tools, and processes at commercial scale.” And according to the order, the bioeconomy as a whole is established as the “economic activity derived from the life sciences, particularly in the areas of biotechnology and biomanufacturing, and includes industries, products, services, and the workforce” (Biden, 2022). This vague definition follows the biotechnological approach to the bioeconomy, clearly focusing on how life science-based products can be used to grow the economy (Bugge, Hansen, et al., 2016 apud de Assis Costa et al., 2022, p. 3-4). The order as whole, further follows this basic approach, centering its measures around technological innovation and supply-chain strength. Being so broad, the order’s definition and approach to the bioeconomy remains surface-level and falls flat in considering a balance between growth and sustainability and fails to consider regional issues related to conservation and natural resources.

President Biden’s executive order on the bioeconomy, however, is not the U.S.’s first conceptualization of its bioeconomy. In 2020, the National Academies of Sciences, Engineering, and Medicine (NASEM), the collective scientific national academy of the U.S., proposed the similar definition, “economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences.” NASEM also reported that the country’s bioeconomy scope differed from those of EU countries and Japan, in that it did not include primary sectors such as agriculture, fisheries, and forestry, further reflecting the view that biotechnology is the key driver. Using such a broad and basic view, they claimed it provided the advantages of including mature economic activities and the totality of the primary sectors in measurements (NASEM 2020). Prior to this, the Obama Administration released the National Bioeconomy Blueprint in 2012 that stated “a bioeconomy is one based on the use of research and innovation in the biological sciences to create economic activity and public benefit.” The blueprint was meant to follow several strategic objectives: supporting research and development investments to provide a foundation for the U.S. bioeconomy, facilitating

the transition and commercialization of bio-inventions, developing and reforming regulations to reduce barriers, updating training programs and education to address workforce needs, and identifying the development of public-private partnerships (Obama White House, 2012). However, by 2016, when former President Obama left office, the implementation of the blueprint remained unclear (Congressional Research Service, 2022).

Prior to Trump taking office, the International Advisory Council on Global Bioeconomy claimed that in 2016, the direction of the U.S. bioeconomy became “marked by the more agricultural and bioresources-based vision put forth by individual federal agencies,” especially the Department of Agriculture (USDA) and the Department of Energy (DOE), which have had a long history of supporting research and development in areas relating to the bioeconomy. In 2016, the DOE and USDA co-chaired an interagency group that released a Federal Activities Report on the Bioeconomy that outlined objectives for “expanding the sustainable production and use of biomass.” The group also released a follow-up implementation framework in 2019 meant to increase government accountability, coordination on bioeconomy research, and sustainable technologies (International Advisory Council on Global Bioeconomy, 2020).

In addition to this interagency group, various U.S. federal agencies have included bioeconomy priorities. In 2020, the USDA released a report that included the bioeconomy as one of their science priorities through 2025 and the Department of Health and Human Services awarded \$51 million to establish “the nation’s first Foundry for American Biotechnology.” The same year, the Department of Defense awarded \$87 million to establish the Bioindustrial Manufacturing and Design Ecosystem and the National Science Foundation invested \$250 million annually in biotechnology and bioeconomy activities (Congressional Research Service, 2022).

In 2022, Congress passed the CHIPS and Science Act, marking its first move in enacting legislation related to the bioeconomy. The bill included the Bioeconomy Research and Development Act, previously introduced in 2020 and 2021, which

directed the Office of Science and Technology Policy (OSTP) to implement a National Engineering Biology Research and Development Initiative to advance national security, sustainability, and economic productivity through sustained support for research centers, individual investigators, technologies, and training. The legislation also mandated the National Science Foundation (NSF) to enter into an agreement with the NASEM to conduct a review of and make recommendations for the ethical, legal, environmental, and safety issues related to engineering biology research and development (Congress, 2021). Passed before Biden's executive order, the CHIPS and Science Act laid out a base for U.S. federal bioeconomy legislation.

Although the U.S. has been trying to formulate policies around the bioeconomy for over a decade, its conceptualization of the topic has remained focused on biotechnology and economic growth, with little in the way of consideration for sustainability measures. Additionally, while some agencies such as the DOE and USDA have begun to pivot their definitions of the bioeconomy to consider bioresources, most initiatives or investments that have been put forth have centered around research and development for new technologies. The process of implementing bioeconomy strategies remains similarly slow; Although progress has been made with the executive order and previous investments, the country's legislative bodies have failed to put forth an all-encompassing bioeconomy strategy.

### Implementation

As the executive order was released in September 2022, no reports, most of which are due within 180 days of the order (March), have been submitted to the administration. However, at least some steps to begin the implementation of the bioeconomy plan have been taken. A few days after the order was announced, the White House held a Summit on Biotechnology and Biomanufacturing that was led by National Security Advisor Jake Sullivan, Director of the National Economic Council Brian Deese, and the Director of the Office of Science and Technology Dr. Alondra Nelson. They were joined by various agency secretaries and leaders as well as Senator Mark Warner and Congresswoman

Deborah Ross (White House, 2022). The White House also invited academics and public and private sector experts to discuss how the \$2 billion in funding would be invested into bioeconomy research, development, and infrastructure (Morgan, 2022).

Several of the relevant federal agencies have also since released the steps they plan to take to begin implementation of the plan. This includes the Department of Health and Human Services, which announced that in their implementation of the order, they intend “to leverage biotechnology and biomanufacturing in order to achieve medical breakthroughs, reduce the overall burden of disease, and improve health outcomes.” The agency further committed to supporting the development of Food and Drug Administration (FDA) research programs for advanced manufacturing technologies, the Advanced Manufacturing Innovation Hub in the FDA’s Office of Counterterrorism and Emerging Threats, and the FDA Center for Advancement of Manufacturing Pharmaceuticals and Biopharmaceuticals to enhance coordination and collaboration. They also stated they would collaborate with the Department of Defense to invest \$1 billion in bio-based domestic manufacturing infrastructure and \$40 million to expand the role of biomanufacturing for active pharmaceutical ingredients and antibiotics and continue to fund predoctoral research internships in the biotechnology industry (HHS, 2022). Similarly, the U.S. Department of Agriculture (USDA) announced in December that it invested \$9.5 million to support the scale-up of sustainable bio-product manufacturing through their Bioproduct Pilot Program, which funds research and development of value-added products from agriculture. The agency wrote that the “program’s exploration into bioproducts accelerates USDA’s efforts to develop circular bioeconomies, where agricultural resources are harvested, consumed, and regenerated in a sustainable manner” (USDA, 2022). The Department of Defense also subsequently announced that through the order, they would invest \$1.2 billion into bioindustrial domestic manufacturing infrastructure and enhancements to biosecurity and cybersecurity systems (DOD, 2022).

In addition to the investments announced by the administration and the various federal agencies, the OSTP put out a public request for information in December, 2022. The

request “seeks public input on how advances in biotechnology and biomanufacturing can help us achieve goals that were previously out of reach and what steps can be taken to ensure we have the right research ecosystem, workforce, data, domestic biomanufacturing capacity, and other components to support a strong bioeconomy.” The request closed on January 20, 2023 and updates have not yet been provided (OSTP, 2022).

### Response

With little in the way of implementation or buzz around the bioeconomy plan, public reaction has been minimal. There has been slight conservative push-back that often seems more in opposition to the fact that the plan was heralded by Democrats, rather than its contents. An article in the City Journal, the public magazine published by the conservative Manhattan Institute, called the order a “biotech bureaucratic bonanza” that will likely work against boosting the bioeconomy, while the “libertarian” think-tank the Cato Institute criticized the plan for federal “micromanagement” of supply chains that they claimed would make them weaker (Garver 2022) (Miller and Cohrseen, 2022). They further pressed that boosting domestic production would make the country more vulnerable to domestic shocks. Some complaints have also come from deeper right-wing fringe groups. A press release from the Citizens’ Council for Health Freedom, a far-right group, called the order a “dystopian” plan that “falsely” asserts the COVID-19 vaccine is safe (Citizens’ Council for Health Freedom, 2022).

Inversely, some scholars and science groups have voiced support for the plan and shared recommendations for future actions to boost the country’s bioeconomy. The Federation of American Scientists wrote that the plan lays out “a wide path forward for the U.S. bioeconomy,” but that the U.S. bioeconomy needs legislative support to grow the biotechnology and biomanufacturing sectors. They also further outlined some questions that still need to be answered, including what areas of industry make up the bioeconomy, what factors should be considered when measuring the bioeconomy, and what current barriers the bioeconomy faces to grow (Jeffery, 2023). Stanford scholars



Megan Palmer and Drew Endy, who have worked with the White House on the bioeconomy, have also emphasized the importance of the order while highlighting that further work needs to be done to ensure bioeconomy growth is achieved in an ethical and equitable way (Morgan, 2022).

Due to the U.S.'s importance in the global economy, the order has also solicited reactions from the international bioeconomy community. After the announcement of the order, Chinese biotechnology stocks fell and companies like Hong Kong-based Wuxi Biologics had a 20 percent decline the next day. On the other hand, investors from Korea began discussions on new production facilities in the U.S. (World Bio Market Insights, 2022).

As implementation of the order continues and submitted reports and recommendations become public, response to the bioeconomy plan will need to be analyzed and understood. From workforce and procurement to international engagement measures, the strategy will likely affect not only domestic industries and citizens but also the international bioeconomy community.

### Political context

The Biden administration chose to pursue a bioeconomy executive order over federal legislation because it allowed the President to issue immediate measures and avoid the political battles a bill would face in congress and ultimately likely fail. The structure of the U.S. government and focus on separation of powers can create legislative hurdles that can prevent both ambitious and disastrous bills from passing. The government consists of three branches: the executive (the President and their administration), the legislative (Congress), and the judicial (the Supreme Court). These three branches are meant to keep each other in check and ensure one does not hold too much power. However, as within the U.S.'s two-party system, these checks also often prevent substantial legislation from passing. The two-party system formed because of winner-takes-all elections that just require winners to gain a simple majority of the vote

(Smith 2012). With just two parties representing almost all elected leaders in the country, they tend to stand in opposition of each other and work to make the other seem ineffective and wrong to gain political victories and polarization only intensifies these processes. As polarization of the country's congress progresses and both major political parties work to block ambitious legislation, a robust bioeconomy bill is likely dead on congress's floor. When the government is divided by party, it has been found that the legislative process slows down by 60 days on average and even slower when the level of party polarization is higher (Hughes and Carlson, 2015).

Although environmental legislation used to be passed with bipartisan support, such as the Clean Water Act and the Clean Air Act that were passed in the 70s by a conservative government, a post-Reagan anti-government push amongst conservatives has resulted in a Republican party that consistently votes against climate bills (Dujack 2022). And while a majority of the American public supports the adoption of economic legislation that promotes climate action and environmental protection, representatives, many of whom receive funding from large polluters and damaging industries, will claim it hurts production and ultimately will not be helpful. The most recent legislation that passed that included bioeconomy measures was the Inflation Reduction Act, which only passed because a compacted version was able to go through the budget reconciliation process. This process allows the bill to pass with a simple majority through both the House of Representatives and the Senate rather than passing with 60% of the Senate. This has been the most significant legislation with climate and bioeconomy measures since the 1970s. Similarly, it is likely that any additional bioeconomy legislation in the U.S. would have to go through a budget reconciliation process.

Although legislation that goes through the budget reconciliation process can pass with a simple majority, the current Democratic majority is fragile, with some senators breaking from party positions often and frequent elections that can switch the leaning of the various branches of government. As the 2024 elections approach, Democratic control of the Senate and the office of the President are weak and Republicans control the House of Representatives. Not only is Democratic control of the Senate slim, but multiple

senators often buck party objectives and vote with the opposition. For the House, as beginning in 2023, control is in the hands of Republicans who have prioritized investigations and process changes over passing legislation they know will not move forward. Should the Presidency switch parties in 2024, then bills not supported by the president will fail upon arrival because of their veto power. With all of these processes, bioeconomy legislation is almost impossible to pass.

## **Costa Rica's approach to bioeconomy**

### Summary

Costa Rica's strategy differs greatly in its scope, approach, and implementation from that of the United States. President Carlos Alvarado Quesada, in office from May 2018 to May 2022, set a progressive agenda for his administration. A cornerstone of his agenda was decarbonizing Costa Rica and creating a sustainable economy. Therefore, his government introduced and implemented "The National Decarbonization Plan" with the goal to transform its economy into "a modern, green, emission-free, resilient and inclusive economy" by 2050, also meeting their commitment to the Paris Agreement. This plan is an umbrella under which many other strategies live, including the "National Strategy for Bioeconomy," implemented in August 2020, and our main point of comparison for this analysis.

The scope of Costa Rica's plan encapsulates the entire Costa Rican economy, explicitly including all of its regions and communities, including the most rural and marginalized. The strategy orients itself around three main objectives:

1. To transform Costa Rica into a model for sustainable development, taking advantage of its biological resources as a means to create social inclusion and equity, balanced territorial development, conservation, knowledge and sustainable usage of its biodiversity, and becoming internationally competitive

2. To establish bioeconomy as one of the pillars of Costa Rica's development, promoting innovation, the accumulation of wealth, the diversification and sophistication of the economy, applying the principles of circular economy and seeking to remove fossil fuels from processes of production and consumption
3. To promote the convergence of the country's richness in biological resources and the use of national experts in the field of biology for its valorization

These can be broken up into key strategies, which include bioeconomy for rural development, biodiversity and development, biorefineries for residual biomass, advanced bioeconomy, and urban Bioeconomy and green cities. Then, these can be further broken up into dozens of specific targets and systems to implement in order to create the goal of creating a sustainable and circular bioeconomy (MICITT, 2020, pp. 22).

The dozens of objectives and targets detailed throughout the strategy can be summarized into three themes: sustainable development, circular economy, and social inclusion. Each clearly highlighted above. Though it does have one additional theme, the implementation of the theme prioritizes social inclusion (MICITT, 2020, pp. 22). The government ensures that all Costa Ricans have the opportunity to participate in this bioeconomy and reinforces the importance of indigenous communities, youth, and women to the success of the plan. The government's commits that these groups that have been historically excluded from economic development are no longer so (MICITT, 2020, pp. 36). Their inclusion will be essential towards achieving their goal of balanced territorial and economic development.

The government's approach in the creation of the strategy demonstrates its holistic nature, and its methodology reflects its objectives. To begin, the creation of this strategy was an inter-agency effort including the Ministry of Science, Technology and Telecommunication, the Ministry of Agriculture and Livestock, the Ministry of

Environment and Energy, and the Ministry of Economy, Industry and Commerce (MICITT, 2020). However, their efforts expanded beyond government agencies and included support from local universities, such as the University of Costa Rica and Institute of Technology of Costa Rica, members of the private sector, and civil society organizations, in addition to receiving support and guidance from the German government (MICITT, 2020, pp. 7). The plan's commitment to social inclusion can be seen from the beginning.

To implement this strategy, the government has an aggressive timeline with a target completion year of 2030. It has three phases, the first named "Impulse," the second named "Scaling Up," and the final named "Consolidation." During the Impulse phase, which ended in 2022, the government established necessary institutions, developed in more detail their plan of action, identified key strategic projects, and allocated and identified needed resources. They moved from this phase to the current one, Scaling up, during which they consolidate these institutions, establish a legal framework, expand the plan of action to the regional level, and determine the next round of strategic projects. They finish implementation with the Consolidation phase during which they do as the name suggests and consolidate the established economy and secure Costa Rica's position as a "model country of bioeconomy." Each phase is a step towards achieving their knowledge-based economy aligns itself with the Fourth Industrial Revolution, and it will include multiple forms of development, including territorial, economic, technology, urban, and knowledge (MICITT, 2020, pp. 69–70).

### Conceptualization

The Costa Rican strategy adopts one definition of bioeconomy, which is, "the production, utilization, conservation, and regeneration of biological resources, including the knowledge, science, technology, and innovations associated with these resources, in order to provide information, products, processes, and services to all economic sectors, with the aim of moving towards a sustainable economy" (MICITT, 2020, pp. 14). This definition combines the biotechnological, bio-resources, and bio-ecological

definitions of bioeconomy presented earlier in this report. It prioritizes conservation and biodiversity, while also progressing the Costa Rican economy through technology and innovation. This bioeconomy employs multiple approaches in order to achieve its sustainable, circular economy, some of which admittedly lean more bioecological in their conceptualization.

This definition and strategy include the technological approach, falling comfortably under the bio-technological conceptualization of bioeconomy. Each key strategy includes technological methodologies in order to accomplish its goals. For example, its commitment to “biodiversity and development” includes a section on “the development of technological applications in support of conservation and to showcase the beauty of Costa Rica’s beauty” (MICITT, 2020, pp. 53). Although these technological applications are not critical components to the conservation of biodiversity in the region, the strategy understands the usefulness of technology as a tool to promote and implement this key strategy. In another key strategy, “advanced bioeconomy,” the strategy discusses the long-term goal of developing and investing in bio-nanotechnologies in order to build up the government’s number of patents (MICITT, 2020, pp. 58). Although this strategy does include biotechnology, this approach serves as a tool through which to achieve broader, more bio-ecological and bio-resources related goals.

The bio-resources conceptualization of bioeconomy appears throughout this strategy, but a primary example of it is in key strategy three (3), named “Biorefineries of residual biomass.” Its objective is to optimize and minimize the waste from the many agricultural and extractive industries that exist in Costa Rica, specifically forestries, fisheries, and agroindustries that produce a large amount of biowaste. The strategy does not want to eradicate or even scale back these industries, but it instead wants to develop technologies and production methods that will utilize the waste to produce bioenergy, other biomaterials, and advanced bioproducts of high value. Similar to the bio-resources definition of bioeconomy, this key strategy wants to transform these extractive industries into sustainable industries through new solutions (MICITT, 2020, pp. 54). The bio-resources understanding of bioeconomy aligns most closely with the

spirit and conceptualization of bioeconomy discussed in this strategy because it optimizes the creation and strengthening of the economy while being sustainable and thoughtful about regional ecology.

Although the strategy does not meet the economic criteria of the bioecological definition of bioeconomy, it does include some of its spirit. First, the strategy does not prioritize economy over conservation. The strategy's first overall objective is to establish Costa Rica into a model country of sustainable development, and it mentions the importance of conservation in its development (MICITT, 2020, pp. 14). It follows this with the second overall objective, which then mentions economy and production (MICITT, 2020, pp. 14). Admittedly, the ordering of objectives is a smaller detail in the larger scope of the plan, but it is significant that they chose to place conservation before economy. This reflects the balance of priorities as a whole. However, it remains a more bio-resources conceptualization of bioeconomy because, as described earlier, the bioecological conceptualization necessitates a deprioritization of economy for the sake of conservation, which is certainly not the case here.

In conclusion, this strategy blends all three conceptualizations of bioeconomy into its strategy and approaches. As a result, Costa Rica presents its own conceptualization that optimizes the benefits of each in order to achieve its own goals. It does so intentionally by providing its own definition of bioeconomy at the beginning of the strategy. It is not possible to know yet the impact that Costa Rica's definition will have on the academic and global conceptualizations of bioeconomy, but a CEPAL report on "Nature-based solution and the bioeconomy" uses Costa Rica's definition of bioeconomy to frame its analysis (Meza and Rodriguez, 2022, pp. 18). Its conceptualization has entered the international system and may be adopted more broadly.

## Implementation

Despite the Costa Rican strategy being in effect for over two (2) years, there has been little formal analysis of the plan holistically, evaluating how effective it is as a bioeconomy strategy. Instead, journalistic articles and reports by non-governmental organizations discuss its implementation and progress.

BIOFIN published a helpful summary report on the government's progress towards meeting the strategy's goals. They raised \$8.35M with the support of the United Nations Development Programme and the Inter-American Development Bank and launched eighty-eight (88) projects for this strategy. In conjunction with the Costa Rican government, BIOFIN published a data visualization model that shows the amount of money raised, the types of projects launched, the locations of these projects, and the categories of each project (according to the objectives of the strategy). The data visualization shows an even distribution of projects fulfilling the key strategic goals with forty-four (44) advanced bioeconomy projects, fifty (50) rural development projects, forty (40) biorefinery for residual biomass projects, thirty-three (33) biodiversity and development projects, and twenty-one (21) urban bioeconomy and green cities projects. They also highlight the progress towards their social inclusion objectives of the strategy because 44.9% of the projects are led by women. All projects need different amounts of financial support and mentorship, and the report specifies that 44.39% of the projects request financial support above all other kinds. The article ends highlighting two (2) specific programs that will receive "non-reimbursable funds," and it mentions a program to incubate sustainable tourism led by indigenous organizations and groups in the regions of Buenos Aires de Puntarenas and Pérez Zelédon (BIOFIN, 2021).

Evaluating the progress detailed in the report above in comparison to the strategy's objectives, it becomes clear that during the first year, the Costa Rican government and its partners invested financially and practically into the establishment of this project. They finished the first year, which is half the allocated time, of the Impulse phase and worked towards all of this phase's objectives. They established an institution,



Observatorio de Bioeconomía, to report on progress, to provide information and resources to interested parties, and to serve as a database for bioeconomy projects. Despite this objective technically being fulfilled, it is important to note that the website has not been updated since the publishing of the BIOFIN report in August 2021. On the Observatorio's website, it does provide some detail into the implementation of the strategy, which is part of its elaboration of a plan of action, meeting another objective. The BIOFIN report details the progress for the Impulse phase's final two objectives and the strategic projects thus far, and the resources required to sustain and/or complete them.

Following its strong first year, articles and reports on the Observatorio and general Costa Rican bioeconomy initiatives become more difficult to find. In August 2022, BIOFIN and the government did not publish a report on the progress made in the strategy's second year and similarly did not publish one at the end of the Impulse phase. Through our research, we found an article discussing new initiatives around financing, investing, and entrepreneurship for bioeconomy projects. The first article, titled "Announcement of two initiatives to promote entrepreneurship in agriculture and Bioeconomy," by Carlos Cordero Pérez details two initiatives of entrepreneurship. The first being funded by the Costa Rican government, named BioInnova-Training Program, has the goal of supporting projects that contribute to the development of the circular economy, one of the strategy's listed forms of Bioeconomy, that also prioritize social inclusion. The second initiative is funded by the CRUSA Foundation and Deep Science Ventures, named Tropical Agriculture and Bioeconomy, which supports sustainable and regenerative agricultural projects. Both have equal parts technological, educational, and agricultural focuses while ensuring that all projects promote social inclusion. This article, published on "El Financiero," which is another Costa Rican newspaper, is the only news publication to mention these initiatives, and we did not find them published on the government's Observatorio de Bioeconomía website.

The final report to highlight on the progress of the strategy's implementation is published by the United Nations and CEPAL, named "Nature-based solutions and the

bioeconomy.” Although it does not evaluate the strategy specifically, it provides an analysis on bioeconomy initiatives in Costa Rica. It cites Costa Rica as a prime example of a country with a technoproductive, nature-based approach to development. It is, in addition to Colombia, an example of a positive approach to putting care and value of biodiversity and natural resources at the center of development (CEPAL, 2022, pp. 51). The report highlights one specific project, the Jesús María River Basin, as being exemplary. It reversed major deforestation in the Jesús Maria River Basin; “more than 750 sustainable farm evaluations and plans have been produced and 86,000 hectares have been positively influenced both directly and indirectly, through the pursuit of conservation and sustainable production activities” (CEPAL, 2022, pp. 71).

### Response

In its first year, the international community reported on and invested into the success and implementation of Costa Rica’s bioeconomy. The United Nations Development Programme, the World Bank, and United Nations Economic Commission for Latin America and the Caribbean each shared the strategy and Costa Rica’s accomplishment of successfully implementing the project. CEPAL went so far as to publish an article, which included praise on the strategy from the Chairman of the German Bioeconomy Council, Dr. Joachim von Braun, who said that, “Costa Rica is now entering an elite league of bioeconomically based strategies...it is a groundbreaking strategy that is building a very positive bio-ecological image” (CEPAL, 2020). Therefore, at the highest level, the response to the strategy has been supportive and positive.

On the local level, the response to the project’s first year seems to be generally positive. An article, titled “National bioeconomy project: What has happened in the past year?” in a major Costa Rican newspaper, named “La Republica,” lauds the progress of the plan as of August 2021. Similar to the paragraph above, the author, Ronny Gudiño discusses the data provided by BIOFIN and highlights the government’s progress thus far. Gudiño does point out a gap in the implementation of the strategy, saying that, “Curiously, despite the above, the majority (68) are projects located in the Central

region, demonstrating the need to expand to other zones in the country.” Although it is an understandable criticism because of the ambitions of the strategy, the government did specify in its goals that it would be during the Scaling up phase that they would focus on building up and incubating more regional and rural projects. Nevertheless, the geographic diversity of the bioeconomy projects should and will remain a focus in the evaluation of this strategy moving forward. Overall, our research suggests that the first year of the Bioeconomy strategy’s implementation was a success.

Since the first year, reports and articles about the project have slowed down significantly. As mentioned earlier, there was an article published by *El Financiero* in 2022 that discussed two entrepreneurship initiatives under the bioeconomy strategy, and CEPAL also published a report on nature-based solutions that mentions the Costa Rican bioeconomy strategy. This is a significant decrease in reporting on the strategy since 2020/2021. It is unclear whether this is because of a waning interest in the strategy from the local and international community or if priorities have changed since the first year. Nevertheless, information and updates on the strategy can only be found through government briefings and quotes after the implementation’s first year, which we will discuss in more detail in the next section.

### Political context

Despite the promising start to Costa Rica’s bioeconomy strategy, its future has become uncertain. In May 2022, Rodrigo Chaves Robles became President of Costa Rica. Unlike his predecessor, he did not run on a progressive agenda and is known for having an anti-establishment and “maverick” reputation (Stuenkel, 2022). During the COVID-19 pandemic, Costa Rica’s largest economic sector, tourism, suffered one of its worst periods. This shook the foundations of the previous administration and called into question its financial and economic agendas; President Rodrigo Chaves Robles, with his previous experience at the World Bank and as Costa Rica’s Financial Minister, became a viable candidate for the office and to turn around this economic situation (Stuenkel, 2022).

During President Chaves Robles' first international trip to the World Economic Forum, he made two commitments: one committing to Costa Rica's decarbonization and the other committing to working more closely with the private sector. He reaffirmed some of Costa Rica's commitments to some aspects of the bioeconomy strategy with the following statement, "We have invested very little in sewage systems, and we have too much river pollution; we are going to work on that. Also, dealing with waste management, we are not recycling, we are not doing enough circular economy."

However, the government's commitment to the strategy also has become unclear. It remains to be seen how President Chaves Robles' politics will develop in terms of climate change and Costa Rica's sustainability commitments because despite his support of certain aspects of the bioeconomy strategy, quoted above, he also shared during his campaign that Costa Ricans should "use and benefit from a resource that god gave us" in reference to natural gas (Idle, 2023). Thus far, Costa Rica has not backed out of its sustainable development strategies or decarbonization commitments, but President Chaves Robles has not yet finished his first year as Costa Rica's leader.

Looking to the future, the politics of Costa Rica have changed, and because the strategy's implementation and scope remains at the federal level, it is beholden to the current administration of the Costa Rican government. Nevertheless, the Costa Rican government's commitment to bioeconomy remains, despite it now being secondary to economic development. But will conservation and social inclusion remain priorities? Will biodiversity continue to be regenerated? There is a lot of uncertainty around the future of bioeconomy, sustainability, and decarbonization in Costa Rica; however, two aspects do remain clear: (1) the new administration is prioritizing economic development over climate goals and initiatives and (2) the political will behind bioeconomy has decreased significantly since its first year. Ultimately, the Costa Rican bioeconomic model moves further away from its bioecological conceptualization.

## Field research report

As part of building our benchmarking measures, we took a trip to Belém, Pará in order to engage directly with stakeholders and learn more about the creation of the plan. All of the stakeholders participated in the creation of the plan and have a vested interest in its successful implementation.

We engaged with government officials during a bioeconomy roundtable hosted by the Ministry of Environment of Pará and the government of the United Kingdom. Additionally, we met directly with Camille Bemerguy from SEMAS (Pará State Secretariat of Environment), who spearheaded the creation of the plan and played a large, if not the largest, role in it. Lastly, we visited the National Institute for Space Research and learned about how the government uses satellite technology to track deforestation throughout the rainforest in Pará.

We also had interviews with two researchers, who supported PlanBio's creation. First, we met with Gabriela Savian from the Amazon Environmental Research Institute, known in Portuguese as Instituto de Pesquisa Ambiental da Amazônia (IPAM), which is a scientific, non-governmental non-profit research organization that engages in research and knowledge production to achieve the sustainable development of the Amazon. Second, we met with a governmental research institution, named Fundação Amazônia de Amparo a Estudos e Pesquisas (FAPESPA), focused on research into science, technology, and innovation, studying the Amazon to understand it better and to protect it more effectively, while keeping in mind the importance of socioeconomic factors and outcomes. IPAM worked closely with the government in the drafting of PlanBio and actively participated in the process. FAPESPA also worked on PlanBio through its workshops and roundtables but not as intensively as IPAM.

Lastly, we interviewed members of civil society, who participated and shared their local knowledge as part of the creation of PlanBio. We interviewed the national director of the Conselho Nacional de Extrativistas do Pará (CNS), Ivanildo Brilhante, who

understands the region and also shared important information on conservation, community investment, and preservation of the rainforest. And finally, we met with Erica Monteiro, who is a member of Coordenação Nacional de Articulação das Comunidades Negras Rurais Quilombolas (CONAQ) and the State Coordination Office for the Associations of Quilombo Remnant Communities of Pará (ARQMO), a leader in her local Quilombo community and an advocate for the Quilombo regionally, nationally, and internationally. Both participated in the creation of the plan through the government's workshops, sharing their opinions and knowledge of the region, conservation, and effective, successful methods of economy.

We utilized an informal interview style as our information-gathering methodology. We met with each stakeholder individually and discussed PlanBio. For these interviews, we prepared our questions ahead of time in order to ensure that we gathered responses and data that we could compare in our subsequent analysis. Our questions were curated and designed to gather information in the following areas. First, we wanted to learn each stakeholder's definition of bioeconomy and identify the critical differences between each of their perspectives. Second, we learned more about how they participated in the creation of PlanBio and their understanding of its goals in order to ascertain whether or not those goals aligned with how they would define success for their strategy. The in-person interview style was important to the data collection process because it allowed us to build trust and understand their perspective on the strategy within their local context, which deepens and strengthens our understanding as researchers. This format allowed us to engage directly with each stakeholder with the benefit of translation.

### Selected interview responses

*How did each stakeholder define "bioeconomy"?*

**Camille Bemerguy, SEMAS**, did not give us a specific definition of bioeconomy but instead highlighted the role that the definition played in the creation of the strategy. Its

definition needed to be local, specific to Pará's context so that it could be the guideline and foundation for the strategy.

**Erica Monteiro, CONAQ**, provided us an understanding of bioeconomy by explaining what it should not be. For example, bioeconomy should not be companies encroaching and displacing communities for the sake of conservation and/or economic development.

**Gabriela Savian, IPAM**, explained the concept of bioeconomy in terms of what a bioeconomy should achieve. It should have zero deforestation in addition to social and environmental safeguards. She added that this will be achieved through nature-based solutions, in addition to the usage of science and technology, the integration of traditional knowledge, and the implementation of productive chains. Her understanding aligns with that of Camille Bermeguy, SEMAS, because she also views bioeconomy as a concept that is inherently local; therefore, her concern is not in producing a ubiquitous understanding or definition.

**Ivanildo Brilhante, CNS**, defines a bioeconomy as one that is “alive, values what is alive, and is social.”

**Marcel Botelho, FAPESPA**, defined bioeconomy as a balance between two priorities, conservation and economy, while also maintaining a high standard of quality of life, including the rights to health, education, and life. He also argued that his definition and view of bioeconomy as inherently local because these measures and categories, in order to be effective and impactful, had to be specific to the context of Pará.

*What are indicators of success, and how does each stakeholder measure it?*

**Camille Bermeguy, SEMAS**, described a successful bioeconomy as being one that had the following characteristics. She provided three baseline characteristics to bioeconomy: net zero emissions, eliminating deforestation, and improved quality of life. However, she added more specificity to what a successful bioeconomy should look like.

First, its agricultural sector would be sustainable and effective at combating deforestation. Moreover, it would become customary practice to include sustainability and conservation into their agricultural projects. Second, there would be an increase in research and innovation directly in the Amazonian states, studying the resources of the rainforest and also providing opportunities that reverse the brain drain in Pará. metrics to measure the success of a bioeconomy. This knowledge production also could also increase financial investment into the region and start opportunities to exchange and collaborate on research projects with universities around the world. To measure these different factors, she suggested a new GDP measure specifically designed to measure bioeconomy.

**Erica Monteiro, CONAQ**, highlighted the importance of quality of life and social inclusion to bioeconomy. Her community no longer has access to a school; therefore, children no longer are receiving an education, and their local healthcare facility has been abandoned. Therefore, she reinforced the importance of quality of life measures into the evaluation of a successful bioeconomy.

**IPAM, Gabriela Savian's** definition for bioeconomy also included her conceptualization of a successful bioeconomy. A bioeconomy has zero deforestation and includes social and environmental safeguards. Therefore, it promotes sustainability and conservation while also ensuring quality of life. She argues in favor of a similar measurement strategy as that of Camille Bermerguy (SEMAS), a GDP that specifically measures bioeconomy and its success indicators.

**Ivanildo Brilhante, CNS**, describes a successful bioeconomy as one that conserves and improves the environment, while also guaranteeing and improving quality of life. He also believes that a bioeconomy also requires social inclusion; therefore, all communities in the region would have to be culturally and politically recognized, measuring and, more importantly, acknowledging each community's involvement in the bioeconomy and giving them a platform for regular political participation. He did not



suggest specific measures or metrics to quantify these indicators, but he did provide us with a conceptualization of how success would look.

**Marcel Botelho, FAPESPA**, provided us with the following indicators for a successful bioeconomy. First, it reduces environmental impact and achieves zero carbon emissions. Second, it improves access and the quality of education and health in the region. Lastly, it stimulates economic growth and has a positive impact on current GDP. To measure the success of bioeconomy, he argues in favor of combining three indicators: GDP measurement, health measurement, and education measurement. In his experience, the most accurate measurements for quality of life in Pará have been education and health.

*What was the approach to constructing PlanBio? And how did you contribute to it?*

**Camille Bemerguy, SEMAS**, proposed PlanBio because she originally is from the region, and she wants Pará to be a part of the global movement towards bioeconomy. Her approach prioritized the implementation of PlanBio, and therefore she wanted to involve as many sectors as possible to contribute to the strategy. She estimates that forty (40) different groups contributed to it. Dialogue played a central role in this strategy from the beginning because social inclusion is key to Pará's bioeconomy and also because it would garner support for the strategy.

**Erica Monteiro, CONAQ**, contributed to PlanBio through the dialogue by sharing her knowledge and her community's traditional knowledge to the strategy. Although there were workshops that included a diverse set of stakeholders, she questioned the nature of the dialogue because it first did not engage with entire communities (only a singular representative) and also did not explain the strategy to the community directly. She felt uncomfortable being put in the position of singularly representing the entire Malungo organization.

**Gabriela Savian, IPAM**, works closely with the government because of the close relationship between IPAM and the government of Pará. She and her organization provided technical assistance and supported them in designing the plan. She also said that the approach to PlanBio was one of dialogue between a diverse set of stakeholders.

**Ivanildo Brilhante, CNS**, participated as a part of the bioeconomy workshops that served as the points for dialogue of PlanBio. He contributed his knowledge on living in and protecting the forests and also ideas about facilitating dialogue, such as translation services for those who did not speak Portuguese. He participated in the team that wrote PlanBio and evaluated what was included in the latest draft.

**Marcel Botelho, FAPESPA**, supported the development of PlanBio, providing scientific and technical support. He characterized the approach and nature of PlanBio as an attempt to have dialogue between local communities and the state government. The creation of the plan helped to develop the broader priorities of the government.

### Discussion

Through the interviews, we learned that these stakeholders did not share the same definition for bioeconomy. However, each definition provides an important perspective into the priorities of each stakeholder. To begin, the definitions shared two critical similarities. First, each stakeholder reinforced the importance of bioeconomy as a localized concept, reflecting the social and environmental context of the region. Although Ivanildo Brilhante (CNS) did not explicitly state that bioeconomy is local, by stressing the importance of the social, he localized his definition as well. The prioritization of social inclusion and livelihood is the second similarity shared by all of the definitions. Erica Monteiro (CONAQ) shared that bioeconomy should not have negative impacts on local communities for the sake of conservation and economic development. Quality of life and livelihood are equally important to conservation and economic

development. Marcel Botelho (FAPESPA) shared this view and mentioned the importance of a high quality of life that fulfilled the rights of life, health, and education.

The similarities of the definitions provide a foundation for understanding bioeconomy; however, it is equally important to identify the differences between the definitions. To begin, the definitions of Ivanildo Brilhante (CNS), Gabriela Savian (IPAM), and Marcel Botelho (FAPESPA) included the importance of conservation and environmental impact. Erica Monteiro, Quilombola community, and Camille Bemerguy, SEMAS, did not mention these factors in their definition. In the case of Erica Monteiro (CONAQ) this reflects a prioritization of quality of life indicators; alternatively, in the case of Camille Bemerguy (SEMAS), she discussed this consideration during our discussion on measuring success. Additionally, the definition shared by Camille Bemerguy (SEMAS) purely prioritized its role in PlanBio; bioeconomy, as a concept, needed to fit into the local context of Pará and as a result serve as the foundation of the strategy. She prioritized its role in policymaking because the concept had a purpose beyond the theoretical.

The most surprising difference between these definitions is the inclusion (or exclusion) of economy and economic development. Marcel Botelho (FAPESPA) discussed the importance of economy to the concept most directly; he highlighted it as one of the three main priorities of bioeconomy. Gabriela Savian (IPAM) did not discuss economic development directly but focused instead on nature-based solutions, production chains, and the usage of science and technology to implement bioeconomy. Erica Monteiro (CONAQ) discussed the negative impacts of economic development that needed to be taken into account and mitigated. The other stakeholders did not mention economic development. Despite this lack of inclusion, in the discussion about a successful bioeconomy and the measures associated with it, economic development was included more so as a critical concept.

Despite the differences across the definitions, the stakeholders characterize a successful bioeconomy similarly. They all stressed the importance of quality of life and

social inclusion to a successful bioeconomy. Erica Monteiro (CONAQ) highlighted the importance of quality of life indicators by describing her community's situation; they do not have easily accessible healthcare facilities or providers. The schools in their area recently have been closed. Therefore, if the basic needs of a community are not met, it cannot be a successful bioeconomy. Camille Bemerguy (SEMAS), Ivanildo Brilhante (CNS), and Marcel Botelho (FAPESPA) went so far as to add that in its success, a bioeconomy should improve quality of life. Erica Monteiro (CONAQ) only discussed the importance of quality of life; therefore, it is the only success indicator shared across all stakeholders.

Another characteristic shared across four of the stakeholders' conceptualizations of a successful bioeconomy is that of conservation and reduced environmental impact. Camille Bemerguy (SEMAS) went further stating that in its success a bioeconomy would eliminate deforestation and achieve net-zero emissions. Gabriela Savian (IPAM) also included the elimination of deforestation in her conceptualization and added the importance of sustainability. Marcel Botelho (FAPESPA), on the other hand, prioritized the goal of net-zero emissions to achieving reduced environmental impact. Lastly, Ivanildo Brilhante (CNS) focused on the importance of conservation through extractivist methodology to the improvement of the environment. Although each stakeholder discussed the reduction of environmental impacts differently, they all included it in their successful bioeconomy.

Three stakeholders included directly or indirectly economic development into their conceptualization of a successful bioeconomy. Marcel Botelho (FAPESPA) did so the most explicitly by stating that a successful bioeconomy would stimulate economic growth. Camille Bemerguy (SEMAS) and Gabriela Savian (IPAM) did not mention it directly, but each suggested GDP as a measure of success for the bioeconomy, which points to the importance of economic development. Further in the discussion, it will discuss in greater detail the suggested measures of success for bioeconomy, including GDP.

Two final, notable characteristics include the role of knowledge production and of political participation. Camille Bemerguy (SEMAS) noted the importance of research and innovation to a successful bioeconomy, explaining that providing these opportunities will reverse the brain drain in the region and also deepen our understanding of the resources in the forest. Although no other stakeholder mentioned this in their conceptualization of a successful bioeconomy, Gabriela Savian (IPAM) did touch on the role of science and technology in bioeconomy while defining the concept. Both share a view that knowledge production has an important place in bioeconomy. Ivanildo Brilhante (CNS) shared the other notable characteristic, the importance of political and cultural recognition. A successful bioeconomy requires social inclusion and the ability for all communities to participate in the dialogue process of policy implementation. As a result, communities, such as the Extractivist community, need a platform upon which they can be active political participants.

During the stakeholder interviews, we also asked each of them to share what measures should be used to benchmark the success of this bioeconomy strategy. To begin, Ivanildo Brilhante (CNS) and Erica Monteiro (CONAQ) did not suggest any specific forms of measurement; therefore, we will implement the knowledge that they shared in the "Key Takeaways" subsection of this report in order to represent faithfully what was shared with us during the interviews. Another important note, none of the stakeholders included measurements of environmental impact in their success measurements. This is an oversight, but it is likely because they were implied. The other three stakeholders did suggest forms of measurement for PlanBio. They all suggested using GDP to track the economic growth resulting from the strategy; however, they had different visions for this measurement. Camille Bemerguy (SEMAS) and Gabriela Savian (IPAM) both suggested a GDP designed to measure bioeconomy. They believe that the next phase of this strategy would benefit from consultation of an economist to create this measurement because they did not have a vision of what it would include. On the other hand, Marcel Botelho (FAPESPA) believed that the already established GDP measurement would be sufficient to track the economic impact of the strategy. Camille Bemerguy (SEMAS) and Gabriela Savian (IPAM) did not have any additional

suggestions for forms of benchmarking measurement; however, Marcel Botelho (FAPESPA) said it would be equally important to track quality of life measures, in addition to economic ones. Therefore, when benchmarking, impacts on health and education also should be measured as a reflection of quality of life.

Thus far in this discussion, we have reviewed what the stakeholders shared about their views on (1) the definition of bioeconomy, (2) the characteristics of a successful bioeconomy, and (3) the measures of success for bioeconomy. In this final section of the discussion, we discuss the approach supporting PlanBio and each stakeholder's contribution to PlanBio. There was a consensus on the role of dialogue to the creation of PlanBio and its importance to the strategic success of the plan and its subsequent implementation. Each stakeholder contributed knowledge to the strategy, based upon their experience and background. In particular, the traditional knowledge shared by Erica Monteiro (CONAQ) and Ivanildo Brilhante (CNS) played an important role to PlanBio because their communities already engage in forms of bioeconomy. Camille Bemerguy (SEMAS) shared with us that the people who live in the forest already know what to do and how to live sustainably; in the end, it is the government that needs to learn how to support them. Erica Monteiro (CONAQ), Ivanildo Brilhante (CNS), and Camille Bemerguy (SEMAS) share this perspective, and as a result, it reinforces the importance of dialogue as this plan's methodological approach.

Four of the five stakeholders discussed the role of dialogue in PlanBio. They confirmed the usage of dialogue as the approach to PlanBio and its inclusion of a diverse set of stakeholders. However, both Erica Monteiro (CONAQ) and Ivanildo Brilhante (CNS) shared reservations about usage of dialogue, during the implementation of PlanBio. The government's approach to dialogue was a first step; it included representatives to many communities. As Erica Monteiro (CONAQ) described, it did not engage whole communities in the creation of PlanBio, relying on representatives to speak for everyone. Erica Monteiro (CONAQ) represents one section of the larger Malungo organization, and she could not speak to the expectations, knowledge, and reservations of other people and leaders in her community. Additionally, both stakeholders

expressed concerns about dialogue continuing throughout the implementation process and beyond. Ivanildo Brilhante (CNS) shared that past policies and broken promises have left his community and others doubtful of the state government's long-term commitment. They have to build trust and pay back a historical debt for the treatment of local communities. He believes that if the state government commits further to social inclusion and open dialogue with communities, it will be an important step to gaining the trust and, consequently, support of local communities.

### Key learnings from field research

Our team's research trip to Pará provided us with crucial information to create this benchmarking section that we would not have been able to obtain otherwise. First, it became clear that bioeconomy does not have a standardized definition, and its conceptualization reflects the various perspectives of bioeconomy. This also applies to how each stakeholder describes a successful bioeconomy. However, a few key themes did appear across the interviews, and they are the categories that should be used to evaluate the success of a bioeconomy; (1) economic growth, (2) well-being, (3) environmental impacts, (4) innovation, and (5) social inclusion.

To expand upon the final category, social inclusion, Camille Bemerguy (SEMAS) shared that the state selected dialogue as the approach in order to secure the support of local communities, such as the Quilombola and the Extractivists. The interviews with Ivanildo Brilhante (CNS) and Erica Monteiro (CONAQ) substantiate this belief; however, the government must continue to facilitate dialogue, with a diverse set of stakeholders and also educate the communities affected by PlanBio about its impact. It is crucial to the path forward, and it will build trust and support for PlanBio.

### **Bioeconomy benchmarking**

As the bioeconomy plans continue through their implementation processes, all three countries will measure the success of their plans through various benchmarks aligned

around major themes: economic, well-being, environmental, technological (innovation), and inclusion components.

### Economic

As the names suggest, the bioeconomy plans of Pará, the U.S., and Costa Rica all have economic focuses with aims of either growing specific industries, economic development, or overall restructuring. All three countries have estimated the values of their bioeconomies and have put forth these plans as a way to boost their overall economies.

Pará's PlanBio aims to achieve overall economic growth, establish an environment that attracts investments to value chains and new businesses, and promote local development, jobs, income, and fair distribution of benefits. As of 2019, it has a bioeconomy valued at around BRL 5.4 billion in generated income. With the bioeconomy plan and its transition to a new economic model, it could grow to be worth more than \$30 billion to the state by 2040. How to determine the growth of Pará's bioeconomy has varied among the plan's various stakeholders, but multiple actors highlighted the importance of GDP measures. Both representatives from SEMAS and IPAM called for forming a model that calculates the GDP of the bioeconomy, including only production and consumption around bioeconomy-based products. Inversely, FAPESPA hopes to follow Pará's overall GDP, as they believe overall economic growth will show the bioeconomy plan is benefiting the state. Other stakeholders, however, are less focused on economic measures of growth and instead hope to see enough earnings that are distributed equitably to ensure livelihoods are secured.

The United States' executive order on the American bioeconomy, though focused on economic growth of biotechnology and biomanufacturing industries, does not outline specific economic goals or measures. The order, which includes a \$2 billion investment, aims to boost biomass production, expand biomanufacturing production capacity, expand market opportunities for bioenergy and biobased products, and strengthen



biobased supply chains. Currently, the U.S. bioeconomy is valued at nearly one trillion dollars and is predicted to grow to over \$30 trillion over the next twenty years. However, unlike Pará, the U.S. bioeconomy order does not address the distribution of benefits or the promotion of local development, jobs, and income, but rather looks at the country as a big picture, looking to boost economic growth at a high level.

Similarly to the U.S., Costa Rica's bioeconomy plan does not set out concrete economic goals outside of overall growth. Unlike the other plans, however, Costa Rica's is a restructuring of the country's economy, which places the entire economy under the umbrella of bioeconomy. Thus, in valuing its bioeconomy, Costa Rica has estimated its 2023 GDP value to be \$78 billion. Looking forward, implementation of Costa Rica's plan will be seen as successful if the entire GDP increases and the country's overall economy experiences growth.

### Well-Being

While many economic plans focus on economic metrics, many of these, including GDP measures, fail to consider metrics of well-being such as health and education. Pará's bioeconomy plan does not specify measures of well-being, but almost every stakeholder consulted mentioned goals related to their standard of living. FAPESPA called for measuring health and education in addition to GDP growth and emissions reduction to understand the success of the plan, while the representatives from CNS and the Quilombola community highlighted their need for social impacts. Without understanding how the plan affects overall well-being, economic growth or environmental benefits alone cannot signal a successful policy.

Like Pará, the U.S. bioeconomy executive order did not reference well-being aims or goals. However, the order included a component on the biotechnology and biomanufacturing workforce, which mandates the expansion of training and education programs and the promotion of career education and expanded career pathways. The plan also includes a component focused on research and development to further

societal goals, which broadly stated as health, climate change and energy, food and agricultural innovation, resilient supply chains, and cross-cutting scientific advances.

Costa Rica, on the other hand, included multiple well-being components in its bioeconomy plan, including benchmarks related to hunger, clean water, housing, and education. The plan aims to eliminate hunger, ensure clean water access, and create education programs that focus on technical skills for the bioeconomy. Costa Rica also outlined a key strategy that calls for housing programs for lower income and middle income communities to ensure city development is sustainable and affordable for everyone. A component Costa Rica failed to include in its social well being measures is health; The plan does not mention health as a goal of the overall strategy.

### Environment/Climate

The bioeconomy plans' focus on biobased production and nature-based economic activity tethers the plans to environmental and climate factors. With this in mind, environmental measures such as emissions reductions, forest regeneration, and renewable energy growth can be vital in analyzing bioeconomy implementation.

Pará's bioeconomy plan includes multiple environmental goals and estimations. It includes plans for energy, transportation, land-use, and forestry changes that will reduce greenhouse gas (GHG) emissions and regenerate forests. If implemented, the plan is estimated to reduce GHGs by 37% by 2030 and by 43% by 2035. Similarly, it is estimated that the plan will regenerate 5.6 million hectares of forest by 2030 and 7.41 million hectares by 2035. The state expects to achieve carbon neutrality by 2036. PlanBio additionally includes plans to increase climate financing through the Eastern Amazon Fund (FAO) and the Bioeconomy Guarantee Fund. With these estimations and goals in mind, an adequate implementation will see significant reductions in greenhouse gas emissions, regeneration of millions of hectares of forest, and carbon neutral state.

Inversely, the U.S. bioeconomy plan fails to include any components focused on climate or the environment and merely references climate change as a societal goal. The plan's research and development component mentions biotechnology and biomanufacturing should be leveraged to protect against climate change and orders the Secretary of Energy to assess how biotechnology impacts climate change. Similarly, the plan's data component includes identifying data that is critical to understanding climate advances. These light mentions leave a lot of room for improvement and any future U.S. bioeconomy plans should consider environmental measures to ensure the bioeconomy is sustainable.

As a part of the country's overall Decarbonization Plan, Costa Rica's bioeconomy plan is deeply tied to environmental and climate goals, including achieving net-zero emissions. One element of the plan states, "Conservation and restoration of biological resources as well as their direct use and sustainable transformation to meet the needs of the environment, people, and various economic sectors." The plan also includes a key strategy related to green cities and urban bioeconomy, which includes calling for the reduction of single-use plastic. Additionally, Costa Rica's bioeconomy plan is related to the country's Deforestation Plan (under the umbrella of the Decarbonization agenda) and therefore pairs with goals to eliminate deforestation and regenerate deforested areas around the country. With these numerous environmental goals, Costa Rica's plan will prove successful if it achieves net-zero emissions, reduces single-use plastics, regenerates forests, maintains clean water, and sustains the overall conservation and restoration of biological resources.

### Innovation/Technology

In addition to boosting economic growth and sustainability, all three bioeconomy plans include components focused on technology and innovation, which are seen as necessary to establish a secure bioeconomy. However, while the U.S. plan focuses on streamlining innovation, making regulatory processes efficient, and protecting against international threats, Pará's bioeconomy plan highlights the need to promote knowledge

and protect intellectual property and Costa Rica emphasizes the knowledge production process.

Pará's bioeconomy plan is actively trying to improve technology development in the state as research development and innovation is one of the three pillars behind the policy. As a central pillar, the plan intends to "promote and apply scientific knowledge and technology research that promotes inclusive innovation with integrated social, economic, and environmental benefits," as well as identify and map knowledge about the bioeconomy across research institutes, incentivizing applied research and transforming it into new technologies, trainings, and tools that will improve local production. Pará also placed emphasis on using certifications, the protection of intellectual property, and designation of origin to ensure the state's biodiversity products are valued in ways that add the region's unique qualities to local products. With an emphasis on research development and innovation, implementation will need to monitor how investments and development value local knowledge and production.

The U.S.'s bioeconomy plan is heavily centered around technology and innovation with most components of the plan outlined in such a way to promote the development of biotechnology in the country. In addition to a component solely focused on harnessing biotechnology and biomanufacturing research and development, the executive order also includes measures to establish a data initiative that will secure biodata with the aim of driving technological breakthroughs and to make biotechnology regulation more clear and efficient. The government hopes to ensure the regulatory system is designed in such a way as to promote innovation and the development of biotechnology products. Additionally, the plan includes measures meant to assess foreign threats to the U.S. bioeconomy, which includes the acquisition of U.S. capabilities, technologies, and biological data. With hopes to better protect intellectual property, the executive order intends to prevent domestic innovation from leaving the country.

Costa Rica's approach to technology and innovation places focus on knowledge production with stated goals of creating a "knowledge society" and including "innovation

and productive sophistication.” All of Costa Rica’s plan’s key strategies include research and innovation as a pathway to advancing its goals. The key strategies of “Bioeconomy for Rural Development” and “Biodiversity and Bioeconomy” include the creation of regional laboratories. In the Biorefineries for Residual Biomass key strategy, it includes producing more knowledge of residual biomass, developing forms of more sustainable bioenergy and biomaterials production, producing high value bioproducts, providing general support to the private sector for research, and supporting the synergy of science, technology, and innovation to support the efficient completion of the bioeconomy plan. Additionally, Costa Rica’s plan calls for establishing a favorable business climate for the development of new biotechnology and biotechnology products and creating more regional laboratories across the country. Like Pará and the U.S., Costa Rica’s plan places emphasis on scaling up innovation and the development of biotechnology as a way to reach its sustainability goals.

### Inclusion

As the implementation of the three bioeconomy plans progress, inclusion and dialogue measures will be vital in ensuring benefits reach local populations and no communities are excluded from the bioeconomy gains. And while such components are crucial, they are not always included or centered enough; the United States failed to include any serious efforts for inclusive dialogue, while Costa Rica and Pará may overestimate their own.

Although Pará’s plan includes inclusion measures and touts a diverse dialogue process, the state will need to put forward more good-faith efforts to engage local communities in the development and implementation of the bioeconomy plan. The plan itself calls for honoring cultural and genetic heritage as well as traditional knowledge by protecting and valuing traditional practices, guaranteeing the rights of local populations, and promoting alternative pathways to sustainable development. The creation of the plan itself followed a dialogue process that included multiple dimensions. The first, a listening component, was centered around three multi-sectoral workshops, 14 bilateral meetings

between SEMAS and other state government institutions, and a series of ethnic-regional workshops in four population poles: Altamira, Belém, Santarem, and Marabá. Additionally, once the original PlanBio was released, the state allowed for public electronic consultation. This resulted in 421 downloads. While the plan includes inclusivity measures and mentions of valuing traditional knowledge, some traditional communities still feel their knowledge is not being valued enough. Conversation does not always translate to consultation and to ensure the further development of the bioeconomy strategy maintains an emphasis on inclusion and dialogue, state government institutions will need to engage deeper with local populations. This includes consulting more than one group representative, as local groups are not monolithic with uniform opinions, and holding continuous conversations to ensure every part of implementation is inclusive.

Unlike Pará, the U.S. executive order does not emphasize inclusion or dialogue. The plan was formed without consultation of public groups or communities and its only inclusion-related measure is the workforce component that highlights the need for increased diversity and a focused discussion on promoting Historically Black Colleges and Universities, Tribal Colleges and Universities, and Minority Serving Institutions. Similarly, once the executive order was released, information and comment collection has centered around a top-down approach focused on experts. After the plan was announced, the White House hosted a summit collecting comments and opinions on the order from academics, industry experts, and legislators. As an invite-only summit, there was a lack of general public participation and inclusion. The White House did also launch a public comment period, but with little advocacy or communications related to the bioeconomy plan, most people around the country were unaware of the plan and its components. Thus, the public comments were also concentrated around technocratic opinions and ideas.

Similarly to Pará, Costa Rica placed emphasis on inclusion and diversity. Although the development of the bioeconomy strategy was a government-led process, civil society, research organizations, and universities also participated in the creation of the plan.

However, their dialogue process seemingly did not go as far as Pará's as a country-wide plan requires greater engagement across a wider population that makes inclusive dialogue particularly challenging. Moving forward, interacting with more local populations will help Costa Rica better implement its plan. Within the plan itself, a major element was applying "traditional and modern knowledge about biological resources, processes and principles in the development of new products, processes and services." The plan includes creating a program for National Protection of Traditional Knowledge and Public Health and provides opportunities for youth to attend technical schools and colleges that promote all of the key strategies, ensuring that everyone takes part in the bioeconomy. As implementation progresses, a benchmark measure for Costa Rica is the inclusion of marginalized groups in the bioeconomy plan's various initiatives. The groups include: Gender and youth, Indigenous peoples, and territorial development.

### Recommendations

As Pará enacts PlanBio, there are a number of measures that need to be established to ensure implementation and further bioeconomy articulations achieve the state's goals and promote sustainable development. This includes defining metrics for economic growth, environmental protection, constituent well-being, technological research and innovation, and inclusion and using quantitative and qualitative data to ensure accuracy.

As a transformation of the state's economy, it will be vital for city officials and researchers to develop a way of valuation that can measure the economic activity of bioeconomy-related production. This can look like a bioeconomy-specific GDP model that can be altered to include more products as the state's bioeconomy evolves or using the state's existing GDP model to look at overall economic growth. Additionally, monitoring the price growth and levels of production of the various agricultural products and services of Pará can highlight the ways in which the bioeconomy plan has affected growth, trade, and prices.

Once economic models are established, the state will need to include well-being dimensions in its progress reporting. While economic growth is a focus of the plan, to ensure it is actually beneficial to the diverse constituents of the state, well-being will also provide a beneficial understanding to the impacts of PlanBio. This should include metrics for education, health, housing, and more that not only underscore how these factors have improved or grown but also show levels of access.

Environmental and climate aspects also play a central role in Pará's bioeconomy plan and thus need to be meticulously evaluated. This should include measuring reforestation, emissions reductions, and progress on carbon neutrality. If these aspects trend in the right direction once implementation is initiated, it will also be fruitful to measure environmental aspects such as access to clean water, levels of air pollution, and weather resilience. With these measures, the state can understand how the plan impacts the state's environmental and climate goals.

To bolster the changes outlined in the plan, a key component is ramping up technological production and innovation. To understand how the plan affects research and innovation, the state should collect data related to the number and size of investments the state's research institutions receive, how many projects such institutions take on, and how these projects value genetic heritage and traditional knowledge. Additionally, the state should analyze how intellectual property is being protected and work to secure patents and trademarks for innovations created within the state.

Finally, Pará's monitoring of the plan's implementation will depend largely on how successful its inclusion measures are. To do so, the state needs to ramp up and establish regular meetings and consultations with the diverse set of stakeholders involved in the plan. It will also be critical to create communications and advocacy materials that translate the plan's technical language into easy-to-understand summaries that ensure wide-spread understanding amongst constituents. Another helpful strategy to ensure inclusion in implementation is to establish portals for public



comment that allow constituents to submit opinions, reports, or suggestions as the strategy progresses.

## **Conclusion**

Among the regions we compared – Brazil, Costa Rica, and the United States – and around the world, several concepts related to the bioeconomy are still being settled, generating different strategies that meet the demands and visions for development according to each location. Within the nature field, these strategies range from a focus on land-use to fields of biotechnology and bioresources. Since the Paris Agreement and the recent Global Biodiversity Framework, these approaches have been strengthened by increased political action, reflecting the urgent need to address climate change and the biodiversity crisis.

This practical project provides evidence supporting the viability of bioeconomy as a useful instrument for addressing the challenges posed by these interrelated global challenges. By emphasizing the unique characteristics of each territory, well-structured and implemented bioeconomy plans can offer a means of achieving both economic prosperity and ecosystem preservation, especially if combined with other complementary public policies. Nevertheless, the benchmarking study, which represents the principal output of the research, reveals areas in need of improvement across all analyzed locations.

To begin, it is evident that Brazil lacks a comprehensive national bioeconomy plan, despite the country's significant organic progress in this area through private, philanthropic and international community-financed programs, as well as local initiatives carried out historically by traditional communities. With the onset of the Luiz Inácio Lula da Silva presidency in January 2023, the current political leadership is further engaging with the need to develop strategies to reduce deforestation in the Amazon, given its importance to the country and its role in maintaining global climate stability. At the same time, experts recognize that curbing deforestation in the Amazon requires a concrete plan aimed at providing economic alternatives for the local population. Contemporary

environmental policies also acknowledge that command and control measures must be supplemented by substantial support for value chains anchored in the standing forest. Without such support, forest protection becomes unviable.

Regarding the groundbreaking initiative of the State of Pará, it is noteworthy that the narrative of inclusion of traditional communities was not entirely substantiated by representatives of these communities with whom we interacted. These representatives underscored that the conversations held with groups of leaders, which were conducted by the State for the first time, cannot replace broader consultations with appropriate communication methods that align with the realities of these communities. Furthermore, forest populations point out the lack of basic rights such as education and health, especially when the State resorts to “new buzzwords” that overlap with their historical demands. To overcome the crisis of distrust among the communities, the State must address the challenge of establishing dialogue in an appropriate manner and delivering concrete results that reach the most vulnerable territories first. Another critical aspect for improving PlanBio pertains to coordinating the Environment Secretariat with other key secretariats, particularly Agriculture and Economy, to avoid the plan becoming insular within the environment sector when it should be cross-sectoral.

Despite the challenges, we believe that the federal government could benefit greatly from the experiences and insights gained from the development of PlanBio in the state of Pará, which appears to have a strong technical foundation. While the true effectiveness of the plan will depend on its implementation, monitoring, and impact on quality of life and environmental sustainability over time, there are already valuable lessons and expertise concentrated in the Amazon region that can guide Brasília in developing a comprehensive national bioeconomy plan.

Conversely, Costa Rica already implemented a strategy at the national level, the “National Strategy for Bioeconomy,” and it serves as a model for its strategy and implementation; however, it has weaknesses and considerations from which other countries and states can learn. First, this strategy’s ambitious approach and implementation at the federal level serve as both a weakness and a strength. It has a

far-reaching impact, with the goal of transforming the Costa Rican economy, but it is beholden to the support and will of the federal government. As administrations change and political interests evolve, the strategy will be prioritized and deprioritized, resulting in an inconsistent implementation. Second, Costa Rica is the smallest megadiverse country in terms of landmass and also a smaller producer of carbon emissions. Therefore, the scope of its project, though significant, is also on a relatively smaller scale. Its approach will look quite different from other megadiverse countries because of this difference and must be considered when evaluating the strategy and its implementation. Lastly, although the bioeconomy strategy stated social inclusion as one of its themes, the lack of reporting and information accessible online make it difficult to evaluate the truth and implementation of this theme. To do a more accurate assessment, it would be important to do a similar field research approach, speaking directly with stakeholders and learn their opinions on the strategy and their inclusion in its creation and implementation. Part of Costa Rica's strategy is to also transform itself into a bioeconomy and sustainable development global leader. The coming years will be critical to the success of Costa Rica's strategy, and its evaluation must be done through not only economic but also social and ecological measures.

The U.S., on the other hand, has taken a meager approach that holds too tight a focus on biotechnology and biomanufacturing that highlights the consequences of a limited plan that lacks inclusion. As bioeconomy policy in the country progresses, the country has interesting lessons to be exchanged with Global South countries when it comes to designing a more robust and inclusive bioeconomy. Future bioeconomy measures should include components more explicitly related to preserving biodiversity, reducing emissions, transitioning to green energy, and achieving not only climate, but social goals. Without direct mentions of environmental aims, regulators and industry will implement the outlined measures with loose considerations for climate that will likely undervalue the negative environmental impacts production causes. Additionally, it lacks an inclusive consultation process, instead taking a top-down approach focusing on technocratic expertise. By only relying on legislators, industry, and academics, any bioeconomy policy will fail to capture the full extent of constituents' various needs and

goals. A broader and more bottom-up approach will help create more sustainable bioeconomy policies.

Across all countries, whether they are megadiverse or not, bioeconomy strategies present a strong opportunity for sustainable development, and if they are conceptualized with a combination of the biotechnological, bio-resources, and bio-ecological approaches while also addressing each of their local contexts, then their opportunity for success greatly improves. Thus far, the ideal bioeconomy model remains a theoretical one, yet to be fully implemented, but through this project, we have identified key measures that each one requires in order to succeed: economic growth, well-being, environmental impacts, innovation, and social inclusion.

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