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Challenges for a Brazilian Amazonian bioeconomy based on forest foods

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ABSTRACT

The creation of a forest bioeconomy based on the extraction of non-timber forest products (NTFP) is being recommended to create wealth from standing forests and halt deforestation in Amazonia. Current proposals do not recognize the limits of this system, nor the impacts of capitalism that drive NTFPs with elastic demand into monoculture plantations. We use a narrative review to revisit the history of these ideas and examine public policies. Among 2,253 Amazonian NTFPs, 1,037 produce edible fruits and 131 of these are extremely abundant (hyperdominant) across the biome and common in the extractive economy. Low productivity per hectare in the forest, low return on labor to harvest the production, and scarcity of labor are three critical limits to expanding supply, with the last being the most critical in forest areas. Overcoming these limitations requires changes in public policies and public investment for health care, communication, logistics, and especially for quality education designed for rural areas and a forest bioeconomy. A mix of public policies to alleviate market failures and increase supply, efficiency, and demand via R&D, minimum prices, payment for environmental services, distinct types of certifications may be able to make food NTFP harvesting, processing, and commercialization lucrative enough to halt rural exodus and keep forest specialists in standing forests. An Amazonian forest bioeconomy depends upon both social and biodiversity, and the full participation and collaboration of Indigenous People and local communities in developing these value chains that can contribute to food security.

1. Introduction

Amazonia is attracting global attention because deforestation, land use and climate changes are destroying and degrading native forests and emitting significant amounts of greenhouse gases (Nobre et al., 2016), all driving the forest system to critical transitions by 2050 (Flores et al., 2024). In response, many governments, academic forums, and civil society organizations are advocating a "bioeconomy" to generate wealth from "standing forests" (Nobre and Nobre, 2019; Abramovay et al., 2021; Nobre et al., 2023; Ribeiro et al., 2024; Rosenfeld et al., 2024). Among the many proposals are plans to continue and expand the harvesting of non-timber forest products (NTFPs) (called extractivism in Brazil), without recognizing the limitations of this extractive system (e.g., low productivity, low returns on labor, labor scarcity, among others) nor the effects of capitalism that are observable when market demand increases (Homma, 1982, 1993; Ruiz-Pérez et al., 2004; Homma, 2014, 2018; Ollinaho and Kröger, 2023). In a biome with continental dimensions, this is a significant challenge, especially as the conventional alternative is to replace the forest with monoculture plantations for food production (Nobre et al., 2016; Hanusch, 2023), which is precisely the kind of land use change that is contributing to climate change that is already impacting the forests where NTFP extraction might be enhanced (Evangelista-Vale et al., 2021; Rosenfeld et al., 2024). Many NTFPs are foods, which are significant parts of the region's traditional extractive economy (Abramovay et al., 2021). Foods from forests are a worldwide alternative (Vira et al., 2015), but progress to change the international food nexus has been extremely slow because of the dominance of the agribusiness plantation nexus, a root cause of the Anthropocene (Haraway, 2015; Hancock, 2017; Kröger, 2022; Ollinaho and Kröger, 2023). In this Comment, we offer a narrative review to examine some of the

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limitations of creating a food-based forest bioeconomy in Amazonia and identify and propose public policies that might contribute to this.

Before delving into history and current ideas, it is important to consider the numerous definitions of bioeconomy. The term is relatively new, but already several categories can be conceptualized with different levels of research & development (R&D) inputs, reliance on capitalist market forces, impacts on Indigenous Peoples and local communities (IPLCs), and sustainability outcomes (Bugge et al., 2016; Costa et al., 2022; Garrett et al., 2023). Bugge et al. (2016) identify three categories: “bio-technology” relies on bio-technology R&D and commercialization in different sectors of the economy, often with an emphasis on biofuels – in Brazilian Amazonia, the technology intensive agroindustries of annual and perennial monocultures, called the “plantation economy” by Ollinaho and Kröger (2023); “bio-resource” focuses on R&D for processing of biological raw materials and new value chains, with a better balance of markets vs sustainability – in Brazilian Amazonia, numerous indigenous crops such as cacao (*Theobroma cacao*) and açaí-do-pará (*Euterpe oleracea*) in small-to-medium scale plantations; “bio-ecology” highlights sustainability and ecological processes that optimize the use of energy and nutrients, promote biodiversity, and avoid monocultures – in Brazilian Amazonia, numerous agroforestry systems and extractive products used and produced by IPLCs, called the “sociobiodiverse economy” by Ollinaho and Kröger (2023). These visions contrast with Indigenous visions, where a bioeconomy is based on “producing in a sustainable way, at the rhythm of the villages and in harmony with nature, aiming to obtain sufficient gains for collective wellbeing, … while maintaining the relationship of otherness, respect and reciprocity between humans and more-than-humans” (Baniwa et al., 2024: 17). Given the sharp contrast, how much capitalism is desired by IPLCs is still not clear.

Both Costa et al. (2022) and Garrett et al. (2023) refine the bio-ecology vision for the still relatively intact ecosystems of Amazonia, especially in – but not limited to – Indigenous Territories (where an alternative vision currently dominates (Baniwa et al., 2024)) and sustainable development conservation units, with greater emphasis on sociodiversity, standing forests and sustainability. These still relatively intact ecosystems are poorly understood by the national and local political and economic elites who consider them “backward” and therefore are poorly served by public services and policies (Pinto, 1980; Souza, 2009; Parry et al., 2010; Hanusch, 2023). It is in these relatively intact ecosystems that an IPLC extractive economy functions and offers products to local, national and international markets (Clay and Clement, 1993; Clay et al., 1999; Abramovay et al., 2021).

2. Extractivism and the logic of the capitalism

A little history can help think about the future. During the Portuguese colonization of Amazonia, the predominant activity was the extraction of so-called “drugs from the backlands”, NTFPs that were traded internationally (Homma, 2003; Clement, 2019) in what can be called the colonial bioeconomy. In the late 19th century, this bioeconomy was dominated by rubber (*Hevea brasiliensis*) extraction. When demand for rubber increased, northeastern Brazilian workers (rubber tappers) were brought in to increase supply, generating the rubber boom (Homma, 1982, 1993). In 1876, rubber was introduced to the English colonies in Asia for planting in monocultures, ending the exclusivity of Amazonia, and the boom collapsed. Curiously, some local governments and entrepreneurs in Amazonia had embraced the idea of domesticating rubber and cultivating it in monocultures, but most rubber barons opposed monoculture, claiming that it would destroy one of their main capitals: the native forests, rich in rubber trees (Silva Bentes, 2023).

The transfer of Amazonian species out of the region and into monoculture also occurred with cinchona (*Chinchona* spp.), cacao, annatto (*Bixa orellana*), guaraná (*Paullinia cupana*), and, more recently, with açaí-do-pará and peach palm (*Bactris gasipaes*), although only cinchona, cacao, and annatto were taken to other continents. This dynamic occurs throughout the tropical world (Ruiz-Pérez et al., 2004; Belcher and Schreckenberg, 2007), most frequently with food-producing species. Conceptually we can consider that products of a bio-ecology bioeconomy are transformed into products of a bio-resource bioeconomy or even a bio-technology bioeconomy. These transformations occur because capitalism alters traditional methods and relations of production to better integrate the value chain with national and global markets (Homma, 2018; Herrera, 2019; Kröger, 2022; Rosenfeld et al., 2024).

What are the factors that can determine this boom-bust sequence of extractivism and the transition to monocultures if Amazonian forests are full of options and many are very abundant (ter Steege et al., 2013)? Homma (1982) observed that some of these options have inelastic demand – supply meets demand that does not expand even when prices fall – and others have elastic demand – demand exceeds supply in a short time, as in the case of rubber. This contrast of inelastic demand versus elastic demand is the critical point in all visions of expanding a forest bioeconomy based on extractive products, as species with elastic demand will generate more value than species with inelastic demand.

There are NTFPs, such as Brazil nuts (*Bertholletia excelsa*), where even a price increase does not increase production immediately (Afonso et al., 2022; see Fig. 5.2c), as plantations require long lead times or additional stands are too far away. Failure to make full use of available extractive products (e.g., rubber, Brazil nuts, açaí, etc.) is related to the low abundance or aggregated distribution of plants in the forest, the great effort necessary for harvesting, low price paid to producers, precariousness and costs of logistics, lack of labor, perishability, distance from markets, among others. Each extractive product has its specific limitations (Homma, 2014). Most NTFPs, however, have inelastic demand because the current market has not yet found alternative uses due to a lack of R&D or simply a lack of interest. NTFPs that produce food may become elastic more easily than those that produce other products, as shown by cacao, Brazil nut, and açaí-do-pará.

Amazonia’s socio-biodiversity offers enormous potential to be explored. There are at least 2253 arboreal NTFPs (trees and large palms), among which 1037 produce food, 1001 have medicinal uses, and many others are used in cosmetics, craft manufacturing, etc. by IPLCs (Coelho et al., 2021). The potential of some of these food NTFPs is considerable given their abundance (Table 1), but most of this is not transformed into value. The two açaís and Brazil nut are currently the main Amazonian NTFPs (Rosenfeld et al., 2024). Patauá (*Oenocarpus bataua*) produces a fruit pulp oil with a fatty acid profile similar to olive oil (*Olea europaea*) (Balick and Gershoff, 1981); buriti (*Mauritia flexuosa*) is rich in beta-carotene, which is often lacking in Brazilian diets even where buriti is common; extractive cacao is fueling a new specialty chocolate market in Amazonia with dozens of new companies processing “wild” cacao. One of the advantages of focusing on food NTFPs is that there is considerable published information (Clay and Clement, 1993; FAO, 1993; Clay et al., 1999; Cavalcante, 2010; Coradin et al., 2022), as well as an abundance of edible product in the forest.

Why do extractive products with elastic demand leave the forest and go into monoculture? In a capitalist economy, several production factors can be analyzed to answer this question: low productivity per hectare in the forest, low return on labor to harvest the production, scarcity of labor, among others. Monocultures tend to be more productive and easier to harvest, and often can attract labor. We examine each factor below.

Productivity per hectare depends on each species. In the forest, the abundance of plants per hectare of species such as rubber and cacao is often limited by diseases, but the abundance of other species is not limited in this way, such as the açaís and Brazil nuts. Some species are extremely abundant or hyperdominant (ter Steege et al., 2013), which means they occur in large aggregations, which sometimes look like plantations in the forest, again like both açaís, Brazil nut, and even cacao. Of the 222 hyperdominant species, 131 produce food (Coelho et al., 2021). Some of the hyperdominant food species were managed by

Table 1
Six extremely abundant arboreal species from Amazonian forests with high quality food potential and some production data from extractive value chains.

Order[1]	Common name	Species	Abundance[2] (# plants)	Food quality	Extractive production (t)	Reference
1	Açaí-do-amazonas	*Euterpe precatoria*	$5{,}4 \times 10^9$	Energy, anthocyanins	53,729 (Amazonas)	IBGE[3]
6	Patauá	*Oenocarpus bataua*	$3{,}6 \times 10^9$	Energy, unsaturated fatty acids	No records in IBGE	
7	Açaí-do-pará	*Euterpe oleracea*	$3{,}6 \times 10^9$	Energy, anthocyanins	164,902 (Pará)	IBGE
22	Buriti	*Mauritia flexuosa*	$1{,}5 \times 10^9$	Energy, beta carotene	No records in IBGE	
24	Cacao	*Theobroma cacao*	$1{,}4 \times 10^9$	Energy, theobromine	No records in IBGE	
178	Brazil nut	*Bertholletia excelsa*	$4{,}0 \times 10^8$	Protein	38,169 (Brazil)	IBGE

[1] ter Steege et al. (2013) estimated the abundance of arboreal species in Amazonia by extrapolation from 1400 inventory plots; this order follows their analysis.
[2] Abundances from ter Steege et al. (2013), who did not consider that 20% of Amazonia has already been deforested.
[3] https://www.ibge.gov.br/explica/producao-agropecuaria/.

Indigenous Peoples to become more abundant in the forest (Levis et al., 2018), which demonstrates that it is possible to increase abundance in the forest, again like açaís, Brazil nuts and cacao.

However, in a capitalist system, even high abundance in the forest does not offer the same yield as a monoculture plantation. This is because in the forest there is interspecific competition for nutrients, light, water, and predation relationships that divert part of the yield to non-human consumers (toucans love açaí!). When a species is planted in monoculture, other actors become important, such as agronomists to guide fertilization, irrigation, weed and pest management, plant breeders who select more productive plants, with uniform quality, well-adapted to monoculture, and technologists who help with harvesting and processing.

Açaí-do-pará is the newest example of the transition of an extractive product to monoculture (Homma et al., 2014). Until the 1980s, açaí-do-pará had inelastic demand, but in the 1990s the combination of entrepreneurs and R&D transformed the demand into elastic, and the açaí boom began. Açaí-do-pará is the seventh most abundant arboreal species in Amazonia (Table 1). In the Amazon River estuary alone, there are 10,000 km^2 of açaí groves in humid areas with up to 600 clumps/hectare mixed with other useful and non-useful arboreal species (Calzavara, 1972). Well managed with good practices (Nogueira et al., 2005), a biodiverse açaí grove can yield 3 tons of fruit per hectare (t/ha). However, with the increase in demand, many producers abandoned good practices and eliminated competing species, leaving monocultures in areas that were previously biodiverse açaí groves (Freitas et al., 2015, 2021); the yield of these monocultures can reach 8.4 t/ha (Santos et al., 2012). This transformation of biodiverse açaí groves into monocultures reduces biodiversity and the supply of ecosystem services (Freitas et al., 2015, 2021), and yields might even become limited by pollination (Campbell et al., 2023). In addition to this, agronomists, plant breeders, and technologists from Embrapa Amazônia Oriental developed a production system for irrigated monoculture plantations on non-flooding land, which, when well-managed, can produce 8.9 t/ha. In 2022, nearly 1.6 million tons of açaí-do-pará fruits were produced from extractive, managed, and planted açaí, the majority from monocultures created from biodiverse açaí groves or planted in already deforested areas. The transition from extractivism to monoculture took around 20 years (Homma et al., 2014).

The return on labor is another crucial factor, especially when there is a labor shortage. In the forest, a rubber tapper walks kilometers to collect a few liters of rubber latex per day because rubber trees are rare in the forest; a Brazil nut collector also walks a lot because Brazil nut groves rarely have 10 trees per hectare. Apart from the distances, the trees are heterogeneous because they were never selected for uniformity. For example, one rubber tree can produce half a liter of latex and another just a few drops; one Brazil nut tree can produce 100 fruits and another doesn't even produce that year. The return on labor depends on all these variables, as well as the gatherer's experience and age (Alves et al., 2022). These examples demonstrate the need to select for uniformity, i.e., plant breeding (Homma, 2012), which can be done with community participation (van Leeuwen, 2009) and possibly avoid the transition to monoculture.

There is a growing shortage of labor in Amazonia, especially the specialized labor that knows the forest; this is the human capital that an expanded forest bioeconomy depends on. This is because there are many incentives to abandon rural areas, and few to remain (Parry et al., 2010). The set of deprivations, such as insufficient income, and difficulty in accessing goods and services that enable better living conditions (education, health, energy, transport, adequate housing, basic infrastructure), leads to rural exodus, generating a shortage of labor in forests and rural areas. and an excess of unskilled labor on the outskirts of urban centers.

Which of these three factors is most important for a forest bioeconomy? We think that the scarcity of labor is the most critical factor because the presence of specialists in the forests is decisive for the extraction of Amazonian NTFPs. This is true for both NTFPs with inelastic and elastic demands. How can we encourage forest specialists to stay in rural areas and encourage young people to learn from them, when current social incentives promote rural exodus? The answers to these questions are what can enable an inclusive and fair forest bioeconomy in Amazonia.

3. Enabling a new forest bioeconomy

Considering the lower productivity and lower return to labor of NTFPs in standing forests, and the growing scarcity of forest specialists, public policies to enhance this human capital and give an additional advantage to food NTFPs will be necessary. A new food-based forest bioeconomy will depend on the interaction among forest specialists, entrepreneurs, businesspeople, governments, academia, NGOs, and consumers, with a mix of market forces (supply, demand, efficiency, etc.) and public policies to alleviate market failures and increase supply, efficiency, and demand via R&D, minimum prices, subsidies of numerous types for producers, etc. The current mix of market forces and public policies is failing to keep the forests standing and the rural population in the forest (Parry et al., 2010). We affirm this, despite the existence of some good examples that show it is possible in some specific situations (Medina et al., 2022; MDIC-PNUD, 2023), especially in some Extractive Reserves (Resex), Sustainable Development Reserves (RDS), other conservation units, Indigenous Territories and even some INCRA settlements (Plese and Pereira, 2020; Giatti et al., 2021; Baniwa et al., 2024). The question is how to increase the number of good examples in Amazonia. Below, we offer a short framework to enable a future forest bioeconomy, based on enhancing human capital, price supports, including payments for environmental services, certification, and R&D; which is more important depends upon the IPLC involved, as each has a different history. We do not address processing, which needs to be negotiated with each IPLC, because it is discussed elsewhere (Clay and Clement, 1993; Clay et al., 1999; Nobre and Nobre, 2019; Abramovay et al., 2021; Nobre et al., 2023). As a given NTFP becomes more important, R&D to develop and process new products becomes continually more important, as shown for the açaís in the last two decades (Silveira et al., 2023). While our focus is on Brazilian Amazonia, some of these public policies are already used elsewhere and others can be.

Governments need to reformulate their education policies for IPLCs that are currently designed more for urban centers. If correctly done, this will contribute to resolving issues of labor supply and employment (Francez and dos Santos Rosa, 2013; Santana, 2020) and generational succession in rural areas (Botelho and Almeida, 2020). High quality, inclusive and equitable education is a fundamental element in creating solutions for sustainable development among these IPLCs, although delivering this is a challenge far from urban centers (Parry et al., 2010). Schools at all levels need to be improved, especially schools in the rural communities themselves, with adaptation of the school calendar to rural activities, adaptation of books and classes to be relevant for the Amazonian rural environment, and that inspire students to consider that rural areas can provide a better livelihood than migrating to cities. Books and classes that focus on local forest products and that teach entrepreneurship can leverage the community's forest bioeconomy and identify new food options among NTFPs for the regional market, enhancing food security and sovereignty. Rural education experiences, such as the "Asas da Florestania" program, in Acre (Paula et al., 2020), "Escola da Terra", in Pará (Araújo Silva and Saboia, 2022), and the experiences of Amazonian universities in training teachers for rural education (Oliveira Menezes et al., 2021), are examples with important lessons that need to be propagated across the entire region.

Rural extension and production promotion agencies need to have trained technicians to interact with IPLC forest specialists to improve forest productivity and the return on labor. Managing populations of NTFP species requires a set of good practices, such as those developed for the management of açaí-do-pará (Nogueira et al., 2005). If Indigenous Peoples had no difficulty in increasing the abundance of their preferred food NTFPs (Levis et al., 2018), with correct guidance, they and other local communities can also increase the uniformity of the harvested product, via participatory plant breeding within the set of good practices (van Leeuwen, 2009). Good practices are essential throughout the entire value chain, such as the good practices for controlling aflatoxin contamination in the harvesting and processing of Brazil nuts, developed by the Federal University of Amazonas (Kluczkovski et al., 2020).

As demonstrated in the discussion of the transition from extractivism to monoculture, plant breeding is an important success factor, as it contributes to the greater productivity of a more uniform and attractive product for entrepreneurs, businesspeople, and consumers (Homma, 2012), and is thus an important part of bio-technology and bio-resource bioeconomies. For a bio-ecology bioeconomy, participatory plant breeding is an alternative that works more quickly (Clement, 2001; van Leeuwen et al., 2005; van Leeuwen, 2009) and has several advantages for communities: (1) it keeps genetic resources under the control of IPLCs, as recommended by the Protocol of Nagoya (2020) and the Brazilian Law on Access to Biodiversity (Law 13,123, 05/20/2015); (2) it uses and reinforces traditional ecological knowledge; (3) it combines logically with product classification into quality classes (Schroth et al., 2004), which is another way for IPLCs to market more uniform products; (4) it begins to produce improved seeds at the end of the first selection cycle; (5) it combines with forest enrichment as practiced by Indigenous Peoples for millennia (Levis et al., 2018); and (6) most importantly, it does not require a doctorate in plant breeding, and any technician from an extension agency can be trained to interact with community specialists (van Leeuwen, 2009).

Aiming to guarantee a minimum income for producers through subsidy premiums for various agricultural and extractive food products, the Brazilian federal government established the Minimum Price Guarantee Policy for Sociobiodiversity Products (PGPM-Bio). Currently, there are 17 products listed (MAPA Ordinance No. 376, of 12/22/2021), eight of which are Amazonian NTFPs: açaí, andiroba (*Carapa guianensis*), babassu (*Attalea speciosa*), extractive rubber, buriti (*Mauritia flexuosa*), extractive cacao, Brazil nut, murumuru (*Astrocaryum murumuru*), in addition to managed pirarucu (*Arapaima gigas*). This policy helps to guarantee a fairer economic return for these products and is an incentive for forest specialists to produce and remain in rural areas. Expanding the list of food species will be easy.

In addition to encouraging forest conservation through PGPM-Bio, the incorporation of payments for environmental services (PES), such as maintaining forest resources, could be incorporated into the minimum price calculation. Since many forest specialists now understand that the ecosystem services they provide are for society, it makes sense to include payment for these services within the PGPM-Bio. The challenge that PGPMBio faces is to measure and pay for the ecosystem services that IPLC forest specialists provide to society when they conserve stocks of forest resources. Adding value through PES could contribute to maintaining forest specialists active. Furthermore, this valuation will help forest specialists act as guardians of the forest (Souza and Menezes, 2022). As an added benefit, these NTFPs are products with low carbon emissions (Fernandes et al., 2022), which is gaining recognition in the modern market and can be incorporated into the PGPM-Bio.

The Bolsa Floresta Program is a public policy in the State of Amazonas, established in 2007, which involves IPLCs that work with the management of pirarucu, turtles, and forest extractivism in 28 state conservation units. In areas where the program was implemented, it provides ecosystem services in the form of avoided deforestation (Silva et al., 2021). As a way of supporting families in situations of extreme poverty and encouraging environmental protection, the federal government established the Bolsa Verde Program (Decree n° 11,635/2023) (Simão et al., 2013), which restarted payments to families in Amazonian Resex and traditional communities in the second half of 2023.

The Food Acquisition Program (PAA) and the National School Lunch Program (PNAE) have consolidated themselves as important food and nutritional security policies, feeding 40.2 million children daily (Kroth et al., 2020). Since 2009, through Law No. 11,947, the PNAE incorporated sustainable development and respect for food culture in its guidelines. Based on this legal framework, there is a greater concern in adapting school menus to local realities, considering each region's agricultural vocation and the inclusion of foods that value regional biodiversity and respect the local food culture in school meals (Sousa et al., 2015). By law, at least 30 % of the funding made available must be used to purchase foodstuffs coming directly from family farming, associations, or cooperatives. This represents a movement towards the inclusion of socio-biodiversity foods and can be easily expanded to include foods from forests.

A series of ongoing public policies can strengthen the commercialization of socio-biodiversity products, especially NTFP food products. In 2009, the Ministry of Agriculture and the Ministry of the Environment launched joint Ordinance No. 17, which established technical standards for organic products from extractivism (Brasil, 2009). The Ordinance allows all those products gathered in native or modified ecosystems to be recognized as organic if the system does not depend on the systematic use of external inputs. This paved the way for organic certification of foods from forests, which began to be better valued by public purchasing programs (see PAA and PNAE above) and the consumer market in general (Schmitt et al., 2020).

Other policies that contribute to increasing the proportion of value that remains with producers at the beginning of a value chain include Geographical Indications, granted by the National Institute of Intellectual Property (INPI). These include Indications of Origin, such as the one granted in 2023 for açaí-do-amazonas from the municipality of Freijó, Acre, and Denominations of Origin, such as the one granted in 2022 for guaraná produced by the Sateré Mawé Indigenous People, in the Andirá Marau Indigenous Land, on the border of Amazonas and Pará (Congretel et al., 2021). Geographical Indications are often complemented by other 'green seals' recognized by the market, such as fair trade, organic or simply free of agrochemicals, sustainable forest management (granted by the Forest Stewardship Council). In 2016, the Bailique Agroextractive Producers Cooperative (AmazonBai) in Amapá received both a sustainable forest management certificate and a chain of custody certificate for their açaí-do-pará from the FSC (Pinheiro, 1922). Foods from forests can also enter the healthy product movement, the slow food movement, vegetarianism, locavorism, etc.

R&D funding agencies can make important contributions by supporting the development of food NTFPs: (1) good management practices, including participatory plant breeding; (2) good practices for harvesting and processing with appropriate technologies; (3) new uses and forms of exploitation; (4) new species to meet new demands from companies that use biological compounds or models (Nobre et al., 2016); (5) new technologies aimed at increasing labor and land productivity in extractive activities; etc. This support must be associated with IPLCs to value their knowledge for the benefit of conservation and obtain results that can be absorbed quickly. Observe that we do not recommend conventional plant breeding, as this will inevitably lead to monocultures that do not contribute to keeping the forest standing nor to conserving biodiversity (Silva et al., 2023).

4. Final considerations

The expansion of a forest bioeconomy associated with forest conservation requires attention to people in rural areas, as this human capital is as important as forest products and is often forgotten in discussions. We have focused more on food from forests because they are often forgotten in a country that values and encourages conventional agribusiness as if only agribusiness could produce the food that the country and the world need.

The expansion of a forest bioeconomy with a "standing forest" requires changes in paradigms and enormous investments, as emphasized by Nobre et al. (2023). Public policies and public investments can change paradigms, but they require a clear understanding of the limits of the capitalist system to keep the forest standing. Letting market forces decide, as neoliberals wish, will result in more deforestation, as the capitalist system knows agribusiness very well, but knows little about valuing "standing forests".

Public policies have key roles in strengthening the forest bioeconomy of Amazonian socio-biodiversity. They can provide adequate infrastructure for the development of new products, minimum price guarantees, valuation of ecosystem services provided by IPLCs, product certification, and technical and technological solutions to improve production with conservation, among other initiatives.

Finally, a bioeconomy based on socio-biodiversity needs the full participation and collaboration of Indigenous and traditional (extractivists, riverside dwellers, quilombola populations) populations in all parts of the value chain. Improving the lives of these rural populations depends on quality education, food and nutritional security and sovereignty, sustainable management, forest enrichment, and planting in abandoned fields with NTFPs of economic value. In other words, the valorization of human capital in rural areas. In these new bioeconomic initiatives for valuing forests, the knowledge, values, and rights of these populations will guarantee the conditions for the development of a bioeconomy that respects and values the Amazon Forest.

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