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PRIVATE SECTOR PERCEPTION OF REDUCING DEFORESTATION IN BRAZIL: ANALYSIS OF CHALLENGES FROM 2010 TO 2019

Patrícia Gallo[1,2*], p.gallo@bluoverda.org, https://orcid.org/0000-0003-4472-971X
Maria Fernanda Gebara[2], mfgebara@gmail.com, https://orcid.org/0000-0003-1494-1082
Tatiane Micheletti[1,3], tati.micheletti@gmail.com, https://orcid.org/0000-0003-4838-8342
Alice Dantas Brites[4] alicebrites@gmail.com, https://orcid.org/0000-0002-6500-4243

1 BluoVerda Deutschland e.V., 01127 Dresden, Germany
2 Center for International Forestry Research - CIFOR, 16115 Bogor, Indonesia
3 University of British Columbia, 170-6371 Crescent Road Vancouver, BC Canada
4 University of São Paulo, 05508-220, Butantã, São Paulo, Brazil

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ABSTRACT

Purpose: This paper aims to shed light on the private sector's perspective on REDD+ in Brazil, and how this perspective has evolved over time.

Methodology/Approach: This research is part of the Global Comparative Study on REDD+ (GCS REDD+) on policies and political processes from the Center for International Forestry Research (CIFOR). Each country team used the same guideline to conduct the interviews.

Findings: Our results indicate that national business organizations believe that REDD+ is an affordable way to mitigate climate change. However, it suggests that while this sector is seeking financial benefits from REDD+ activities, it is taking a very cautious and risk-averse approach to this framework. We conclude that the private sector is not engaged and does not self-identify within the operational challenges that REDD+ policymakers are grappling with as they seek to embrace the possibilities of this mechanism.

Research Limitation/Implication: To explore how these private sector actors perceive REDD+, whether such a perspective has changed from 2010 to 2019, and its implications for further REDD+ design in the national context.

Originality/Value of the paper: We examined private actors' positions on key statements about financing, benefit sharing and equity, governance, and challenges over three different time periods. We argue that a better understanding of how the private sector perceives REDD+ will contribute to national framing and more effective multi-level governance across the country.

KEYWORD: REDD+, stakeholder, policy network analysis, governance, policy domain, Brazil

1. INTRODUCTION

Various mechanisms have been discussed to provide developing countries with incentives to protect forests. It is already known that Reducing Emissions from Deforestation and Forest Degradation (REDD+) is a mitigation instrument that calls for policies and measures that enhance the value of the carbon stored in standing forests. As the concept of REDD+ has evolved over time, the need to pursue good forest governance, the realization and strengthening of human rights, socio-economic equity, and environmental resilience has been recognized (Purnomo et al., 2023). In this sense, the REDD+ negotiations started to involve several stakeholders from different levels in its context (Brockhaus et al. 2014). As stakeholders, several segments of the private sector, could have a strong influence on the future of REDD+, as such an economic sector is usually deeply involved in activities on the ground. The private sector can be considered a key stakeholder in REDD+ as it is a source of implementation, innovation, and investment (Henderson et al. 2013).

This sector is critical in Brazil because many large private companies are among the leading influencers of policy and drivers of deforestation and forest degradation (Gibbs et al. 2015, May et al. 2011a, b, May et al. 2016, Nepstad et al. 2014). Although the definition of the private sector in a policy context is often complex, ambiguous, and scattered (Maniatis et al. 2019), several companies engage in activities that can lead to deforestation and forest degradation. At the production end of the supply chain, there are forestry companies that harvest timber, agricultural companies that clear forests for crop products, and mining companies that clear forests as part of their extraction activities. Within the supply chain, there are traders, processors, manufacturers, and retailers who buy the products, and investors who provide the financing to keep the companies operating. Informal, small- and medium-sized producers, community-based cooperatives, and ecotourism companies (which may work in forests) are also an important segment (CIF 2013).

When talking about REDD+, the private sector is usually associated with financing issues. Since the beginning of the negotiations, financing has been a major constraint to the implementation of REDD+ frameworks. Therefore, in the face of declining public sector resources, attracting private sector capital is strategic to scale up investment and engagement in REDD+ actions (Sheng 2020). Globally, this sector has the potential to provide an additional US$13 billion per year from 2020 to support the development of REDD+ strategies in different context-dependent instruments (Lujan & Silva-Chávez 2018). Currently, available funding comes mainly from donors (e.g., wealthier countries such as Norway and Germany), governments, and other non-private investor sources, amounting to about US$1 billion annually. However, the estimated financial resources needed to halt deforestation globally through sustainable agriculture measures and REDD+ activities would be around US$150-200 billion per year by 2050 (IETA 2018, Wensing 2021). Angelsen et al. (2018) note that land-based climate solutions receive only 3% of global climate finance. Although approximately 467 REDD+ project developers have been identified globally as of May 2018 (Sheng, 2020), the high expectations for private sector engagement have not materialized (Atmadja et al. 2018). Most of these projects are implemented by the private sector, with for-profit actors and non-governmental organizations accounting for 32% and 36%, respectively (Simonet et al. 2018). Some studies show that there is no agreement on the size and sources of REDD+ financing, the role of the private sector and market-based mechanisms, or the modalities for disbursing international REDD+ funds (Lubowski & Rose, 2013, Norman & Nakhooda, 2015).

Beyond the financial contribution, private sector engagement could foster greater information flow among stakeholders and promote innovation and best practices for sustainable products and processes (GEF 2011). The private sector can also contribute its expertise to address key drivers of deforestation under attractive conditions (Bernard et al. 2012) and influence consumption (excluding sources of deforestation from their supply chain). Studies such as Wunder et al. (2020) and Fatorelli et al. (2015) suggest that drawing lessons from the experience of REDD+

projects can help improve the design of jurisdictional programs and highlight the importance of integrating project and REDD+ national strategies for better coordination, collaboration, and coherence in the implementation of REDD+ frameworks. Nevertheless, the findings of Gebara et al. (2014) show that private sector organizations are minimally involved in the communication and collaboration networks within the REDD+ policy arena in Brazil, which could have serious implications for the effectiveness of REDD+ initiatives and the national REDD+ strategy (namely ENREDD+). Moreover, these drivers are usually not adequately addressed in the country's policy design. To date, much effort has been devoted to developing strategies to stimulate and expand private sector participation and engagement in REDD+. For example, several studies have focused on the opportunity costs and benefits of REDD+ to inform investment decisions for private initiatives (Mbatu 2016). On the other hand, little has been done to identify who the key private sector actors are in terms of their roles, their connections, coalitions and networks, and the diversity of the sector in terms of expertise, interests, and perceptions.

Our study is significant in this context, as it aims to shed light on the private sector's perspective on REDD+ challenges in Brazil. To provide valuable insights for this process, we examined how these private sector actors perceive REDD+, whether such a perspective has changed from 2010 to 2019, and its implications for the further design of REDD+ in the national context. We sought to understand how the private sector interprets and assigns meaning to REDD+ in the Brazilian context, within the political and institutional framework of ENREDD+. Based on interviews, we analyzed their perceptions of the potential of REDD+ developments and the critical challenges and obstacles to the effective implementation of ENREDD+. Capturing different actors' perceptions of the policies and measures to which they are subject is a strategic way of revealing the cognitions, attitudes, and beliefs of different groups of actors (OECD 2012). Perceptions are then the lens through which they view REDD+. Exploring this information can provide useful information on the legitimacy of REDD+ and its further implementation.

2. ANALYTICAL FRAMEWORK

2.1 REDD+ politics: perceptions and performance

We examine perceptions of REDD+ in Brazil to understand how REDD+ policymaking and implementation unfold in practice. We suggest that the ways in which different actors perceive REDD+ influence the political dynamics and arenas in which REDD+ is designed and implemented. These dynamics and arenas co-evolve with social practices as REDD+ goals, justifications, policies, and interventions emerge, evolve, become institutionalized, change, or disappear. Thus, actors' perceptions are important because actors' systemic roles are context dependent and can change over time (Cleaver 2012, Di Gregorio et al. 2015, van der Hoff et al. 2015). Understanding actors' perceptions of REDD+ is then key to guiding policymakers in the right direction, so that they have more information when selecting specific policies for REDD+ implementation. However, policymakers do not have a "toolbox" full of instruments from which they can choose the most appropriate one based on complete information. This is because the selection of an intervention is a highly complex, contingent, and sometimes self-dynamic political process, and decision-makers are faced with a choice of measures (Böcher & Toller 2003). Perceptions therefore contribute to ongoing discussions about the nature of political attitudes towards REDD+, which is particularly relevant when dealing with a multi-faceted policy intervention such as REDD+ (Brockhaus et al. 2014, Gebara et al. 2020). Fujisaki et al. (2016) also suggest that those affected by REDD+ should have their voices heard in decision-making processes.

Moreover, it is argued that policymakers' consideration of actors' perceptions and interests improves the performance of policy design and implementation and makes actors more willing to cooperate, because "when people see an authority as legitimate, they feel they should defer to its

decisions and rules and follow them voluntarily out of obligation rather than fear of punishment or expectation of reward" (Tyler & Fagan 2008). We follow this assumption that the consideration of different perceptions and interests improves performance and thus enhances cooperation among actors. We argue that actors who share similar characteristics and interests are more likely to have similar perceptions, and these perceptions make actors more inclined to cooperate and collaborate.

2.2 Framing Perception

The concept of perception, like most concepts in the social sciences, has been defined in several ways since it was first used (Lindsay & Norman 1977). Perception is "the process by which each individual selects, organizes, and evaluates sensory stimuli from the external environment to create meaningful experiences for himself or herself" (Adler 1991, 73). The perceptual process itself is not public or directly observable, except to the perceiver himself, whose rules are directly given in the experience (Lima 2014). While Rao & Narayana (1998) state that there can be no behavior without perception, Adler (1991) adds that perception organizes our experience to guide our behavior. Thus, the perception of REDD+ by different actors influences how these same actors organize (build their opinions), interpret (base their judgments), and assign their attitudes (sustain their behavior) towards REDD+. Moreover, it is assumed that such behavior can influence policy design once the identified actors are involved in the Brazilian REDD+ policy arena and may favor different policy responses and practical efforts. Perceptions are also particularly important for on-the-ground activities, as public opinion, satisfaction, and engagement are often critical motivating factors for broad acceptance of conservation approaches such as the REDD+ framework (Bureekul 2000, Chesoh 2010, Norsworthy 2000, Lima 2014).

Our study was only interested in organizational perceptions and interpretations of REDD+, as opposed to individual perceptions. Although we are linking an individual organizational perception to a collective perspective, the heterogeneity within a group of the same category needs to be acknowledged. For example, it can be argued that the perception of a company interested in selling carbon credits on the voluntary market may be different from the perception of a soy trader when considering the scope of REDD+. Nevertheless, we address this issue by identifying specific findings that show similarities in the views and actions of actors towards national REDD+ policies. This can be used to characterize the target group, assuming that there is a convergence of perceptions within the actors. As the REDD+ process is still evolving in Brazil, perceptions and actions are likely to change as the process evolves. Nevertheless, the analysis of perceptions and their potential impact on policy outcomes offers policy recommendations that reflect the structural constraints and opportunities for effective future policy changes.

3. WHAT DOES REDD+ MEAN IN BRAZIL?

Since 2010, the federal government has taken steps to set targets and develop policies related to REDD+. In 2015, Brazil launched the ENREDD+. In addition, Brazil committed to reduce forest loss by 80% in the Amazon region and 40% in the Cerrado regions. Thus, the Brazilian government made three government plans as the centerpiece for the implementation of REDD+ nationwide: i) the Action Plan for the Prevention and Control of Deforestation in the Amazon (PPCDAm), ii) the Action Plan for the Prevention and Control of Deforestation and Fires in the Brazilian Cerrado (PPCerrado), and iii) the Plan for Low Carbon Agriculture (ABC). In addition, the National Policy for Climate Change (NPCC) and the 2012 Forest Code are the two guiding umbrella frameworks for REDD+ implementation in the country (Gebara et al. 2020). The ENREDD+ is being developed based on three pillars: (i) coordination of public policies on climate change, biodiversity and forests, including safeguards; (ii) monitoring, reporting and verification (MRV) of results; and (iii)

collection and distribution of payments for REDD+ results. In addition, ENREDD+ reiterates the commitment to results-based payments as the expected financing modality (May et al. 2016).

REDD+ began as a theoretical idea in which developed countries would financially reward forest-rich countries for preserving their forests. While the idea sounds powerful, its operationalization and implementation has been complex. In Brazil, studies suggest that REDD+ has different dimensions in terms of its conceptualization, adding to the complexity of this area within the country (Gebara et al. 2020, van Hoff et al. 2015). The parallel development of different REDD+ discourses (sustainable development versus carbon commodification) has prevented the realization of coordinated efforts. Another major challenge in the Brazilian context is the integration of subnational initiatives into a national strategy, due to disagreements between federal and state actors. In summary, the REDD+ agenda reiterates persistent issues already on the political agenda in Brazil, such as property rights, land grabbing, deforestation, and social inequality, and brings new issues to the forefront, such as benefit-sharing systems, safeguards, technical capacity for REDD+ implementation, and access to REDD+-related knowledge and information. As a result, the Brazilian REDD+ agenda is creating a new political arena involving a variety of political actors (Gebara et al. 2020).

From 2005 to 2011, deforestation in Amazonian forests decreased by more than 70% due to a combination of conservation policies implemented and supply chain interventions (Assunção et al. 2015, Nepstad et al. 2014). Brazil was the first country to voluntarily submit a Forest Reference Emission Level (FREL) to the UNFCCC and to have it made available. It was also the first country to submit REDD+ results to the Biennial Update Report for technical analysis, and is the first country to receive results-based payments from the Green Climate Fund (GCF) (UNFCCC 2019). The allocation of US$96 million for emission reductions achieved between 2014 and 2015 is an important result that demonstrates recognition of the country's efforts in implementing REDD+ related public policies over the past decades.

From another dimension, at the project level, focused on building methodologies for accounting and developing voluntary markets, there are several initiatives, especially in the Amazon region (Gebara & Agrawal 2017). At the jurisdictional level, state governments such as Amazonas, Mato Grosso, Acre and Pará, and now Tocantins and Rondônia, have played (and continue to play) a proactive role in the Brazilian REDD+ space. For example, the states of Acre and Mato Grosso are involved in the REDD+ for Early Movers (REM) program. Such initiatives, supported by international donors, aim to accelerate, or incentivize the transition to a global UNFCCC system. In 2018, the state of Acre was in the second phase of the program, while Mato Grosso was in the first phase of planning and implementing the REM program. In addition, Acre also signed an agreement with California, as part of the Governors Climate and Forests Task Force, to participate in its cap-and-trade market. Since 2018, the government of Tocantins has been working to implement a jurisdictional REDD+ program. Some Amazon states have also independently negotiated with the governments of Norway and Germany to propose a financing alternative to the Amazon Fund. The Amazon Fund is a private fund created by the federal government in 2008 to collect donations for non-reimbursable investments to prevent, monitor and combat deforestation (NORAD, 2011). However, the Bolsonaro administration unilaterally dismissed the Amazon Fund's steering committee and suspended its activities as of August 2019 (Gallo et al. 2020). The fund was revived in January 2023, when his successor, President Lula da Silva took office.

4. METHODOLOGY

4.1 Research approach and instruments

This research is part of the Global Comparative Study on REDD+ (GCS REDD+) on policies and policies processes from the Center for International Forestry Research (CIFOR). As this research is part of a larger multi-country study, a framework guideline was developed to better

compare countries and across time periods (Di Gregorio & Brockhaus 2010). Each country team used the same guideline to conduct the interviews. The data collection involved three main steps: (i) identification of key policy actors (organizations); (ii) a survey of social organizations (structured questionnaire); and (iii) in-depth interviews with actors (semi-structured interviews). We first identified policy actors that are part of the national REDD+ policy domains by reviewing previous analyses of REDD+ actors, agents, and institutions (Gebara et al. 2014) and a systematic review of REDD+ in the Brazilian media (May et al. 2011a, 2011b, 2016; Gebara et al. 2017).

We conducted the interviews in three different periods: Phase 1: from June 2010 to September 2011; Phase 2: from July 2015 to August 2016; and Phase 3: from March to August 2019. In Phase 1, 56 of the 65 organizations contacted participated; in Phase 2, 72 of the 130 organizations contacted participated; and in Phase 3, only 59 of the 138 organizations contacted participated. The participating organizations were then divided into 13 categories. Regarding the private sector (the target category for the current analysis), organizations were divided into national business organizations and international business organizations. In 2010, we conducted four interviews (with national business organizations only). In 2015, we conducted 18 interviews (with 16 national and two international organizations), and in 2019, we conducted 13 interviews (with national business organizations only). Our interviewees - across the three rounds of interviews - ranged from environmental project developers (e.g., REDD+, restoration projects), environmental law consultants, national forest sector companies (e.g. paper and pulp, timber, non-timber forest products), agricultural/livestock commodity companies, food chain retailers, national agribusiness and business associations, and environmentally focused media organizations.

In the questionnaire, we asked the organization to share its views on key REDD+ issues. The position statements covered key issues being debated in the international and national REDD+ spheres, benefit-sharing frameworks, financial and governance issues, and REDD+ challenges. Position statements (or stances) were formulated to facilitate a response of either agreement or disagreement (non-neutral statements). The semi-structured interviews were based on a guide of semi-open-ended questions that encouraged the interviewees to speak in depth on four main topics, in particular on (i) the benefit-sharing mechanism, (ii) their perception of the main political challenges and opportunities in national REDD+ policy-making, with particular attention to governance aspects, (iii) the dynamics and effectiveness of participation related to the development of ENREDD+, and (iv) their assessment of ENREDD+ policy processes. The interviews were audio-recorded and transcribed for analysis.

4.2 Data Analysis

While descriptive statistics were used to categorize the stakeholders' stances on selected issues based on the Likert scale, content analysis was realized to find a detailed explanation related to the stakeholders' perception (Gebara et al., 2020, Pham et al. 2021a, 2021b). We classify stakeholder attitudes into four categories as follows: (i) unknown/no response; (ii) disagree - strongly disagree; (iii) neither agree nor disagree; (iv) agree - strongly agree. In the results section, we show the level of agreement for each stance. The content analysis was based on the literature by Hsieh & Shannon (2005). Considering the nature of the data we obtained, we decided to use directed content analysis. According to Hsieh & Shannon (2005), directed content analysis can be used to validate or conceptually extend a theoretical framework or theory. Therefore, the strength of this type of content analysis lies in its ability to support and extend existing theories.

At this point, it is important to highlight the limitations of this study. During the first round of interviews, ENREDD+ was in its early stages of implementation, and participants were still unsure how to incorporate REDD+ efforts into their practices, so many actors declined to participate. In the second round, the ENREDD+ process was more advanced. However, the legal regulation of ENREDD+ was still uncertain, and several actors did not accept our request for an interview. Finally, in the third round, the main constraint was the delicate political moment that Brazil is

facing. We believe that the lack of a robust and integrated REDD+ regulatory framework at the national level, especially during rounds two and three, was the main reason why some organizations declined to participate or did not respond to our request to participate in the research. Therefore, not all key private sector actors involved in national REDD+ initiatives or behind the drivers of deforestation and degradation in Brazil participated in this study. Nevertheless, all participating organizations are considered relevant within the Brazilian REDD+ policy domain.

5. RESULTS

5.1 What do private sector actors consider as the main policy challenges in the REDD+ Brazilian context?

Most organizations tended to agree that most of the topics presented are considered challenges in the Brazilian REDD+ policy context (Table 1). These results were consistent throughout the three rounds. However, respondents expressed strong confidence in Brazil's technological capacities for monitoring carbon (MRV system), as for the first round 50%, for the second round 35% and for the third round, only 31% of the respondents acknowledged this stance as a challenge in the Brazilian context.

Table 1. Responses to the stances about challenges (including "strongly agree" and "agree")

One of the main challenges for effective ENREDD+ implementation is …	**Round1 2010-2011 N=4**	**Round2 2015-2016 N=18**	**Round3 2019-2020 N=13**
Lack of knowledge and awareness on REDD+ by relevant stakeholders	75%	71%	85%
Achieving effective coordination between state agencies, the private sector, and civil society	50%	88%	77%
The lack of technical expertise for monitoring carbon emissions and sequestration	50%	35%	31%
The effective clarification of tenure rights	50%	82%	92%
Contradictions among laws and regulations in forestry, agriculture, and other sectors	50%	64%	62%
Contradictions among laws and regulations at different jurisdictional levels (e.g., between national and sub-national levels)	_	62%	62%
Social conflict and local resistance	25%	29%	38%
Effectively addressing main drivers of deforestation without compromising development objectives	25%	63%	69%
Achieving broad consensus on changes in existing land use plans	100%	76%	85%
Low capacity to enforce laws and regulations	50%	85%	85%
Negotiating with powerful special interests influencing the main drivers of deforestation	75%	76%	77%
Lack of finance	_	79%	70%

(-) means that question was not made in the first round of interviews

Source: Own results

While for round 1, the stance "Achieving broad consensus on changes in existing land use plans" received the highest level of agreement among respondents (100% strongly agreed and agreed with this stance), for the second round, the stance "Achieving effective coordination between state agencies, the private sector, and civil society, received the highest level of agreement with 88% answering "strongly agree" and agree". For the third round, 92% of the respondents considered the stance "The effective clarification of tenure rights" as the major challenge in the Brazilian context. Throughout the three rounds, respondents mostly disagreed with the stance about social conflict and local resistance (respectively 25%, 29% and 38%), meaning that the participants do not see it as a significant constraint in the national REDD+ scope.

Other factors, such as lack of knowledge and awareness of REDD+ among relevant stakeholders, low capacity to enforce laws and regulations, and negotiating with powerful vested interests that influence the main drivers of deforestation, were strongly identified by the private sector throughout the three rounds as constraints to effective implementation of the ENREDD+ framework. Indeed, these findings are corroborated by the in-depth interviews, especially regarding the lack of clarity about what REDD+ entails in the Brazilian context. For several interviewees, there is a gap between design and implementation, and these actors still perceive REDD+ as a separate agenda from other land use policies in Brazil. Laing et al. (2016) also note that a good understanding of the objectives of REDD+, as well as its values and risks, is generally lacking among private sector actors.

5.2 Governance Challenges

Overall, our results show that the most significant challenges identified by respondents in the Brazilian scenario are those related to governance. Governance is considered the most important pillar in this development, and respondents also indicated that governance could be considered an umbrella term that encompasses and leads to other significant conflicts (e.g., tenure conflicts, law enforcement). The complexity of the term governance is difficult to capture in a simple definition, and the literature shows different conceptions (Cabello & Gilbertsson 2012, Graham et al.2003, Pierre & Peters 2000).

Despite coordination efforts related to REDD+, governance remains a significant challenge in the country (Gallo & Albrecht 2019, May et al. 2016). This challenge is pervasive across levels of government (as evidenced by the different perspectives on REDD+ between federal and state governments), civil society, or between government and the private sector (Fatorelli et al. 2015). Law enforcement and consensus building on forest management and land use plans are also major challenges in the context of ENREDD+. In this sense, promoting incentives for sustainable land use seems to be an essential step for the implementation of ENREDD+. In addition, more effective law enforcement procedures and apparatus would greatly contribute to overcoming the constraints associated with addressing illegal deforestation.

On the other hand, the surveyed organizations show a strong consensus on the governance of REDD+, as shown in Table 2. The responses to the statements show that there is widespread agreement that strengthened governance is a prerequisite for successful national REDD+ frameworks. It is widely expected that REDD+ can have a positive impact on governance, as most stakeholders did not agree that REDD+ will weaken the administrative capacity of governments. In other words, according to the interviewees, strengthened administrative capacity should strengthen REDD+ implementation capacity. In the first round of interviews, 50% answered "neither agree nor disagree", in the second round, 6%, and in the third round, 8%.

Table 2. Responses to the stances about governance (including “strongly agree” and “agree”)

Stances	**Round1 2010-2011 N=4**	**Round2 2015-2016 N=18**	**Round3 2019 N=13**
REDD+ leads to improved forest governance (e.g., illegal logging, access to justice and rule of law);	75%	88%	85%
Strengthened governance is a pre-condition for successful REDD+;	75%	88%	92%
REDD+ schemes further weaken the limited administrative capacity of the state;	0%	0%	0%
REDD+ further weakens the decision-making authority of forest-dependent people	_	0%	0%

(-) means that question was not made in the first round of interviews

Source: Own results

It is also expected that REDD+ will not reduce the decision-making power of forest-dependent people (positive impact on governance). 12% responded "neither agree nor disagree" to this statement in the second round and 17% in the third round. On the other hand, it is claimed that good governance depends on democratic participation, decentralization, and information sharing. However, according to some respondents, these aspects are lacking in the Brazilian context. A lack of cooperation, communication, and policy coherence between specific actions, levels of government, and different sectors were cited by actors as limitations to good governance. As a result, interviewees questioned how governance is decentralized from the state to other organizations and coordinated between institutions working at different levels of governance.

5.3 Financial Challenges

Our findings suggest that there is still no consensus among private sector actors on the primary sources of finance to achieve adequate funding, as shown in Table 3. This may indicate that organizations are uncertain whether REDD+ will ensure an equitable distribution of costs and benefits in the implementation of REDD+ activities. In Round 3, during the in-depth interviews, we also asked stakeholders if they thought REDD+ was the cheapest option to stop deforestation in Brazil. Curiously, several of the interviewees agreed with this statement. However, one opinion was particularly interesting: *"In fact, for me, REDD+ is not the cheapest option to stop deforestation, but REDD+ is the best option to capture new investments to reduce deforestation, which in turn is the cheapest way to reduce carbon emissions in Brazil" (11 March 2019)*.

Table 3. Responses to the stances in financing (including "strongly agree" and "agree")

Stances	**Round1 2010-2011 N=4**	**Round2 2015-2016 N=18**	**Round3 2019 N=13**
REDD+ is a financially affordable way to mitigate climate change;	50%	46%	46%
REDD+ schemes should be mainly financed through foreign government contributions;	50%	57%	54%
Without finance from carbon markets, REDD+ will not make a major contribution to emission reductions;	75%	71%	85%

Source: Own results

Although the actors were quite divided, the organizations agreed that REDD+ programs should be mainly financed by foreign government contributions. This may indicate a lack of awareness of the role and responsibilities that the private sector should play in REDD+ policy development in the country. However, it could also indicate a reluctance to invest in REDD+ initiatives when considering the balance of risks and benefits. As we analyzed the in-depth interviews, we were able to better understand this concern. For example, one interviewee said: *"It is challenging for the private sector to safely invest in an area where the property right issue is a great unknown" (18 April 2019)*. Tenure disputes can affect the distribution of risks, costs and benefits of financial transfers related to forest conservation (Cotula & Mayers 2009) and remain a notorious dilemma in Brazil (Azevedo et al. 2017, Gebara & Agrawal 2017). In contrast, most organizations agreed that markets should complement funds, allowing for greater private sector participation in national ENREDD+ policy frameworks. Other respondents (more conservation-focused private actors) were concerned that most investments and access to credit lines in Brazil are directed towards the implementation of development initiatives, leading to potential deforestation involving influential sectors that are part of these initiatives (e.g., agribusiness and mining sectors).

5.4 Benefit-sharing Challenges

In general, all respondents agreed that the benefits of REDD+ should be shared among different stakeholders. Across the three rounds, most organizations agree that REDD+ should mainly benefit actors with legal rights (as shown in Table 4), although respondents were emphatic that the term "legal" itself is controversial. Most respondents also agree that the benefits of REDD+ should mainly accrue to those who have already conserved forests. Organizations were quite divided on whether they agreed or disagreed with the statement "REDD+ benefits should go mostly to those who bear the costs of REDD+". The position that "REDD+ benefits should mostly go to actors who actually reduce emissions" received the highest level of agreement in rounds 2 and 3 (88% and 92% respectively), showing a strong preference for a performance-based approach.

Table 4. Responses to the stances about benefit sharing (including “strongly agree” and “agree”)

Stances[1] **1. Adapted from Lutrell et al. 2013**	**Round1** **2010-2011** **N=4**	**Round2** **2015-2016** **N=18**	**Round3** **2019** **N=13**
REDD+ benefits should mostly go to actors with legal rights;	75%	71%	77%
REDD+ benefits should mostly go to actors that actually reduce emissions	_	88%	92%
REDD+ benefits should mostly go to those that have been already conserving forests (forest stewards);	_	82%	85%
REDD+ benefits should mostly go to those bearing the costs of REDD+ (e.g., opportunity costs);	_	47%	62%
REDD+ benefits should mostly go to effective facilitators of implementation;	_	18%	23%
REDD+ benefits should mostly go to the poor and the marginalized	_	8%	17%

(-) means that question was not made in the first round of interviews

Source: Own results

The statements "REDD+ benefits should mostly go to effective facilitators of implementation" and "REDD+ benefits should mostly go to the poor and marginalized" are controversial for respondents. Specifically, on the latter, most organizations were unsure whether REDD+ should ensure equity in the distribution of benefits by targeting "the poor and marginalized". Among the respondents who took a position, there are more organizations with a negative than a positive attitude towards this discussion, although the level of agreement for Round 3 is significantly higher than for Round 2 (8% and 17% respectively). At the same time, however, a significant percentage of actors were unable or unwilling to express an opinion on this question in both rounds (27% for Round 2 and 25% for Round 3, respectively). This shows how, in the context of REDD+, benefit-sharing schemes have proven to be complex to implement, with different discourses and rationalities being debated by actors (Lutrell et al. 2013).

The dominant rationales for benefit sharing in REDD+ are linked in ways that reflect socio-political values and current policy objectives (Wong et al. 2019). For example, narratives about the importance of directing benefits primarily to poor smallholder farmers and forest communities stem from concerns that REDD+ could result in fewer benefits for these groups and create new risks (Peskett & Brodnig 2011, Skutsch, Torres, & Fuentes 2017). Moreover, it is often not the landowner who provides the emissions reductions. In several countries, including Brazil, ownership of carbon rights is considered to be somehow linked to forest use rights (Larson et al. 2010). In this context, marginalized people, as local communities, may be limited and ineligible to benefit from REDD+, as in many cases they do not own the land title, relying on customary tenure. This risks reducing the immense social and environmental potential of rural areas where REDD+ initiatives are likely to be implemented in Brazil. On the other hand, Wong et al. (2019) note that targeting

mainly poor smallholders and communities as REDD+ beneficiaries to address equity and legitimacy concerns may overlook the broader scale drivers to effectively reduce deforestation. This is a critical issue within the REDD+ framework that has not yet been effectively addressed.

5.5 Equity Challenges

We also asked the following question: "Can you comment on the extent to which equity (fairness) issues are or will be considered in the design and implementation of ENREDD+?" The answers varied widely and showed different interpretations of equity. Some respondents interpreted it as distributional equity, referring to policies aimed at regulating benefits and benefit-sharing systems. Respondents believe that the process in Brazil is not equitable due to the centralization of financial instruments at the federal level. They stated that this increases transaction costs and consequently reduces their interest in investing in REDD+ activities.

Others, however, referred to procedural equity, assessing the degree of inclusiveness in the policymaking process. Some believe that equity issues have been incorporated into the policy process, given the progress in developing the safeguard system in Brazil. However, they do not feel that this process is sufficiently participatory. Respondents stated that although communication and information channels have been established, they are ineffective. Some respondents also raised concerns about the lack of consideration and attention to their specific interests and issues, particularly in relation to complicated bureaucratic processes and the lack of legal and institutional support and transparency. One respondent illustrated this with a practical example: "*Look at the forest management sector in the Amazon. This sector is practically bankrupt. There are many obstacles, and even if you are certified, you end up competing on the same level with illegal logging and end up as the villain of the story for using the forest" (17 April 2019)*. Therefore, it is essential to design contextually relevant safeguard systems according to the narratives for benefit-sharing models to achieve effectiveness, equity, and legitimacy (Wong et al. 2019). However, discussions on equity are very controversial because equity can be a very abstract issue, especially at the local level, as the problem is to somehow conceptualize a multifaceted dynamic between individual interests (Lima 2017).

6. DISCUSSION

6.1 Moving ahead with the ENREDD+

Between 2010 and 2018, REDD+ processes were intensively discussed, developed and progressed rapidly in Brazil. ENREDD+ was launched and included in Brazil's objectives for the Paris Agreement. Multi-stakeholder discussions on financing and benefit-sharing mechanisms, as well as the development of safeguards systems, took place with increasing frequency. In October 2018, a new president was elected and subsequently new reforms were introduced, which also influenced the REDD+ context in the country. Although REDD+ is still being developed in the country, as Brazil received $96 million from the Green Climate Fund, there is little confidence that it will drive transformational change. By no means are perceptions unanimous on all issues, but the results show a generalized picture. However, our analysis suggests that respondents' perceptions remain consistent over time. Over time, the reluctance expressed by respondents is somewhat in line with the evolution of environmental and ENREDD+ governance in the country. We argue that changes in perception are politically driven. When there is political change and uncertainty, the institutional position on ENREDD+ challenges and opportunities also change.

For example, one respondent said: *"If you had asked a while ago what is the major challenge in the REDD+ context in Brazil, I would have said financial issues. Today, I say that is to*

keep REDD+ under the governmental agenda" (14 March 2019). Furthermore, in 2010/2011, the ENREDD+ legal framework was in its early stages of implementation and respondents were unsure how to integrate REDD+ efforts into their practices. Other respondents cited the adoption of the 2012 Forest Code framework as a possible negative factor affecting the scope of ENREDD+. Since 2014, deforestation rates have been increasing again, especially in the Amazon region (PRODES 2016), and this fact was acknowledged by respondents in the last two rounds of data collection. Today, a renewed push for economic development at the federal level has increased the deforestation rate to 11,088 km2, the highest level since 2008 (PRODES 2020). Bidone and Kovacic (2018) argue that environmental policies, especially in the Amazon region, have evolved through overlapping economic narratives rather than a change in governance logic. In short, as one of the interviewees said: *"The government or non-governmental initiatives try to solve everything at once and end up solving nothing. We spend a lot of money in the beginning and middle of the process of policy making. For implementation then there is not enough money. So, it is necessary to alleviate bureaucracy. There are some specific things that we can call REDD+ within scattered government initiatives, but there is no central plan. We still lack a strong regulatory mark and better forest governance." (5 April 2019).*

Governance challenges and the emphasis on financial and equity aspects remain the most controversial issues hindering the effective implementation of ENREDD+ in the country, according to respondents. Currently, the scope of environmental governance in Brazil is very controversial. For example, the government has suspended the activities of the Amazon Fund since 2019, citing alleged irregularities in the use of funds by NGOs. The government has yet to prove such irregularities (Gallo et al. 2020). Several studies show that REDD+ policies are susceptible to political changes with each election cycle, and still have a top-down approach, mainly determined by the government (Gebara et al. 2020; Moeliono et al. 2020; Pham et al. 2021a). Coordination and participation were two words that emerged during the interviews. The need for coordination among different actors in Brazil remains weak, which can be a barrier to effective and consistent ENREDD+ policymaking. There is no common understanding and alliance of interests within the government, Amazonian state development plans and private sector actors, which are to some extent incompatible with what ENREDD+ proposes. In addition, bilateral and multilateral agreements usually involve only the national level. Therefore, sub-national governments argue and seek autonomy to enter bi- and multilateral agreements.

Gebara et al. 2020 showed that REDD+ specific actions in Brazil are more focused on policy and measure design than on REDD+ implementation on the ground. While the institutionalization of REDD+ is central, it is important to better understand why organizations are less involved in local activities. Our findings indicate that the federal government has done very little to engage with the key stakeholders that respondents believe need to be involved in policy development and implementation at the local level. Many respondents said that the channels exist, but they are ineffective in fostering a collaborative environment. For Bodin et al. (2016), adopting the concept of "collaborative heterogeneity" to address the complexity of REDD+ implementation is a key strategy. This would promote knowledge sharing based on a diversity of experiences and the development of more holistic strategies. Gebara et al. (2020) also argue that for further implementation of ENREDD+, legitimization of the different interpretations and perceptions of REDD+ and the resulting pluriversality of its concept and governance practice is needed.

In new forms of governance, such as those envisioned for the REDD+ framework, policy decisions are made through a socio-political structure of multi-stakeholder interaction that operates at multiple levels and includes civil society, NGOs, and the private sector with decentralized networks rather than a hierarchy (Dedeurwaerdere 2005, Newig et al. 2010, Thompson et al. 2011). Failure to address weak institutional capacity and coordination, accountability, transparency, and public participation - a set of principles to be endorsed - may exacerbate current conflicts over the use of forest resources (Angelsen et al. 2018, Vatn & Angelsen 2009). Such a scenario suggests that strengthening the capacity for institutional coordination directly depends on co-governance with the

different actors of civil society (Fatorelli et al., 2015). On the other hand, it is strongly argued that a strong political commitment to negotiate with conflicting interests is also necessary (Gallo and Albrecht 2019). Moreover, there is still little evidence of synergy and coordination between national and regional activities in Brazil (Duchelle et al. 2018), or that existing REDD+ schemes have improved forest governance in tropical countries (Ozinga 2012). Efforts have failed to achieve transformative change, often due to the inherent complexity and interconnectedness of different actors that have not been effectively addressed in this context (Vatn & Angelsen 2009).

For Lutrell et al. (2013), a fundamental turning point would be to define what REDD+ aims to achieve and its specific targets for reducing deforestation in different countries, as the objectives of REDD+ will have a profound impact on the design of benefit and cost sharing mechanisms. REDD+ countries face difficulties in incorporating different mechanisms into their strategies and plans (Loft et al. 2015, Lutrell et al. 2013). The Brazilian case is no different, and ENREDD+ still needs to better integrate principles and define specific benefit-sharing strategies to ensure social equity. Several factors contribute to this complexity in Brazil. For example, REDD+ is strongly linked to land tenure and property rights, and thus to carbon ownership. Despite this, around 70 million hectares are undesignated and unmonitored, and 16.6% of land is unregistered or of unknown tenure (Azevedo-Ramos & Moutinho 2018, Sparovek et al. 2019). It is also known that in order to provide protection, more attention needs to be paid to mechanisms that would distribute these benefits (Leventon et al. 2014).

In addition, several states had developed their REDD+ policies before the federal government. However, as mentioned above, a coherent approach between federal and state policies is currently lacking. Interviewees emphasized that despite efforts to structure ENREDD+ at the national level, there is a need for more efficient and streamlined bureaucratic structures to attract investment and facilitate access to financial resources, especially for smallholders and traditional and indigenous communities when applying for projects within official frameworks (e.g. Amazon Fund, Floresta+ Amazônia). Furthermore, Sheng (2020) argues that incentive coordination contracts can improve private investors' understanding of the value and risks of REDD+ projects by negotiating the optimal distribution of benefits. In terms of decentralization, some Brazilian REDD+ initiatives have adopted the concept of jurisdictional schemes and the stock-and-flow approach (distributing funds to different land tenure categories according to their balanced contribution to carbon stocks and deforestation reduction), aiming at a fair distribution of REDD+ benefits. However, the remaining challenging question is how to ensure relevant local beneficiaries and access to and benefit from these payments (Guerra & Moutinho 2020).

Our findings suggest that actors then do not perceive many activities integrated under the ENREDD+ umbrella because they are not clear about what the ENREDD+ agenda is and how it should be structured, and therefore do not address the operational challenges. For example, knowledge remains incomplete and there are still challenges and gaps that make it difficult to make comprehensive and conclusive statements on the state of REDD+ finance (Lima 2017). Since 2010, there has been an intense debate in Brazil on whether REDD+ should be linked to the carbon trading system, as there is still an unclear rule on carbon counting and trading in the international scenario. On the other hand, Brazil has maintained the structure of different sub-national and national funds that focus on receiving resources for REDD+. However, the challenge so far is to find an approach that is flexible enough to avoid limiting REDD+ financing, as it has already been argued that the costs of maintaining forests are much higher than when REDD+ was conceived and differ significantly between implementation systems (Gregersen et al. 2010, Lutrell et al. 2018). There is growing recognition of the importance of implementation and transaction costs (apart from opportunity costs), particularly at the outset of interventions, which have influenced the overall financial structure of REDD+ initiatives (Fosci 2013, Lutrell et al. 2018, Phan et al. 2014).

Despite the Brazilian federal government's historical opposition to voluntary investments, forest carbon markets are now being recognized by the federal government. The government is

creating a distinction between REDD+, which is seen as public actions with international public funding to combat deforestation and forest degradation, and forest carbon markets, called Floresta+ Carbono, a program whose objective is to support a voluntary carbon market related to native forests. The Ministry of the Environment (MMA) created a program called Floresta+, which is an umbrella program that includes new voluntary payments for environmental services (PES) program, the voluntary carbon market program, and the REDD+ RBP (results-based payments) pilot (the funds received from the GCF). The Brazilian REDD+ Alliance (2020, p. 13) analyzed Floresta+, but in their opinion "the initial reaction is that this program does not significantly change the playing field for REDD+ project development and investment in Brazil". Some other criticisms of the program relate to the lack of permanence, additionality, or leakage procedures. Although market activity for voluntary REDD+ credits is growing, Brazil's historical negative attitude towards international investors in voluntary REDD+ projects and the weakness of national environmental policies make investors reluctant to support Brazilian REDD+ projects. In addition, ENREDD+ does not yet include the growing number of initiatives seeking private and decentralized funding for compliance goals under the national umbrella, as such projects require emissions transfers to purchasing countries. Changing this scenario could be an opportunity for a voluntary cooperation model for climate change mitigation that would help Brazil meet its NDCs and lead to more private investment in forest protection.

6.2 Private sector as deforestation drivers *versus* private sector as conservation enablers

Agricultural and cattle ranching expansion, infrastructure development, and selective or illegal logging are among the most frequently cited drivers of deforestation in Brazilian territory, while public policies, institutional weakness, and international market demand are considered important underlying causes of deforestation (Greenpeace 2015, Walker et al. 2013, Wertz-Kanounnikof et al. 2008). Similarly, the construction of the Trans-Amazonian Highway in 1972 has contributed to a significant amount of deforestation in the Amazon (Skole et al. 1994). These roads were originally designed for subsistence farming settlements; however, illegal loggers have used these roads to further deforest the surrounding forested areas (Skole et al. 1994). In addition, the Brazilian recession of the 1980s led to large-scale deforestation due to massive development projects, such as to service foreign debt (DeShazo et al. 2016). Nevertheless, social, and environmental constraints are not adequately considered in the design and implementation of several initiatives.

On the other side of the debate, Brazil's overseas trading partners, especially buyers of commodities produced in the Amazon and Cerrado biomes, are concerned about avoiding what they call "imported deforestation" and have increasingly demanded assurances that the goods they buy are produced according to respectful environmental standards. Leading private actors are making commitments to reduce deforestation, and some sectors of Brazilian agribusiness have gotten the message. They are adopting more sustainable production models to distance their products from illegal deforestation practices. For example, voluntary certification programs have been adopted by producers of commodities as diverse as beef, coffee, palm oil, and soy (Hajjar et al. 2018), and the encouraging example of the soy moratorium has motivated meat producers to follow suit (Picoli et al. 2020). Moreover, studies suggest that some policies adopted in Brazil regarding rural credit achieve the goal of promoting the diffusion of low-carbon agricultural technologies (Carrer et al. 2020, Garret et al. 2018), although there are still constraints related to access to financial resources, technical assistance, and the effectiveness of governance in this context (da Silva et al. 2017, Picoli et al. 2020, Virah-Sawmy et al. 2019). Thus, from one perspective, some private sector segments commit to eliminating deforestation from their operations or supply chain. In contrast, zero-deforestation policies may be insufficient to achieve a broader impact due to leakage, lack of transparency and traceability, selective adoption, marginalization of smallholders, and lack of

standardized criteria to assess the implementation and effectiveness of commitments (Garret et al. 2019, Lambin et al. 2018).

The Brazilian case shows, however, that there is not always an inherent contradiction between conservation and production. In the years of deforestation reduction, between 2004 and 2012, soy production increased and the cattle herd grew in the Amazon (Koch et al. 2019). This fact suggests that collaboration between different economic sectors and organizations may be possible to achieve their goals. It also suggests that what may be lacking for better collaboration is a more integrated channel for coherence, coordination, communication, mediation, and information sharing. Improving communication, understanding and coordination, and strategically managing trade-offs are critical issues for successful policy development among different actors and have been reported as an effective strategy to mitigate potential conflicts (Gebara et al. 2020, May et al. 2016, Peters 2018). However, Ravikumar et al. (2018) note that it is important to distinguish between coordination failures that can be addressed through improved coordination in REDD+ policy design and implementation, and those that arise from fundamental differences in goals and interests among stakeholders. Nevertheless, efforts to promote complementarity of interests and capacities among different actors could also contribute to achieving the multiple objectives that REDD+ interventions have come to mean for different actors (Agrawal et al. 2022, Myers et al. 2022).

One of the main concerns of the private sector to participate in ENREDD+ actions is related to financial and managerial risks. Sanches & Bataglia (2015) point out that Brazilian legal institutions lack efficient mechanisms to support economic transactions, due to an ineffective judicial system and an unstable contractual legal base. As a result, transaction costs are high and encourage the use of collective and private coordination mechanisms to minimize risks. Changes in political institutions, property rights, contract law, norms and customs affect the reconfiguration of economic organization (Sanches & Bataglia 2015). Thus, for such a strategy to be efficient, equitable, and effective, changes in Brazil's institutional environment are needed (Lima 2017). Finally, one respondent identified an interesting perspective on REDD+ and business in Brazil: *"Thinking of Brazil where you do not have regulated carbon markets or a regulatory framework to incentivize REDD+ initiatives, which allows that REDD+ activities can be implemented is a change of the mindset of the civil society and business community about how they see negative impacts on their activities and how this can be mitigated regardless of the government's position. Moreover, it depends very much on how the market environment understands and sees the value in forest conservation (14 March 2019)".* Thus, this supports the thinking of different rationalities, which underpins conservation in Brazil. Although is difficult to identify shifts in the paradigm of ecological modernization in Brazil, there is a rise of new social experiences and initiatives, as the creation of the Partnership Platform for the Amazon (PPA), which seeks for new sustainable economic development models, directly involving private sector actors. Another example, a small but substantial addition to REDD+ funding in Brazil comes through mainly private funds via voluntary carbon credit markets. According to Simonet et al. 2020, the value of carbon credits sold on the voluntary carbon market from Brazilian REDD+ projects was approximately US$250 million, or 27% of the approximately US$950 million generated globally in 2020.

7. CONCLUSION

The financial contribution of business organizations may be essential in the national REDD+ context, but as some segments of the private sector drive deforestation and forest degradation - which have historically been inextricably linked to economic development - a key determinant of the success of REDD+ in Brazil will be ensuring the practical and participatory engagement of the private sector in the process. Therefore, it is crucial to create the legal basis for private investment through an efficient governance and regulatory framework that follows sustainable principles. This

study aims to provide valuable insights for the policy development and implementation of REDD+ in the Brazilian context. We examined how Brazilian national business organizations perceive REDD+ as a concept and a tool for implementing forest conservation measures. We focused on critical challenges that mainly reflect financing, benefit sharing, equity, and governance in the national arena. Given that REDD+ involves multiple actors within its framework, it is relevant to assess their different opinions, perceptions, and interests. Our results show that REDD+ is a controversial conceptualization according to the respondents, as it is a mechanism to compensate for environmental services and support the reduction of deforestation rates. It is also interesting to note that the issues analyzed are all linked to governance issues, according to most of the stakeholders. From the respondents' point of view, governance is a primary condition for success, and at the same time one of the biggest challenges in the ENREDD+ framework is to influence the financial and benefit-sharing structures.

The surveyed private sector in Brazil is not embracing REDD+ and is taking a risk-averse approach. On the one hand, the question arises as to why these actors take such a position. This scenario emphasizes conflicts over competing governance environments, tenure regimes, and the opportunity costs of using private land according to market demands. In the words of one respondent: "If the private sector is not participating and embracing the idea of REDD+, it is because the private sector is not finding opportunities and ways to go along with the conservation issue" (May 15, 2019). Usually, we can assume that business organizations are looking to reduce business risks, lower business costs, and generate revenue. On the other hand, the question of what else drives private sector investment in conservation efforts remains and should be further explored. Brazil is a sensitive global case study. Many organizations and producers along the production chain are willing to invest in innovative technologies to achieve sustainability and zero deforestation. However, the political arena is still dominated by a section of influential agribusiness stakeholders (linked to land grabbing) who are gradually introducing environmental measures while lobbying the government to strengthen its agribusiness development policies.

International pressure on Brazil to reduce its deforestation rates suggests two possible paths. If Brazil continues its current trajectory of unsustainable and rapid exploitation of its natural resources, it could jeopardize the Free Trade Agreement negotiations with the European Union and other business opportunities around the world. On the other hand, this international pressure could strengthen the sense of sovereignty over the national territory. According to the political rhetoric of the current government, Brazil is already sending signals that it will be more difficult for international cooperation to influence the direction of Brazil's development. This is partly due to the growing opportunities in other emerging markets such as China, Russia and Hong Kong, especially for soy and beef. As a result, some commodities are becoming less dependent on European countries, which are much more sympathetic to environmental issues (Guéneau et al. 2018). While development in Brazil can be based on its natural resources and ecosystem services, it must be based on a sustainable model that considers social, cultural, economic, and environmental principles as its structural pillars. However, it is also important to recognize that Brazil is not solely responsible for this scenario. International and national policies must combine sustainable production processes with the promotion of conscious consumption and responsible lifestyles.

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DECLARATION OF CONTRIBUTIONS TO THE ARTICLE - CRediT

ROLE	PGallo	MGebara	TMicheletti	ABrites
Conceptualization – Ideas; formulation or evolution of overarching research goals and aims.	X			
Data curation – Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.	X	X		
Formal analysis – Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data.	X		X	
Funding acquisition - Acquisition of the financial support for the project leading to this publication.	X			
Investigation – Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.	X			
Methodology – Development or design of methodology; creation of models.	X	X		
Project administration – Management and coordination responsibility for the research activity planning and execution.	X	X	X	X
Resources – Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.	X	X	X	X
Software – Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.				
Supervision – Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.	X	X		
Validation – Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.	X	X	X	X
Visualization – Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.	X	X	X	X
Writing – original draft – Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).	X	X	X	X
Writing – review & editing – Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.	X			