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Strategic Analysis of the Forest Carbon Market in Brazil

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Abstract: The forest carbon market in Brazil presents a complex scenario filled with challenges and opportunities. This study employed SWOT analysis to evaluate the dynamics of this market, based on the perceptions of 77 specialists from various professional fields. The analysis revealed that extensive forest cover and biodiversity preservation are significant strengths that position Brazil as a potential leader in the global carbon credit market. However, weaknesses such as illegal deforestation and fragile public policies undermine the effectiveness of conservation efforts. Opportunities include the growing international demand for carbon credits and the recognition of the importance of local communities in forest conservation. Nevertheless, external threats like land conflicts and political instability pose considerable risks. The study concludes that it is crucial to strengthen public policies and regulatory frameworks, promote technological innovation, and ensure the active inclusion of local and indigenous communities to guarantee the sustainability and growth of Brazil's forest carbon market. The research suggests that despite significant challenges, Brazil can overcome these obstacles with the implementation of effective strategies.

Keywords: climate change; forest carbon market; nature-based solutions

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1. Introduction

We are currently facing a concerning scenario, as indicated by the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) published in 2023 [1], which shows that the temperature has already risen by 1.1 °C. The intensification of global warming, exacerbated by the significant increase in greenhouse gas (GHG) emissions over the last century, is a well-documented phenomenon, as highlighted by Zhang et al. [2]. Scientists have found that Earth's climate is always changing due to various factors, including changes in Earth's orbit, biotic processes, solar radiation fluctuations, volcanic eruptions, oceanic and orogenic modifications related to tectonic plates, and natural variations in atmospheric GHG concentrations. Additionally, human actions have been identified as the primary causes of the current climate changes [3].

An increase in temperatures, a significant reduction in precipitation, and changes in wind speed in several semi-arid regions are expected as a consequence of global warming [4]. According to the AR6 [1], climate change will intensify the impacts on natural and human systems, increasing regional disparities and negatively affecting biodiversity, human health, and food production. These changes include challenges to water security, severe health effects due to rising epidemics, especially vector-borne diseases, degradation of coral reef ecosystems, risks to food security due to frequent and extreme droughts, and damage to life and infrastructure caused by floods, landslides, sea level rise, storm surges, and coastal erosion.

Various strategies are considered in the fight against climate change, such as the role of carbon sinks, energy efficiency, the use of renewable energy, and the minimization of emissions from the burning of fossil fuels, which should be monetarily evaluated to prioritize their implementations based on cost-effectiveness [5]. Mitigation strategies include conventional decarbonization efforts such as renewable energy and carbon capture; negative emissions technologies like reforestation and biochar; and radiative forcing geoengineering, which is still in the theoretical field or early testing stages [6].

Nature-based solutions (NbS), particularly forests, are also gaining prominence as essential strategies for climate change mitigation, supporting biodiversity and ensuring the flow of ecosystem services vital for human well-being [7]. However, several barriers, including measurement challenges, inadequate financial models, and rigid governance structures, hinder the effective integration of NbS into climate and development policies [7]. Emissions trading schemes (ETSs) have become vital for meeting global emissions reduction targets. They are gaining momentum, as witnessed by increasing market size and improved information mechanisms, which examine key emissions markets—the European Union, New Zealand, California, and Hubei (China) [8].

In Brazil, the main GHG emissions originate from land use changes, making forest conservation and restoration crucial strategies, not only to address the root cause of emissions but also to foster the emerging carbon market [9]. However, the opportunity cost between conserving excess forest and converting it to alternative economic activities, such as soybean cultivation, remains significant, highlighting the need to value forest conservation beyond financial incentives [10]. Emissions trading schemes (ETSs) incentivize climate action by allowing entities to exchange emissions allowances created by the reduction in greenhouse gases (GHGs) in the atmosphere or by their removal. As such, ETSs bring together companies, investors, and policymakers to ensure a cleaner transition to meet net-zero emissions targets [8].

In this context, carbon credit markets offer a solution, providing compensation for emissions reductions through reduced deforestation and forest degradation, as well as improved forest management under the REDD+ acronym [11]. The global carbon market has seen substantial growth, with its total value increasing by 34%, reaching EUR 194 billion and registering over 14,500 carbon credit projects [12]. In 2019, the total volume of carbon credit emissions in the voluntary market reached 142 $MtCO_2e$, with 66.2% of this volume linked to the VCS standard [12]. To address climate issues, countries have developed carbon markets and climate policies, including the establishment of the Chicago Climate Exchange (CCX) in 2003, where 400 enterprises traded carbon instruments until 2010, and the European Union Emissions Trading System (EU ETS) in 2005, which is now the world's largest and most active carbon trading system [13].

With increasing emissions reduction targets in the coming years, the need for a robust and effective carbon market arises, which should become the main source of funding for forest owners adopting management practices aimed at carbon storage and sequestration [5]. Historically, emissions trading was regulated by the Kyoto Protocol until 2020, which established an emissions trading system (ETS) between countries and introduced mechanisms such as Joint Implementation and the Clean Development Mechanism (CDM) [12]. Various climate policies have been proposed globally, such as the Energy Independence and Security Act of 2007 signed by George W. Bush to reduce US dependence on international crude oil, address global climate change, and expand renewable energy production, the Clean Energy Plan announced by Barack Obama in 2015, and the UK's Ten Point Plan for a Green Industrial Revolution issued in November 2020 [13].

In voluntary carbon markets (VCMs), there is an organic demand, unlike in regulated markets, which are driven by mandatory targets [14]. Sellers in VCMs usually include forest owners and managers, with these markets experiencing significant expansion, facilitated by more flexible legislation and simplified exchange procedures [14]. Regulated markets are defined by mandatory carbon management regimes, such as the European Union Emissions Trading System (EU ETS), a cap-and-trade scheme where regulated entities

trade allowances within a set emissions limit [15]. California's Cap-and-Trade Program exemplifies this, allowing excess emissions to be offset through the purchase of credits for climate benefits achieved in other locations [16].

The commercialization of carbon credits, which is essential for emissions reduction, requires accurate forecasts of the carbon price, considering factors such as climate changes and extreme weather events, which impact the demand for energy and emission rights [17]. Both regulated and voluntary markets have recently experienced growth in carbon credit transactions, but certification presents challenges for credit generation, despite increasing reliability [12]. Inconsistency in information for evaluating carbon credits compromises market integrity and generates financial and reputational risks [7]. The risk of the double counting of climate benefits in systems like CORSIA and transactions under Article 6 of the Paris Agreement needs special attention to maintain the integrity of the Paris Agreement [18]. The carbon market is an important way to guide enterprises to actively participate in environmental governance and promote enterprises to achieve green transformation [19].

It is important to note that, in the international context, when talking about Brazil and climate change, the discussion often focuses on the Amazon region, globally recognized for its vital role in climate balance and biodiversity. This is reflected in the international bibliography, where most references about Brazil are associated with the Amazon, highlighting its importance and the challenges faced by the region.

This research addresses the Brazilian forest carbon market with a focus on the Brazilian Amazon. It specifically aims to assess the importance of nature-based solutions, emphasizing forests as tools for climate change mitigation. Additionally, it seeks to identify the strengths, weaknesses, opportunities, and threats to optimize the market's contribution to combating global warming. The study aims to understand the magnitude and impacts of climate change, comprehend the role and potential of the carbon market in financing forest conservation and reforestation efforts in Brazil, and provide support for developing public policies and regulatory frameworks that promote collaboration between sectors and the inclusion of local communities and indigenous peoples.

The core of the methodological approach used in this dissertation is the SWOT (strengths, weaknesses, opportunities, and threats) analysis for the strategic analysis of the Brazilian forest carbon market. We used a questionnaire applied to sector specialists, whose responses were analyzed to identify the main opportunities and challenges for the sector.

2. Materials and Methods

To achieve the objectives of this study, a comprehensive methodology integrating both quantitative and qualitative analyses, including the construction of a detailed SWOT matrix, was chosen. This approach ensured a detailed evaluation of the perceptions and experiences of professionals involved in the Brazilian forest carbon market, capturing both economic and environmental aspects and identifying key strategies for market growth and its challenges.

The process began with the development of a structured questionnaire designed to collect relevant information aimed at evaluating the strengths, opportunities, weaknesses, and threats perceived by professionals, thus composing a SWOT matrix, based on a literature review. The main sources of literature included reports and publications from the Intergovernmental Panel on Climate Change (IPCC), peer-reviewed journal articles, reports from non-governmental organizations, and publications from academic institutions addressing climate change mitigation strategies, sustainable forest management, and carbon markets. Key references included IPCC reports [1,20,21], studies on climate change mitigation strategies [5,6,22], and carbon market analyses [10–12].

The scope of this study encompasses the Brazilian forest carbon market, with a special focus on the Amazon, known for its ecological value and significant potential in carbon sequestration projects. The choice of Brazil reflects its global environmental relevance and the challenges associated with developing the forest carbon market. The selected variables

reflect the diverse nature of the market, addressing economic, environmental, social, and regulatory dimensions. The economic variables include the market value of carbon credits and the economic impact of projects. The environmental variables consider the capacity of Brazilian forests to sequester carbon, the deforestation rates, and the forest restoration potential. The social variables reflect the impact of projects on local communities. The regulatory variables address the legal and political framework governing the carbon market in Brazil.

To ensure the validity of the questionnaire, a pilot test was conducted with a group of randomly selected specialists, which helped identify and correct any ambiguities or difficulties in the questions. Additionally, consultation with experts in the field ensured that the questions were relevant and comprehensive in relation to the study's objective. The sample consisted of individuals with proven experience in the carbon market, encompassing a wide range of professionals from environmental NGOs, academics, government representatives, and private sector participants. The representativeness of each area in the survey participation was detailed in the results. The questionnaire was disseminated online via Google Forms, and data collection took place over a month, with reminders sent to increase the response rate.

The quantitative data were analyzed using Microsoft Excel, while the qualitative responses were analyzed manually. The integration of quantitative and qualitative results allowed a deep understanding of the dynamics of the Brazilian forest carbon market. After analyzing the responses, a detailed SWOT matrix was constructed, which formed the basis for the strategic analysis. Data handling involved verification and preparation, coding of quantitative data, and content analysis of qualitative responses. Data triangulation enabled cross-validation, strengthening the research conclusions. Confidentiality measures were adopted to protect the participants' identities.

3. Results and Discussion

The investigation into the Brazilian forest carbon market involved 77 specialists, providing a diversified view of the sector. The participants had varied academic backgrounds and were primarily forest engineers (18.2%) and environmental engineers (11.7%); among the participants were also lawyers, agronomists, and economists (5.2% each) and those from a broad range of disciplines (49.4%), including environmental scientists and biologists. Most of the participants were from private companies (75.3%), indicating strong business sector interest, while state public entities, academic institutions, federal agencies, NGOs, funding agencies, and sectoral associations also contributed.

The common professional roles included analysts (45.4%), coordinators (16.9%), and managers (9.1%), with other roles such as researchers, consultants, entrepreneurs, technicians, public managers, students, directors, and professors also represented. The data showed that most of the respondents (39.9%) had 1–3 years of experience, while 33.8% had less than one year, reflecting both maturity and novelty in the market.

The diversity of specializations and experiences in areas like forest engineering, environmental engineering, law, agronomy, and economics is essential for a comprehensive analysis of the Brazilian forest carbon market. This multidisciplinary approach enriches the analysis, integrating environmental, legal, economic, and social aspects, and provides a solid foundation for the subsequent strategic SWOT analysis of the collected data.

3.1. Strengths

The analysis of the strengths of the Brazilian forest carbon market, based on the questionnaires, revealed an overall average of 8.09, with variations between 6.87 and 9.14. Only 2 items had a mode different from 10, and half of the standard deviations exceeded 2, indicating significant divergence in item evaluation (Table 1).

Table 1. Descriptive statistics of strengths in the forest carbon market.

Description	Mean	Mode	Median	Standard Deviation
Extensive forest cover in Brazil	9.14	10	10	1.17
Preservation of forest biodiversity, with the possibility of generating additional carbon credits	8.90	10	9	1.37
Large availability of land for restoration/recovery projects	8.77	10	9	1.56
Conservation of endangered species	8.40	10	9	1.93
Potential for creating ecological corridors to connect preservation and conservation areas, contributing to biodiversity maintenance	8.38	10	9	2.12
Potential for job creation in conservation and restoration projects, especially in rural areas	8.13	10	9	1.94
Traditional knowledge about forest management by traditional peoples and communities that can contribute to the implementation of forest carbon projects	7.77	10	8	2.27
Large number of protected areas, such as UCs, that can be subjects of forest carbon projects	7.39	7	7	2.33
Development of sustainable tourism projects in forest areas	7.17	10	8	2.39
Existence of forest certification systems that attest to the quality and sustainability of forest carbon projects	6.87	7	7	2.23

The "Extensive Forest cover in Brazil" emerged as the main strength, with an average of 9.14 and a mode and median of 10, highlighting the collective appreciation of the country's forest wealth.

The "preservation of forest biodiversity" was also highly valued, with an average of 8.90 and a mode of 10, despite a standard deviation of 1.37 indicating a moderate variation in opinions. Sreekar et al. [23] demonstrated that the commercialization of nature-based carbon credits at USD 5 per ton of CO_2 could expand protected areas, generate USD 121 billion annually in return on investment, and sequester up to 3 $GtCO_2e$. However, the IPCC [20] "Mitigation of Climate Change" report warns of the risks of inadequate conservation and reforestation implementations.

The large availability of land for restoration and recovery projects was recognized as crucial, with an average of 8.77, showing that most of the participants perceived this as a significant strength, evidenced by the mode of 10 and median of 9, although a standard deviation of 1.56 reveals variations in responses.

Among the identified strengths, the "Traditional knowledge about forest management by traditional peoples and communities" was elucidated by the work of Garcia et al. [24], who highlight the vital role of indigenous peoples in forest carbon projects in the Amazon. According to them, carbon credits generated by REDD+ projects in the voluntary carbon market (VCM) are the property of indigenous peoples, granting them exclusive rights over forest management and carbon revenue distribution. This recognition not only demonstrates that traditional knowledge is a valuable resource but also underscores the importance of including these communities in the development and implementation of forest carbon projects, ensuring that their values and practices are respected and valued.

The standard deviations indicate a general agreement on the relevance of the identified strengths but reveal divergences in certain aspects. Areas with higher standard deviations, such as protected areas and forest certification systems, suggest the need for additional discussions to align visions and methodologies. In contrast, topics such as extensive forest cover and biodiversity demonstrate a broader consensus, indicating a shared perception of their importance.

The participants also highlighted several fundamental elements that reinforce Brazil's potential in the carbon credit market, emphasizing the country's established expertise in

forest management. They underscored the extensive forest cover and rich biodiversity, along with robust technical–scientific knowledge and the availability of professionals specializing in the environmental area. These factors constitute a favorable scenario for the development and implementation of carbon credit projects. Sustainable practices, such as agroforestry and integrated farming systems, were recognized as valuable opportunities for carbon sequestration, encompassing both above- and below-ground biomass.

Moreover, the importance of regulating the Brazilian carbon market was emphasized by participants as crucial for stimulating both private and public initiatives aimed at forest conservation and restoration. The strengthening of ESG policies by companies was acknowledged for its positive impact, steering the supply chain towards more sustainable practices and the pursuit of emissions reduction methods. This trend not only enhances environmental benefits but also fosters the socio-economic development of local communities, generating employment and promoting sustainable tourism in forest areas.

The synergy between the three main strengths—extensive forest cover, biodiversity preservation, and land availability for restoration—creates an optimal environment for environmental conservation and carbon credit production. This combination offers a significant contribution to sustainability and helps mitigate climate change.

3.2. Opportunities

Table 2 highlights an optimistic evaluation of the opportunities in the Brazilian forest carbon market by the specialists, with an overall average of 8.5. This average suggests a positive perception, with means ranging from 7.94 to 8.95, which are indicative of opportunities considered to be of great importance. Additionally, the standard deviation values for the items were lower than those in other sections of the SWOT matrix, suggesting a stronger consensus among the respondents.

Table 2. Descriptive statistics of opportunities in the forest carbon market.

Description	Mean	Mode	Median	Standard Deviation
Increasing international demand for carbon credits from forest conservation projects	8.95	10	10	1.65
Valuation of biodiversity and ecosystem services	8.94	10	9	1.52
Implementation of policies to promote research and development of technologies for forest conservation	8.73	10	9	1.49
Implementation of public policies aimed at encouraging forest conservation and reducing greenhouse gas emissions	8.71	10	9	1.73
Recognition of the importance of local communities and traditional peoples in forest conservation	8.68	10	9	1.72
Increasing demand for sustainable products	8.40	10	9	1.63
Improvement of land management	8.32	10	9	1.94
Possibility of raising financial resources	8.31	10	9	1.91
Implementation of training and capacity-building programs	8.06	8	8	1.76
Strengthening public–private partnerships	7.99	10	8	1.82
Technological innovation	7.94	10	8	2.04

The "increasing international demand for carbon credits" received the highest mean (8.95), demonstrating a strong consensus on its importance and potential for expansion. Some concerns were raised by the participants, suggesting the need for a more careful approach, particularly regarding the additionality and permanence of REDD+ projects, indicating the relevance of ensuring the effectiveness of these initiatives in the long term.

The "valuation of biodiversity" and the "recognition of local communities" were emphasized as crucial, with means of 8.94 and 8.68, respectively. These points reinforce the importance of public policies and practices that promote environmental conservation and climate justice, integrating local communities into conservation efforts.

The "improvement of land management" and the "strengthening of public-private partnerships" were recognized as areas requiring attention, with means of 8.32 and 7.99, indicating the need for advancements. The raising of financial resources, with a mean of 8.31, was highlighted as vital for the development of more comprehensive projects, especially those involving traditional populations.

"Technological innovation" presented the lowest mean and showed a large standard deviation (2.04), revealing significant variations in the specialists' opinions. This divergence emphasizes the need for caution regarding the risks associated with new technologies.

In addition to these opportunities, areas not mentioned in the initial questionnaire, such as the "regulation of the carbon market" and "public-private partnership for project development", were identified, suggesting the importance of clear governance and closer collaboration between sectors. The "exploration of the bioeconomy" also emerged as a promising area, indicating significant potential for the sector.

These opportunities underline the recognition of collaborative and innovative approaches that are essential to maximize the potential of the Brazilian forest carbon market.

3.3. Weaknesses

The analysis of weaknesses in the Brazilian forest carbon market, as detailed in Table 3, reveals a significant recognition of these challenges by the specialists, with an overall average of 7.3. The identified challenges range from illegal deforestation and logging to limitations in the legal and operational infrastructure, highlighting critical areas that require immediate attention to improve market efficiency and sustainability.

Table 3. Descriptive statistics of weaknesses in the Brazilian forest carbon market.

Description	Mean	Mode	Median	Standard Deviation
Illegal deforestation and logging	8.25	10	9	2.36
Fragility of public policies and national regulatory frameworks related to forest conservation and the carbon market	8.14	10	9	2.08
Challenges in the implementation and scalability of forest projects	8.00	10	8	1.94
Complexity and bureaucracy in the certification and validation processes of forest carbon emissions reduction projects	7.75	10	8	2.30
Lack of transparency and reliable systems for monitoring and verifying forest carbon emissions reductions	7.66	10	8	2.31
Lack of technical and financial capacity of local communities and traditional peoples to participate and benefit from forest carbon projects	7.49	10	8	2.48
Inequality of access to the forest carbon market in Brazil	7.45	10	8	2.31
Risks associated with fraud and forgery of Brazilian forest carbon credits	7.36	10	8	2.52
Difficulties in obtaining certified carbon credits and trading them in the market	7.12	10	8	2.55
Technological and scientific knowledge limitations	6.48	9	7	2.58
Introduction of invasive exotic species into forest ecosystems	5.83	5	6	2.51

"Illegal deforestation and logging" emerged as the greatest weaknesses, with a mean of 8.25, but a high standard deviation (2.36) indicates a divergence of opinions among specialists. This variation suggests the complexity of the issue and the need for multi-

faceted strategies to effectively address these illegal practices and ensure the integrity of conservation projects.

The "fragility of public policies and regulatory frameworks", with a mean of 8.14, reflects the urgent need to strengthen the legal and institutional structures that support forest conservation and the carbon market. This weakness highlights the imperative of establishing a more robust and efficient regulatory environment.

The "challenges in the implementation and scalability of forest projects" were also recognized as a significant barrier, with a mean of 8.00 and the lowest standard deviation (1.94) among the weaknesses, indicating a broader agreement on the importance of this challenge. The need for vast land areas to make projects financially viable underscores the obstacles to expanding and replicating successful initiatives.

The "complexity and bureaucracy in the certification processes", although recognized as a guarantee of project reliability, implies a prolonged development and implementation period, which becomes an obstacle to the agility and efficiency of the market.

Interestingly, the "introduction of invasive exotic species" was perceived as the least of the weaknesses (mean of 5.83), but the high standard deviation (2.51) reveals a variety of opinions, highlighting the complexity of ecological management in conservation and restoration projects.

The specialists also suggested the importance of developing national and international demand, improving project traceability, and enhancing specific methodologies for Brazilian biomes, indicating areas for innovation and improvement. Addressing land irregularities and legal insecurity, along with increasing competition among validating entities, was identified as essential for strengthening the market.

In summary, the results and comments from the specialists clearly illustrate the weaknesses in the Brazilian forest carbon market, underscoring the critical need to reinforce public policies and overcome operational barriers to promote a more robust, transparent, and accessible carbon market.

3.4. Threats

The analysis of the threats section reveals the specialists' perspectives on the external challenges that threaten the Brazilian forest carbon market, as illustrated in Table 4. With an overall average of 7.5 for the listed threats, reflecting the relevance of these challenges, a moderate consensus on the importance of these threats is observed, despite divergent views, as indicated by the standard deviations above 2.

"Land conflicts and lack of legal security" emerge as the most significant threat, with the highest mean (8.99) and the lowest standard deviation (1.47), indicating a high degree of agreement among specialists. This concern underscores the urgency of resolving these conflicts and strengthening legal security to ensure the integrity and viability of forest carbon projects.

The "vulnerability to changes in international carbon policies" and potential changes in market regulations, with a mean of 7.82 and a standard deviation of 2.30, highlight the concern with global regulatory instability and its impact on local projects.

The "political and economic instability in Brazil", as well as the "competition with other economic sectors", such as agriculture, livestock, and mining, both with means of 7.77, reflect the threats posed by the country's internal dynamics and the competition for natural resources, potentially harming forest areas.

Notably, the consideration of the "lack of credibility of REDD+ and AFOLU carbon credits" as an unlisted threat originally suggests concerns about the perception and effectiveness of these mechanisms in the broader context of conservation and carbon trading.

The presence of varied threats with high standard deviations reflects the complexity and multiplicity of challenges facing the Brazilian forest carbon market, ranging from legal and regulatory issues to socio-economic and environmental impacts.

These specialists' perceptions underline the need for a multifaceted approach to mitigate these threats, emphasizing the importance of robust public policies, integrating

sustainable practices in competing sectors, and strengthening societal engagement in forest conservation and the benefits of the carbon market. Addressing regulatory instability and ensuring a conducive environment for sustainable development and the effective implementation of forest carbon projects is vital.

Table 4. Descriptive statistics of threats in the forest carbon market.

Description	Mean	Mode	Median	Standard Deviation
Land conflicts and lack of legal security	8.99	10	10	1.47
Vulnerability to changes in international carbon policies and potential changes in carbon market rules and regulations	7.82	10	8	2.30
Political and economic instability in Brazil	7.77	10	8	2.37
Competition with other economic sectors, such as agriculture, livestock, and mining, which may pressure forest areas	7.77	10	8	2.24
Economic and market pressures that may encourage illegal exploitation of forest resources	7.71	10	8	2.16
Lack of awareness and engagement of society regarding the importance of forest conservation and the benefits of the forest carbon market	7.64	10	8	1.95
Increased pressure for the conversion of forest areas into agricultural land or other uses	7.48	10	8	2.66
Lack of specific tax incentives and benefits for forest carbon projects	7.42	10	8	2.35
Risks associated with extreme weather events	7.25	8	8	2.32
Dependence on external funding for the implementation of forest carbon projects	7.18	7	7	2.28
Difficulties in obtaining financing and resources for forest carbon projects	7.13	7	7	2.16

3.5. Strategic Analysis

Following a detailed analysis of the questionnaires administered to the sector specialists, an updated SWOT matrix was developed. This instrument emphasizes the three most critical aspects identified in each SWOT category: strengths, weaknesses, opportunities, and threats. The selection was based on the importance attributed to these aspects by the participants, highlighting the most significant factors.

The new SWOT matrix is presented below and is examined in depth. Each element is analyzed for its implications for the sector and the possible strategies to leverage strengths and opportunities, mitigate weaknesses, and address threats (Table 5).

Table 5. New SWOT matrix.

Internal	External
Strength	Opportunity
Large forest cover in Brazil	Increasing international demand for carbon credits from forest conservation projects
Preservation of forest biodiversity	Valuation of biodiversity and ecosystem services
Large availability of land for restoration/recovery projects	Implementation of policies to promote research and development of technologies for forest conservation
Weakness	Threat
Illegal deforestation and logging	Land conflicts and lack of legal security
Fragility of public policies and national regulatory frameworks related to forest conservation and the carbon market	Vulnerability to changes in international carbon policies and potential changes in carbon market rules and regulations
Challenges in the implementation and scalability of forest projects	Political and economic instability in Brazil

This matrix serves as a crucial strategic tool. Further strategic analyses were conducted to deepen understanding and provide clear directions for future actions. These analyses include:

- Offensive Actions (Strengths and Opportunities): Brazil's vast forest area and biological diversity, combined with international demand for carbon credits, position the country as a potential leader in the global carbon market. Promoting policies that encourage innovation and technological development for forest conservation can optimize these advantages.
- Defensive Actions (Strengths and Threats): Brazil's extensive land availability for restoration and biodiversity protection can neutralize threats such as land disputes and sensitivity to international carbon policy changes. Strengthening legislation and legal security is an essential step.
- Debilities (Weaknesses and Opportunities): Vulnerabilities like fragile public guidelines and project implementation challenges can be overcome by exploiting current opportunities. Improving land management and enhancing community capacity are measures accelerated by emerging sector opportunities.
- Vulnerabilities (Weaknesses and Threats): Issues like illegal deforestation and logging, combined with political and economic instability, require a cautious approach. Strengthening governance and command-and-control policies and establishing incentives for sustainable forest management practices are fundamental strategies.

These strategic analyses are crucial to achieving the research objective: proposing strategies and recommendations to strengthen Brazil's forest carbon market, overcoming challenges, and seizing opportunities (Figure 1).

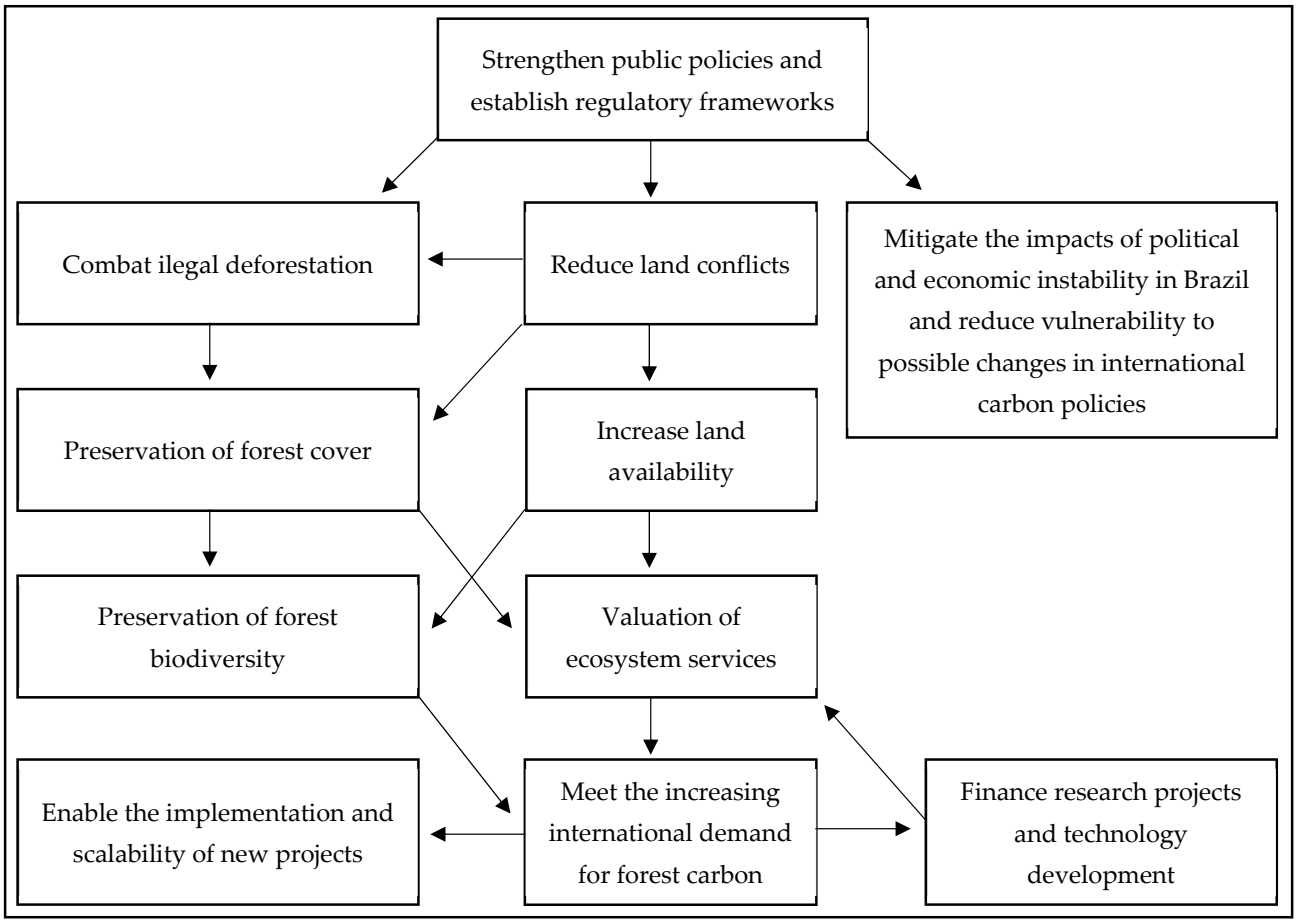

Figure 1. Interrelations among the main evaluated components.

Strengthening public policies and regulatory frameworks is vital to combat deforestation in Brazil. The World Bank [11] highlights that subsidies and rural credit policies, combined with the structure of the Rural Land Tax (ITR), promote deforestation for agriculture. Additionally, the Plano Safra, the main subsidized credit program, intensifies this trend in the states of the Legal Amazon. Conversely, JP Morgan [15] emphasizes that the voluntary carbon market cannot replace effective public policies in combating climate change.

Illegal logging, agriculture, and land grabbing are identified by the World Bank Group [11] as primary deforestation causes, exacerbated by weak law enforcement and poor land governance. This scenario underscores the need for actions to reduce land conflicts, such as mapping untitled public lands and modernizing land registration.

Preserving forest cover is essential for maintaining biodiversity and ecosystem services. AR6 [1] recommends minimizing additional stresses, reducing habitat fragmentation, and protecting small-scale refuges. Vargas et al. [10] emphasize that implementing and expanding forest projects requires large land areas to be financially viable, highlighting the importance of an integrated approach to forest conservation and sustainable development.

The IPCC [21] warns about the dangers of large-scale reforestation and biomass production, which can negatively impact biodiversity, food and water security, and local communities and indigenous rights. If poorly managed, these practices increase dependence on carbon removal, putting additional pressure on land and biodiversity. The scarcity of high-quality carbon credits, according to ICC Brasil and WayCarbon [12], is attributed to variations in accounting and verification methodologies, limiting the necessary capital for more effective projects.

Incentivizing research and development in forest conservation technologies is crucial for sector innovation and efficiency. Dong et al. [22] conclude that nations with significant green technology advances are more efficient in carbon emissions. Rej et al. [25] suggest government promotion of these innovations, especially during economic progress phases.

Carbon financing projects that protect tropical forests, as highlighted by Koh et al. [26], contribute to both nature conservation and climate change mitigation. Pache et al. [5] reinforce the need for a functional and stable carbon market in light of increasing emissions reduction targets. Finally, the World Bank [11] and Pache et al. [5] emphasize the importance of integrating technologies to quantify, spatialize, and monetize carbon storage and sequestration, providing a systemic view for carbon market advancement.

The SWOT analysis of the Brazilian forest carbon market highlights valuable opportunities, such as extensive forest cover and international interest in carbon credits. However, it also reveals significant challenges like illegal deforestation and political instability. These insights direct the need to strengthen public policies and sustainable practices, ensuring the long-term growth and effectiveness of the market.

4. Conclusions

This research, conducted with 77 specialists from various professional fields, provided valuable insights into the Brazilian forest carbon market. The in-depth analysis of the questionnaire responses highlighted the sector's main strengths, opportunities, weaknesses, and threats, reflecting its complexity and the challenges faced.

Brazil's vast forest coverage and biodiversity preservation emerged as key strengths, showcasing the country's natural wealth and creating a robust foundation for carbon credit generation. The growing international demand for carbon credits presents a significant opportunity for Brazil, driven by the global recognition of the importance of biodiversity and ecosystem services.

However, illegal deforestation and weak public policies are major weaknesses, challenging the effectiveness and integrity of forest conservation projects. Additionally, external threats, such as land conflicts, political and economic instability, and vulnerability to changes in international carbon policies, pose significant risks that could adversely impact the market.

The results suggest an urgent need to strengthen public policies and regulatory frameworks to combat deforestation and ensure the effectiveness of carbon projects. Collaboration between public and private sectors, technological innovation, and the active inclusion of local communities and indigenous peoples are essential for the market's sustainability and growth.

A recent example is the decision by the Brazilian Supreme Federal Court (STF) in 2023, rejecting the thesis of the temporal framework for the demarcation of indigenous lands, which brings a new context for forest conservation and the carbon market in Brazil. This legal change, by affirming the fundamental rights of indigenous peoples over their lands based on ancestry and tradition can positively influence biodiversity preservation and the expansion of the forest carbon market. It underscores the importance of integrating forest conservation policies with the recognition of indigenous rights, aiming for sustainable development that values both biodiversity and traditional cultures.

This research has limitations that should be considered. The possibility of bias in the participants' responses, influenced by their professional experiences and areas of expertise, is one of them. The questionnaire-based methodology may not have fully captured the complexity and nuances of the carbon market.

For future research, it is recommended to use more in-depth qualitative methods, such as detailed interviews or case studies, to better understand the specific dynamics of the Brazilian forest carbon market. It would be beneficial to expand the research to include analyses of ongoing forest carbon projects, evaluating their environmental, social, and economic impacts. Comparative studies with established carbon markets in other countries could offer additional insights and best practices to enhance the Brazilian market.

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