INBAR Working Paper

Technical Paper

Bamboo Market and Value Chain in Brazil

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Executive summary

Brazil's estimated 5.26 million hectares of bamboo resources indicate a significant potential for industrial development and biodiversity conservation. Building upon this, the current study looks at the market dynamics, value chain intricacies, and strategic opportunities within Brazil's bamboo sector. It emphasizes the importance of bamboo as a non-wood forest product that contributes substantially to local economies, rural communities, and environmental sustainability. Recognizing bamboo's versatile applications across industries like construction, textiles, and bioenergy, the report emphasizes the need for a detailed value chain analysis to enhance its competitive edge and economic contributions.

The primary objective of this report is to map out the bamboo value chain in Brazil, identifying key stakeholders, market dynamics, and regulatory frameworks. This includes a thorough examination of each step from cultivation to end-use, highlighting the roles of key stakeholders. The report also delves into global trends and their influence on the bamboo sector, assesses production, consumption, import/export trends, and evaluates existing regulatory frameworks. Additionally, a SWOT analysis is conducted to evaluate the strengths, weaknesses, opportunities, and threats within the Brazilian bamboo market. Finally, the report suggests actionable recommendations to enhance the value chain and promote sustainable growth.

The study employs a multifaceted methodological approach to provide a comprehensive analysis of Brazil's bamboo industry. It begins with a thorough literature review, examining existing publications on the bamboo sector in Brazil. This is complemented by web analysis and collaborative mapping, using platforms such as "Bambuzeiros do Brasil" to map bamboo-related entities. To gather detailed insights, the study collects qualitative and quantitative data through questionnaires and stakeholder interviews, engaging over 300 companies and stakeholders. Additionally, the study analyzes import/export data from Brazil’s official trade records to understand trade dynamics. Geographic Information Systems (GIS) mapping is used to visualize the geographical distribution and trade flows of bamboo products, providing a spatial context to the data.

The market analysis shows that Brazil's bamboo market has experienced substantial growth over the past five years, driven by both domestic and international demand. Key products include furniture, construction materials, and handicrafts, with over 300 companies involved in bamboo-related activities, primarily concentrated in São Paulo and Rio de Janeiro. Economically, bamboo supports rural economies by providing employment and fostering sustainable land use. It plays a crucial role in Brazil's bioeconomy, offering opportunities for low-income farmers and contributing to biodiversity conservation.

In terms of trade dynamics, Brazil excels in exporting high-value bamboo products such as furniture and artisanal works, with the United States being the largest export destination. In 2023, the total export value of bamboo products reached approximately USD 3.61 million. Major exports to the United States include bamboo furniture and cutting boards. Meanwhile, Brazil imports significant quantities of bamboo kitchenware, charcoal, and mats, primarily from China, with the total import value surging to USD 32.26 million. Over the recent five years, this import growth has accelerated, reflecting strong domestic demand that outpaces local production capabilities. China, as a leading supplier, plays a vital role in catering to Brazil's needs for high-quality bamboo products.

The SWOT analysis highlights Brazil's strengths in extensive bamboo resources, supportive legislation, and advanced material expertise, while identifying weaknesses such as high operational costs and reliance on imported treatment compounds. Opportunities lie in expanding market reach, leveraging advanced wood technologies, and promoting bamboo as an eco-friendly alternative. However, threats include market fluctuations, logistical challenges, and the informal market's impact on regulated trade. Key products in import and export include high-value furniture and artisanal products for exports, and kitchenware, charcoal, and fiber products for imports. Increasing local production in these areas could significantly reduce import dependency and enhance Brazil's competitive edge in the global bamboo market.

To capitalize on these opportunities and address the challenges, the report suggests several main recommendations. For strategic development, it is essential to enhance partnerships with international buyers, implement comprehensive training programs for farmers, and upgrade local processing facilities to improve product quality. Product diversification can be achieved by

investing in research and development for new bamboo-based products, such as engineered materials and fiber-reinforced composites. Effective marketing and promotion strategies include developing strong branding, utilizing digital marketing channels, and participating in international trade shows to increase visibility. In terms of policy and legislation, advocating for supportive policies, implementing quality control measures, and fostering collaborations with international partners to enhance technological capabilities and market access are crucial. By addressing these areas, Brazil can maximize the potential of its bamboo resources, driving sustainable economic development and contributing to global environmental goals.

1. Introduction

Non-wood forest products (NWFPs) are recognized worldwide for their substantial economic contributions. These resources bolster local economies, sustain rural communities, and are essential for food security, nutrition, health, and energy demands (Chamberlain et al, 2022). While NWFPs are exceptional to the economies of forests and are widely used, their full economic and social contributions are not always adequately documented, leading to a lack of visibility in official statistics and policy considerations (Chamberlain et al, 2022). It is estimated that at least 3.5 billion people rely on NWFPs, underscoring their importance in the household economies of rural populations, particularly in developing countries (Mahonya et al., 2019). NWFPs provide a vast array of benefits including contributions to human nutrition, the supply of renewable materials, and the provision of cultural and experiential services, which are in line with the evolving global move towards a bio-economy (Muttilainen et al, 2022; Weiss et al., 2020). The diversity of NWFPs' economic roles are broad, encompassing both direct and indirect contributions to employment, income generation, and household food security (Mahonya et al., 2019). Consequently, NWFPs are vital to the prosperity and well-being of communities' economies, globally.

In Brazil, because of its extensive forested landscapes, (around 500 million hectares of forest) (Afonso, 2022), Non-Wood Forest Products (NWFPs) are interwoven with the social, cultural, and economic development, contributing substantially to the nation's bioeconomy. The multifaceted nature of NWFPs is vividly demonstrated in their role in promoting sustainable land use, particularly within the Brazilian Cerrado, as they fulfill material and socio-cultural needs, thus reinforcing the symbiosis between human well-being and environmental stewardship (de Mello et al., 2023). Additionally, a state-of-the-art analysis underscores the historical role of NWFPs in reducing poverty and encouraging conservation, thereby improving the quality of life of populations living in forested regions (Silva et al., 2020).

The Estimation and Analysis of Bamboo Resources and Species Distribution in Brazil, an INBAR Working Paper published in 2024, reveals significant findings that underscore Brazil's rich bamboo diversity and substantial bamboo coverage. The coverage is estimated at approximately 5.26 million hectares, although this figure is conservative and the actual bamboo coverage is likely higher due to the lack of complete remote sensing data and other methodological limitations. The

study highlights considerable regional variations, with the state of Acre showing the largest bamboo presence at approximately 4.56 million hectares. This extensive coverage underscores the importance of bamboo in Brazil's bioeconomy and highlights the potential for further industrial development and biodiversity conservation. Additionally, the study identifies 316 bamboo species within 52 genera across Brazil, emphasizing the rich biodiversity and the critical role of platforms like REFLORA in advancing the understanding of bamboo resources.

Bamboo, as a representative NWFP, stands out for its contributions to the economy and the environment, offering pathways out of poverty through employment and sustainable development opportunities (FAO, 2001), (Montgomery, 2021), (BBP, 2020). This is particularly salient in Brazil, where bamboo's versatility spans across multiple industries — from pulp and paper to bioenergy, and beyond — supporting low-income farmers and fostering biodiversity. The environmental benefits of bamboo are highlighted by its role in climate change mitigation and deforestation prevention, aligning with the country's expansion of bamboo cultivation (Chamberlin et al., 2019; Pan et al., 2023;Song et al., 2011).

Brazil's historical engagement with bamboo traces back to indigenous use for producing and using essential items, a practice enriched over centuries. This integration has seen ebbs and flows, influenced by economic factors and competition from other industries. Today, bamboo stands at the cusp of a renaissance, fueled by global interest and advancements in sustainable management practices (Sun et al., 2023).

Bamboo is one of the fastest-growing plant in the world and has a wide range of uses, including construction, paper, textiles, and food (Montgomery, 2021). India has the largest area of bamboo forests, with an estimated area of 17,416,000 hectares, followed by China with 6,816,500 hectares (Global Forest Resources Assessment, 2020). The average value of world trade in bamboo ware is about USD 60 billion (Guillermo Ramo Fernández, et al, 2021). Bamboo can also contribute to climate change mitigation by sequestering carbon and reducing greenhouse gas emissions (Song et al., 2011). Bamboo flooring can reduce the demand for forest hardwood cultivation and help prevent deforestation (Atanda, 2015). Manufacturing bamboo products can create employment for thousands of families, especially in developing countries, where bamboo grows locally in some of the world's most underprivileged communities (Wang et al., 2021).

Value chain analysis is a strategic tool employed to dissect a company's operations and pinpoint the activities that contribute most significantly to its competitive edge. This analysis delineates the various actions involved in producing and delivering a valuable product, which may be goods, services, or a combination of both, to the market. It is instrumental in identifying the weaker links in the chain and devising strategies to enhance value creation. The essence of the value chain approach lies in breaking down a business into its critical activities for strategic examination, a methodology that is universally applicable across industries.

Value chain research has been widely applied and it focuses on upgrading and development, particularly supporting small-scale farmers and producers in rural areas. The concept of global value chains or global supply chains responds to the growing phenomenon of global production fragmentation, where business functionalities and production activities along a value chain are carried out by various entities located in different countries (L. Jones et al., 2019). Value chain analysis has two important elements that facilitate the understanding of upgrading: functional upgrading, which involves developing a more comprehensive array of activities over different segments of the value chain, and product upgrading, which focuses on designing, fabricating, and distributing higher value products (Rodrigue, 2020). Small-scale farmers' inclusion in high-end, transnational value chains has been promoted as a solution to rural poverty, gender inequality, and deforestation, with the expectation that it can stimulate growth in rural areas and address environmental issues linked to small-scale farming (Mathinya et al, 2023).

In this study, the value chain framework is utilized to study both current and prospective models of bamboo product development, with Brazil serving as the focal case study. This approach has been adopted in various countries, including Ethiopia, Ghana, Kenya, Colombia, Kenya and Uganda, to name a few. These initiatives have received backing from the International Bamboo and Rattan Organization (INBAR), highlighting the global recognition and application of value chain analysis in enhancing the bamboo sector's contribution to economic development.

This study, "Bamboo Market and Value Chain in Brazil," was conducted through a collaborative effort by the International Bamboo and Rattan Organization (INBAR), BAMbuild, NAP BioSMat at the University of São Paulo (USP), FAPESP, projeto PIPE número: 2022/01191-3 e 2022/08553-8), and other key partners. As part of a broader initiative, this study aims to deepen our

understanding of the sector, leveraging Brazil's vast bamboo diversity and the supportive legislative environment to foster sustainable management and sector integration. Through this endeavor, the study aims to catalyze sustainable growth and environmental stewardship within Brazil's bamboo sector. This report will specifically focus on key areas including the production chain, market dynamics, national and international market analyses, and strategic recommendations for value chain enhancement, informed by global value chain research and its implications for rural development and environmental sustainability.

1.1. Objectives of the report

The primary aim of this report is to depict the current state of the bamboo value chain in Brazil, identifying the companies, the size of the market, amount of export and import in the last years, which are the regulatory frameworks in progress, compare with the international market and propose recommendations for strengthening the bamboo value chain in Brazil. The specific objectives of the report are as follows:

Mapping of Brazil's Bamboo Value Chain: To delineate each step of the bamboo value chain in Brazil, from cultivation and harvesting through to processing, manufacturing, distribution, and end-use. This includes identifying key stakeholders involved at each stage, such as local farmers, processors, manufacturers, distributors, retailers, and consumers, to understand their roles, challenges, and opportunities.

Mapping of Market Dynamics: Examining global trends influencing the bamboo sector's evolution, encompassing technological advancements, consumer behavior shifts, and emerging business models.

1.1.1. National Market Analysis:

- Description and Analysis of the Production Chain: Unpacking the intricacies of Brazil's bamboo production chain.
- Evolution of Production, Consumption, Prices, Imports, and Exports: Assessing historical trends and current dynamics within Brazil's bamboo market.

- Regulatory Framework and Proposals: Evaluating existing regulations and suggesting adjustments to foster sector growth.
- Profile and Segmentation of the Bamboo Sector in Brazil: Providing a detailed profile of Brazil's bamboo sector, segmenting it based on key criteria.
- Synergies with Other Sectors: Identifying potential collaborations and synergies with other supported industries.
- Participation of Domestic and Foreign Investments: Assessing investment trends and key differentials in the bamboo sector.
- SWOT Analysis: To conduct a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis specific to Brazil's bamboo industry. This will help in understanding the internal and external factors that influence the sector and can guide strategic decision-making.

1.1.2. International Market Analysis:

- Global Value Chain: Investigating the global bamboo value chain and identifying key participants.
- Global Market Segmentation: Categorizing the international bamboo market based on relevant factors.
- Target Audience and Access Strategy for Companies: Defining the target audience and proposing effective access strategies.
- International Trade Flows: Analysing the flow of bamboo products in the international market.
- Markets with Potential and Complementarity: Identifying markets with significant potential and complementary features.

1.1.3. Formulating Strategic Recommendations:

Integral to this report is the development of actionable recommendations aimed at enhancing each segment of the bamboo value chain in Brazil. These recommendations will be grounded in the insights derived from the national and international market analyses, the SWOT analysis, and will be designed to address the identified challenges while capitalizing on the opportunities within the sector.

2. Methodology

This study employs a multifaceted methodological approach to comprehensively analyze Brazil's bamboo market and value chain, with a particular focus on the geographical distribution of resources and the socio-economic dynamics within the sector.

2.1. Study Area

The study is conducted in Brazil, a nation with a vast expanse of land and a rich demographic and ecological diversity. This diversity is crucial to our examination of the bamboo production chain and market dynamics. Brazil ranks as the fifth-largest country in the world, covering an area of 8,510,417.771 km². It is also the world's seventh most populous nation, with a population of 203,062,512 according to the latest data from the Brazilian Institute of Geography and Statistics (IBGE, 2022). The intersection of this extensive land area, demographic diversity, and a wide variety of biomes underscores the unique position of Brazil in terms of geographic and demographic complexity. Such an analysis provides insights into the distribution and significance of the bamboo production chain across different regions.

The country's geographic diversity is significant, featuring six distinct biomes, presented in Table 1, each contributing to the nation's biodiversity and playing a role in shaping its cultural and economic nature. The Estimation and Analysis of Bamboo Resources and Species Distribution in Brazil study has revealed the presence of 316 species across 52 genera, with an extensive bamboo coverage estimated to be around 5.26 million hectares, which may still be an underestimation of the actual resources. This study leverages the foundational data provided by the bamboo resources and species distribution Study, utilizing it as a base to explore the interconnectedness of bamboo resources with the economic, cultural, and environmental facets of the country. The geographical and demographic parameters set forth by this survey inform the subsequent stages of our value chain and market analysis, ensuring a targeted and contextually relevant approach.

Table 1: Brazil Geographic Survey.

Country Area	8,510,417.771km²	
Country Latitude	-07º 09'18"	-07º 32'09"
Country Longitude	-60º 12'45"	-53º 23'50"
Biomes Areas	Amazônia	4.196.943 km²
	Cerrado	2.036.448 km²
	Mata Atlântica	1.110.182 km²
	Pampa	176.496 km²
	Caatinga	844.453 km²
	Pantanal	150.355 km²

Source: IBGE 2022

2.2. Data Collection Sources

2.2.1. Literature Review

Conducted a comprehensive analysis of the bamboo value chain in Brazil, this report first employs a literature review approach, focusing on publications that explore various aspects of the bamboo industry within the country. The literature search was strategically designed to capture the most relevant studies by incorporating specific keywords related to the bamboo value chain and market analysis in Brazil and across the globe. The search terms used were “bamboo value chain” and “bamboo market analysis” in combination with “Brazil,” applied to titles, abstracts, and keywords to ensure a precise alignment with the research objectives. To encompass significant Brazilian literature, terms in Portuguese were also included in the search criteria.

The explored databases include but are not limited to:

- Biblioteca Digital Brasileira de Teses e Dissertações (Brazilian Digital Library of Theses and Dissertations)
- Google Scholar

- ResearchGate
- International Network for Bamboo and Rattan (INBAR) Website
- Scopus

2.2.2. Web Analysis and Collaborative Mapping Insights

To understand the landscape of Brazil's bamboo sector, we integrated web analysis and collaborative mapping into our research methodology. Using the "Bambuzeiros do Brasil" platform, founded by Bruno Imbroisi, we accessed a comprehensive directory of over 300 bamboo-related contacts. This rich source of data enabled us to identify and categorize the geographic distribution of companies, institutions, and individual enthusiasts engaged in the bamboo industry.

Our approach involved detailed reviews of company websites to evaluate their product offerings and market positioning. This was paired with remote sensing techniques to obtain a visual representation of bamboo cultivation areas, providing a more robust understanding of the sector's value chain. The platform's dynamic nature, with ongoing updates from Imbroisi and community contributions, was invaluable for our analysis, offering real-time insights into the evolving bamboo network in Brazil.

Figure 1 sourced from the Bambuzeiros do Brasil platform, illustrates the widespread distribution of bamboo-related entities and underscores the industry's diversity and extent across the nation.

Figure 1. Distribution of bamboo-related entities in Brazil, showcasing the industry's reach and diversity. (Source: Bambuzeiros do Brasil platform, accessed from https://www. Bambuzeirosdo brasil.com.br 2023/**)**

2.2.3. Data Collection through Qualitative and Quantitative Questionnaires

A set of structured questionnaires was designed to capture primary information on the bamboo value chain. The initial round of questionnaires focused on basic inquiries, with a qualitative exploratory approach, yielding 60 responses that shaped the second round of more detailed questionnaires. The primarily open-ended questions allowed us to understand the critical criteria defining the sector, which informed the development of the subsequent questionnaire. This phase resulted in 60 valuable responses, offering a broad perspective on the industry's landscape.

Building on the qualitative data, a second round of questionnaires was designed with a quantitative focus. These questionnaires featured structured queries with a range of numerical options to quantify aspects of the bamboo value chain. The shift to quantifiable data aimed to refine the initial insights and provide a more detailed analysis of the sector.

2.2.4. Stakeholder Interviews

In addition to the questionnaires, over 100 in-depth interviews were conducted with various stakeholders to enrich the data with personal narratives and expert opinions. These discussions were partly facilitated during the first International Conference on Bamboo Development in Southern Countries, supported by INBAR, where we engaged with a diverse group of participants, offering a wealth of knowledge and experience. The interviews were supplemented by contacts acquired through various channels.

2.2.5. Trade Data Acquisition- Data Retrieval Process

For the evaluation of trade flows involving bamboo products, we sourced data directly from Brazil's official trade records. We utilized the "Estatísticas de Comércio Exterior em Dados Abertos" platform, provided by the Ministry of Development, Industry, Commerce, and Services of Brazil. This open database allowed us to conduct a transparent and precise analysis of the country's import and export activities related to bamboo. The data retrieval was methodically executed through the following steps to ensure accuracy and relevancy:

Platform Navigation: The open trade statistics was accessed via the official government platform (www.gov.br).

Time Frame Selection: Filters were applied to isolate the trade data to the most recent complete year, providing a snapshot of the latest trade patterns.

HS Code Classification: We utilized specific Harmonized System (HS) codes associated with bamboo products to refine our search and extract pertinent trade records.

Data Structuring: The extracted data was downloaded in a structured format, an Excel file, enabling us to perform detailed analyses.

This methodical approach to data collection ensured that we gathered reliable and precise information relevant to Brazil's bamboo trade, forming a solid base for our subsequent market analysis.

2.2.6. Ethical Considerations and Data Privacy

All data was retrieved and used in compliance with data privacy regulations and ethical research standards. As the data was sourced from an open government database, no private or confidential information was accessed or utilized in the analysis.

2.3. Analytical framework

Quantitative Analysis: Certain statistical tools were employed to analyse the trade data, focusing on the export and import values of different bamboo products. In addition, Key performance indicators (KPIs), such as trade volumes, growth rates, and market shares, were calculated to assess the trade dynamics. Then, trend analysis was used to observe patterns over time, and comparative analysis helped in understanding Brazil's position in the global bamboo market.

Qualitative Analysis: For the company data, we undertook a content analysis of the information gathered, categorizing companies based on their products and services. We also analysed the geographical distribution and market reach of these companies, identifying clusters and gaps in the market.

GIS Mapping: To visualize the geographical spread and trade flows, Geographic Information Systems (GIS) mapping was utilized. This allowed us to plot the locations of the companies on a map of Brazil and overlay trade data to provide spatial context to the numbers. The mapping highlighted:

- **Geographic Concentrations**: By mapping company locations, we identified regions with high densities of bamboo-related activities, providing insights into potential hubs of production and innovation.

- **Trade Flow Visualization**: We integrated trade data with the GIS to depict export and import values geographically, allowing for a visual representation of trade intensities and directions.
- **Comparative Regional Analysis**: The GIS mapping enabled us to perform a comparative analysis between different regions, identifying disparities in development levels and opportunities for growth.

3. Data Analysis of Bamboo Companies

This section presents an analysis of the data collected from approximately 300 bamboo companies operating across Brazil. This analysis is crucial to understanding the current landscape of the bamboo industry and its stakeholders, including the geographical distribution, variety of products, market reach, and the economic impact these companies have on the national and international levels.

3.1. Company Profiles and Products

In Brazil, the categorization of bamboo products is diverse and multifaceted, reflecting the versatile nature of bamboo as a resource. Figure 2 represents a treemap visualization of various bamboo product categories, based on data collected from approximately 317 operational bamboo companies in Brazil. The treemap visualization offers a succinct overview of the bamboo product landscape as sourced from the surveyed companies. It illustrates the proportional representation of each product category within the industry, giving stakeholders a clear understanding of market segments and product diversity.

In the figure, the main categories of bamboo products are identified, each with a specific color and size associated with its market share. The most prominent category is "Chairs", comprising 14.01% of the market, showcasing the significant role bamboo plays in the furniture industry. "Tables" follow closely, making up 12.93% of the product distribution, which reinforces the importance of bamboo in seating solutions due to its strength and sustainability.

The "Decoration/Crafts" category accounts for 12.66% of the market, demonstrating bamboo's aesthetic appeal and the creativity it inspires among artisans. "Bamboo Slats" represent 8.08% of the product mix, pointing to their widespread use in construction and manufacturing due to their versatility and durability.

Other notable categories include "Bamboo Pots" and "Bamboo Seedlings", with 6.46% and 5.39%, respectively, indicating a growing trend in the use of bamboo for horticultural purposes and sustainability projects.

Lesser-known and equally important are the niche segments such as "Charcoal", "Geodesic Dome", and "Sculpture", each constituting 0.53% of the market. Although smaller in proportion, these categories underscore bamboo's potential in unconventional markets and innovative applications.

In figure the data is based on a total of 371 products among entities. This quantifies the scope of the dataset and reaffirms the substantial sample size that underpins the analysis.

In summary, the treemap visualization not only depicts the rich diversity of bamboo-based commerce in Brazil but also signifies the strategic opportunities that lie in each segment. For businesses, investors, and policymakers, this analysis can serve as a guiding tool to identify growth areas, investment priorities, and the potential for innovation in the bamboo sector.

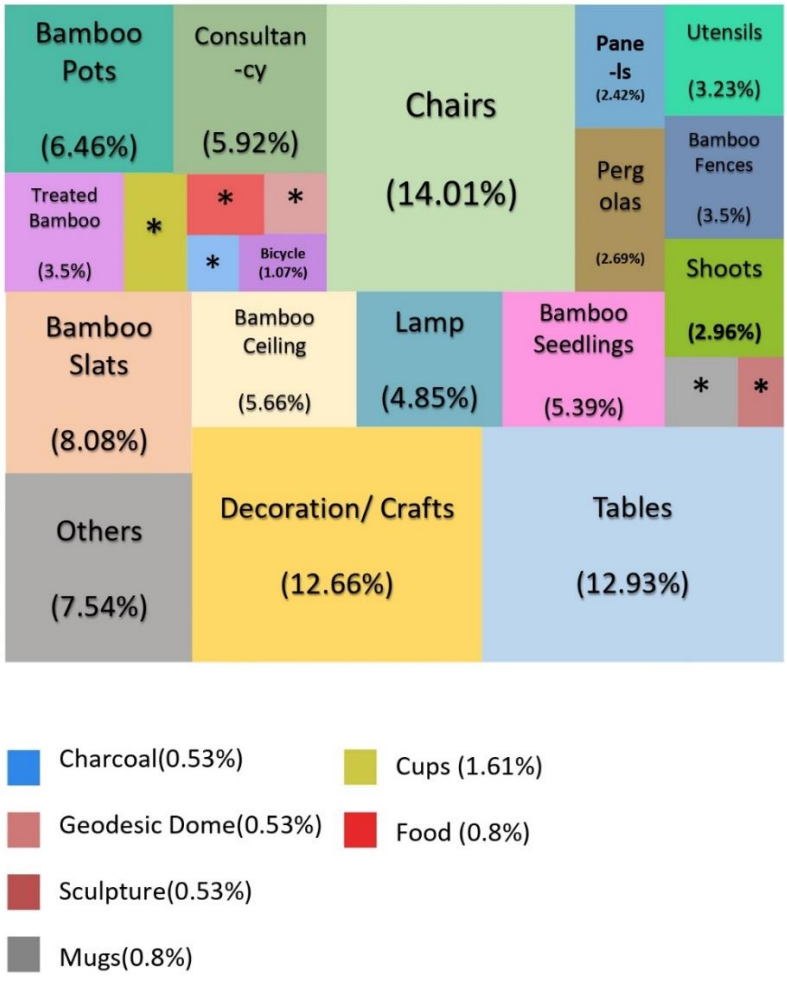

Figure 2. Treemap of bamboo products across Brazil.

Also, it is worth mentioning that despite the relatively small size of many of the bamboo companies surveyed, the product range is impressively broad, highlighting the resourcefulness and versatility of these enterprises. This diversification is indicative of a robust sector that capitalizes on the multifunctional nature of bamboo.

The observed variety in the product range—from construction materials such as bamboo slats, which are essential for their structural qualities, to utensils, which leverage bamboo's lightweight and renewable properties—suggests a strategic approach by these companies to tap into different market needs. It reflects a keen understanding of the unique properties of bamboo, which allows it to be transformed into a wide array of products.

Moreover, the presence of companies with multiple product lines may be a response to the dynamic demands of the market. By offering more than two product types, these companies are not only expanding their market reach but are also enhancing their resilience against market fluctuations. This is particularly important for small enterprises that need to maintain competitiveness and ensure business sustainability.

The production of a diverse range of products from construction materials to daily use items like utensils is also a testament to the innovation within the industry. Companies are exploring the full potential of bamboo, which is not only environmentally friendly but also economically beneficial. It allows for the creation of niche markets, such as bamboo charcoal and geodesic domes, while simultaneously serving mainstream sectors with products like furniture and crafts.

This strategic diversity also bodes well for the sector's contribution to the economy, as it can cater to both domestic needs and international markets. As companies continue to innovate and explore new uses for bamboo, the industry is likely to see sustained growth and an increased contribution to the green economy.

3.2. Diversified Utilization of Bamboo: Categorization across Sectors

Bamboo's versatility is exemplified by its broad application across multiple sectors, indicating not only its adaptability but also the innovative spirit of the industries that utilize it. The analysis of

company practices within each sector illustrates a significant inclination towards producing a diverse range of bamboo products.

1. **Utensils**: This sector stands out with the highest engagement, where companies frequently produce a wide array of products, from simple bamboo cutlery to more complex kitchen utensils, often combining multiple product lines.

2. **Farming**: Companies engaged in farming utilize bamboo for a variety of purposes, such as tools, structures, and even as a crop itself, with many firms integrating bamboo into dual agricultural practices.

3. **Construction**: The construction sector demonstrates the structural utility of bamboo, not just for scaffolding or temporary structures but also in permanent architectural features, with companies often offering a blend of construction solutions.

4. **Handicraft**: Creativity thrives in the handicraft sector, with firms typically crafting multiple types of decorative items and personal accessories, showcasing the aesthetic versatility of bamboo.

5. **Furniture**: Firms in the furniture sector leverage the strength and beauty of bamboo to produce both functional and decorative pieces, commonly expanding their offerings to include a range of indoor and outdoor furniture.

6. **Courses**: Educational enterprises offer training in various bamboo-related disciplines, often encompassing both practical skill development and theoretical knowledge dissemination.

7. **Research**: The focus within this sector is on developing innovative uses for bamboo, with research companies often conducting multiple projects spanning different applications and product developments.

8. **Food**: Though fewer in number, companies in the food sector are beginning to explore bamboo's culinary potential, with some engaging in both the production of bamboo as food

and its use in food-related products such as canned and fermented shoots, pickle, shoot powder, bamboo juice and water, beverages, bamboo shoot fortified food products, and bamboo starch.

9. **Energy:** Bamboo is utilized as a renewable biomass resource, with pioneering companies working on more than one front to develop bamboo-based energy solutions.

This diversified utilization pattern underlines the extensive nature of bamboo's role within the Brazilian economy, with a majority of firms across all sectors engaged in producing more than one type of bamboo product. The findings indicate that multi-product production is a common strategy, likely driven by the resource's versatility and the market's demand for sustainable and innovative bamboo-based solutions. Figure 3 provides an overview of the bamboo industry in Brazil, highlighting both the sectoral diversity and the geographic spread of bamboo-related activities.

The ribbon chart in Figure 3 A illustrates the segmentation of companies according to the number of sectors in which they operate, showing the visual distribution of companies that operate in 1, 2, or 3 sectors. Each ribbon represents the relationship between the sectors and the number of companies operating in each of these combinations. The different widths of the ribbons indicate the volume of companies in each category, with a wider ribbon representing a larger number of companies operating in a certain sector or combination of sectors. This visualization facilitates the identification of sectoral operation trends, such as the presence of diversification or specialization in companies.

For instance, in the Tools sector, there are 37 companies engaged in primary activities, 8 companies in secondary activities, and 4 companies in tertiary activities. This indicates that the majority of companies in the Tools sector focus primarily on primary activities, with fewer companies extending their operations to secondary and tertiary activities.

Figure 3 B complements this by mapping out the physical locations of these activities, showing that certain regions, especially in the south and southeast, have higher concentrations of specific

bamboo-related sectors. This geographic distribution aligns with the sectoral data, offering insights into regional strengths and potential areas for targeted development and investment.

The map illustrates the regional diversity in bamboo-related activities, highlighting sectors such as research, handcraft, seedling production, treated bamboo, pharmaceuticals, food, and construction. The concentration of bamboo construction activities in the southern and southwestern regions and the widespread demand for bamboo crafts are particularly notable.

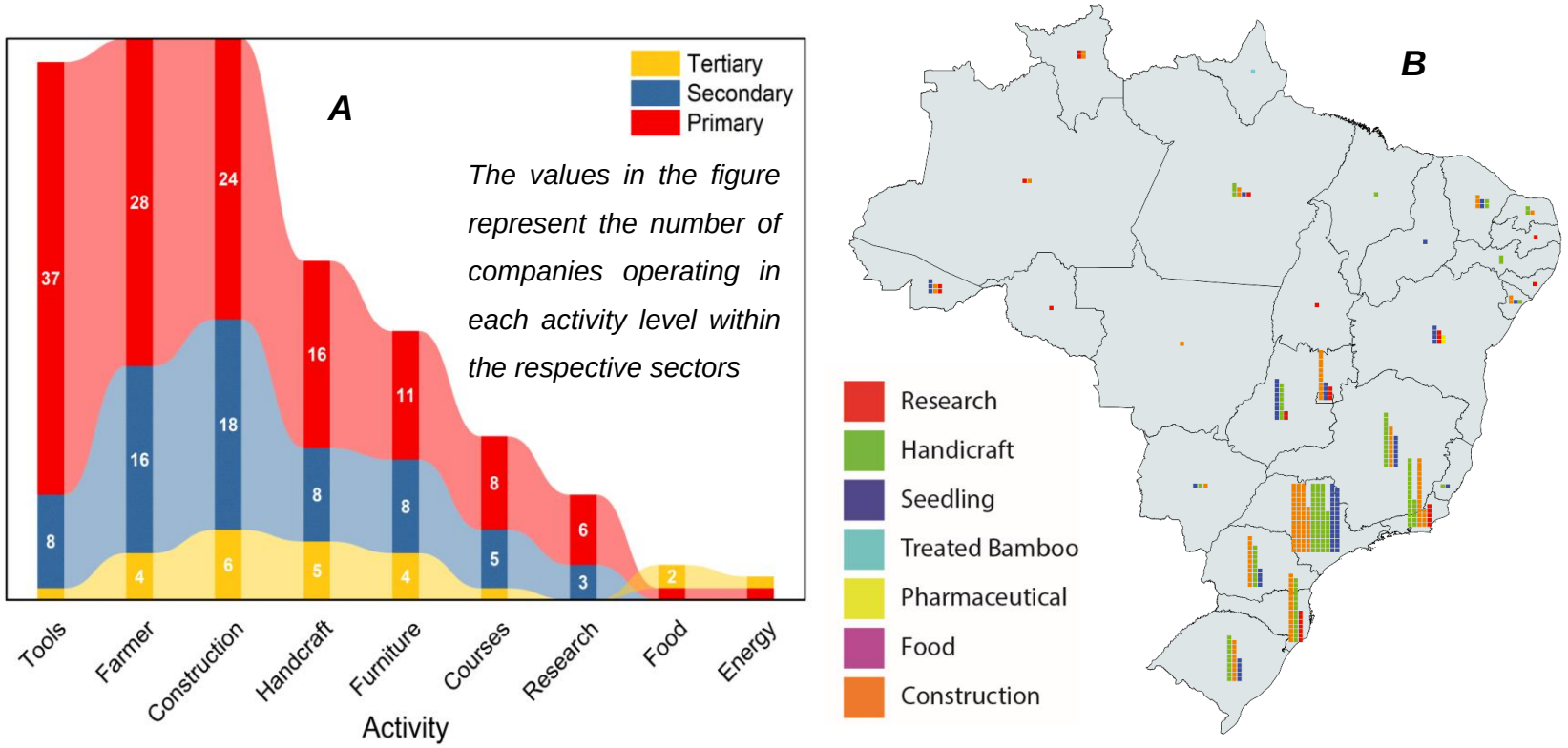

Figure 3. Segmentation and Geographic Distribution of Bamboo-Related Activities in Brazil, (A) Segmentation of Bamboo-Related Companies by Sector and Activity Level, (B) Geographic Distribution of Bamboo-Related Activities Across Brazil.

3.3. Geographical Distribution

The distribution of bamboo-related companies across different Brazilian states is presented in Table 2. In figure 4, it utilizes varying shades of color to indicate the density of companies within each state, offering a clear visual representation of the industry's concentration in certain areas.

Based on the data collected, we can offer an exploratory analysis that provides an indicative rather than definitive picture of the distribution of bamboo-related companies across various states in Brazil. It is important to note that while this data sheds light on a pattern of industrial presence, the actual number of companies may vary. This variation could be due to a range of factors including, but not limited to, the dynamic nature of the industry, the potential existence of unregistered or newly established businesses, and the limitations inherent in the data collection process.

Table 2. Geographical distribution of bamboo-Related companies in Brazil by state.

State	Number of companies	Companies per 1000 km²
São Paulo	120	0.483
Rio de Janeiro	36	0.822
Santa Catarina	27	0.282
Minas Gerais	24	0.041
Goiás	20	0.059
Rio Grande do Sul	16	0.057
Bahia	8	0.014
Acre	7	0.043
Pará	5	0.004
Ceará	4	0.027
Amazonas	2	0.001
Mato Grosso	2	0.002
Mato Grosso do Sul	2	0.006
Rondônia	1	0.004
Espírito Santo	2	0.043

Rio Grande do Norte	2	0.038
Tocantins	1	0.004
Piauí	1	0.004
Roraima	3	0.013
Paraíba	1	0.018
Alagoas	1	0.036
Sergipe	1	0.046
Amapá	1	0.007
Pernambuco	2	0.020
Maranhão	1	0.003
Paraná	16	0.080
Distrito Federal	11	0.040
TOTAL	317	0.037

As per above Table 2, São Paulo emerges as the state with the highest reported number of bamboo-related companies, with a total number of 120 businesses operating within its borders. This figure significantly outnumbers the bamboo business in other states. This may be due to São Paulo's robust industrial infrastructure and economic environment conducive to business growth.

The data also suggests a moderate concentration of companies in states such as Rio de Janeiro, Santa Catarina, Minas Gerais, and Goiás, with each hosting between 20 and 36 companies. These numbers, while tentative, indicate a possible regional clustering of the industry.

It was achieved from a total number of 317 companies across all states, set against the backdrop of Brazil's substantial land area. It is, however, imperative to approach this total with caution, acknowledging that it likely represents a snapshot of a more complex and fluid industry landscape.

It's essential to consider these figures as approximations that serve as a starting point for further investigation and verification. Additional research, potentially incorporating field surveys, cross-referencing with official business registries, and outreach to industry associations, would be

beneficial in refining these estimates and gaining a more comprehensive understanding of the bamboo-related industrial panorama in Brazil.

Building upon the preliminary insights from the current dataset, it's worth acknowledging the role of technological solutions in enhancing data accuracy and comprehensiveness. Bruno's initiative in developing a robust system for data entry on the "Bambuzeiros" map platform is a commendable step towards achieving a more inclusive and detailed representation of bamboo-related companies in Brazil.

In contrast, the vast Amazonas, with its expansive area, shows a relatively sparse industrial presence in this sector, reporting only two companies. This could be attributed to various logistical, economic, or environmental factors that may impact the establishment and operation of businesses in the region.

Furthermore, several states including Rondônia, Tocantins, Piauí, Paraíba, Alagoas, Sergipe, Amapá, and Maranhão are reported to have only a solitary company within this dataset. This minimal presence could point to underdevelopment in this sector within these regions or could simply be a reflection of the data not capturing the complete picture.

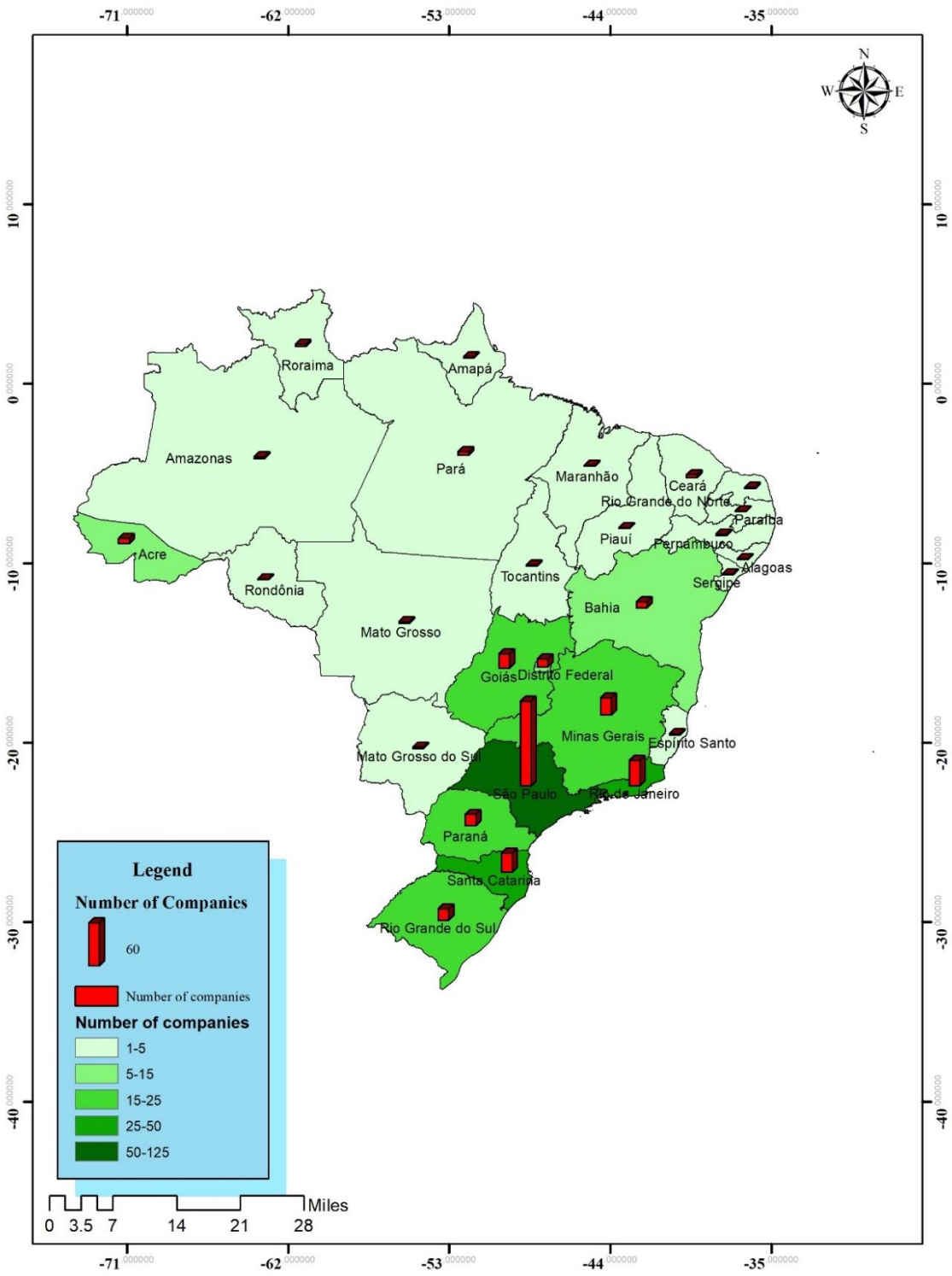

Figure 4. Distribution of bamboo-related companies across different Brazilian states.

4. Bamboo Value Chain Analysis

The bamboo value chain, illustrated in Figure 5, is a comprehensive representation of the journey from bamboo cultivation to product marketing. In what follows the analysis of each stage is presented.

4.1. Bamboo Value Chain Stages

4.1.1. Production

Bamboo production is the foundation of the value chain, which is split into two distinct approaches:

- **Natural Stand:** This involves the sustainable management and harvesting of bamboo from its natural habitat, supported by responsible silviculture practices to ensure the bamboo's growth is ecologically sound.
- **Plantation:** Bamboo is also cultivated in controlled plantation environments, aimed at commercial production. These plantations serve as carbon sinks and contribute to ecological restoration, furthering environmental conservation efforts.

The production phase is marked by ecological considerations, where both the natural stand and plantation methods focus on sustainability.

4.1.2. Processing

The processing phase transforms raw bamboo into usable materials and products, which is divided into three key stages:

- **Primary Processing:** In this initial phase, bamboo is treated to produce basic forms such as poles, food items, and fodder/leaves.
- **Secondary Processing:** Involves more intricate processes like cutting, crushing, splitting, and slivering, which prepare the bamboo for further refinement.
- **Tertiary Processing:** At this advanced stage, bamboo undergoes manufacturing into high-value products like laminates, panels, woven products, and pulping, as well as value added into prefabricated products.

An additional stage, Waste Recycling, ensures the sustainable use of all bamboo materials, where waste products are repurposed, thereby minimizing loss and maximizing resource utilization.

4.1.3. Utilization

The utilization stage is where processed bamboo is incorporated into various applications:

- Industrial Use: Bamboo is widely used in industrial sectors, particularly in construction and architecture, thanks to its strength and versatility.
- Domestic Use: On a household level, bamboo finds its place in numerous domestic applications, from structural elements to everyday items.

The range of bamboo products is diverse, including poles, engineered laminates, panels, tiles, floorboards, paper products, food items, and composites. The sector also innovates with bamboo-based energy sources, such as charcoal and briquettes.

4.1.4. Marketing

Marketing bridges the gap between bamboo products and consumers:

- Local and Foreign Markets: Products are marketed and distributed within Brazil and to foreign markets, catering to various consumer needs.
- Household/Domestic: A focus on household and domestic marketing targets the end-user directly, promoting bamboo products for home use.

Throughout the value chain, critical factors such as transportation, demand and supply balances, and regulatory compliance influence each stage. Feedback mechanisms, depicted by dotted lines in the figure, allow for the continuous improvement of production and processing based on market demands and consumer feedback. This cyclical approach ensures the bamboo industry remains adaptive and responsive to market conditions.

The value chain underscores the importance of each step in adding value and reflects the industry's commitment to sustainability. From the carbon-sequestering capacities of bamboo plantations to the ecological benefits of sustainable harvesting and the economic potential of processed bamboo products, the value chain demonstrates the multifaceted significance of bamboo within Brazil's economy and its potential for contributing to a greener future.

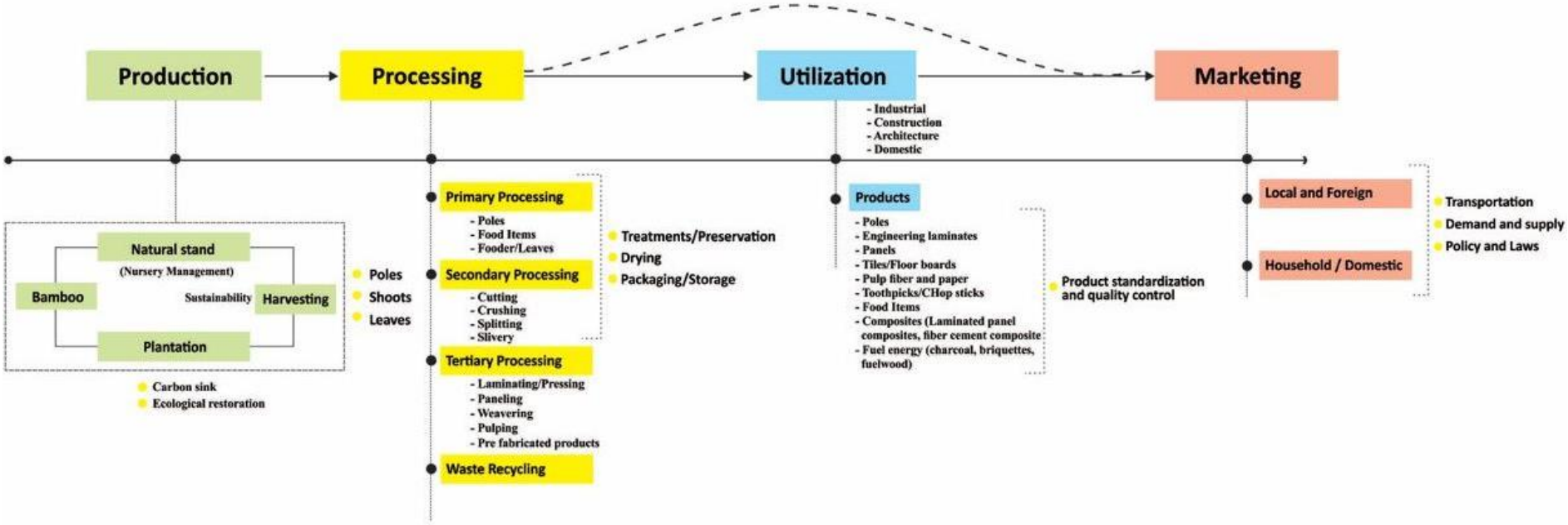

Figure 5. Bamboo value chain.

4.2. Critical Factors Influencing the Bamboo Value Chain

The efficiency and success of the bamboo value chain are governed by several critical factors, which can significantly impact the flow from production to marketing:

Transportation and Logistics: The movement of raw materials and finished products is central to the value chain's functionality. Efficient transportation affects the cost, quality, and timing of the delivery of bamboo products.

Demand and Supply Dynamics: Market demand and the capacity to supply bamboo products determine the scalability and sustainability of the value chain. Understanding these dynamics is crucial for aligning production with market needs.

Regulatory Compliance and Standards: Adherence to national and international regulations, including trade policies, environmental laws, and product standards, ensures legal operations and market access.

Quality Control: Maintaining high-quality standards throughout the value chain is imperative for customer satisfaction and brand reputation, influencing both processing techniques and final product quality.

Market Feedback Mechanisms: Feedback from consumers and market trends allows for iterative improvements in products and processes, making the industry more responsive and competitive.

Innovation and Technology: Technological advancements can optimize each stage of the value chain, from precision agriculture in bamboo cultivation to innovative processing methods that enhance product quality and diversification.

Environmental Impact: Sustainable practices across the value chain not only protect ecological systems but also meet the increasing consumer demand for environmentally responsible products.

Socio-economic Factors: The value chain is also influenced by socio-economic factors such as labor conditions, community engagement, and fair-trade practices, which can affect the social license to operate.

Each of these factors plays a pivotal role in the functioning of the bamboo value chain and must be carefully managed to ensure the industry's overall growth and sustainability.

4.3. Stakeholder Engagement in the Bamboo Value Chain

Understanding the roles and relationships of stakeholders within the bamboo value chain is crucial to understanding the whole picture of the industry's dynamics. Stakeholders are the backbone of the value chain, each playing specific roles that collectively contribute to the industry's success. The primary stakeholders in Brazil's bamboo value chain include:

- **Producers:** These are the farmers and cultivators who grow bamboo. Their practices, which range from small-scale traditional farming to large-scale commercial plantations, significantly affect the quality and sustainability of the bamboo supply.
- **Processors:** This group includes entities involved in the primary, secondary, and tertiary processing stages of bamboo. They transform raw bamboo into a variety of products, influencing the material's value addition.
- **Distributors and Retailers:** These stakeholders are responsible for the distribution and sale of bamboo products to local and international markets. They act as the link between producers, processors, and final consumers.
- **Final Consumers:** The end-users of bamboo products, whose preferences and demands drive the market trends and influence the value chain's responsiveness to consumer needs.
- **Government and Regulatory Bodies:** These stakeholders set the legal and economic framework within which the bamboo value chain operates. They influence through policy-making, regulatory standards, subsidies, and trade agreements.
- **Research Institutions and NGOs:** Organizations that provide technical support, innovation, and advocacy play a vital role in advancing sustainable practices and market development within the bamboo sector.

- **Financial Institutions:** Banks and investors provide the capital necessary for the expansion and technological advancement of bamboo operations.
- **Transporters:** Companies that specialize in logistics and transportation ensure the movement of bamboo products from farms to processing centers and from manufacturers to markets.

5. Market Analysis

5.1. Global Bamboo Market Growth and Projections: Insights and Opportunities

Based on the report presented by the market analysis group “Future Market Insights: Bamboo Products Market Outlook 2023 to 2033”, the global bamboo market is experiencing significant expansion, underscored by a notable valuation of USD 73,432.4 million in 2023. Forecasts predict a robust growth trajectory, with a compound annual growth rate (CAGR) of 6.0%, aiming for a market size of USD 131,506.2 million by 2033. This growth is fueled by concerted global sustainability efforts, a concerted push towards reducing plastic waste, substantial infrastructure investments, and a noticeable rise in consumer awareness regarding sustainable products. Additionally, manufacturers are increasingly turning towards sustainable resources, further propelling market growth. According to the report, in 2022, the U.S. dominated the North American bamboo products market with an 82.2% share, projected to reach USD 12.3 billion by 2033. Other significant markets include Germany in Europe, and China, India, Australia, and Japan in the Asia-Pacific region, with India's market expected to grow annually by 10.3%, reaching USD 2.1 billion by 2033, and China's market projected to grow by 9% annually, achieving a total value of USD 3.4 billion by 2033.

According to Grand View Research Report on Global Bamboo Market Size and Share (2022-2030), the global bamboos market is expected to grow at a compound annual growth rate of 4.5% from 2021 to 2030 to reach USD 88.43 billion by 2030.This segment's growth is driven by escalating demands for green construction materials, growing awareness of the health benefits associated with bamboo, and the launch of eco-friendly bamboo products. The shift towards replacing plastic products with bamboo alternatives is anticipated to further stimulate market sales. Bamboo's inherent versatility and durability, alongside its non-toxic nature, make it an ideal choice for a variety of construction materials and household products, such as cutting boards and dinnerware, which are favored for their resistance to bacterial growth, chemical-free nature, and biodegradability.

Innovative bamboo applications continue to emerge, paving the way for new market entrants. Key industry players include MOSO International BV, Bamboo Village Company, Kerala State

Bamboo Corporation, and others, who are contributing to the market's dynamic evolution through innovation and expansion.

This integration not only complements the existing Market section but also provides a broader perspective on the global bamboo industry, its economic potential, and the strategic implications for stakeholders involved in the bamboo panels value chain.

5.2. Analysis of Bamboo Product Trade in Brazil for 2023

In 2023, the Brazilian states exhibited a dynamic profile in the trade of bamboo products, with notable differences in import and export values. The trade data for bamboo products to and from Brazil was systematically acquired from the official repository of the Ministry of Development, Industry, Commerce, and Services of Brazil, utilizing their platform "Estatísticas de Comércio Exterior em Dados Abertos." This comprehensive database offers open access to detailed trade statistics, facilitating transparent and rigorous analyses of import and export activities.

5.2.1. A Comparative Analysis of Statewise Imports and Exports in 2023

This section intricacies of Brazil's bamboo trade on a state level, contrasting the import and export activities to draw meaningful insights. The analysis draws from Table 3, which provides concrete figures on imports and exports in US dollars for each state, offering a quantitative foundation for the subsequent findings. The key findings are indicative of varied economic activities across the states, with São Paulo and Santa Catarina being noteworthy for their high import values, and Santa Catarina and São Paulo again leading in exports. This disparity suggests a robust domestic market with nuanced supply and demand dynamics.

The findings, as presented in figures 6 and 7 also highlights states with balanced trade, such as Rio Grande do Sul, and those with notable discrepancies between imports and exports, such as Alagoas and Rio de Janeiro, hinting at potential areas for market development. Emerging markets with untapped potential are signaled by lower trade figures, as seen in Amapá and Piauí. Furthermore, the trade gaps in states like Goiás and Roraima raise questions about their specific roles within the national economy, whether as primary consumers or suppliers.

The overarching narrative from the 2023 trade data paints a picture of a diverse Brazilian bamboo market, featuring both mature markets with balanced trade and nascent ones poised for growth. The significant import values in certain states underline a strong domestic demand, potentially spurring local production, while the impressive export figures from states like Santa Catarina and São Paulo showcase Brazil's growing prowess as a significant player on the global stage.

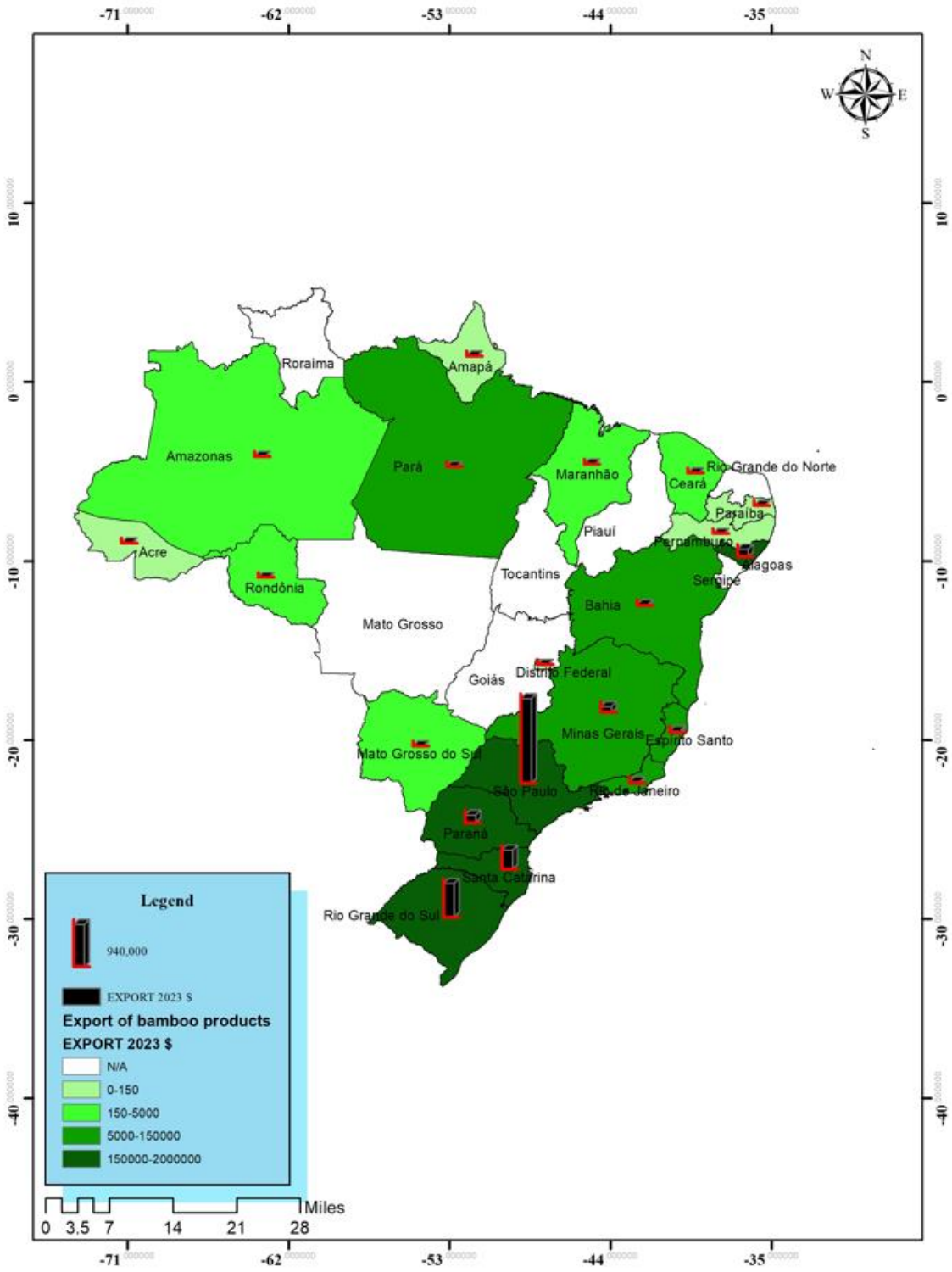

Figure 6. Geographical distribution of bamboo product exports by Brazilian states in 2023 in USD.

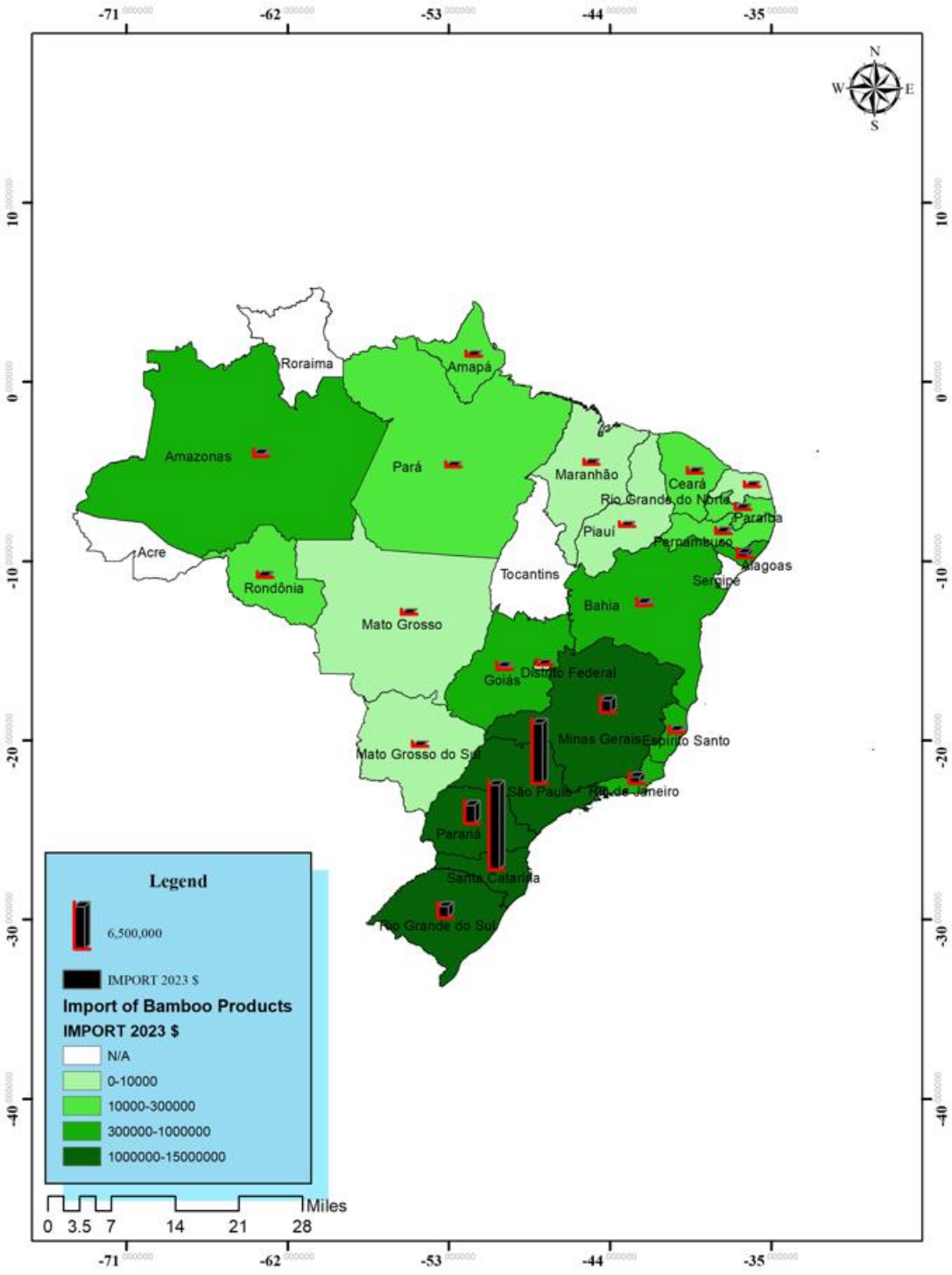

Figure 7. Geographical distribution of bamboo product imports by Brazilian states in 2023 in USD.

Table 3. State-by-state import and export values in Brazil's bamboo trade.

State	IMPORT 2023 USD	EXPORT 2023 USD
Acre	-	93
Alagoas	655,825	162,584
Amapá	11,919	48
Amazonas	361,842	242
Bahia	343,965	18,863
Ceará	99,552	1,007
Espírito Santo	320,738	27,075
Estrito Federal	9,009	103
Goiás	367,905	-
Maranhão	23	722
Mato Grosso	1,216	-
Mato Grosso do Sul	3,880	1,538
Minas Gerais	1,859,022	129,049
Pará	33,035	9,282
Paraíba	108,907	55
Paraná	2,747,978	171,018
Pernambuco	212,268	6
Piauí	644	-
Rio de Janeiro	993,634	27,696
Rio Grande do Norte	8,325	-
Rio Grande do Sul	1,704,687	748,948
Rondônia	185,459	160
Roraima	-	-
Santa Catarina	13,004,493	425,414
São Paulo	9,228,459	1,877,462
Sergipe	-	-
Tocantins	-	-
Dont declare	-	8,025
TOTAL	32,262,785	3,609,390

5.2.2. International Bamboo Trade Overview: Brazil's Import and Export Values by Country

The global trade landscape for bamboo products is vast and complex, with Brazil playing a significant role in both importing and exporting to and from various countries. These transactions are pivotal to understanding the market dynamics of bamboo products within and beyond Brazilian borders. Table 4 presents the international bamboo trade values with Brazil. Figures 8 and 9 illustrate Brazil's bamboo export and import activities respectively, offering a geographic representation of the trade flows. From the analysis of this data, the following key insights emerge regarding Brazil's bamboo trade:

- **China as a Major Importer**: The data illustrates that China is the predominant source of bamboo imports into Brazil, with imports worth over 30 million USD, indicating a strong reliance on Chinese bamboo products and materials.
- **Significant Exports to the United States**: The United States emerges as the largest export destination for Brazilian bamboo products, with exports amounting to over 1.1 million USD, which points to a substantial demand for Brazilian bamboo in the U.S. market.
- **Diverse Export Destinations**: Brazil exports bamboo products to a wide array of countries, from Angola to Antigua and Barbuda, which shows the versatility and acceptance of Brazilian bamboo products across different cultures and market preferences.
- **European Trade Ties**: France stands out both as an importer and an exporter in the European market, suggesting a reciprocal trade relationship with Brazil in the bamboo sector. Additionally, substantial imports from Germany and Italy indicate a strong European interest in Brazilian bamboo.
- **Latin American Trade Links**: Neighbouring countries such as Argentina, Chile, and Paraguay show import and export activity, reflecting regional trade dynamics and Brazil's influence in the South American bamboo market.
- **Asian Market Engagement**: Beyond China, countries such as India and Indonesia are notable contributors to Brazil's imports, revealing a rich and varied supply chain across Asia.
- **Minimal Transactions with African Countries**: Trade with African nations like Angola and Mozambique presents relatively minimal figures, suggesting either nascent markets or targeted trade relations focused on specific bamboo goods.

Brazil's active role in the international bamboo trade, serving as both an importer and exporter, is evident from the trade data. The diversity of its trade partners suggests global recognition and demand for Brazilian bamboo products. This international presence not only demonstrates the economic importance of the bamboo sector in Brazil but also highlights the opportunity for market expansion and increased share in the global trade.

Table 4. International bamboo trade values with Brazil.

Country	Import to Brazil USD	Export from Brazil USD
Angola	-	57,136
Antigua and Barbuda	-	16
Argentina	-	10,424
Armenia	-	716
Australia	-	4,838
Austria	-	2,031
Bahamas	-	63
Bahrain	-	251
Bangladesh	33,108	1,646
Barbados	-	31
Belgium	30,806	1,883
Bermuda	-	32
Bolivia	-	209,758
Bonaire, Saint Eustatius and Saba	-	2,122
Canada	-	4,255
Cape Verde	-	99
Cayman Islands	-	19
Chile	-	41,569
China	30,460,915	17,883
Colombia	-	33,399
Congo	-	1,040
Costa Rica	-	74,044
Curacao	-	131
Cyprus	-	455
Czech Republic	-	57
Denmark	1,066	817
Dominican Republic	-	19,359

Ecuador	-	139,506
El Salvador	-	14,498
Estonia	-	105
France	38,637	70,213
French Guyana	-	48
Gabon	-	18
Germany	382,461	2,991
Greece	-	110,906
Guadeloupe	-	101
Guam	-	356
Guatemala	-	53,907
Guinea-Bissau	-	78
Guyana	-	873
Honduras	-	28,930
Hungary	192	-
India	37,144	2,201
Ireland	-	87
Isle of Man	-	140
Indonesia	267,561	-
Italy	405,386	71,997
Japan	9,798	1,431
Lebanon	-	129
Liberia	-	4,090
Madagascar	-	4,463
Malta	-	2,389
Marshall Islands	-	4,278
Mauritius	-	270
Lithuania	360	-
Mexico	-	173,102
Morocco	1,282	-
Mozambique	-	205
Myanmar	15	-
Netherland	79,977	6,551
New Zealand	-	648
Nicaragua	-	429
Nigeria	-	-
Norway	513	2,322
Panama	-	229,058
Paraguay	-	359,581
Peru	-	32,397

Philippines	17,575	265
Poland	33,174	675
Portugal	3,980	78,054
Puerto Rico	-	60,687
Qatar	-	18
Russia	-	119,226
Saint Vincent and the Grenadines	-	3
Saudi Arabia	-	26,679
Singapore	-	824
South Korea	-	20,330
Spain	12,536	8,397
Sri Lanka	45	-
Suriname	-	527
Sweden	1,000	-
Switzerland	-	6
Thailand	2,398	1,308
Tonga	-	68
Trinidad and Tobago	-	2
Tunisia	116	-
Turkey	7,457	-
United Arab Emirates	-	188,813
United Kingdom	44,223	5,127
United States	103,415	1,156,076
Uruguay	-	96,514
Venezuela	-	33,269
Vietnam	286,950	10,150
Zimbabwe	545	-
Not clear	150	-
TOTAL	32,262,785	3,609,390

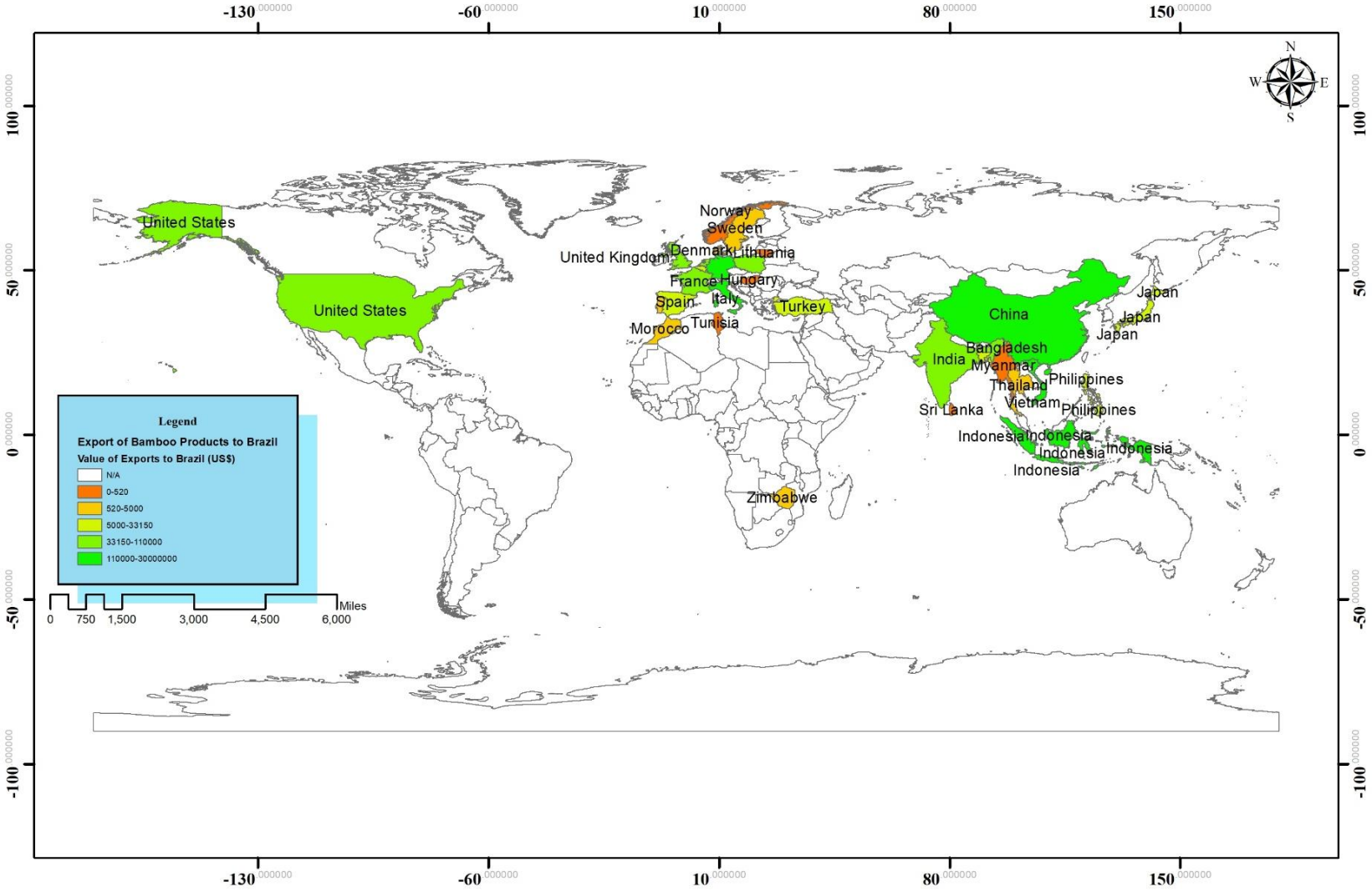

Figure 8. Geographical distribution of countries exporting bamboo products to Brazil in 2023.

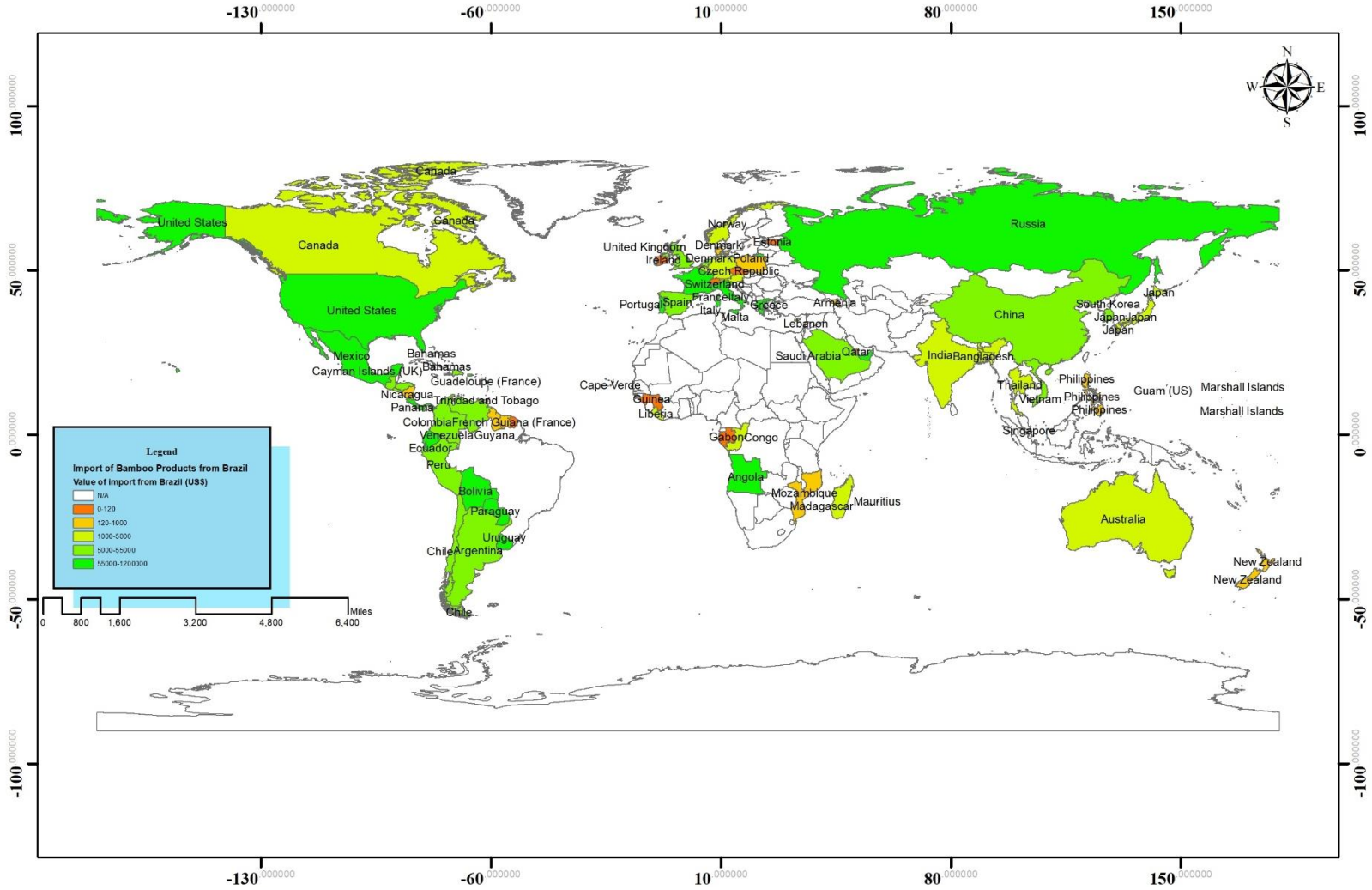

Figure 9. Geographical distribution of countries importing bamboo products from Brazil in 2023.

5.3. Overall Trade Trends (2019-2023)

This section offers a view of Brazil's bamboo product trade over the past five years, focusing on key metrics such as the USD FOB value and quantity of both imports and exports. It presents a snapshot of Brazil's evolving bamboo market dynamics, revealing growth patterns and trade volume changes.

5.3.1. Export Value and Volume Trends

Detailed analysis of export trends, highlighting the upward trajectory in export values and volumes, with a notable expansion in the variety and quantity of bamboo products exported.

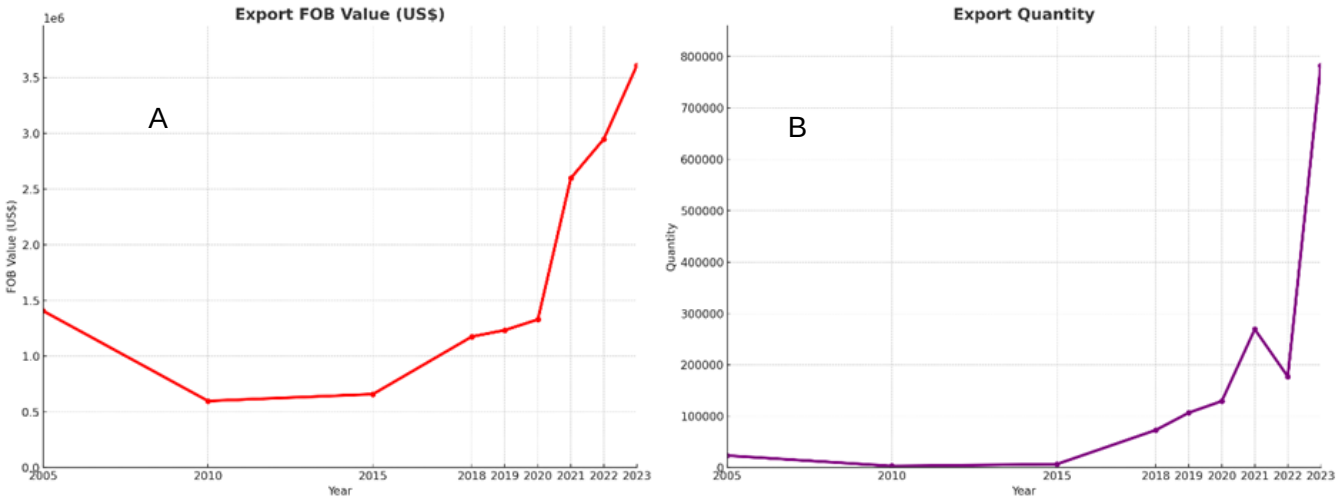

Figure 10. Twenty-year trend analysis of bamboo product exports from Brazil (2005-2023).

The trend of bamboo product exports from Brazil between 2005 and 2023 shows the following:

Analysis of Export FOB Value (US$)

The Export FOB Value graph (Figure 10 A) displays the trend in the monetary value of bamboo products exported from Brazil over the specified period. From 2005 to around 2010, there is a noticeable decline in export value, dropping from approximately $1.5 million to $0.5 million. This decline could be attributed to various factors such as global economic conditions, changes in demand, or competitiveness in the international market.

From 2010 onwards, the export value begins to stabilize and then gradually increases, reaching about $1.0 million by 2017. The most significant upward trend is observed post-2017, with a sharp increase in the export value, culminating in a peak of $3.7 million in 2023. This remarkable growth in the latter years suggests a robust expansion in Brazil's bamboo product export market, potentially driven by increased global demand for sustainable products, improved market access, or enhanced production capabilities.

Analysis of Export Quantity

The Export Quantity graph (Figure 10 B) complements the analysis of the FOB value by showing the actual quantities of bamboo products exported over the same period. The quantity data shows a similar initial decline, stabilizing at around 50,000 units between 2010 and 2015. From 2016 onwards, there is a gradual increase, with a significant spike occurring from 2020 onwards. By 2023, the export quantity reaches around 800,000 units.

The sharp rise in both the FOB value and export quantity in recent years indicates a strong correlation between the volume of exports and their monetary value. This correlation underscores the growing importance and acceptance of bamboo products in international markets, reflecting successful efforts in market penetration and the increasing popularity of eco-friendly products.

5.3.2. Import Market Dynamics

Discussion on import trends, showing a general increase in the demand for imported bamboo products, with 2023 marking the highest values within the observed period. Figure 11 summarize the total annual imports in terms of USD FOB and Quantity and present the general trend of product imports to Brazil over the years 2005 to 2023.

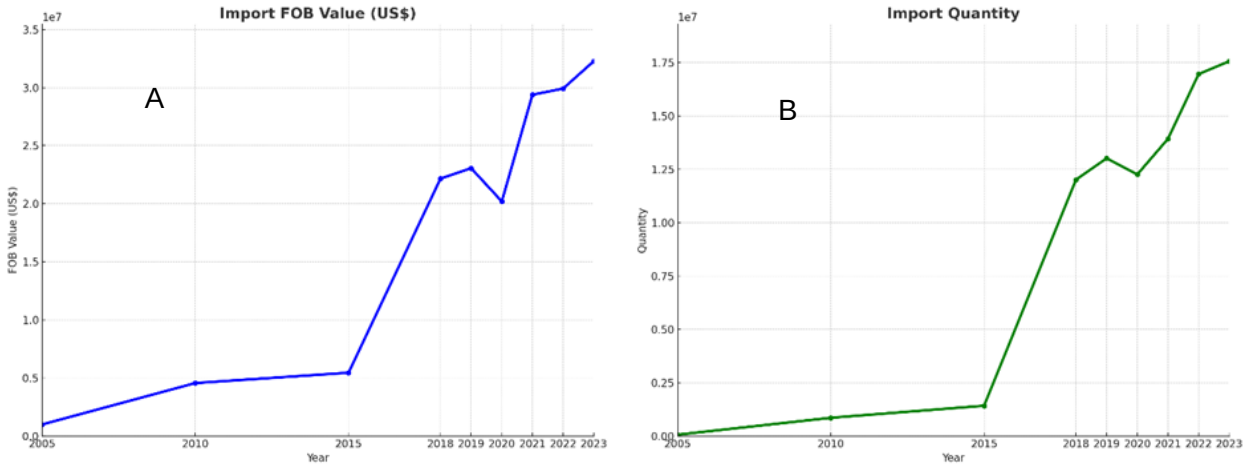

Figure 11. Five-year trend of bamboo product imports to Brazil (2005-2023).

Analysis of Import FOB Value (US$)

The Import FOB Value graph (Figure 11 A) depicts the trend in the monetary value of bamboo products imported to Brazil from 2005 to 2023. Key observations include:

- **2005-2015**: A gradual increase in import value is observed, starting from approximately $2 million in 2005 to around $5 million in 2015. This period reflects a steady but moderate growth in the import value of bamboo products.
- **2016-2023**: A notable upward trend is seen from 2016 onwards. The import value significantly jumps to about $20 million by 2017 and then sees a sharp increase in 2019, reaching approximately $23 million. Despite a slight dip in 2020, the values rebound and rise sharply in subsequent years, peaking at approximately $32.26 million in 2023.

Analysis of Import Quantity

The Import Quantity graph (Figure 11 B) shows the volume of bamboo products imported over the same period. Key points include:

- **2005-2015**: The import quantity remains relatively low and stable, with minor fluctuations, indicating modest and steady demand for imported bamboo products.
- **2016-2023**: A dramatic increase is evident from 2016 onwards. The import quantity sees a substantial rise, particularly from 2018, where it jumps from around 2.5 million units to

nearly 12.5 million units in 2019. There is a minor dip in 2020, but the quantity continues to increase sharply, peaking at approximately 17.5 million units in 2023.

This significant growth in import quantity from 2016 onwards suggests a rising demand for bamboo products in Brazil, reflecting an expansion in market reach, increased consumer demand, and possibly a diversification in the types of bamboo products imported.

5.4. Leading Bamboo Products in Trade

This section dissects the top-performing bamboo products in Brazil's trade, contrasting the high-value exports with the large-volume imports to draw conclusions about market preferences and production strengths. Table 5 presents top bamboo export and import products by value and quantity.

The top products by export value are primarily furniture and other bamboo works, indicating high-value items lead the export in terms of dollar value. In contrast, when looking at quantity, items like kitchen articles made of bamboo dominate, suggesting these are produced and exported in large volumes despite their lower individual value.

The Mercosur Common Nomenclature (NCM) is a classification system for goods used by the Mercosur member countries, including Brazil, for foreign trade purposes. The NCM code 4421.91.00 refers to all works based on bamboo that are not categorized as furniture, seats, boards, basketworks, charcoal, and kitchen goods. This includes bamboo plywood, mats, joinery, pulp and fiber, and others shown in Figure 12. These "Other works in bamboo" lead in both value and quantity, suggesting a high demand for these products within the country.

Table 5. Top bamboo export and import products by value and quantity in 2023.

Description	Export USD FOB	Export Quantity	Highest Export Value Country	Import USD FOB	Import Quantity	Highest Import Value Country
Bamboo Furniture	2,845,820	154,405	USA	2,396,309	211,420	China
Other seats of bamboo	431,442	424	USA	244,288	6,353	Indonesia
Other works in bamboo	175,914	44,155	Paraguay	12,836,552	9,809,513	China
Bamboo cutting boards	50,584	7,593	USA	2,517,762	1,279,008	China
Bamboo for kitchen	49,730	559,508	Paraguay	6,851,511	2,477,409	China
Bamboo charcoal	11,420	12,202	Liberia	34,225	16,301	China
Bamboo Chopsticks	4,111	826	Paraguay	2,871,358	2,494,564	China
Bamboo Basketwork	15,828	158	Italy	1,903,493	514,381	China

Other Works in Bamboo: This category, classified under the Mercosur Common Nomenclature (NCM) code 4421.91.00, encompasses a diverse range of bamboo products that are not categorized as furniture, seats, boards, basketworks, charcoal, or kitchen goods. It includes items such as bamboo plywood, mats, joinery, pulp and fiber, and various other crafted or industrial bamboo products. These items are characterized by their versatility and are commonly used in construction, manufacturing, and various other applications.

The data indicates a diversification in the bamboo export market, while imports suggest a consumer inclination towards eco-friendly, everyday items. This growth trajectory signifies bamboo's expanding global footprint, fueled by its sustainability and versatility.

Figure 12 showcases the percentage composition of bamboo product imports and exports by category from 2019 onwards. This detailed analysis provides insight into the evolving trends in Brazil's bamboo market, reflecting both international and domestic demands for various bamboo products.

Exports (Figure 12A):

- **Consistent Demand for Furniture and Artisanal Works:** The export data indicates a significant and consistent demand for bamboo furniture, which comprises the largest share of exported bamboo products. This trend highlights the international market's appreciation for high-quality, durable bamboo furniture.
- **Artisanal Products:** There is also a noticeable export of artisanal bamboo products, including handcrafted items. These products cater to niche markets that value traditional craftsmanship and unique designs, showcasing the versatility and aesthetic appeal of bamboo.
- **Diverse Export Categories:** While furniture dominates, other categories like bamboo kitchenware and charcoal also feature, indicating a broad range of export goods. This diversity suggests that Brazil's bamboo industry is well-equipped to meet various global demands, from luxury items to practical goods.

Imports (Figure 12B):

- **Varied Demand for Utilitarian Products:** The import data reveals a significant emphasis on utilitarian bamboo products, such as kitchenware. This indicates a growing domestic consumer shift towards sustainable and eco-friendly materials for everyday use.
- **High Import of Bamboo Charcoal and Matting:** The presence of bamboo charcoal and matting in substantial quantities highlights their versatility and widespread application in domestic markets. These items are likely used in both industrial and household contexts, underscoring their practical value.
- **Increasing Variety of Imported Goods:** The import chart shows a broader range of bamboo products being brought into Brazil, reflecting a dynamic and expanding market. This trend suggests an increasing awareness and adoption of bamboo-based products among Brazilian consumers.

Comparative Insights:

- **Market Dynamics:** Both charts indicate a dynamic bamboo market characterized by a blend of luxury and practical goods. The export market focuses more on high-value items like furniture and artisanal products, whereas the import market caters to practical, everyday items.
- **Sustainability Trends:** The significant share of kitchenware and other utilitarian products in imports suggests a growing trend towards sustainable consumption patterns in Brazil. Consumers are increasingly opting for bamboo products due to their eco-friendly attributes.
- **Versatility and Appeal:** Bamboo's versatility is evident in its use across various sectors. From high-end furniture and artisanal goods to practical kitchenware and industrial charcoal, bamboo's multifaceted appeal is driving its growth in both export and import markets.

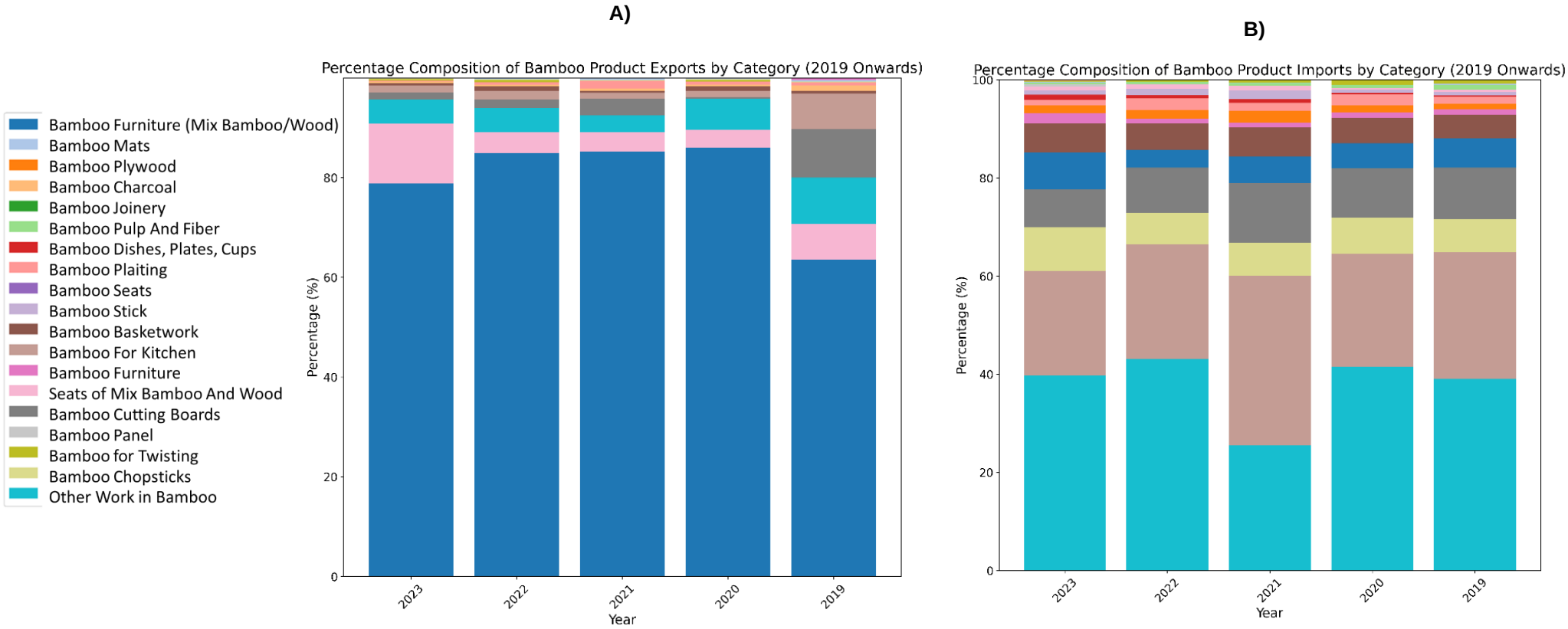

Figure 12. Proportional breakdown of bamboo product exports (A) and import (B) (2019-2023).

5.5. Overall Trade Balance Analysis (2019-2023)

This section provides a synthesized overview of Brazil's trade activities related to bamboo products from 2019 to 2023, focusing on the trade balance, which reflects the difference between exports and imports in terms of US dollars and quantity. The analysis reveals the growth of the market and the progressive trade deficit, highlighting the dynamics between Brazil's increasing exports and its even more rapidly increasing imports of bamboo-related goods. Table 12 present the annual data on bamboo product exports and imports in terms of US dollars and quantity, illustrating Brazil's growing market and the widening trade deficit.

Table 6. Annual Bamboo Trade Metrics in Brazil (2019-2023).

Year	Export USD FOB	Import USD FOB	Balance USD FOB	Export Quantity	Import Quantity	Balance Quantity
2019	1,234,059	23,057,839	-21,823,780	106,867	13,014,299	-12,907,432
2020	1,329,722	20,195,535	-18,865,813	129,406	12,256,665	-12,127,259
2021	2,598,524	29,379,133	-26,780,609	269,283	13,925,061	-13,655,778
2022	2,949,504	29,909,586	-26,960,082	177,216	16,957,738	-16,780,522
2023	3,609,390	32,262,785	-28,653,395	782,576	17,561,503	-16,778,927

Key Insights:

- **Trade Balance (USD FOB)**: Brazil has a significant trade deficit in terms of USD FOB for bamboo-related products, with imports far exceeding exports each year. The deficit has been growing, reaching its peak in 2023 at approximately -28.65 million USD.
- **Quantity**: Similar to the USD FOB, the quantity trade balance shows a large deficit, with the number of imported items vastly outnumbering the exported ones. The deficit in quantity was highest in 2023, with a difference of approximately -16.78 million units.

Trend Analysis

- **Exports:** There is a noticeable upward trend in the value and volume of bamboo products exported from Brazil, increasing from about 1.23 million USD in 2019 to approximately 3.61 million USD in 2023. This growth indicates a strengthening export market, driven by international demand for high-value bamboo goods such as furniture and artisanal products.
- **Imports:** Brazil's imports of bamboo products have also been increasing more significantly in value and volume compared to exports. Import values peaked at over 32 million USD in 2023, leading to a widening trade deficit. The rise in imports suggests a robust domestic demand for bamboo products.

Analysis of Bamboo Product Imports and Exports

Table 6, annual bamboo trade metrics, Table 5, and Figure 12, which depict the percentage composition of bamboo product imports and exports by category from 2019 onwards, offer valuable insights into Brazil's bamboo trade dynamics. By analyzing these data, we can categorize the products into three groups: Balanced Trade Opportunities, Export Specializations, and Opportunities for Domestic Development. This categorization highlights Brazil's existing production capacity, areas for potential import substitution, and sectors requiring foundational development.

Balanced Trade Opportunities

Products in this category are both imported and exported, indicating an existing production base in Brazil with potential for increased self-sufficiency. Key products include:

- **Bamboo Furniture:** Exported at significant values in 2023 (USD FOB: $2,845,820) and quantities (154,405 units), compared to imports (USD FOB: $2,396,309; 211,420 units). This dual presence indicates a strong production base that could be expanded to meet domestic demand fully.
- **Bamboo Charcoal:** Exported modestly (USD FOB: $11,420; 12,202 units) but also imported (USD FOB: $34,225, 16,301 units) in 2023. Increasing local production could reduce the need for imports.
- **Bamboo Chopsticks:** Both exported (USD FOB: $4,111; 826 units) and imported (USD FOB: $2,871,358; 2,494,564 units). Enhancing production capacity could help Brazil become more self-sufficient in this category.

Export Specializations

These products are predominantly exported, showcasing Brazil's strengths and competitive advantage in the global bamboo market. They indicate sectors where Brazil has established a strong production base and can further capitalize on international demand:

- **Other Seats of Bamboo:** Exported (USD FOB: $431,442; 424 units), showing Brazil's capability in this niche market.
- **Bamboo Cutting Boards:** Solely exported (USD FOB: $50,584; 7,593 units), indicating a specialization that could be further developed.
- **Bamboo Basketwork:** Exported (USD FOB: $15,828; 158 units), reflecting an established niche market.

Opportunities for Domestic Development

Products in this category are primarily imported, suggesting areas that require more attention for development within Brazil. These sectors present opportunities for foundational research, investment, and local production capabilities:

- **Other Works in Bamboo (mainly bamboo fiber and pulp):** Imported heavily (USD FOB: $12,836,552; 9,809,513 units), encompassing items like bamboo plywood, mats, joinery, pulp, and fiber. Developing local production for these versatile products could significantly reduce import dependency. For pulp, in 2020 and 2021, there were exports of about $1549 USD FOB, but after that, the value in the database shows 0, while imports continue. Therefore, it seems that the possibility exists and needs more attention.
- **Bamboo Kitchenware:** High import values (USD FOB: $6,851,511; 2,477,409 units) suggest a strong domestic demand that is not being met by local production.

Year-over-Year Growth

The "Year-Over-Year Growth Analysis" examines the changes in Brazil's bamboo trade from 2019 to 2023. The data reflects a growing trend in export values, which increased from approximately 1.23 million USD in 2019 to around 3.61 million USD in 2023. Despite the positive trend in export values, Brazil's trade balance remained negative throughout the years due to higher import values, peaking at over 32 million USD in 2023. Additionally, quantity balance shows that imports consistently outweigh exports, indicating a strong reliance on imported bamboo products. This trend suggests an expanding market for bamboo products in Brazil, but also highlights the challenges in meeting domestic demand through local production.

This comparison highlights Brazil's position as a net importer of bamboo-related products, with a significant and growing trade deficit in this sector. The data suggests a strong domestic demand for bamboo products, not fully met by domestic production, leading to substantial imports.

5.6. Top Trading Partners Analysis

Figure 13 presents the top countries in relation to Brazil's trade, categorized by trade balance, export value, and import value:

Based on Trade Balance (Surplus)

This chart shows the countries with which Brazil has the highest trade surplus. The United States stands out as the country with the highest positive trade balance with Brazil, followed by Paraguay, Panama, Bolivia, and the United Arab Emirates.

- **United States**: Brazil has a significant trade surplus with the United States, with exports exceeding imports by over 1.05 million USD.

Other seats of rattan, bamboo, or similar materials (FOB value: $279,787 in 2023): This category still represents a significant export value. Strengthening efforts could involve similar strategies as mentioned before, such as expanding product range, improving quality, and exploring new marketing channels. Bread cutting boards, other cutting boards, and the like, made of bamboo (FOB value: $14,316 in 2023): Bamboo cutting boards have a potential market due to their eco-friendly nature.

Strengthening efforts could focus on product innovation, enhancing product quality, and marketing strategies to target consumers looking for sustainable kitchenware options. Other articles of wood, for table or kitchen, of bamboo (FOB value: $982 in 2023): Despite the lower value, there's still potential to strengthen this category. Similar strategies of diversification, quality improvement, and targeted marketing can be applied here. Bamboo seats (FOB value: $376 in 2023): This category may have niche markets. Strengthening efforts could include enhancing product design, collaborating with interior designers or furniture retailers, and focusing on marketing campaigns targeting eco-conscious consumers.

Trays, dishes, plates, cups, etc. of bamboo (FOB value: $329 in 2023): Eco-friendly tableware made of bamboo has potential in the market. Strengthening efforts could focus on expanding product range, partnering with restaurants or retailers, and emphasizing the sustainability aspect in marketing campaigns. Other works in bamboo (FOB value: $240 in 2023): This category includes various bamboo handicrafts or decorative items. Strengthening efforts could involve promoting the uniqueness and craftsmanship of these products, targeting specific consumer segments, and exploring partnerships with retailers or online platforms specializing in home decoration.

Bamboo Wood Charcoal (FOB value: $93): Bamboo wood charcoal is a niche product with potential in markets that value natural and sustainable alternatives to traditional charcoal. Strengthening efforts could involve highlighting the eco-friendly properties of bamboo charcoal, such as its renewable sourcing and low emission during combustion. Marketing campaigns targeting eco-conscious consumers, outdoor enthusiasts, and barbecue aficionados can help increase demand for bamboo wood charcoal in the US market.

Paraguay, Panama, Bolivia, and United Arab Emirates: These countries also show substantial trade surpluses, indicating strong export relationships.

Panama: Furniture of bamboo: With a significant FOB value of $217,382, there is potential to further strengthen exports of furniture made from bamboo and similar materials. Strategies could include product diversification, enhancing product design and quality, and targeting specific segments within the Panamanian market, such as eco-conscious consumers or interior designers. Bamboo wood charcoal, even agglomerated: Despite a relatively low FOB value of $1,198, there may be untapped potential for bamboo wood charcoal in Panama. Strengthening efforts could involve promoting the benefits of bamboo charcoal for grilling and cooking, collaborating with local retailers or restaurants, and exploring export opportunities beyond traditional charcoal markets. Other works in bamboo: This category encompasses various bamboo handicrafts and decorative items. Strengthening efforts could focus on showcasing the unique craftsmanship and cultural significance of these products, targeting tourists or souvenir shops, and leveraging Panama's status as a tourist destination to increase sales.

Bolivia: Furniture of bamboo: With a notable FOB value of $184,611, there is room for further growth in exports of furniture made from bamboo and similar materials to Bolivia. Strengthening efforts could involve expanding product range, improving product quality, and targeting specific consumer segments, such as homeowners or hospitality businesses. Bread cutting boards, other cutting boards and the like, made of bamboo: This category presents an opportunity for strengthening exports by focusing on product innovation, enhancing design and functionality, and partnering with local retailers or kitchenware distributors in Bolivia to increase market penetration. Other works in bamboo: Strengthening efforts in this category could involve collaborating with Bolivian artisans or handicraft cooperatives, participating in local craft fairs or exhibitions, and

exploring export opportunities for unique bamboo handicrafts that resonate with Bolivian consumers.

Paraguay: Furniture of bamboo: With a significant FOB value of $150,785, there is potential to further strengthen exports of furniture made from bamboo and similar materials to Paraguay. Strengthening efforts could involve similar strategies as mentioned for Panama and Bolivia, tailored to the preferences and market dynamics of Paraguayan consumers. Other works in bamboo: This category, with an FOB value of $125,726, presents opportunities for strengthening exports by highlighting the craftsmanship and cultural significance of bamboo handicrafts. Strengthening efforts could involve collaborating with local artisans, promoting bamboo handicrafts as unique souvenirs or gifts, and targeting tourism-related markets in Paraguay. Other seats of rattan, bamboo, or similar materials: Strengthening efforts could involve product differentiation, exploring customization options, and establishing partnerships with local furniture retailers or hospitality businesses to increase demand for bamboo seats in Paraguay.

United Arab Emirates: Furniture of bamboo: While the FOB value for this category is lower compared to other countries at $129,255, there may still be opportunities to strengthen exports to the UAE. Efforts could include targeting high-end consumers or luxury markets in the UAE, showcasing unique designs or sustainable features of bamboo furniture, and establishing partnerships with interior designers or home decor retailers. Other seats of rattan, bamboo, or similar materials: With an FOB value of $59,335, there is potential to further strengthen exports of bamboo seats and similar products to the UAE. Strengthening efforts could involve highlighting the durability and aesthetics of bamboo seats, targeting hospitality or event planning businesses, and exploring opportunities in the growing market for eco-friendly furniture in the UAE. Basketwork, of bamboo: This category, with an FOB value of $123, presents opportunities for strengthening exports by catering to niche markets in the UAE. Strengthening efforts could involve promoting the artisanal craftsmanship and cultural significance of bamboo basketwork, targeting affluent consumers or collectors interested in unique home decor items, and collaborating with luxury retailers or boutique stores. Other works in bamboo: While the FOB value for this category is relatively low at $82, there may still be potential for strengthening exports by focusing on niche markets or specialty products that resonate with UAE consumers. Strengthening efforts could involve showcasing innovative bamboo products, leveraging the UAE's reputation as a hub for

innovation and design, and collaborating with local distributors or online platforms to increase visibility and sales.

Based on Exports

The **United States** stands out as the top destination for Brazil's exports, followed by Paraguay, Panama, and Bolivia.

Based on Imports

China: By far, China is the largest source of imports to Brazil, showcasing a strong trade relationship and significant collaboration between the two countries. This partnership is reflected in the diverse range of bamboo products imported from China, catering to various market needs in Brazil.

Other Works in Bamboo (FOB Value: $12,204,147 in 2023): This category encompasses a wide range of bamboo handicrafts and artisanal products, indicating a significant import demand. To strengthen the Brazilian market and promote exports, Brazil can focus on collaborating with Chinese artisans, showcasing the cultural significance of bamboo products, and targeting specific market segments such as home decor or gift items. Other Articles of Wood, for Table or Kitchen, of Bamboo (FOB Value: $6,683,280): Brazil imports various bamboo kitchen and tableware items from China. To promote exports in this category, Brazilian marketers can emphasize the quality and eco-friendliness of bamboo products, offer customization options to cater to consumer preferences, and explore partnerships with retailers specializing in kitchen and dining products. Chopsticks (Hashi or Fachi), of Bamboo (FOB Value: $2,859,947): This category includes bamboo chopsticks, indicating a demand for traditional dining utensils. Brazil can strengthen exports by highlighting the craftsmanship and cultural significance of bamboo chopsticks, offering premium-quality options for upscale dining establishments, and targeting niche markets such as Japanese cuisine enthusiasts. Bread Cutting Boards, Other Cutting Boards, and the Like, Made of Bamboo (FOB Value: $2,477,176): Bamboo cutting boards are popular imports from China, indicating a demand for sustainable kitchenware products. To promote exports, Brazil can emphasize the durability and natural antibacterial properties of bamboo cutting boards, target environmentally conscious consumers, and collaborate with retailers specializing in kitchen accessories. Basketwork, of Bamboo (FOB Value: $1,576,921): Bamboo basketwork represents

another category of imports from China. Brazil can strengthen exports by showcasing the craftsmanship and versatility of bamboo baskets and containers, targeting markets such as home organization, storage solutions, and decorative accessories. Furniture of Other Materials, Including Rattan, Osier, Bamboo, Similar Materials (FOB Value: $1,510,094): This category includes various types of furniture made from bamboo and similar materials. To promote exports, Brazil can focus on product innovation, market diversification, and certification for sustainable manufacturing practices to appeal to international buyers seeking eco-friendly furniture options. Bamboo Furniture (FOB Value: $685,008): Specifically focusing on bamboo furniture imports, Brazil can capitalize on the growing demand for sustainable and stylish furniture solutions. Strategies may include showcasing Brazilian craftsmanship, offering customizable designs, and targeting environmentally conscious consumers in international markets.

Italy and Germany: These countries are also notable sources of imports to Brazil, contributing to the trade deficit.

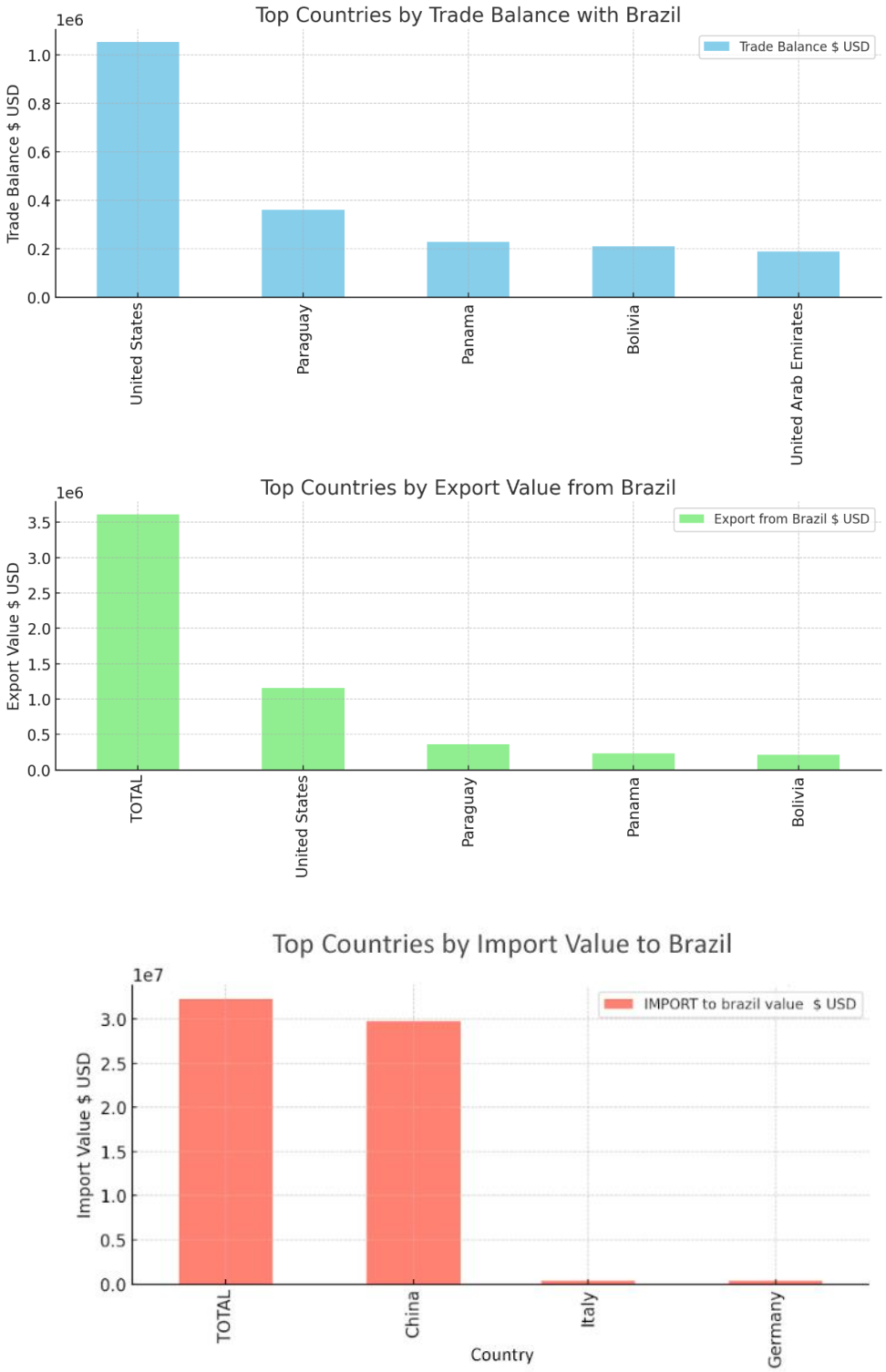

Figure 13. The top countries in relation to Brazil's trade.

5.7. Bamboo Market Dynamics

The bamboo market in Brazil presents a dynamic flow that encapsulates the entire lifecycle of bamboo, from environmental impacts to its diverse applications. This flow is characterized by a cyclical, interconnected system that sustains various industries and contributes to environmental conservation and energy production.

Definition of Dynamic Flow in the Bamboo Value Chain: Dynamic flow refers to the continual movement and transformation of bamboo through various stages of its lifecycle. It encompasses the growth, harvesting, processing, and end-use of bamboo, highlighting the interactions between these stages and their impacts on different scales – from local communities to the global environment. This concept underscores the sustainable, renewable, and versatile nature of bamboo as a resource.

Analysis of the Bamboo Dynamic Flow:

1. **Environmental Impact:**
    - Biodiversity Conservation and Carbon Sequestration: Bamboo cultivation aids in preserving biodiversity and sequestering carbon, demonstrating its ecological benefits.
2. **Sustainable Management:**
    - This principle ensures that the bamboo lifecycle, from cultivation to product development, adheres to practices that maintain ecological balance and benefit local economies.
3. **Bamboo Growth and Harvesting:**
    - Sustainable methods are employed in Brazilian regions, underscoring the importance of environmentally friendly practices.
4. **Bamboo Processing:**
    - Includes steps such as drying, pest treatment, and cutting, preparing bamboo for a variety of uses while maintaining sustainability.

5. **Industrial Applications:**
    - Bamboo is innovatively used in furniture, textiles, construction, food industry, and paper production, showcasing its versatility.
6. **Energy Usage:**
    - Bamboo biomass is transformed into energy, contributing to renewable energy solutions.

Figure 14 provided visually encapsulates the multi-stage journey of bamboo, annotated with color-coded dotted lines that delineate the levels of impact:

- Blue lines denote a global impact, emphasizing bamboo's role in global environmental strategies and market trends.
- Green lines represent the country-level impact, highlighting contributions to Brazil's economy and industrial capabilities.
- Yellow lines focus on the local impact, reflecting the direct effects on job creation, local ecosystems, and community practices.

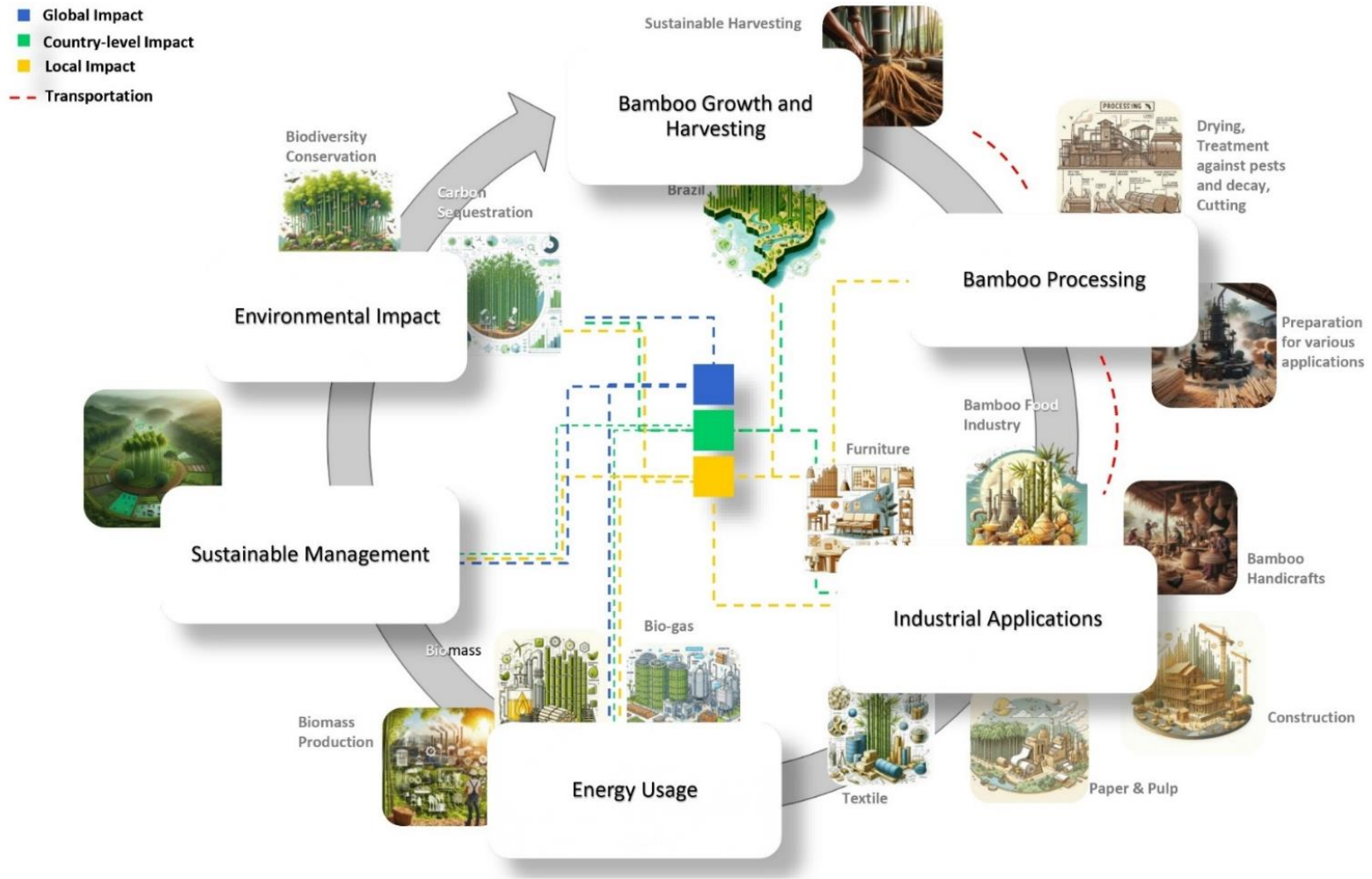

Figure 14. The multi-stage journey of bamboo

6. SWOT Matrix

The SWOT matrix is a strategic marketing analysis tool designed to assess the Strengths, Weaknesses, Opportunities, and Threats associated with a particular subject of examination. In this case, it is applied to the Brazilian bamboo market. This versatile framework can be effectively used to evaluate and strategize for a wide range of entities, including companies, materials, and products (Leigh, 2009). In the context of the bamboo industry, our SWOT analysis is based on a thorough value chain and market analysis of Brazil, covering all stages of the bamboo production process. This analysis is enriched by insights gathered from diverse stakeholders, including farmers, researchers, entrepreneurs, and artisans. By examining Brazil's bamboo product trade data, including export and import trends, and product analysis, SWOT analysis is developed for the bamboo industry in Brazil.

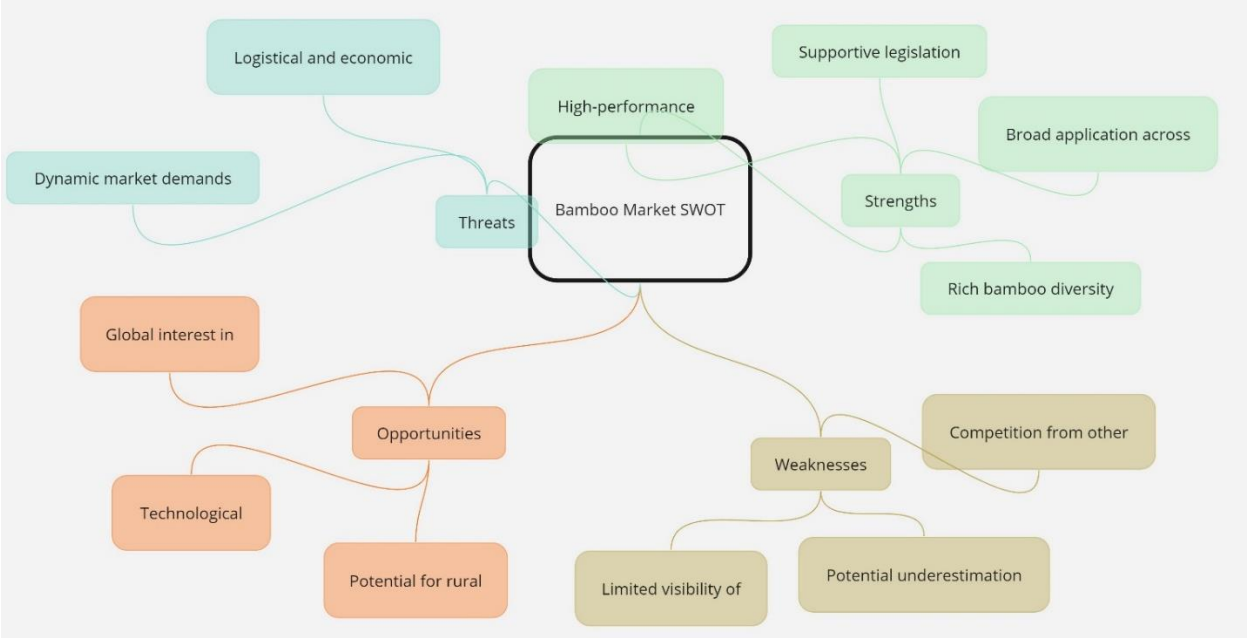

Figure 15. Bamboo market general SWOT.

6.1. Strength

Bamboo's exceptional mechanical properties, such as its tensile strength and flexibility, are well-documented in the literature (Wu et al., 2023), and have been echoed in stakeholder feedback. Notably, its rapid growth rate, a byproduct of a swift photosynthesis cycle, allows for significant carbon sequestration (Yiping et al., 2010). This capability contributes to its sustainable profile. Moreover, stakeholders confirm bamboo's biodegradability and short harvesting cycle (3-5 years), enhancing its environmental appeal and aligning with sustainability principles (Ogihara et al., 2008).

The findings also reveal Brazil's rich bamboo diversity and its extensive application across industries, bolstered by supportive legislation and expertise in high-performance materials and value chain analysis. Brazil's bamboo sector benefits from the country's vast arable land, with 63,994,479 hectares available for cultivation, as reported by EMBRAPA in 2016. This extensive land availability positions Brazil to become a major player in bamboo production and expand its use across diverse industries. Bamboo's versatility is evident in its applications across multiple sectors, including industrial uses such as cellulose production and panel manufacturing. In the realm of family farming, bamboo supports artisanship and small crafts, providing economic opportunities for local communities. The rich biodiversity of bamboo species in Brazil further enhances the sector's potential for sustainable economic development and environmental benefits. By leveraging these strengths, Brazil can capitalize on bamboo's multifaceted uses and contribute to a more sustainable and innovative future.

6.2. Weaknesses

Despite its strengths, bamboo also has inherent weaknesses. Its limited durability without treatment necessitates ongoing maintenance and part replacement. The material's processing is energy-intensive, requiring specialized machinery due to the bamboo's inherent forces (van der Lugt et al., 2006). Additionally, the natural variability of bamboo can impact its application suitability, as uniformity in characteristics such as thickness and diameter is not guaranteed. Pests pose another challenge, often requiring pesticide use and preventive treatments (Schmidt et al., 2013).

Furthermore, a critical issue arises concerning the necessity of treatment to augment the material's durability. While bamboo possesses inherent resilience, its susceptibility to decay and

pest infestations necessitates treatment for prolonged use, particularly in construction and other enduring applications. However, the absence of standardized certification protocols in Brazil for bamboo treatment compounds poses a significant challenge. The lack of universally recognized standards engenders variability in treatment methodologies and quality, compromising the sector's reliability and impeding market acceptance. A notable concern pertains to the dependence on imported treatment compounds, such as boron solutions, which require Borax as a component. According to stakeholders, this compound is imported, exacerbating supply chain vulnerabilities and escalating operational costs. This reliance on foreign sources not only engenders logistical complexities but also introduces uncertainties regarding quality control and regulatory compliance.

Another significant problem is the informality of the bamboo market in Brazil. A large portion of transactions occur between informal buyers and sellers or small producers, often without formal registration (CNPJ) on both sides involved. This lack of formalization makes it difficult to enforce and apply quality standards, creating insecurity for buyers and sellers. Addressing these challenges warrants a collaborative approach involving industry stakeholders, policymakers, and regulatory authorities. Establishing stringent certification standards for bamboo treatment processes is imperative to uphold product integrity and safety standards. Concurrently, initiatives aimed at fostering domestic production of treatment compounds are paramount. By bolstering domestic manufacturing capabilities, the sector can diminish reliance on imports, fortify supply chain resilience, and nurture local industries.

Mitigating the challenges associated with bamboo treatment requires strategic interventions aimed at standardization, quality assurance, and domestic production enhancement. Additionally, stakeholders recognize competition from other industries, potential resource underestimation, and limited visibility of the economic and social contributions of bamboo activities. These challenges, along with the competition from other industries and the potential underestimation of bamboo resources, are further elaborated in the SWOT table. This section highlights the importance of acknowledging and addressing these weaknesses to enhance the competitiveness of the bamboo sector.

6.3. Opportunities

The versatility of bamboo is a significant strength, with applications spanning from civil construction (Yadav & Mathur, 2021) and decoration to the food industry, benefiting from the nutritional richness of bamboo shoots (Nirmala et al., 2007; Shi & Yang, 1992). The potential for bamboo to replace conventional materials in construction is being explored, leveraging its mechanical potential and cost-effectiveness (Harelimana et al., 2022). Stakeholder insights complement these findings, noting the global interest in sustainable management practices, technological advancements, and the potential for rural development and high-end transnational value chains, all of which represent opportunities for the bamboo sector's expansion.

The Brazilian bamboo value chain presents a wealth of opportunities for growth and innovation. One of the primary advantages is the global interest in sustainable management practices. As international markets increasingly prioritize eco-friendly and renewable resources, Brazil's bamboo industry is well-positioned to cater to this demand by offering products that align with these values. Additionally, technological advancements in the bamboo sector are optimizing various stages of the value chain. From harvesting to processing and manufacturing, these innovations lead to greater efficiency and higher-quality products, strengthening Brazil's position in the global market.

Bamboo's potential as an alternative to traditional timber is another significant opportunity. Its rapid growth and mechanical properties make it a strong candidate for use in construction and other industries, reducing reliance on conventional materials and promoting sustainable practices. Brazil's abundant bamboo resources also create promising export opportunities. By producing high-quality bamboo goods that meet international standards, Brazil can expand its reach into global markets. This includes the export of raw bamboo, as well as finished products such as furniture and construction materials.

Furthermore, the growth of the bamboo industry has the potential to drive rural development across Brazil. By investing in bamboo cultivation and processing, industry can create economic opportunities and stimulate local economies, improving livelihoods in rural regions where other job prospects may be scarce. Moreover, Brazil's existing advanced wood technologies and skilled

workforce, which can be adapted to bamboo, leverage the similarities between wood and bamboo for innovation and efficiency.

6.4. Threats

The Brazilian bamboo value chain faces several threats that could impede its development and success. One major concern is the logistical, economic, or environmental factors that can impact business establishment and operation, especially in vast areas such as Amazonas. The challenges of accessing remote regions, coupled with potential environmental restrictions and high operational costs, could hinder the growth of the bamboo industry in these areas. Dynamic market demands and potential market fluctuations pose additional risks, particularly for small enterprises in the bamboo sector. Market preferences can shift rapidly, and smaller players may struggle to adapt quickly enough to maintain competitiveness. This volatility can create uncertainty and affect the stability of the bamboo value chain.

The lack of extensive research and data on bamboo, compared to more traditional materials like concrete and steel, limits the industry’s ability to innovate and optimize production processes. This knowledge gap may result in slower adoption rates of bamboo products and hinder efforts to expand the industry's market share. Furthermore, the absence of a consolidated national market for bamboo hampers strategic positioning and coordination across the sector. Without a unified approach to market development, the industry may struggle to establish a strong presence both domestically and internationally. High pricing is another threat, as it can deter potential customers from choosing bamboo products over more affordable alternatives. This issue can be exacerbated by inefficiencies in production and supply chains, leading to higher costs for bamboo goods.

Lastly, the presence of an informal market can undermine the formal bamboo sector, creating unfair competition and potentially lowering overall quality standards. This could damage the reputation of Brazilian bamboo products and weaken consumer trust in the market. In summary, these threats present challenges to the growth and sustainability of Brazil's bamboo value chain. Addressing these issues will require concerted efforts from stakeholders across the industry to ensure its long-term success.

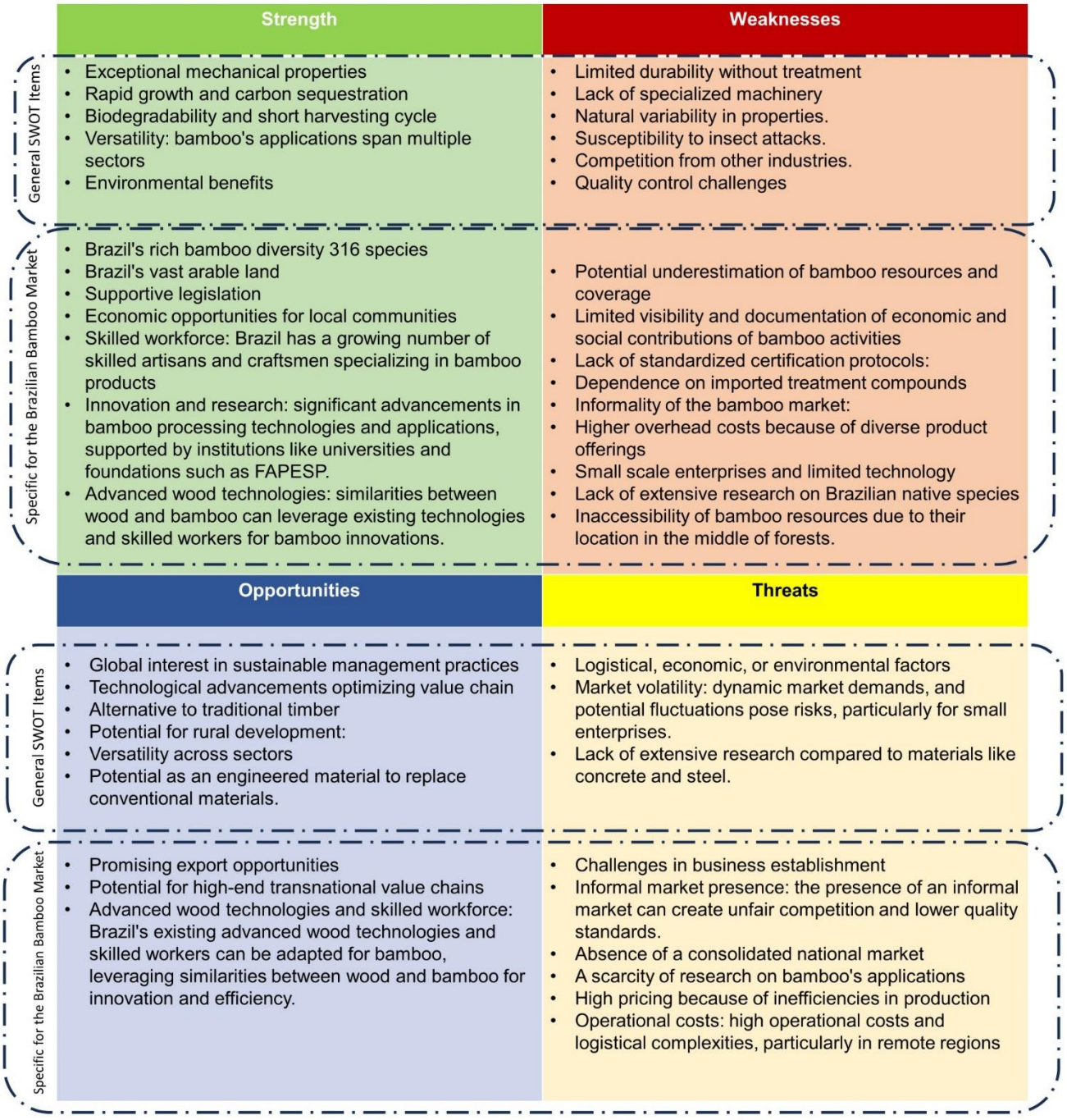

Figure 16. Strength, weakness, opportunity, and threat (SWOT) analysis of Brazilian bamboo market.

Figure 16 provides a summary of SWOT analysis that integrates both general attributes of bamboo and specific aspects pertinent to the Brazilian bamboo market. Although we divide the

analysis into two parts—general and specific—the Brazilian bamboo SWOT analysis contains both general as well as some specific items. The general items highlight the inherent qualities and global market opportunities for bamboo, emphasizing its sustainability, versatility, and mechanical properties. Meanwhile, the specific items underscore Brazil's unique advantages, such as rich biodiversity, vast arable land, supportive legislation, and advanced wood technologies, alongside challenges like market informality, dependency on imports for treatment compounds, and the absence of standardized protocols. Additionally, Brazil can benefit from its existing advanced wood technologies and skilled workforce, which can be adapted to bamboo, leveraging the similarities between wood and bamboo for innovation and efficiency. Furthermore, while Brazil has abundant bamboo resources in forests, their inaccessibility due to location highlights an area for potential improvement in infrastructure and logistics. This layered analysis facilitates targeted strategic planning, enabling stakeholders to leverage strengths and opportunities while addressing weaknesses and threats specific to the Brazilian context.

7. Recommendations

Based on the analysis of the bamboo market and value chain in Brazil, the following recommendations are proposed to enhance the sector's development and sustainability:

7.1. Strategic Recommendations for Each Node of the Value Chain

7.1.1. Bamboo Cultivation and Harvesting:

Export Focus: Establish partnerships with international buyers, particularly in regions with high demand for sustainable bamboo products. Ensure that cultivation practices align with international standards for sustainability and traceability, enhancing the marketability of Brazilian bamboo products abroad.

Domestic Market: Implement comprehensive training programs for local farmers on sustainable bamboo cultivation techniques. Provide support in accessing financing options for infrastructure development and equipment procurement to increase productivity and quality.

Product Diversification: Encourage the cultivation of bamboo species suitable for specific end-uses, such as *Dendrocalamus asper*, *Moso* bamboo, and *Guadua* bamboo for construction materials and furniture production. Invest in research to develop new cultivars with enhanced properties for various applications.

7.1.2. Processing:

Export/import Dynamics: Strengthen partnerships with international processing facilities to leverage advanced technologies and expertise in value-added processing. Collaborate with research institutions to develop innovative processing methods that enhance the quality and value of Brazilian bamboo products.

Domestic Market: Invest in upgrading local processing facilities to meet the growing demand for bamboo-based materials in domestic industries such as construction, furniture, and paper manufacturing. Provide technical assistance and training programs to enhance the skills of workers in bamboo processing.

Product Diversification: Explore opportunities to diversify product offerings through advanced processing techniques, such as laminating, molding, and compression. Develop eco-friendly

alternatives to traditional building materials using bamboo, such as bamboo plywood and engineered bamboo panels.

Industrial applications:

Export/import Dynamics: Develop marketing campaigns targeting international buyers to promote Brazilian bamboo products in high-value markets such as North America, Europe, and Asia. Participate in trade fairs and exhibitions to showcase the quality and diversity of Brazilian bamboo products to potential customers.

Domestic Market: Collaborate with architects, designers, and developers to promote the use of bamboo in sustainable construction projects across Brazil. Provide technical support and training to construction companies on the use of bamboo-based materials in building design and construction.

Product Diversification: Invest in research and development to create new industrial applications for bamboo, such as bamboo fiber-reinforced composites for automotive and aerospace industries. Collaborate with industry partners to test and validate the performance of bamboo-based materials in various applications.

Handicrafts:

Export/import Dynamics: Establish partnerships with international distributors and retailers to promote Brazilian bamboo handicrafts in global markets. Develop branding and packaging strategies that highlight the cultural and artistic value of Brazilian handicrafts to appeal to international consumers.

Domestic Market: Support local artisan communities through training programs and capacity-building initiatives to enhance their skills in bamboo craftsmanship. Create marketing platforms and events to showcase the diversity and creativity of Brazilian bamboo handicrafts to domestic consumers.

Product Diversification: Encourage artisans to innovate and experiment with new techniques and designs to create unique and marketable bamboo handicrafts. Explore collaborations with designers and artists to develop contemporary bamboo products that blend traditional craftsmanship with modern aesthetics.

Food industry:

Export/import Dynamics: Partner with food distributors and retailers to introduce Brazilian bamboo-based food products to international markets. Conduct market research to identify consumer preferences and trends in the global health food industry and tailor product offerings accordingly.

Domestic Market: Collaborate with chefs, nutritionists, and food bloggers to promote the nutritional and culinary benefits of bamboo-based ingredients in Brazilian cuisine. Develop recipes and cooking demonstrations that showcase the versatility and flavor of bamboo shoots and other bamboo-based foods.

Product Diversification: Invest in research and development to create new bamboo-based food products, such as bamboo shoot snacks, bamboo leaf tea, and bamboo fiber supplements. Work with food scientists to optimize processing techniques and enhance the nutritional value and sensory attributes of bamboo-based foods.

7.1.3. Utilization:

Maximizing Resource Efficiency: Implement integrated production systems to optimize the use of bamboo resources across the value chain. Bioproducts from one stage should serve as inputs for another, reducing waste and maximizing resource efficiency.

Waste Reduction and Recycling: Invest in technologies and processes aimed at minimizing waste generation during bamboo cultivation, processing, and manufacturing. Develop recycling and reuse initiatives for production scraps and bioproducts to promote sustainability and cost-effectiveness.

Value-Added Processing: Explore value-added processing techniques to enhance the versatility and marketability of bamboo products. This could include the development of engineered bamboo materials, bamboo-based composites, or innovative surface treatments to expand product applications and increase value.

Circular Economy Practices: Embrace circular economy principles by closing the loop on bamboo production and consumption. Develop strategies for the collection, refurbishment, and repurposing of end-of-life bamboo products to minimize environmental impact and create new revenue streams.

7.1.4. Marketing:

Brand Promotion and Positioning: Develop a strong and cohesive branding strategy for Brazilian bamboo products, emphasizing the country's commitment to sustainability, quality, and innovation. Position Brazilian bamboo as a premium and eco-friendly choice in the global market.

Market Segmentation and Targeting: Conduct market research to identify key target segments and niche markets for Brazilian bamboo products. Tailor marketing messages and strategies to resonate with the values, preferences, and needs of specific customer segments, whether they are environmentally conscious consumers, design enthusiasts, or health-conscious individuals.

Digital Marketing and E-commerce: Leverage digital marketing channels and e-commerce platforms to reach a broader audience and facilitate direct sales of Brazilian bamboo products. Invest in website optimization, search engine marketing, and social media advertising to increase online visibility and engagement.

Trade Show Participation and Networking: Participate in international trade shows, exhibitions, and industry events to showcase Brazilian bamboo products and build relationships with potential buyers, distributors, and partners. Use these opportunities to highlight product innovations, sustainability credentials, and competitive advantages.

Public Relations and Influencer Collaborations: Develop strategic partnerships with influencers, industry experts, and thought leaders to amplify the reach and impact of marketing efforts. Collaborate on content creation, brand endorsements, and co-branded initiatives to increase brand awareness and credibility in the market.

Government Support and Advocacy: Advocate for government support and incentives to promote the export and marketing of Brazilian bamboo products. Work with trade associations, chambers of commerce, and government agencies to address trade barriers, access new markets, and promote the image of Brazilian bamboo on the global stage.

7.2. Strategic Recommendations for Specific Product Line

7.2.1. Strengthening the Bamboo Furniture and Artisanal Products Line

The strongest product line in the Brazilian bamboo sector appears to be furniture and artisanal products. The export of high-value items like bamboo furniture has shown significant growth, indicating a robust production base and market demand. To further enhance this product line, the following strategic recommendations are proposed:

Product Diversification: Expand the range of bamboo furniture and artisanal products by incorporating innovative designs and new applications to cater to diverse consumer preferences.

Quality Enhancement: Improve product quality through the adoption of advanced processing techniques and rigorous quality control measures, ensuring that products meet international standards.

Marketing Strategies: Develop strong branding initiatives and participate in international trade shows to increase visibility and attract a broader customer base, thereby boosting sales and market presence.

7.2.2. Addressing Weaknesses in the Bamboo Value Chain

The weakest link in the Brazilian bamboo value chain is the high dependency on imports for treatment compounds and the absence of standardized protocols. This reliance on imported materials and lack of standardization can be mitigated through the following strategies:

Developing Local Production: Invest in the local production of treatment compounds and establish standardized protocols for bamboo processing, reducing dependency on imports and ensuring consistency in quality.

Research and Development: Support R&D initiatives aimed at developing and optimizing treatment methods using locally available resources, fostering innovation and self-sufficiency.

Training and Education: Provide comprehensive training programs for stakeholders to adopt best practices in bamboo treatment and processing, enhancing the overall skill set within the industry.

7.2.3. Identifying and Mitigating Threats

Market Fluctuations: Address the risks posed by dynamic market demands and potential fluctuations, particularly for smaller enterprises, by developing flexible business models and diversification strategies.

Logistical Challenges: Overcome logistical challenges, such as accessing remote regions and managing high operational costs, by improving infrastructure and streamlining supply chain operations.

Informal Market: Combat the presence of an informal market that creates unfair competition and lowers quality standards by implementing stricter regulations and quality assurance programs.

7.2.4. Capitalizing on Opportunities

Eco-Friendly Alternatives: Promote bamboo as a sustainable, eco-friendly alternative to traditional timber and plastics, attracting environmentally conscious consumers and tapping into the growing demand for green products.

Technological Advancements: Invest in advanced processing technologies to enhance product quality, diversify applications, and increase the competitiveness of bamboo products in the global market.

Export Opportunities: Expand into international markets with high demand for sustainable products by developing strong partnerships, participating in global trade fairs, and leveraging Brazil's unique bamboo resources.

7.3. Policy Recommendations

Supportive Legislation: Enact policies that encourage sustainable bamboo cultivation, processing, and trade, including subsidies for eco-friendly practices and tax incentives for bamboo businesses.

Standardization and Quality Control: Establish and enforce quality standards for bamboo products to ensure competitiveness in domestic and international markets.

Research and Development Support: Allocate government funds for R&D in bamboo cultivation, product development, and market analysis to foster innovation.

Trade Facilitation: Simplify export-import procedures for bamboo products and negotiate trade agreements to open up new international markets.

Strengthen Relationship with China: Strengthen trade and technology transfer relationships with China, the leader in the bamboo industry, to acquire advanced technology and equipment.

Collaborate on joint ventures and knowledge-sharing initiatives to improve Brazilian bamboo processing capabilities.

7.4. Innovation and Investment Opportunities

Product Innovation: Encourage the development of innovative bamboo products through competitions, grants, and incubation programs for start-ups and SMEs.

Technological Advancements: Invest in research on advanced bamboo processing technologies and sustainable cultivation methods to improve product quality and environmental sustainability.

Market Development: Explore untapped domestic and international markets for bamboo products, particularly in eco-friendly and green building sectors.

Public-Private Partnerships: Foster collaborations between government, industry, and research institutions to co-fund bamboo projects and share knowledge and resources.

Promotion of Native Bamboo: Promote the cultivation and use of native bamboo species. Develop infrastructure to make bamboo resources in forests accessible for sustainable management and utilization.

These recommendations aim to address the current challenges and leverage the opportunities within the Brazilian bamboo sector, promoting sustainable growth, environmental stewardship, and economic development. Furthermore, aim to address the identified weaknesses and threats while leveraging the strengths and opportunities within the Brazilian bamboo sector to ensure its sustainable growth and contribution to the bioeconomy.

8. Conclusion

The value chain analysis within the bamboo sector in Brazil reveals a system from cultivation to end-use, showcasing the bamboo's journey through various stages of growth, harvesting, processing, and its applications in diverse industries. This interconnected flow highlights bamboo's role not only as a versatile and sustainable resource but also in contributing to environmental conservation through carbon sequestration and biodiversity preservation. Sustainable management practices are emphasized, ensuring the ecological balance and local economies benefit from the bamboo lifecycle.

In the processing stage, bamboo undergoes procedures such as drying and pest treatment, preparing it for a myriad of uses while maintaining sustainability principles. This leads to its utilization in industries like furniture, textiles, construction, and even energy production, where bamboo biomass is converted into renewable energy sources. The dynamic flow of bamboo underscores its renewable, versatile nature, and the sector’s impact from local to global scales is significant.

The analysis of product categories reveals a diverse range of bamboo applications. Chairs (14.01%) and tables (12.93%) are the most significant categories, followed by decoration/crafts (12.66%) and bamboo slats (8.08%). Other notable products include bamboo pots, consultancy services, bamboo ceilings, and lamps. Additionally, many companies in the sector produce multiple products, indicating a versatile and dynamic industry. Activities within the bamboo sector are segmented into primary, secondary, and tertiary activities. Tools, farming, and construction dominate the primary activities, with significant involvement in handcraft and furniture. Secondary activities are well-represented in construction and handcraft, while tertiary activities, including courses and research, play a significant role. This demonstrates a balanced engagement across the bamboo value chain, with substantial contributions from both primary and secondary sectors, and emerging importance in tertiary activities, particularly in education and research.

Brazil's trade dynamics reveal strong performance in exporting high-value bamboo products such as furniture and artisanal works, particularly to the United States, which is the largest export destination. From 2019 to 2023, the export value of bamboo products increased from USD 1.23 million to USD 3.61 million, marking a significant overall increase of 192.7%. However, the country

also faces a substantial import demand for bamboo kitchenware, charcoal, and mats, primarily sourced from China. During the same period, imports rose from USD 23.06 million to USD 32.26 million, reflecting a 39.9% increase. China, as a leading supplier, plays a vital role in catering to Brazil's bamboo product needs, demonstrating its capacity to meet global demand efficiently and consistently.

To harness the full potential of Brazil's bamboo resources, several strategic recommendations are proposed. Enhancing partnerships with international buyers, implementing comprehensive training programs for farmers, and upgrading local processing facilities are essential steps for strategic development. Product diversification should focus on research and development for new bamboo-based products, such as engineered materials and fiber-reinforced composites. Effective marketing and promotion strategies include developing strong branding, utilizing digital marketing channels, and participating in international trade shows. Policy and legislation recommendations include advocating for supportive policies, implementing quality control measures, and fostering collaborations with international partners to enhance technological capabilities and market access. By addressing these areas, Brazil can maximize the potential of its bamboo resources, drive sustainable economic development, and contribute to global environmental goals. This report serves as a strategic guide for stakeholders, offering actionable insights and recommendations to strengthen the bamboo value chain in Brazil.

In concluding, it's crucial to acknowledge that despite the extensive research and data collection efforts, there remains a gap in information regarding the full scope of the bamboo sector in Brazil. This study serves as a foundational exploration, highlighting the significant growth, sustainability, and versatility of bamboo. However, it is likely that there are additional bamboo companies and market dynamics that were not captured due to limitations in data access and the vastness of the sector. This underscores the need for ongoing research and engagement within the industry to continuously update and expand our understanding, ensuring that the bamboo sector's potential is fully realized in the context of sustainable development and environmental conservation.

References:

Afonso, S. R. (2022). Innovation Perspectives for the Bioeconomy of Non-Timber Forest Products in Brazil. Forests, 13(12), 2046. https://doi.org/10.3390/f13122046

Atanda, J. (2015). Environmental impacts of bamboo as a substitute constructional material in Nigeria. Case Studies in Construction Materials, 3, 33–39. https://doi.org/10.1016 /j.cscm. 2015.06.002

Chamberlain, J., & Smith-Hall, C. (2022). The keys to unlocking the bioeconomy with non-timber forest products. In The bioeconomy and non-timber forest products (pp. 251–265). Routledge. https://doi.org/10.4324/9781003245001-21

de Mello, N. G. R., Gulinck, H., Van den Broeck, P., & Parra, C. (2023). A qualitative analysis of Non-Timber Forest Products activities as a strategy to promote sustainable land use in the Brazilian Cerrado. Land Use Policy, 132, 106797. https://doi.org/10.1016/ j.landusepol. 2023. 106797.

Fernández, G.R., Long, T.T., Yanxia, L. (2021). A Review of International Bamboo and Timber Trade Regulations'A Multijurisdictional Study; International Bamboo and Rattan Organisation (INBAR).

Harelimana, V., Zhu, J., Yuan, J., & Uwitonze, C. (2022). Investigating the bamboo as alternative partial replacement of steel bars in concrete reinforcement members. The Structural Design of Tall and Special Buildings, 31(6). https://doi.org/10.1002/tal.1921.

Jones, L., Demirkaya, M., Bethmann, E (2019). Global Value Chain Analysis: Concepts and Approaches." Journal of International Commerce and Economics,(2019), https://www.usitc. gov/journals/jice_home.htm.

Leigh, D. (2009). SWOT Analysis. In Handbook of Improving Performance in the Workplace: Volumes 1-3 (pp. 115–140). Wiley. https://doi.org/10.1002/9780470592663.ch24.

Mahonya, S., Shackleton, C. M., & Schreckenberg, K. (2019). Non-timber Forest Product Use and Market Chains Along a Deforestation Gradient in Southwest Malawi. Frontiers in Forests and Global Change, 2. https://doi.org/10.3389/ffgc.2019.00071.

Mathinya, V.N., Franke, A.C., van de Ven, G.W.J.,Giller, K.E. (2023). Can small-scale farming systems serve as an economic engine in the former homelands of South Africa?,Front. Sustain. Food Syst., 7,1222120., doi: 10.3389/fsufs.2023.1222120.

Montgomery, E. (2021). Moving Beyond Wood Pulp Part 2: Bamboo. Environment America. Food and Agriculture Organization of the United Nations. Global forest resources assessment.

Muttilainen, H., & Vilko, J. (2022). Heterogenising forestry value production – Drivers and barriers of entering the non-wood forest products sector. Current Research in Environmental Sustainability, 4, 100141. https://doi.org/10.1016/j.crsust.2022.100141.

Nirmala C, David E, Sharma ML. (2007). Changes in nutrient components during ageing of emerging juvenile bamboo shoots. International Journal of Food Sciences and Nutrition, 58(8), 612–618. https://doi.org/10.1080/09637480701359529.

Ogihara, S., Akihisa Okada, & Satoshi Kobayashi. (2008). Mechanical properties in a bamboo fiber/PBS biodegradable composite. Journal of Solid Mechanics and Materials Engineering, 2(3), 291–299.

Pan, C., Zhou, G., Shrestha, A.K., Chen, J., Kozak, R., Li, N., Li, J., He, Y.,Sheng, C., Wang, G. (2023). Bamboo as a Nature-Based Solution (NbS) for Climate Change Mitigation: Biomass, Products, and Carbon Credits, Climate, 11, 175. https://doi.org/10.3390/cli11090175.

Rodrigue, J.-P. (2020). The Geography of Transport Systems. Routledge. https://doi.org/10.4324/9780429346323

Schmidt, O., Wei, D., Tang, H. T. K., & Liese, W. (2013). Bamboo and fungi. Journal of Bamboo and Rattan, 12, 1–14.

Shi, Q. T., & Yang, K. S. (1992). Study on relationship between nutrients in bamboo shoots and human health. In: Bamboo and its use. In: Proceedings of the international symposium on industrial use of bamboo. International Tropical Timber Organization and Chinese Academy, Beijing, China, pp 338–346

Silva, T. C., Araujo, E. C. G., Lins, T. R. da S., Reis, C. A., Sanquetta, C. R., & Rocha, M. P. da. (2020). Non-Timber Forest Products in Brazil: A Bibliometric and a State of the Art Review. Sustainability, 12(17), 7151. https://doi.org/10.3390/su12177151.

Song, X., Zhou, G., Jiang, H., Yu, S., Fu, J., Li, W., Wang, W., Ma, Z., & Peng, C. (2011). Carbon sequestration by Chinese bamboo forests and their ecological benefits: assessment of potential, problems, and future challenges. Environmental Reviews, 19(NA), 418–428. https:// doi. Org / 10. 1139/ a11-015 .

Sun, H., Wang, J., Li, H., Li, T., Gao, Z. (2023). Advancements and challenges in bamboo breeding for sustainable development, Tree Physiol., 8, 43(10), 1705-1717. doi: 10.1093/treephys/tpad086.

van der Lugt, P., van den Dobbelsteen, A. A. J. F., & Janssen, J. J. A. (2006). An environmental, economic and practical assessment of bamboo as a building material for supporting structures.

Construction and Building Materials, 20(9), 648–656. https://doi.org/10.1016/j. conbuildmat. 2005.02.023.

Wang, R., Guo, Z., Cai, C. et al. (2021). Practices and roles of bamboo industry development for alleviating poverty in China, Clean Techn Environ Policy, 23, 1687–1699. https://doi.org/10.1007/s10098-021-02074-3.

Weiss, Emery, Corradini, & Živojinović. (2020). New Values of Non-Wood Forest Products. Forests, 11(2), 165. https://doi.org/10.3390/f11020165.

Wu, Y., Liu, S., Li, Z., Xu, J., & Xu, W. (2023). Experimental investigation on translaminar fracture behavior of cross-laminated bamboo. Construction and Building Materials, 393, 132112. https://doi.org/10.1016/j.conbuildmat.2023.132112.

Yadav, M., & Mathur, A. (2021). Bamboo as a sustainable material in the construction industry: An overview. Materials Today: Proceedings, 43, 2872–2876. https://doi.org/10.1016/j.matpr. 2021.01.125.

Yiping, L., Yanxia, L., Buckingham, K., Henley, G., & Guomo, Z. (2010). Bamboo and Climate Change Mitigation : a comparative analysis of carbon sequestration.

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