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## Bamboo supply chain: opportunity for circular and creative economy

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## ABSTRACT

This paper presents as a theme the productive capacity of bamboo related to the circular and creative economy. It aims to discuss at potentialities for its development in Brazil. It has become clear that the various stages of industrial production must respect the natural capital, rescuing issues such as the extraction of raw material and its impacts, the optimization of resources, the quality of the material, the use of materials available locally, the generation of employment and local income, socio-environmental responsibility and the search for sustainable and low-cost materials. In the national scenario one can see the abundance of bamboo and its economic potential, both on the scale of family and industrial production. At the same time, new ways of thinking about the economy, including circular and creative economy, are gaining space.

Key words: Supply chain; Bamboo; Circular and Creative Economy.

## 1. INTRODUCTION

Bamboo is a renewable material that has about 1200 species around the world. In Brazil there are approximately 250 species (endemic or introduced), which can be used in food, products, building constructions, among other purposes. The bamboo presents fast growth, stores carbon and has great resistance, being considered a material with low environmental impact, economical and technical feasibility with great possibility of social assimilation.

Currently, the supply chain is in a consolidation phase, since bamboo requires knowledge about the properties of each species, its characteristics of use, guarantee of supply according to age, as well as the treatment used. It requires qualified suppliers capable of ensuring the origin of the product and manpower enabled for handling, as well as equipment that can ensure a qualified industrial or craft production.

In this way, there are many possibilities of generating products at each stage and filling the gaps, which occur from the production of seedlings and planting to the distribution of the products benefited. So, along with the ecological and social advantages that bamboo already presents today, one can notice its easy connection with the circular economy and the creative one.

Such integration would enable a considerable economic growth, which, adding value to a product of national abundance, with great aptitude for agriculture, could make Brazil a world reference in the planting and industrialization of the product, generating new jobs, creating income and economic development in local and national level. This article discusses this potential and identifies the possibilities of obtaining products from the bamboo raw material.

## 2. THEORETICAL REFERENCE

The understanding of the processes, treatment and use of bamboo in Brazil is still incipient. Many studies were carried out, dispersed in the Brazilian states and with little national dissemination (CARDOSO Jr., 2000, MANHÃES, 2007; SILVA, 2011; SOARES, 2011; DRUMOND e WIEDMANN, 2017). In order to achieve the sustainability of the use of bamboo, it is necessary to integrate all stages of the production chain and to encourage good practices: management of plantations, natural preservation (preferably without harming the environment and human health due to the use of toxic chemicals), efficient equipment for the processing and production of primary, semi-elaborated or higher value-added materials and finally, the commercialization and use of components in industrial production.

Bamboo has many uses, and in the first decades of 1900, more than 1500 uses had been registered (MANHÃES, 2007). There are registered uses in agriculture, for irrigation, as biomass, as coal, as food, in construction, in the manufacture of plates and paper, as furniture, as a musical instrument and a series of decorative uses. These uses, the supply chain and circular and creative economy are addressed in more detail in the following items.

### 2.1. SUPPLY CHAIN

According to the Brazilian Flora Species List (FLORA DO BRASIL 2020, 2019), Brazil is the country of the Americas with the highest incidence of bamboo in its territory. There are 258 species of bamboo in Brazil, as well as one of the largest native bamboo forests of the world, located in the South-Western Amazon. In some parts of the southwestern Amazon, bamboo is considered a pest, due to its high incidence and rapid propagation of some species (FERREIRA, 2014), causing the rest of the flora to lose space in the place. What could be an ecological problem can become an economic and sustainable benefit.

According to the International Bamboo and Rattan Network (INBAR, 2018), the global bamboo market moves more than 60 billion dollars a year. With this information, the great diversity of bamboo in the Brazilian territory and the aptitude of its population for agriculture and creativity, one can observe the great economic potential that this tropical material represents for the development of the Country.

Some measures are already being taken by the government, such as the State Plan for the development of bamboo for the state of Acre, whose vision is to use bamboo to improve the per capita income of the state, increase the quality of life of local community. and minimize the environmental problems generated by the degradation of forest areas. All this through technical education, which is being applied

by the Technological Center of Bamboo, inaugurated in May 2018, where the engaged population learns about aspects of the supply chain and their possibility of assimilation of employment.

The first step for an optimized chain is the production of seedlings or the identification of clumps. In the latter case, the extraction must undergo an environmental licensing process, like the other species of flora. In a familiar process, the seedlings can be made from the stem, roots and rhizomes of the bamboo at the time of harvest. There are other forms of propagation, such as seeds, by means of chusquines (method colombiano - OLIVEIRA; PEREIRA; PASCOLI, 2017) and in vitro propagation.

The second step is correct soil management. Cultivation is simple, but larger-scale production can be ensured through some care, such as soil analysis, mowing, herbicide use, ant and termite control, soil pH correction, subsoiling, fertilization, spacing between seedlings and depth of coveamento should be ensured. For woody bamboos, some peculiarities such as their adaptation to hot and temperate climates (rainfall of 1260 to 4500 mm annually incident in the Brazilian states) once again incites the Brazilian aptitude for the production of bamboo. The age at harvest influences the strength of the material and may vary depending on the intended use. It is recommended that the harvest be carried out in drier periods when the bamboo has less sap, reducing moisture, facilitating transport and storage, reducing losses due to cracking as much as possible. However, this depends on the feasibility of material commercialization and on the climatic variations of the site (therefore, generalizations about the most suitable months for harvesting should be avoided).

Immediately after harvesting the bamboo must be treated. There are several possible treatments, from curing in the forest, impregnation of products by immersion, fire treatment, impregnation with CCA (Chromated Copper Arsenate) among other variations. This last treatment, much used for the woods, is prohibited in some countries. So, it is an option not recommended. Another option is the immersion in octaborate (boric acid and borax), which is an economical procedure with good environmental results and durability still under study (about 5 years, according to some professionals - CHALUPE, 2018). Treatment should be carried out according to the purpose of the use and species of bamboo. After treatment and drying, the raw material is then transported to the desired industrial purposes.

The stage of industrialization is very wide, since all parts of bamboo can be used: from its leaves, to the water that accumulates in its culms. The leaves have the highest concentration of silica throughout the plant kingdom, being rich in proteins, fibers, antioxidant compounds and flavonoids (compounds present in foods like fruits, vegetables and cereals with antioxidant, anti-inflammatory and disease prevention function). The leaves of some species such as *Bambusa vulgaris* Vittata and *Phyllostachys pubescens* are used to make tea, contributing to the strengthening of bones, hair, nails, assist in detoxification, are anti-inflammatory, antioxidants, immunity regulators, aphrodisiacs and can be employed in the cosmetic and textile industry, as green manure and in the manufacture of the famous Zhuyeqing, which is a traditional Chinese tea made by the monks.

The bud of bamboo is more targeted for the food industry, for popular segmentation and high gastronomy. From it is made bamboo sugar, juice, beer and so many other millennial and current recipes. From the culms is produced numerous components for the construction, bridges, furniture, musical instruments, bicycles, handicrafts, prostheses, coal (it is known that bamboo charcoal is of excellent quality, and its rapid growth balances the relationship between gas carbon dioxide emitted and absorbed), biomass, flour made with young stalk (rich in starch and used by celiac people), among others (BERALDO; FELISBERTO; MIYAKE, 2016).

With the fibers it is possible to produce a high quality artificial silk, as well as antiallergic mattresses, mats, nets, ropes, clothes, pulp, paper, crafts, etc. There is still the possibility of extracting the water that accumulates in the stalks in order to treat intoxications, hemorrhages, hemorrhoids and diarrhea. The water of the culms is digestive and soothing.

After all its possible uses by the user, the bamboo can undergo a process of extraction of biochemical raw materials to then go to anaerobic digestion and return to the soil as fertilizer or serve as a sustainable fuel through biogas.

Brazilian governmental initiatives already address aspects such as the definition of norms for sustainable management and for use in civil construction. It is necessary to identify market niches, invest in high value-added products such as bamboo laminate, furniture and window frames, observe the possibilities of exporting and partnerships with countries that dominate the material market, such as China, for example. Such perspectives of export were envisaged in the Memorandum of Understanding between the Ministry of Science and Technology of the People's Republic of China and the Ministry of

Science and Technology of the Federative Republic of Brazil on bilateral cooperation in science and technology in the area of development in bamboo in April 2011 (BAMBUS NO BRASIL, 2017).

## 2.2. CIRCULAR AND CREATIVE ECONOMY

The economy that governs humanity at this time is still linear. This economy has as a form of operation the extraction of the raw material, production, use and finally the discard.

This model was consolidated during the second Industrial Revolution, and becomes progressively unsustainable and obsolete for the modern world, considering the scarcity of natural resources, global overpopulation, global crises and inefficiency in waste management. We are approaching the fourth industrial revolution, the so-called industry 4.0, where technology, the internet of things, shared use, allied with personalization and product flexibility, promises to make sustainability tangible and maximize people's well-being. Never have the concepts of repair, redo, redesign, and rethink been so necessary to product design (WEETMAN, 2016).

According to the UNEP (United Nations Environment Program - UN BRAZIL, 2018), 99% of the products we buy are disposed of within six months and more than 2 billion tons of waste are produced for year worldwide.

From this perspective, the circular economy emerges as a new trend of an economic model that aims to articulate a conscious and optimized way of extracting, producing, consuming and discarding (SAMPAIO et al, 2018). According to the Ellen McArthur Foundation (2015) definition, this form of economy aims to "[...] maintain products, components and materials at their highest level of usefulness and value all the time, distinguishing between technical and biological cycles. This new economic model ultimately seeks to dissociate global economic development from the consumption of finite resources. The circular economy responds to challenges related to resources for companies and countries and could generate growth, create jobs and reduce environmental impacts [...]"

It is known that Brazil is currently the largest exporter of agricultural commodities and minerals. Thus, arable land and biodiversity become the essential elements that structure this economy. So, environmental certifications, soil regeneration, post-cultivation and restoration of degraded areas are the least that can be done in a country that depends mainly on natural capital.

A precept of the circular economy, and the perspectives of the Ellen McArthur Foundation for Brazil, is the investment in agricultural technology coupled with vernacular knowledge to change the country's impressions as an exporter of agricultural commodities and biological raw materials, working for an economy that adds value to the product, with the goal of putting the country at the forefront of global sustainable innovation.

Another form of economy that aims to add value to the product in a differentiated way is the creative one, which is a set of businesses based on intellectual, cultural and creative capital. The definition of the Brazilian Service of Support for Micro and Small Enterprises says that this form of economy "...stimulates income generation, creates jobs and produces export revenues, while promoting cultural diversity and human development."

The Creative Economy covers four areas: Consumption (Design, Architecture, Fashion and Advertising), Media (Editorial and Audiovisual), Culture (Heritage and Arts, Music, Performing Arts and Cultural Expressions) and Technology (R & D, Biotechnology and ICT) which according to the Creative Industry Mapping (FIRJAN, 2016) collaborated with 2.64% of the national GDP in 2015, with more than 851.2 thousand professionals.

## 2.2. METHOD

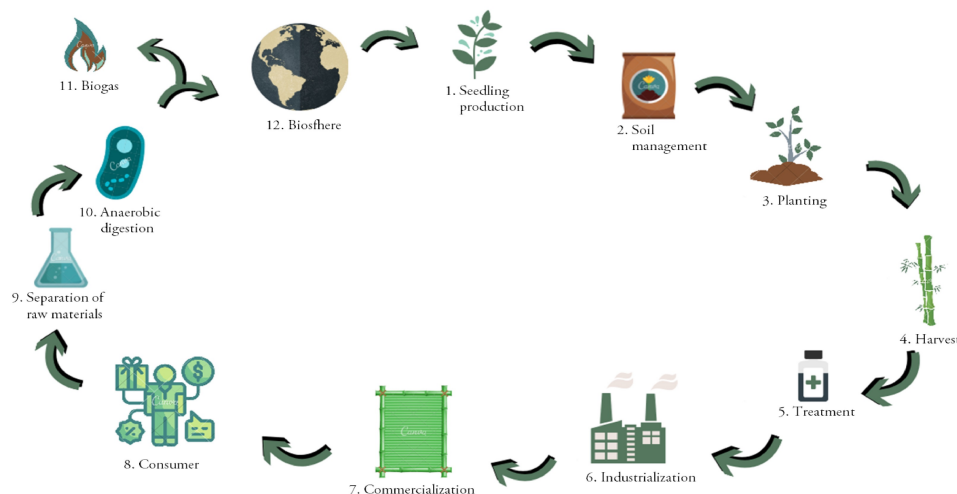
In order to achieve the sustainability of the use of bamboo, it is necessary to diagnose all phases of the production chain in a circular and creative scenario, and to encourage good practices: plantation management, preservation, equipment for the processing and production of primary materials, semi-elaborated or of greater added value and, finally, the commercialization and use of the products. To achieve the objectives of the research, it is presented the modeling of the chain and possibilities of product generation in the stages, in order to obtain its development, by filling the gaps in the process.

As results, it is expected to show the employment potential, technological transfer and knowledge about the supply chain in Brazil.

The first stage of the research consisted of a bibliographical review. The words: bamboo, circular economy OR creative economy and supply chain were used as operators. The initial search in google academic returned 20,200 references, not all relevant to this research, which were confirmed by the research in the CAPES journals portal, presenting the following most relevant authors: Waite (2013), Murray; Skene; Haynes (2017), Weetman (2016), Van Wijk, Van Wijk (2015) and Van Dam (2005). For the understanding of the bamboo supply chain, several references were consulted, besides those found in the systematic review. To understand the activity of the bamboo developed, the book *Bambus no Brasil: dá biologia à tecnologia* (DRUMOND; WIEDMAN 2017) was consulted. At the stage of understanding circular economy, the Ellen McArthur foundation's support material "Rumo a economia circular: racional de negócio para acelerar a transição." was used, and the national perspectives in "Uma economia circular no Brasil: uma abordagem exploratória inicial" (ELLEN MCARTHUR FOUNDATION, 2015). The second stage consisted of the supply chain modeling followed by the identification of the potentialities for the circular economy.

#### 4. NATIONAL POTENTIAL FOR THE CIRCULAR AND CREATIVE ECONOMY

To understand the steps and how they relate to each other, what their products are and what the employment possibilities generated at each stage, a scheme was developed that demonstrates the phases of the bamboo supply chain within a circular and creative economy. [Figure 1]



[Figure 1] Stages of the supply chain. Font: authors.

The products in the steps are as varied as possible. In step 1 we have the production and sale of seedlings and seeds, followed by soil preparation and planting. In the fourth stage, the product is the bud of bamboo, the seedlings rom parts of the bamboo (stems, roots, rhizomes), the green manure and the use of bamboo water that accumulates in the culms for homeopathic purposes.

In the treatment phase a possible product is sodium octaborate, a salt which serves as a fertilizer. In step 5 we have a vast product range, more than 1500 cataloged applications (MANHÃES, 2007), among them: enzymes, hormones, cosmetics, bacteria, coal, energy, biofuel, alcohol, textiles, aqueducts, ropes, bridges, paper, handicrafts, food, silica extract (tabashir), asthma medicine, medicinal drinks (as a substitute for steel), in sealing elements (panels with adobe, quinchas and bahareques, decorative plaited panels, esterijas (mats or mats), tiles, linings, ceilings and beams in civil structures, which can be used in the production of paper, can have various applications in composite materials. The leaves, due to the high concentration of silica are widely used by the cosmetic, pharmaceutical and textile industry, the stalks due to its great resistance are aimed at the civil construction, furniture industry, handicrafts, coal, among others. With fibers it is possible to produce an artificial silk pulp, clothing, among other things.

Opportunities for the creative economy can be found from the beginning of the chain, for example in the manufacture of canned bamboo for human consumption, or even in the purification of springs by simple planting. The greatest potentials arise in the stage of industrialization, commercialization and consumption.

Through the technical and cultural stimulation of the use of bamboo, creative forms of use can add value to the material. Examples include the initiative of the Brazilian company PetBamboo in the production of feeders and drinkers for pets with bamboo fiber. There is also a group of artisans from Acre who produces more than 100 bamboo guitars per year. The production of only one guitar takes about two weeks in an artisan way. Sustainable marketing and differentiated sound and more acute than bamboo provides are aspects that add much value to the product that already has perspectives of industrialization and export. We can also mention the Canadian company ChopValue, which works making furniture and accessories using chopsticks for Japanese food, hydraulic press and a water-based resin for the creation of products with high added value.

After initial use, the circular economy provides for optimization by reusing or using by-products. This means making the sequential use of the material, predicting the smallest internal circuits of the systems, such as restore, renew, re-pass, only to recycle. At this point, the importance of designing for durability is emphasized, as opposed to the linear system that feeds on programmed obsolescence. Professionals of the future need to be molded to design for remanufacturing, renovation and recycling.

After cascading, according to a circular economy, the bamboo can undergo a process of separation of the raw materials that make up the product. Many products can be studied for this destination, including use as fuel for stoves, boilers, engines and sustainable electricity generation through biogas. At the end of the cycle, the material will return to the biosphere, nourishing the soil and allowing the fertilization of other plants in a sustainable cycle.

## 5. FINAL CONSIDERATIONS:

Through the understanding and improvement of the stages of the production chain of bamboo at the national level, primarily in the treatment (to confer quality), industrialization (adding value to the product) and commercialization (export and recognition of the national product of the world market), Brazil would assume an active role in the world market with exports of manufactured bamboo products. There are many opportunities to explore. The production chain of bamboo in Brazil needs promotion, dissemination and incentives that go through governmental policies, innovation in research to develop new uses, adequate equipment, technologies for treatment that do not compromise the health or the quality of the environments where the material is workshops and activities to disseminate the best techniques for the material. Finally, as a gift from the gods, the human being can not miss this opportunity to search for a more sustainable way.

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