Mix Sustentável

O potencial do bambu na integração entre sensibilização ambiental e inclusão produtiva em territórios periféricos urbanos

The potential of bamboo for integrating environmental awareness and productive inclusion in peripheral urban areas

El potencial del bambú para integrar la conciencia ambiental y la inclusión productiva em territorios de periferia urbana

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Resumo: Este artigo tem como objetivo disseminar as potencialidades do bambu como matéria-prima para o desenvolvimento e produção de artefatos que contribuam para a vida produtiva e social em comunidades periféricas urbanas. A pesquisa, realizada no âmbito do mestrado em design, foi conduzida nas comunidades do Confisco e do Coqueiros, em Belo Horizonte, Minas Gerais, Brasil, caracterizadas pela alta vulnerabilidade socioeconômica. Identificou-se que as artesãs locais enfrentavam dificuldades para comercializar seus produtos devido ao elevado custo do aluguel das barracas de feira tradicionais. Diante

ORIGINAL ARTICLE – SCIENTIFIC SECTION
RESPONSIBLE EDITORS: Lisiane Ilha Librelotto, Dr. Eng., Paulo Cesar Machado Ferroli, Dr. Eng.

SUBMITTED ON
23/11/2024
ACCEPTED ON
16/09/2025
PUBLISHED ON
19/01/2026

PID
10.29183/2447-3073.MIX2025.v11.n3.151-175

desse contexto, foi desenvolvida uma barraca a partir dos princípios do ecodesign, utilizando-se o bambu *Phyllostachys aurea*, com as seguintes características: baixo custo, desmontável, compacta, durável, de fácil montagem e capaz de ser produzida com ferramentas simples pelas próprias artesãs. O projeto incluiu oficinas de capacitação em técnicas artesanais de bambuzeria para a manufatura das barracas, promovendo o aprendizado e o empoderamento das participantes. Apesar de ainda estar em andamento, os resultados parciais indicam que a iniciativa pode promover a sensibilização ambiental, a formação crítica e o fortalecimento comunitário, além de ampliar a autonomia produtiva e econômica das artesãs, especialmente entre mulheres negras, periféricas e com baixa escolaridade formal.

Palavras-chave: Bambu; Barraca de feira; Comunidades periféricas urbanas; Autonomia produtiva; Sensibilização ambiental.

Abstract: This article aims to disseminate the potential of bamboo as a raw material for the development and production of artifacts that contribute to productive and social life in peripheral urban communities. The research, carried out as part of a master's degree in Design, was conducted in the communities of Confisco and Coqueiros, in Belo Horizonte, Minas Gerais, Brazil, which are characterized by high socioeconomic vulnerability. It was identified that local artisans faced difficulties in marketing their products due to the high cost of renting traditional market stalls. Given this context, a stall was developed based on eco-design principles, using *Phyllostachys aurea bamboo*, with the following characteristics: low cost, demountable, compact, durable, easy to assemble, and capable of being produced with simple tools by the artisans themselves. The project included training workshops on bamboo craft techniques for manufacturing stalls, promoting learning and empowerment among participants. Although still ongoing, partial results indicate that the initiative can promote environmental awareness, critical thinking, and community strengthening, in addition to increasing the productive and economic autonomy of artisans, especially among Black women from low-income neighborhoods with limited formal education.

Keywords: Bamboo; Market stall; Urban peripheral communities; Productive autonomy; Environmental awareness.

Resumen: Este artículo busca difundir el potencial del bambú como materia prima para el desarrollo y la producción de artefactos que contribuyen a la vida

productiva y social en comunidades periféricas urbanas. La investigación, realizada como parte de una maestría en diseño, se llevó a cabo en las comunidades de Confisco y Coqueiros, en Belo Horizonte, Minas Gerais, Brasil, caracterizadas por una alta vulnerabilidad socioeconómica. Se identificó que los artesanos locales enfrentaban dificultades para comercializar sus productos debido al alto costo del alquiler de puestos de mercado tradicionales. En este contexto, se desarrolló un puesto basado en principios de ecodiseño, utilizando bambú *Phyllostachys aurea*, con las siguientes características: bajo costo, plegable, compacto, durable, fácil de ensamblar y capaz de ser producido con herramientas simples por los propios artesanos. El proyecto incluyó talleres de capacitación en técnicas artesanales de bambú para la fabricación de los puestos, promoviendo el aprendizaje y el empoderamiento entre los participantes. Aunque todavía está en marcha, los resultados preliminares indican que la iniciativa puede promover la conciencia ambiental, el pensamiento crítico y el fortalecimiento comunitario, así como ampliar la autonomía productiva y económica de las artesanas, especialmente entre las mujeres negras de comunidades marginadas con bajos niveles de educación formal.

Palabras clave: Bambú; Puesto de mercado; Comunidades de periferia urbana; Autonomía productiva; Conciencia ambiental.

Como citar: CARVALHO, Bianca Carvalho de; PÊGO, Kátia Andréa Carvalhaes. O potencial do bambu na integração entre sensibilização ambiental e inclusão produtiva em territórios periféricos urbanos. **Mix Sustentável**, Florianópolis, v. 11, n. 3, p. 151-175, 2025. DOI: https://doi.org/10.29183/2447-3073.MIX2025.v13.n4.151-175

1 INTRODUCTION

The impacts caused by climate change are intrinsically related to local vulnerability factors, determined by social, economic, geographic, and institutional conditions (Correa-Macana; Comim, 2013). According to Fry (2009), large brazilian urban centers deal with deep social inequalities, which are intensified by the effects of the climate crisis. These effects cause changes in natural dynamics, manifested in variations in temperature, changes in rainfall patterns, water runoff, river flow, soil moisture, evapotranspiration, and other environmental variables (WayCarbon, 2016). The disruption of these processes results in impacts such as floods, landslides, heat waves, fires, and an increased incidence of disease (Gore, 2020).

In the Belo Horizonte metropolitan area, the study "Analysis of Vulnerability to Climate Change in the Municipality of Belo Horizonte" identified a direct relationship between social vulnerability and the effects of the climate crisis (WayCarbon, 2016). These effects are most severe in low-income communities, which are characterized by precarious occupations and difficulty in adapting to climate change.

Irregular growth and population density in peripheral urban communities, combined with limited financial resources to prepare for or recover from impacts, make these territories more susceptible to the adverse effects of this crisis (Correa-Macana; Comim, 2013; Gore, 2020). Furthermore, low-income communities generally depend more on natural resources for their subsistence, with economies based on agricultural activities, fishing, and handicrafts (Albino, 2017; Correa-Macana; Comim, 2013; Romanello *et al*., 2022).

In addition to these challenges, the rapid pace of social, economic, and political change in Brazil in recent years has radically altered the labor market, resulting in a drastic reduction in jobs across various sectors of the economy. From this perspective, a new dynamic can be observed, characterized by the decline and precariousness of formal salaried employment and the expansion of informal work and self-employment. As such, the economic activities of vulnerable peripheral populations are often linked to small businesses, open-air fairs, and handicraft production.

In this context, strategies that promote income generation and improve quality of life are becoming essential to provide resilience to these communities (Gore, 2020; Jagtap, 2022). One way forward is to strengthen existing activities and value local know-how, such as handicrafts.

In 2024, Brazil had approximately 8.5 million artisans, the majority of whom were women (77%). Handicrafts contribute approximately 3% of the Gross Domestic Product (GDP), generating around R$ 100 billion (Lima, 2024). In Minas Gerais, in 2020, approximately half a million people worked directly with handicrafts, generating annual revenues of around R$ 6 billion (Brazil, 2020).

Despite significant revenues, the gross income generated by handicrafts and the seasonality of sales are insufficient to ensure the survival of most artisans, who need to have other occupations as their main source of income (Pereira *et al*., 2023).

According to Albino (2017), craft activities can also be oriented to respond to local demands and contribute to solutions that promote sustainability and climate adaptation, based on practices that value local knowledge and resources. To this end, the use of natural materials available in the surrounding area, such as bamboo, is not only a low-cost alternative but also ecologically appropriate and socially relevant to community realities (Ferreira *et al*., 2022).

Many species of bamboo are abundant in developing countries and stand out for being a renewable, resistant, and fast-growing material (Ostapiv; Librelotto, 2019; Pereira; Beraldo, 2016). In addition, it has broad applicability and potential to promote environmental, social, and economic benefits (INBAR, 2014; Janssen, 2000; Van Der Lugt, 2008).

In Brazil, especially in rural and urban peripheral contexts, it can be easily integrated into communities through courses and workshops that address planting, treatment, and artisanal bamboo techniques (Ostapiv; Librelotto, 2019). International experiences, such as those promoted by the International Bamboo and Rattan Organization (INBAR), reinforce the potential of bamboo for generating income in developing countries.

Exploring the possibilities of bamboo as a raw material can generate significant short-, medium-, and long-term benefits for urban peripheral communities, as well as contributing directly to confronting the effects of the climate crisis. The promotion of sustainable productive activities, such as bamboo handicrafts, strengthens artisans' autonomy and technical proficiency in materials and processes, generating decent work and income, in line with SDG 8 – Decent Work and Economic Growth, one of the 17 Sustainable Development Goals (SDGs) of the United Nations (UN). Improving social and economic conditions is an essential factor in strengthening community resilience, as it provides greater financial stability and the ability to adapt to extreme weather events.

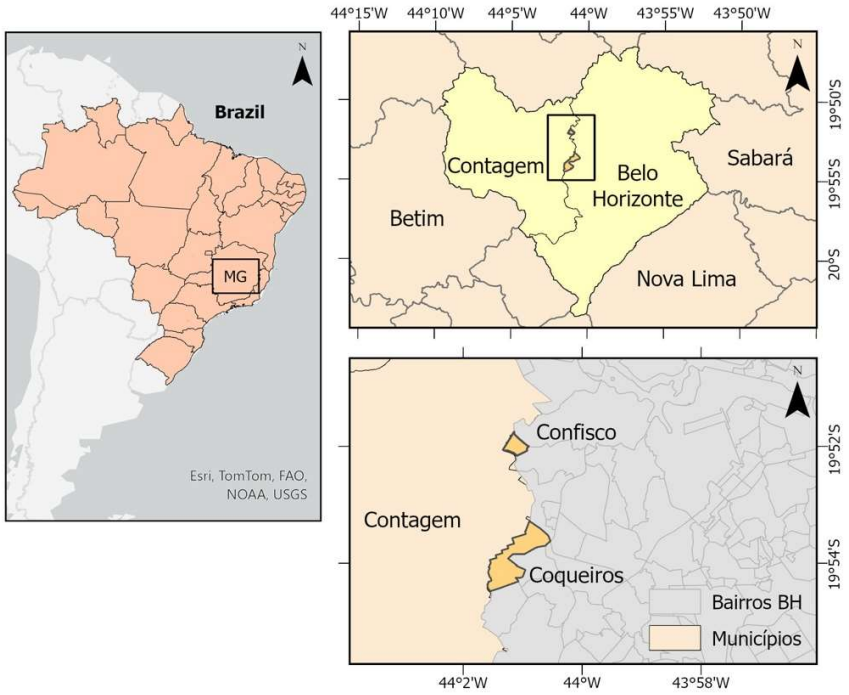
This project incorporates these perspectives by using bamboo as the basis for local solutions in peripheral neighborhoods in the municipality of Belo Horizonte, Minas Gerais, Brazil. By identifying demand for certain products and holding training workshops on bamboo craftsmanship, the initiative seeks to strengthen community resilience, increase economic autonomy – especially among Black women and those living in the periphery – and promote adaptation to the effects of the climate crisis.

2 METHODOLOGY

2.1 Areas of study

The project was developed with artisans and market vendors residing in the periphery of Belo Horizonte (MG), in the communities of Confisco and Coqueiros (Figure 1), characterized by socioeconomic vulnerability.

Figure 1 – Location map of study areas: Confisco and Coqueiros neighborhoods, Belo Horizonte - MG



Source: Authors.

The neighborhoods of Coqueiros and Confisco are in the northwest region of Belo Horizonte (BH). Confisco, located in the Pampulha region (BH), has part of its territory in the municipality of Contagem (metropolitan area), which creates an administrative duality and affects residents' sense of belonging.

Both neighborhoods emerged in the 1980s through occupations by movements fighting for housing for low-income families living in high-risk areas. The configuration and consolidation of these regions into neighborhoods resulted from community mobilization, led mainly by women.

The survey conducted by WayCarbon (2016) on the climate vulnerability of Belo Horizonte in 2016, with projections up to 2030, identified these regions as among the most vulnerable to the effects of climate change, particularly in relation to heat waves and arboviruses.

The territories in question face significant challenges, both in adapting to the effects of climate change and in overcoming socioeconomic limitations. Locally, the economy is mainly driven by small retail businesses and open-air fairs – "*Feira Raiz*" (Root Fair) in Confisco and "*Feira das Famílias Empreendedoras*" (Entrepreneurial Families Fair) in Coqueiros, currently managed by the community itself. These spaces are the main channel for selling products made by local artisans.

2.1 Methods

A documentary survey of the territories was conducted through a literature review and analysis of social, cultural, economic, and environmental aspects. In addition, field visits and roundtable discussions with community leaders and residents were performed, complemented by participation in local collective actions, with the aim of gaining a broader understanding of the dynamics of the territory and its demands. Based on this approach, meetings were held with artisans from the Confisco neighborhood, and the "*Feira das Famílias Empreendedoras*" (Entrepreneurial Families Fair) was monitored at the Agroecological Experience Center (CEVAE) in the Coqueiros neighborhood to deepen understanding of the needs related to the product to be developed – bamboo stalls.

2.2.1. Workshops

The approach proposed for the workshops focused on productive and economic autonomy was theoretical and practical in scope. The main objectives were to share techniques for making and producing the product identified as the main demand and to promote environmental awareness. The process aimed to encourage changes in habits and stimulate reflection on consumption practice and daily production.

Nine integrated workshops were planned. The workshops covered all stages of product manufacturing, from the recognition and harvesting of mature culms to cutting, treatment, drilling, assembly, and the use of the tools necessary to perform the activities. The proposed sequence included: (1) roundtable discussion; (2) harvesting and cleaning of the bamboo culms; (3) cutting; (4) treatment; (5) making bamboo dowels; (6) drilling and assembly; (7) installation for testing; (8) adjusting; and (9) project closing event. To date, two workshops have been held: a roundtable discussion to present the project and another dedicated to identifying mature bamboo culms, as well as harvesting and cleaning them.

Among the theoretical content covered, the following stand out: (i) the causes and effects of climate change; (ii) concepts of the circular economy; (iii) the importance of biodiversity conservation; (iv) the management of everyday waste; (v) the consequences of air, water, and soil pollution on human health; (vi)

the sustainable use of natural resources; (vii) the impacts of production and consumption patterns; and (viii) the selection of materials to produce various artifacts, with an emphasis on bamboo.

2.2.2. Product development

Once the demand had been identified, the product was developed in accordance with the methodological principles of eco-design, which aim to reduce environmental impacts without compromising functionality (Kazazian, 2005). The process followed steps for selecting sustainable materials, optimizing production, distribution and use, extending useful life, and planning for final disposal (UNEP, 1996, *apud* Echeveste; Sauri; Danilevicz, 2002).

The project requirements were identified through semi-structured interviews, non-participant observation, and analysis of similar products, and were subsequently categorized according to their importance and classified as mandatory or desirable.

After generating alternatives, five proposals were developed using Sketchup Pro software. To evaluate and compare them, the Decision Matrix tool was used. Each proposal was evaluated individually, according to the requirements established in the project, using a scoring scale. The scores were assigned according to the level of compliance with each requirement: 1 – insufficient compliance; 3 – partial compliance; 5 – full compliance. The lines marked with (-) correspond to requirements that could not be evaluated. The result of the matrix was obtained by adding up the scores assigned to each alternative, and the product with the highest score was selected to be detailed in the next stages of the executive project. ArchiCAD software was used to develop the executive project.

Scale model and prototype

For the construction of the 1:5 scale model, *Phyllostachys aurea* bamboo was used, with a diameter proportional to the scale, and toothpicks were used as substitutes for bolts due to the reduced scale. Measurements were taken with a scale ruler and pencil, and assembly carried out using a bow saw, a micro grinder, a 1.5 mm high-speed steel drill bit, and glue.

The materials used in the manufacture of the prototype included *Phyllostachys aurea* bamboo, French bolts, washers, and wing nuts. For the bolted joint system, ¼" x 4½" French bolts were used, with flat washers and ¼" wing nuts. For the splice connection, ¼" x 2½" French bolts, flat washers, and ¼" wing nuts were used.

The prototypes were built at the Testing, Modeling, and Prototyping Laboratory (LEMP) of the UEMG School of Design.

3 RESULTS

Through immersion in the communities of Confisco and Coqueiros, by visiting and participating in community activities, it was possible to identify the need to develop a market stall suitable for selling handicrafts. These visits, carried out over more than a year and a half, were part of a continuous immersion process, without a predefined itinerary, with the aim of deepening the relationship with residents and understanding the territory through observation and dialogue. During this period, several productive activities were recognized, mostly carried out by women, who play a central role in generating family income.

To participate in fairs, artisans generally use rented stalls. However, during conversations and interviews, it was identified that the high cost of renting these stalls is a limiting factor for participation in local and regional fairs.

The traditional stalls available for rent (Figure 2), offered directly at the fairgrounds, are mostly made of iron, usually galvanized steel or metal tubes, which makes them relatively heavy structures, and they usually vary between 150 × 150 cm and 200 × 200 cm. The roof is usually made of waterproof vinyl canvas and can be pyramid-shaped or gabled. Many have built-in counters or support tops for displaying products, as well as side skirts.

Figure 2 – Traditional market stall available for rent

Source: Authors.

Furthermore, other recurring problems were identified in relation to the use of rented stalls: (i) variation in prices and availability of stalls depending on holidays and events; (ii) lack of adequate protection against bad weather; (iii) difficulty in assembling and dismantling, with risk of damage to products; and (iv) aesthetic disconnect between handmade products and metal stalls covered with tarpaulins, which reduces the value of local work.

3.1 Raw material

Although not found in the localities, the bamboo species *Phyllostachys aurea*, popularly known in the region as "*cana-da-índia*", was selected for its mechanical strength and low starch content, a characteristic that allows heat treatment with fire. This method is low-cost, requires few resources, and does not depend on chemical inputs or complex infrastructure, making it particularly suitable for practical application in peripheral urban communities (Ostapiv; Librelotto, 2019; Pereira; Beraldo, 2016). For these reasons, heat treatment proved to be the most efficient and viable option for the project.

The species was reported to be present in two institutions close to the communities, but it was not possible to obtain the material through these channels. After several attempts, a bamboo grove was identified at the Ecological Station (EECO) of the Federal University of Minas Gerais (UFMG), which provided the essential raw material for the development of the project, contributing significantly to the advancement of the initiative among vulnerable communities.

3.2 Partial results: workshops conducted

Two workshops were conducted: the first on September 6, 2023, at *Praça do Confisco*, and the second on November 17, 2023, at the Ecological Station (EECO) of the Federal University of Minas Gerais (UFMG). The first workshop had ten participants, while the second had five. The workshops were supported by the Municipal Environment Secretariat (SMMA), which provided a bus to transport participants between the neighborhoods and the EECO.

In the first workshop, the team presented the bamboo stall design to the artisans and market vendors. The design was developed based on the requirements identified in the conversations and interviews and was immediately approved without any suggestions for changes. At that point, the team highlighted the importance of selecting the right materials for producing artifacts and explained the properties of bamboo that make it an eco-efficient material.

Participants were surprised to learn that bamboo properties can be like those of steel, which is often

used in traditional stalls, especially in terms of the relationship between tensile strength and specific mass (Janssen, 2000).

Next, through a roundtable discussion, the team gave a brief explanation of the causes of the current climate crisis and its consequences on everyday life. At this point, participants shared their personal experiences, highlighting the effects they had directly observed, such as heat waves and dengue outbreaks. The second workshop was divided into four stages:

Stage I: Lecture highlighting the characteristics and properties of bamboo, its advantages as a raw material, and its importance as an environmental agent.

During the lecture, the diversity of bamboo uses and the importance of using the material at the ideal stage of growth were highlighted. The stages of culm growth influence its applications, and to produce bamboo stalls, it was ideal for the culms to be mature, when the mechanical resistance properties are already stabilized. In addition, the choice of the species *Phyllostachys aurea* for the study and the methods used to identify this species of bamboo based on its characteristics were discussed.

Moreover, participants learned about the best conditions and period for harvesting quality material. The ideal period for harvesting is during the dry season, when the culms have less moisture (sap and water). At this time of year, they are lighter and less susceptible to attacks by xylophagous insects, which are less active at lower temperatures (Ostapiv; Librelotto, 2019 Pereira; Beraldo, 2016). According to popular belief, in addition to drought, bamboo should also be harvested during the waning moon (Ostapiv; Librelotto, 2019).

The lecture was an enjoyable and relaxed event, in which participants actively engaged, asked questions about the topic, and shared their previous experiences with the material. It was a valuable opportunity to exchange knowledge and strengthen collective learning about bamboo and its applications.

Stage II: Learning to identify mature culms. In the bamboo grove, participants learned how to identify culms between three and six years old based on the following characteristics: absence of culm sheaths, coloration, and the presence of spots on the internodes caused by fungi, mosses, and/or lichens.

It is worth noting that most workshop participants had no previous experience with the material but quickly learned to identify mature culms intuitively, drawing on knowledge acquired in other agricultural activities. This learning demonstrates the participants' ability to adapt, transfer knowledge, and their interest in learning about bamboo and its characteristics.

Stage III: Participants were instructed on the correct technique for harvesting culms, being advised to cut just above the first node near the ground. This practice is essential to prevent the bamboo from having its hollow part exposed and accumulating water inside, which could lead to rhizome rot and the spread of diseases such as dengue fever, which benefit from the accumulation of standing water. The participants then carried out

the harvest (Figure 3). To this end, the team provided the necessary tools, including a bow saw, a tape measure, and pencils.

Figure 3 – Stage III of the second workshop: harvesting mature culms

Source: Authors.

Stage IV: After harvesting the 30 culms, this stage consisted of instruction on the correct way to remove branches and leaves, to avoid damage to the material (Figure 4). The participants then proceeded to clean the culms, which were subsequently divided into three parts to facilitate transport on the bus.

Figure 4 – Stage IV of the second workshop: cleaning

Source: Authors.

As a final assessment, the workshop was fruitful, the participants showed enthusiasm, shared how they felt throughout the activities and were grateful for the opportunity. The program included a snack break offered by the organization and the transportation of bamboo culms, previously harvested and cleaned, for storage at the Social Assistance Reference Center (CRAS) in Confisco.

3.3 The bamboo stall

3.3.3. Non-participant observation

The "*Feira das Famílias Empreendedoras*" (Entrepreneurial Families Fair), located in the Coqueiros neighborhood, takes place at the Agroecological Experience Center (CEVAE). At the observed event (Figure 5), there were five food stalls, one for clothing, eight for handicrafts, and two for candy. The food stalls, which use gas cylinders and stoves, were not analyzed, as bamboo stalls are not suitable for this use.

Figure 5 – Entrepreneurial families fair, in Coqueiros

Source: Authors.

For the fair, two options are offered for displaying products. The first option consists of renting standard event stalls, made of iron with canvas and pine wood counters, measuring 200 x 200 cm, at a cost of R$ 100.00 per day, in addition to a participation fee of R$ 35.00 to cover expenses such as electricity, tables, chairs, and musical attractions. As a second alternative, participants can opt for white plastic tables, measuring 70 x 70 cm

and accompanied by two chairs, at a daily rate of R$ 35.00, which corresponds to the participation fee. It was observed that many of the stalls are shared between two market vendors who work in the same productive activity, thus dividing the rental cost.

Exhibitors who use tables prefer shaded areas due to the lack of cover. Some bring parasols or move around throughout the day to protect themselves from the sun and prevent products such as sweets and chocolates from melting. Besides the sellers' comfort, staying in cooler areas is essential to prevent the loss of merchandise, which can melt at higher temperatures and result in significant sales losses.

Most market vendors who choose to rent tables use various resources to optimize display space and increase product visibility, aiming to attract more customers. In some cases, the rented tables serve mainly as a place to set down meals brought from home and to take notes.

Several adaptations are made to maximize the use of space, such as collapsible tables brought from home, which are larger than those provided by the event, folding screens, and shelving units to highlight products and attract customers' attention. In another effort to diversify and enhance the appeal of the sales space, some vendors use wheelbarrows to display potted plants.

Among the stalls, there are also examples of creative adaptations, such as a flip-flop clothesline installed by a shoe seller, highlighting the artisanal and autonomous nature of the display strategies.

Market vendors transport their goods in boxes, suitcases, or bags, and some keep stock to ensure product availability. These goods are stored under plastic tables or stall counters, often hidden by tarpaulins or towels.

The pine wood counters of the stalls, measuring 200 x 55 cm, are put to good use by all market vendors. However, the sides of the stalls, which are 200 cm deep, are generally not used and do not appear to be necessary for the productive activities analyzed at the fair.

3.3.2. Semi-structured interviews

Semi-structured interviews were conducted with eight vendors at the CEVAE Coqueiros Entrepreneurial Families Fair, with the aim of understanding their needs, preferences, and challenges in relation to the existing stalls, as well as their expectations for an ideal stall. All interviewees were women, aged between 23 and 63, working in different productive activities—such as handicrafts (50%), sweets (25%), natural personal care products (12.5%), and accessories (12.5%). Most lived in the Coqueiros neighborhood (75%), while 25% commuted from Contagem. In terms of experience, 62.5% had up to one year of experience in fairs, and 75% participated exclusively in the local fair, with the high cost of renting stalls being the main impediment to participating in other events.

To transport products and accessories to the fair, 62.5% (n = 5) of market vendors use their own cars;

12.5% (n = 1) rely on ride-hailing services, as this vendor lives further away from the fair location; 25% (n = 2) walk, as they live very close to the event site. The market vendor who uses ride-hailing services mentioned some difficulties with the service, such as finding drivers willing to transport the necessary volume of material, such as bags with products and the collapsible table.

The market vendors reported using boxes, screens, collapsible tables, and shelving units to compensate for the limited space of the rented tables, with the majority (62.5%) opting for it due to its low cost. Those who prefer stalls highlighted comfort, the possibility of better displaying their products to customers, and protection from the weather, although they mentioned the financial burden and instability of the structures and poor quality of the roof covering. Even among those who opted for stalls, some vendors on rainy days resorted to tarps or paused their activities. As for the sun, strategies included changing position, using parasols, and employing thermal bags to preserve the products.

In terms of the need for electricity in the stalls, 75% (n = 6) of the market vendors stated that they did not need it, as they brought their charged card machines from home. For these vendors, electricity was not a concern during the event.

The interviewees highlighted the importance of having a more stable and secure counter, as the ones that came with the rented stalls were light and unstable, which could cause products to fall, especially on windy days; and the presence of a larger eave for protection against rain and sun.

As for the ideal size (length x width x height), 75% (n = 6) consider the dimensions of 200 x 100 x 220 cm to be ideal; 12.5% (n = 1) prefer dimensions of 200 x 200 x 220 cm, which correspond to the stalls available for rent on site; and 12.5% (n = 1) indicated a preference for 100 × 100 × 200 cm. In general, most market vendors are satisfied with the length of the existing structures, considering them adequate for displaying products. However, in relation to width, some pointed out that 200 cm is excessive, resulting in unused empty space.

Regarding the ideal stall, they highlighted ease of assembly, lightness, compactness, side counters, hooks and shelves for display, space for personal belongings, and the use of sustainable materials. All expressed interest in bamboo workshops to build their own stalls, recognizing bamboo as an ecological, lightweight, and aesthetically attractive raw material. The participants associated the proposal with productive autonomy and the appreciation of artisanal work, highlighting the project's potential to strengthen the local economy and the sustainability of the communities.

Faced with the difficulties of covering the costs of renting stalls, market vendors emphasized the importance of having their own structures, which ensure equal exposure for their products and reduce the costs associated with participating in fairs.

3.3.3. Similarity analysis

Based on observations and interviews, relevant characteristics for the project were defined, including functionality, innovation, ease of assembly, disassembly, and transport, compactness, and environmental values. Next, stalls used at fairs around the world that met at least one of these criteria were researched, resulting in the selection of ten models for detailed cataloging, including photos, authorship, location, year, description, material, dimensions, price, and weight.

The analysis emphasized the need to balance structural robustness, weather protection, and display space with other relevant characteristics. This combination results in a functional and efficient stall, capable of satisfying the needs of market vendors in different contexts of use.

3.3.4. Project requirements

As a result, 23 requirements for the creation of the market stall were defined, as presented in Table 1, of which 19 were classified as mandatory (items 1–19). In addition, four requirements were classified as desirable (items 20–23).

These desirable requirements, although not essential for minimum functionality or for fulfilling the main objective of the project, add value, comfort, efficiency, and attractiveness to the solution. They represent elements of differentiation, innovation, and enhancement of the user experience, and can be implemented

according to the availability of resources, time, and technical feasibility, without compromising the delivery of mandatory requirements.

The project requirements guided the generation of alternatives, with the aim of aligning the proposals with the established guidelines, especially those considered a priority. Different possibilities were explored for the configuration of the stall, the structural system, and the connecting elements, including the construction of a scale model and prototypes for visualization and testing of the proposed solutions. These activities were essential for refining the selected alternative and ensuring that the solutions were viable and effective for the needs identified in the previous phases.

Among the alternatives generated, five were selected based on the previously established requirements. For the final choice, a Decision Matrix was developed. As shown in Table 1, alternative 5 obtained the highest score, with 100 points, followed by alternative 4 (98 points), alternative 3 (94 points), alternative 2 (92 points), and alternative 1 (88 points). The final decision was made in favor of the highest-scoring alternative, which consists of a trapezoidal-shaped market stall, both in the floor plan and in the side elevations.

Table 1 – Decision matrix (1 – insufficient compliance; 3 – partial compliance; 5 – full compliance)

Item	Requirement	Alternatives				
		1	2	3	4	5
						
1	Be aesthetically appealing to the public	3	1	3	5	5
2	Be dismountable	5	5	5	5	5
3	Be easy to assemble and disassemble	3	5	5	3	5
4	To be easily transported and stored	5	5	5	5	5
5	Be lightweight	5	5	5	5	5
6	Wide counter and supports for hanging products	3	3	3	5	5
7	Have a sturdy and stable counter	5	5	5	5	5
8	Have a cover	5	5	5	5	5
9	Be strong and durable	3	3	3	5	5
10	Be ergonomic	1	5	5	5	5
11	Use locally available materials	5	5	5	5	5
12	Use durable materials	5	5	5	5	5
13	Enable low-cost implementation	5	5	5	5	5
14	Be produced by the community itself	5	5	5	5	5
15	Use easily replicable artisanal techniques	5	5	5	5	5
16	Enable maintenance	5	5	5	5	5
17	Preserve the local ecosystem	5	5	5	5	5
18	Use predominantly renewable resources	5	5	5	5	5
19	Low energy consumption	5	5	5	5	5
20	Provide support for personal belongings	-	-	-	-	-
21	Be customizable	5	5	5	5	5
22	Provide access to electricity	-	-	-	-	-
23	Use recycled or recyclable materials	-	-	-	-	-
	TOTAL SCORE	88	92	94	98	100

Source: Authors.

The selection of alternative 5 (Figure 6) is justified by its ability to expand the product display space,

provide better use and visibility of the sides, be ergonomically efficient both in use and in two-step assembly, and be easily assembled/disassembled, transported, and stored. In addition, the selected alternative demonstrates structural strength and durability, eliminating potential points of weakness compared to the other alternatives. Visually, it stands out for being attractive and distinctive compared to the stalls commonly found at fairs in the region.

Figure 6 – Trapezoidal alternative 5 selected

Source: Authors.

Following this, the project team constructed the scale model as a mockup, which proved fundamental to understanding the details of the bamboo joint systems, the necessary locking mechanisms, and the logic of the constructions, including the angles of the perforations (Figure 7). In addition to providing an accurate representation, the model enabled practical testing, the identification of necessary adjustments, and the validation of the concept before full-scale implementation.

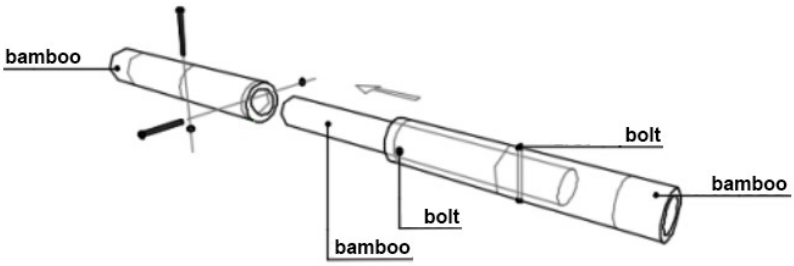
Figure 7 – Scale model 1:5

Source: Authors.

Next, the team built a prototype of the bamboo stall using the material harvested in the second workshop to check the stability of the structure and test the locking system, counter support, and storage space for goods.

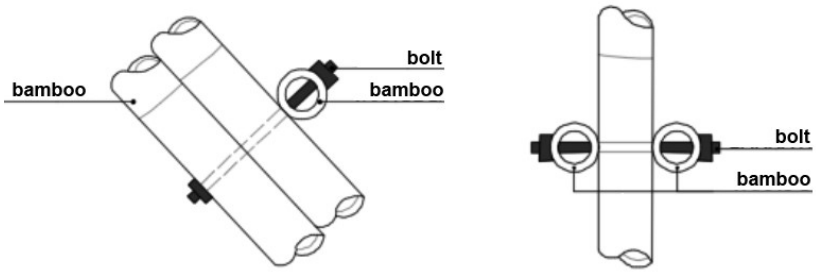
Furthermore, the first prototype was used to test the types of joints chosen for the bamboo, such as the splice connection and the bolted joint system, which are fundamental to the structure and stability of the stall (Figure 8; Figure 9).

Figure 8 – Splice connection



Source: Authors.

Figure 9 – Bolted joint system



Source: Authors.

During this phase, the need for some adjustments was identified, such as the absence of upper and rear diagonal locks, which were incorporated into the next version.

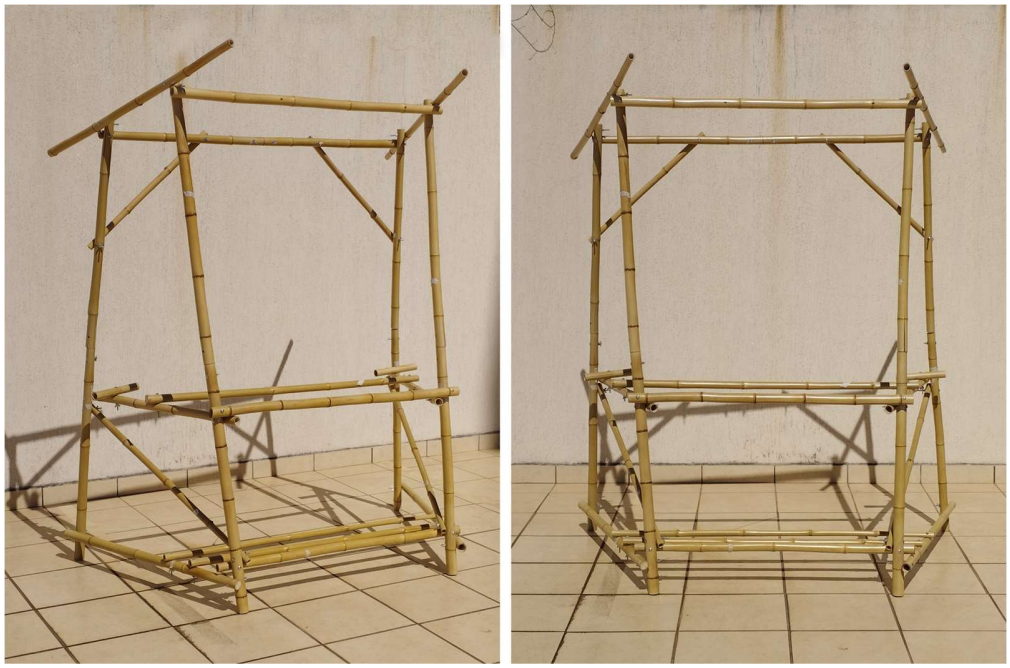
In the second prototype, the practical steps followed the same process as in the first, aiming to improve the previous model. The identified improvements were implemented and refined, increasing the functionality of the product. After assembly, the bamboo parts were heat-treated, acquiring a characteristic golden hue and shine (Figure 10).

Figure 10 – Treatment of culms using a blowtorch and gas cylinder

Source: Authors.

In total, 3,294 cm of *Phyllostachys aurea* bamboo, 36 ¼" x 4½" French bolts with ¼" washers and wing nuts, and 10 ¼" x 2½" French bolts with washers and wing nuts were used, totaling 14.7 kg. The structure measures 200 cm in length, 110 cm in width, and 230 cm in height (Figure 11).

Figure 11 – Second prototype



Source: Authors.

Based on the initial results, adjustments were made, which will be incorporated into the development of the third prototype. After evaluating the use and resistance of the structure in a real environment, co-creation workshops will be promoted for the kits, allowing them to be customized according to different productive activities. The kits will cover the five sectors in which artisans and market vendors work – handicrafts, clothing, cosmetics, recycling, and prepared foods – and will include specific items for each activity, such as hooks for hanging necklaces, shelves for displaying sweets, and wheeled packaging for easy transport.

4 DISCUSSION

During the research activities, it was identified that one of the main demands of the communities of Coqueiros and Confisco, in Belo Horizonte, is access to adequate market stalls, which are essential for the sale of local products and income generation. However, high rental costs and the limitations of the available structures—which are often fragile, damaged, and difficult to assemble—restrict the participation of small producers in street fairs (Araujo; Ribeiro, 2018).

This challenge reflects a reality present in several regions of Brazil. Studies show that artisans who

have their own stalls enjoy greater autonomy, can participate in more events, and reach a wider clientele (Ferreira Júnior; Figueiredo, 2014). Expanding access to this resource, therefore, has the potential to strengthen local economies, promote productive inclusion, and ensure greater freedom of movement, enabling access to fairs in different regions.

The significant presence of women between the ages of 23 and 63 in the craft sector highlights the central role of fairs in generating work and income, despite the seasonality and economic instability that characterize this activity (Brazil, 2020). Even so, public policies to support open-air fairs remain limited and do not correspond to their social relevance (Araujo; Ribeiro, 2018).

Moreover, traditional stalls – usually made of steel with PVC canvas covers – rarely reflect the visual and cultural identity of artisanal products. This disconnect reduces the potential for aesthetic and symbolic appreciation of the work of market vendors.

The initial proposal of the project was to identify community needs that could be satisfied using bamboo – a material that is abundant in Brazil and has strong symbolic value in the reconstruction of cultural identities in these territories (Zambrano; Viteri, 2021). Its ease of cultivation, harvesting, transportation, and handling, combined with artisanal techniques, make bamboo a strategic resource for economic, social, and environmental development in vulnerable contexts (Sasaoka; Pereira; Santos, 2019).

Among the available species, *Phyllostachys aurea* was considered the most suitable due to its mechanical resistance and low starch content, a characteristic that allows it to be treated with fire. The experiment demonstrated the potential of bamboo as an economic and social tool, especially in empowering women, including elderly participants, in the community who actively participated in the workshops. The partial results indicate that the proposed solutions can raise awareness among communities most vulnerable to the effects of the climate crisis about environmental issues, while strengthening the productive and economic autonomy of populations in peripheral urban regions in situations of socioeconomic vulnerability.

However, obtaining the *Phyllostachys aurea* species proved challenging. No bamboo groves were found in the public areas of Confisco and Coqueiros, and initial attempts to acquire them from public agencies were unsuccessful. Despite institutional interest, the lack of technical knowledge about the different species of bamboo hampered the process, highlighting the need to expand the dissemination of information on their correct identification and differentiation (Ostapiv; Librelotto, 2019).

This limitation was overcome through a partnership with the Ecological Station (EECO) at UFMG, which provided the necessary raw materials and demonstrated the importance of inter-institutional collaboration. This experience reinforces that coordination between communities, universities, and public agencies is essential to enable sustainable projects and amplify their social and environmental impacts.

Irregular participation in workshops by people in vulnerable situations—due to work obligations, health problems, or family responsibilities—constitutes an additional barrier to the effectiveness of the process, evidencing the need for support strategies and institutional coordination to ensure the continuity and results of planned actions (Jagtap, 2022).

In addition to the difficulty of accessing bamboo, the implementation of the project was limited by factors such as the lack of adequate infrastructure for holding the workshops. Although they require modest investments, initiatives of this type depend on basic resources—such as transportation, adequate tools, and ergonomic and safe work benches—to ensure their viability. The scarcity of resources and institutional support, added to the time constraints arising from the master's degree program and the limited budget, compromised the continuity of the workshops and the full realization of the planned activities.

Despite the limitations encountered, it is believed that valuing individual expertise and the shared construction of knowledge in community spaces strengthens social ties and promotes values such as friendship, care, solidarity, and respect for cultural differences and the environment. These experiences contribute to broadening communities' sense of belonging and autonomy, encouraging sustainable and contextualized practices that strengthen local resilience in the face of the challenges posed by the climate crisis.

5 CONCLUSION

The theoretical and practical approach of the workshops enabled knowledge to be understood and applied in real situations within the social and productive life of the communities of Confisco and Coqueiros. The engagement and participation of artisans and market vendors ensured that the proposals were culturally relevant and aligned with local needs, strengthening the group's sense of belonging and empowerment.

The prototype bamboo stall is currently undergoing testing. At the same time, the team is finalizing adjustments to advance the project and subsequently test it in situ during the "*Feira Raiz*" (Root Fair) in Confisco and the "*Feira das Famílias Empreendedoras*" (Entrepreneurial Families Fair) in Coqueiros.

Although challenges have been faced so far, such as limited resources and partnerships with the public sector, the results suggest that the proposed solutions have the potential to raise environmental awareness in communities most vulnerable to the effects of the climate crisis, while also strengthening the productive and economic autonomy of populations in peripheral urban areas in situations of socioeconomic vulnerability.

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Acknowledgments

To the Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil, for financial support.