Use of wood waste from Amazonian tree species for the manufacture of products with regional identity

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Abstract

Based on the problem of the quantity of wood waste generated by the timber milling process in sawmills in the state of Amazonas and the possibility of manufacturing products using this material, the aim of this study was to develop a product with regional identity made from this wood waste. The research process involved analysis of cultural issues in the North Region of Brazil and the quantity and quality of wood waste present in the Wood Engineering and Artefacts Laboratory (LEAM/INPA). This wood was donated by the company Mil Madeireira, located in the municipality of Itacoatiara in the state of Amazonas. Assessment of the regional themes of northern Brazil found that animals are represented in many products. This is especially true for handicrafts, where artisans seek to represent animals typical of the region in carvings, paintings, sewing and other crafts. As a result, a mood board was created with images of the most popular animals in the North region. The product was developed from hand drawings and 3D modeling to check the relationship between the pieces. Later, a physical prototype was developed using sawmill waste from the species Peãozinho (Micrandropsis sclerorylum W. Rodr), Cardeiro (Scleronemoma micranthum) and Mandioqueira (Qualea paraenses), after their classification. Based on the quality and quantity of waste generated from milling, one of the proposed alternatives was a coffee table called Arara (Macaw). The coffee table consists of 5 (five) pieces: 4 (four) of wood and 1 (one) of glass. In search of satisfactory results, this idea arose based on two factors: the aesthetic and emotional appeal, and modularity. The product was generated from analysis of elements of the northern Brazilian regional identity and the classification of waste from milling of certified wood and forestry residues. It has been observed that much of the wood is discarded or is burned to generate energy. In addition to the amount of wood wasted, two other factors were also analyzed: the first is the possibility of generating value through the culture of the northern region, specifically that of the state of Amazonas, through the manufacturing of products, and the second is to leverage the production of the wood industry. The product is easy to construct and the process can be taught to third parties, since the technical details are presented so as to facilitate its large-scale production.

Keywords: Regional identity; Wood waste; Amazonian woods; Coffee table; Product design.

1. Introduction

The Brazilian Amazon has a rich diversity in terms of fauna, flora and the culture of the people who inhabit it. Each state within the region has its own individual cultural heritage. This wealth of natural and cultural resources enables the development of a wide range of products. This is no different in the forestry sector, which considers timber production and the furniture and wooden products sector (MARCON *et al*. 2012). Despite being one of the activities of the most important productive sector in the northern Brazilian region, timber production in the Amazon presents several problems related to the processing of wood in terms of waste generation. As a result, a number of governmental and non-governmental initiatives have been created in order to try to contain the quantity of wood waste from timber milling in sawmills and woodworking workshops (MENDONZA *et al.* 2017, CAVALCANTI *et al.* 2003). According to Silva *et al.* (2019), "the use of wood residues from timber milling and naturally fallen trees is highly encouraged by research institutions, agencies and universities".

Although these actions exist, a significant amount of waste is still permitted by law, due to the fact that the National Environment Council - CONAMA approved the reduction of the percentage of log use in sawmills from 45% to 35%, measured by the Lumber Recovery Factor (CONAMA, 2016). This contributes to the devaluation of wood, as 65% of the wood material is lost, regardless of the species, commercial height, diameter of the trees and the quality of the wood material for final use.

The process of milling logs into lumber tends to focus on the heartwood of the trees. In most cases, the sapwood is not commercialized due to a lack of technological knowledge and is discarded in the sawmill yards as waste. In this regard, Lima *et al.* (2018) state that "it is apparent in many wood processing industries that there is technological deficiency in the maximization of the utilisation of logs". In addition to sapwood, several other types of wood waste are also discarded, such as cracked pieces, wooden ends, pieces that do not meet commercial dimensions and pieces with defects. In 2014, Brazil generated about 33.6 million tons of wood waste from forestry activities (BAUER & SELLITO, 2019).

A significant part of this waste is used for energy generation, mainly by burning in an internal boiler, sale to other companies, burning in brick kilns, use in poultry farms and for making briquettes (BAUER & SELLITO, 2019). In addition to energy generation, another use for wood waste is in the manufacture of products.

Generally, in the state Amazonas, most wood products are made by hand. In some cases, products made by artisans cannot be manufactured in series due to a lack of technical details. Another issue is that these artifacts are usually manufactured without the assistance of a designer, design technician or other similar professional, which would create a standard for the production of the artifacts.

Based on the problem described of the quantity of wood waste from timber milling and the devaluation of tree species from the Amazon, this study sought, in addition to the possibility of making products using this material, to develop a product (coffee table) with regional identity from wood waste.

2. Material and Methods

In order to carry out the research, cultural factors in the North Region of Brazil were analyzed through a literature review. The quantity and quality of wood waste present in the Wood Engineering and Artifacts

Laboratory (LEAM/INPA), donated by the company Mil Madeireira, was also evaluated. The research was developed based on the methodology proposed by Barbosa Filho (2009), divided into seven stages:

1. Survey of demand
2. Construction of the concept
3. Creation of functional definition
4. Creation of alternatives
5. Materialization of alternatives
6. Testing and refinement
7. Presentation of final solution (Results)

2.1 Survey of demand and construction of the concept

Assessment of the regional themes of northern Brazil found that animals are represented in many products. This is especially true for handicrafts, where artisans seek to represent animals typical of the region in carvings, paintings, sewing and other formats.

Thus, a mood board (Figure 1) was drawn up with images of the most popular animals in the North region to help choose an animal that would contribute to the creation of a product with regional identity. The animal selected using a non-probabilistic sample was the Scarlet Macaw, due to its typicality and because it has the greatest variety of shapes and characteristics. The animals included in the mood board were: jaguar, scarlet macaw, caiman, capybara, Amazon turtle, anaconda, sloth, giant otter, boto (river dolphin), tamarin monkey and toucan (respectively, from left to right in Figure 1).

Figure 1: mood board.

2.2 Functional definition and creation of alternative

After the selection, stylised drawings of the animal were created in order to avoid reproducing carved representations, which usually aim to faithfully reproduce the shape of the animal or motif. Through this stylisation, the shapes of the macaw were smoothed out to create the table that is the object of this study. Other elements that are representative of the North region were also inserted during the creative process. These were the forest and the canoe, which is the most common means of transport in the municipalities of the region.

The three motifs: the selected animal, the forest and the canoe, were stylized so as to be incorporated into the shape of a coffee table. Based on the drawings, a cardboard model was generated to check the dimensions, angles and the relationship between the parts, as shown in Figure 2.

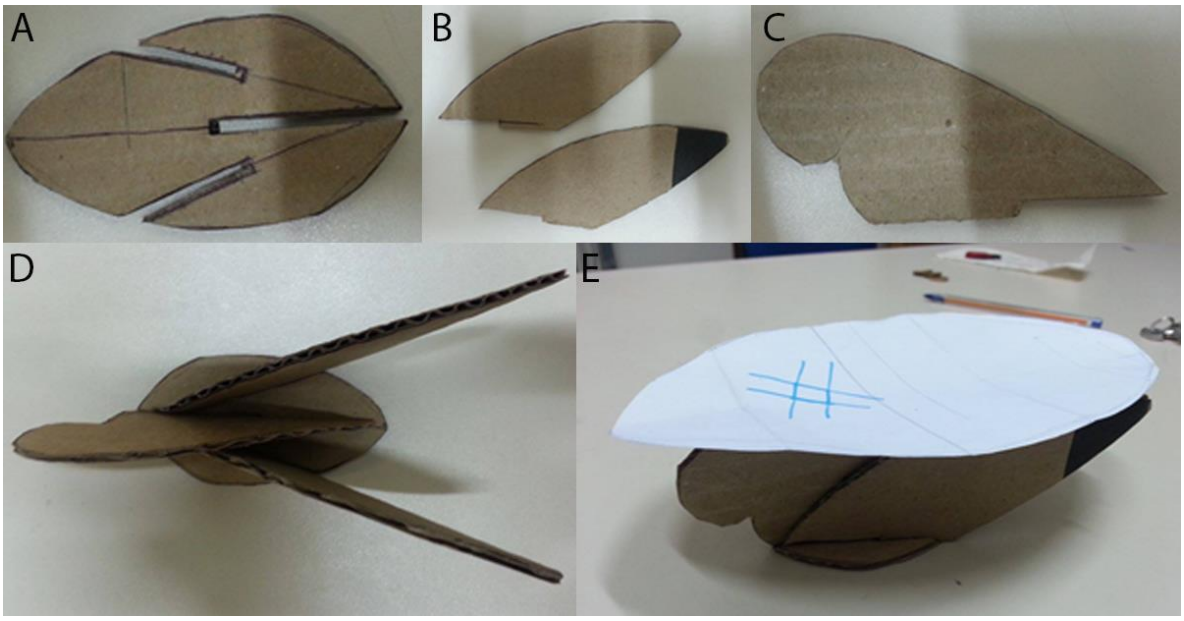

Figure 2. Cardboard model. (A) table base, (B) "wings", (C) "body", (D) assembly of parts, (E) verification of the complete model.

2.3 Materialization of the alternative and testing and refinement

Some adjustments were made after verification of the cardboard model and the measurements were established from a 1:1 scale drawing on a white board.

The coffee table was modeled in the CAD Solid Edge software in order to generate a virtual prototype. This avoids the need to make a physical prototype that would result in the use of materials and generation of waste. The virtual prototype (Figure 3) made it possible to check the dimensioning of the parts and the fit between them. This prototype was then used to draw up the technical details for manufacturing of the product.

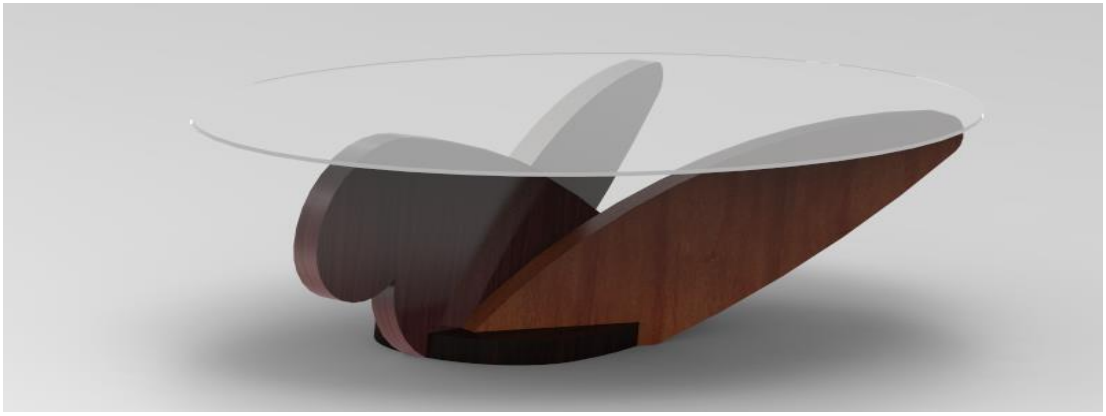

Figure 3. Virtual prototype.

A cardboard model with a 1:1 scale (Figure 4) was also developed for the glass top, which was later sent to a glass factory for fabrication.

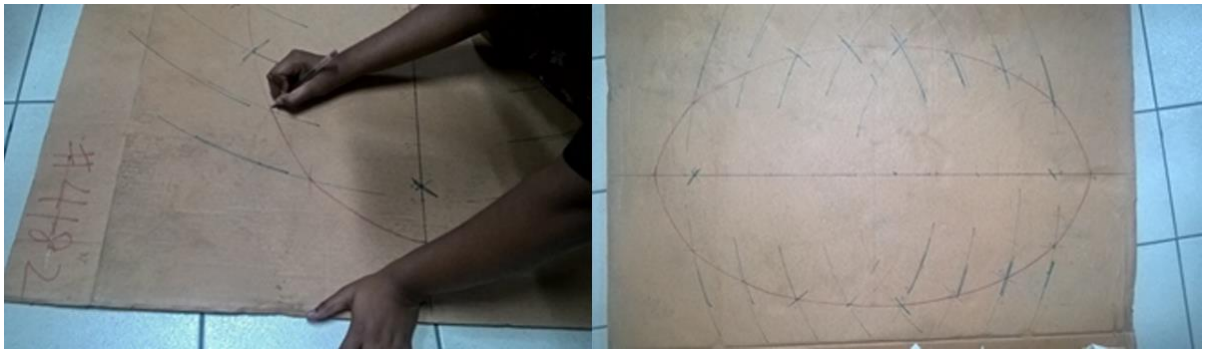

Figure 4. Cardboard model of the glass top.

The wood residues from mechanical processing selected for making the table came from the following tree species: *Peãozinho* (Micrandropsis sclerorylum W. Rodr), *Cardeiro* (Scleronemoma micranthum Ducke.) and *Mandioqueira* (Qualea paraenses Ducke). The Peãozinho is a tree species that is not yet used in the logging chain, due to its small diameter.

The residues were measured and classified by size and by the quality of the wood, considering the heartwood and the sapwood of the Peãozinho due to their contrasting colors (Figure 5). Despite being visually distinct, both have similar properties and approximate densities, with the heartwood having a density of 0.93 g/cm³, and the sapwood having a density of 0.90 g/cm³. (BARROS, 2016)

Figure 5. Peãozinho Board.

After the classification and selection of the waste from the three tree species, the product was constructed using basic carpentry tools, e.g. a circular saw, band saw, thickness planer, calibrator, bench and orbital sander, and manual drill (Figure 6).

Figure 6. Making the Table.

4. ANALYSIS OF THE RESULTS

The product was analyzed considering the volume of waste used, ease of manufacture, aesthetics, and ease of assembly and disassembly.

3. Results

The Amazon is rich in flora and fauna, and one of the most common species is the scarlet macaw. Therefore, the basic shapes that make up the table refer to the shape of this bird's body (body and two wings). The shape of the base is inspired by the shape of leaves, and the glass, which sits on top of the table, has a similar shape to the silhouette of a canoe seen from above, used as a means of transport by riverside dwellers (Figure 7).

Figure 7. Canoes.

We tried to work on all these elements in a single product, aiming to contribute to the valuing of regional identity through the use of shapes that refer to the Amazon rainforest and the culture of the people that inhabit it. The shape of the bird was chosen to further value the species of the region, showing that many elements can be taken advantage of, e.g. a bird, and even the canoe, which is the means of transport used by riverside dwellers. According to Bonsiepe (2011), this is one way to materialize the identity of a given location, in this case by exploring the regional theme and a group of formal characteristics.

The table was developed based on the quality and quantity of waste generated from timber milling. It consists of five pieces: four of wood and one of glass. In search of satisfactory results, this idea arose based

on two factors: the aesthetic and emotional appeal, and modularity.

The coffee tables' architecture is considered to be modular, because, according to Baxter (2011), modular architecture is that in which the blocks are arranged in modules and each module performs its function completely, containing well-defined and fundamental interactions. The application of this concept can also be seen in the work developed by Silva and Nascimento (2016). As such, the parts that make up the proposed table are independent modules, but which complement each other. This results in the formal configuration of the product. As for the modularity factor, we tried to work with joints alone, eliminating the use of any type of connecting element between the wooden pieces. However, during the fabrication of the product it became clear that two screws were needed to fix the parts together better.

Despite the organic shape, the pieces did not present any difficulties regarding the manufacturing process, as will be discussed later. It was necessary to use modularity for this piece to facilitate transport, as well as assembly and disassembly. Although the table will arrive at the final consumer in a disassembled form, they will then be able to assemble it without any specific knowledge.

The raw material used (wood) can come from forest residues (wood from naturally fallen trees in the forest), small diameter trees of species that are widely distributed in the Amazon forest according to the existing database in INPA's Forest Management Laboratory, and waste from timber milling. This follows the central concept of this product, which is to add value to Amazonian wood in its entirety, the wood of native species and the balance found in the relationship between nature, fauna and man through the use of this waste, which until now has been discarded or burned to generate energy.

3.1 The Arara (Macaw) coffee table

The waste came from certified wood that appears on the commercialisation list for the state of Amazonas. According to INPA/CPPF (1989), the tree species *Mandioqueira* and *Cardeiro* have good resistance and can be used for numerous products. The same also applies for *Peãozinho*, as researched by Barros (2016), table 1.

Table 1- Characteristics of the tree species used for making the table

Species	Density (g/cm^3)	Workability	Uses
Cardeiro[1] *Scleronema micranthum* Ducke	0.59	Easy to saw, plain, nail and screw, receives a good finish	Carpentry, Joinery
Mandioqueira[1] *Qualea paraensis*	0.66	Easy to saw, plain, nail and screw, receives a moderate finish	Heavy construction, joinery and carpentry,
Peãozinho[1] *Micrandropsis sclerorylum* W. Rodr	0.99	Moderately easy to saw, screw and nail, receives an excellent finish.	Woodwork and carpentry

[1]INPA/CPPF (1989), [2]Barros (2016)

The structural parts of the table (base, wings and body) were made by three different processes using basic

carpentry machines and tools, as described in table 2. Figure 8 shows general views of the Arara (Macaw) coffee table with its structural parts.

Table 2 - Structural parts of the table, dimensions of waste wood and machines used in the process

Structural parts	Variation in the thickness of the residues (mm)	Machines used
Leaf-shaped base	**Part 1 -** 10 to 15 **Part 2 -** 20 to 30	Thickness planer, band saw, jointer, calibrator and circular sander
Wings	20 to 30	Thickness planer, band saw, jointer, calibrator, circular sander
Body	20 to 30	circular sander, thickness planer, calibrator
Top	the shape of the glass is oval (ellipse) with a thickness of 5mm.	

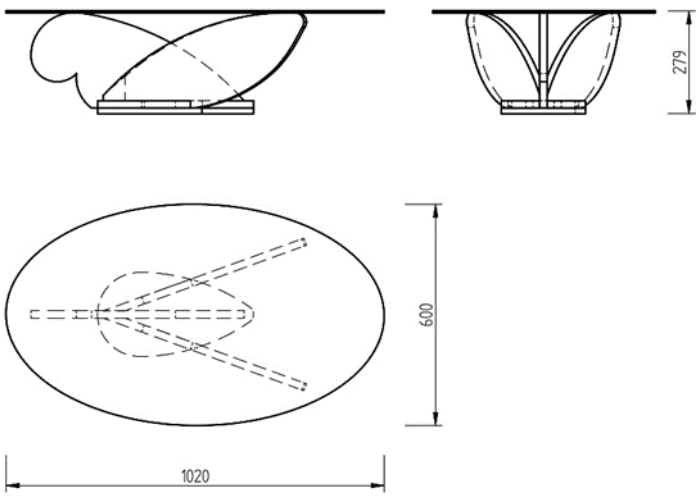

Figure 8. General views of the Arara coffee table.

During the manufacturing process, an excellent result was observed in the milling of the wood of all three species, an important factor as an indicator of product quality. Similar results were obtained by Froes *et al.* (2018) in their research with *matamata* wood. Thus, the finished product meets all the necessary requirements for insertion in the market, mainly because it is a sustainable product with a regional identity (Figure 9).

Figure 9. Arara (Macaw) table.

The opportunity was found to design a product that could be manufactured using waste from milling of certified timber and forest waste. This product is embedded in the context of Amazonian culture and is easy to manufacture for inclusion in the lumber industry's production line. The product is easy to construct and the process can be taught to third parties, since the technical details are presented so as to facilitate its large-scale production.

4. Conclusion

This study offers an alternative wood product with high added value, made from timber milling waste. Wood technology and design enables industries in the State of Amazonas to direct their waste to production of products with regional identity and the capacity to compete in foreign markets. It was developed from the analysis of elements of northern Brazilian regional identity and the classification of waste from the milling of certified wood and forestry residues. It has been observed that much of the wood is discarded or is burned to generate energy. In addition to the amount of wood wasted, two other factors were also analyzed: the first is the possibility of generating value through the culture of the northern region, specifically that of the state of Amazonas, through the manufacturing of products. The second is to leverage the production of the wood industry by making use of timber species from the region that do not have commercial value due to their dimensions and the lack of proposals that contemplate the use of these materials.

5. Acknowledgements

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