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Traditional ecological knowledge of mangrove wood use on the Brazilian Amazon coast

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ABSTRACT

Traditional ecological knowledge (TEK) has been widely used and valued as a reliable source of information in the development of research on the various uses of the forest. Here, the socio-environmental factors that affect the traditional knowledge of extractivists about the uses of mangrove wood in an estuarine-coastal community in the Brazilian Amazon region were analyzed. The grouping of words evoked in semi-structured interviews with 108 local informants highlighted the lexicons that best express the use of mangrove wood. Factorial correspondence analysis was used to assess the intersection between words and age groups, helping to indicate respondents' TEK of these uses. Most respondents say that wood is used for domestic (family) purposes, mainly charcoal and weir, and that these purposes and applications were taught by the older generation of the community. The traditional uses of the species *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa* have been validated by the scientific literature through their technological properties. From this validation, a relevant contribution is to include the participation of users in intervention processes by using their TEK, making the planning process of preventive conservation strategies and management proposals more efficient, promoting the reduction of a future advance deforestation in this region. Likewise, such information is relevant to guide the social actors involved in the implementation of public policies, favouring the creation of new alternatives and solutions for better management and use of wood resources in mangrove areas.

Keywords: Amazonian mangroves, Ethnobotany, Extractivism, Traditional communities, Wood exploitation.

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SIGNIFICANCE STATEMENT

To better understand the extractivist's traditional knowledge of the mangrove timber resource and its different uses, interviews were conducted with residents of six traditional communities inside and outside the Caeté-Taperaçu Marine Extractive Reserve on the Brazilian Amazon coast. We used statistical analyses to obtain the most meaningful content and context of local extractivists' traditional ecological knowledge (TEK) of wood uses from several species of mangrove trees in the region. Most respondents recognized that the main uses are intended for energy production, construction of fishing weirs, and insect repellent with almost all of these types of use compatible with the quality of the wood, in particular the anatomical, physical and chemical properties. The growing demand for wood accelerates the degradation of mangrove forests. Thus, activities based on the traditional knowledge of extractivists still need to be developed in these communities in order to establish alternatives and increasingly appropriate uses of wood from mangrove forests in the Amazon region.

INTRODUCTION

Brazil has one of the most extensive areas of mangroves around the world, approximately 9900 km^2 (Diniz et al. 2019), with about 80% located on the Brazilian Amazon coast (Hayashi et al. 2019), where the largest continuous extension of this ecosystem on the entire planet is found (Nascimento et al. 2013). In the last three decades, the mangroves in this region have lost little in area to anthropogenic activities (Diniz et al. 2019), becoming one of the largest well-preserved mangrove swaths on the planet. Only about 1% of its total area has been affected by negative anthropogenic impacts (Hayashi et al. 2019), noting that those authors were unable to identify, through satellite images, selective logging activities on tree species in Amazonian mangroves.

Mangroves are recognized around the world as one of the most important coastal ecosystems, as they provide a wide variety of goods and services (coastal protection, wildlife habitat, nutrient cycling, fisheries and marine resources, tourism and recreation, and carbon sequestration) (Balmford et al. 2002; Santos et al. 2017). In many countries, traditional coastal communities depend on the exploitation of mangrove forests and their resources, which represents a vital source of livelihood (FAO 2023). Human populations living in or around mangrove areas use this ecosystem as a reference for its social and cultural activities (e.g., recreation and ecotourism), but mainly for their subsistence and movement of local, regional, and even international trade, generating family income through numerous productive practices (estuarine fisheries, collecting shellfish, collecting medicinal plants, extracting clay, collecting firewood, among others) (Vedeld et al. 2004; Dahdouh-Guebas et al. 2006; Walters et al. 2008; Treviño 2022).

The productive activities of fishermen involving plant resources such as wood from mangrove trees in the region do not represent a legalized source of income, as their commercialization is prohibited by Federal Law N°. 12,651/12. However, wood from the mangrove has been of great importance to local fishermen, as they are used for the most diverse purposes (Figure 1), with the species *Rhizophora mangle* L., *Avicennia germinans* (L.) L., and *Laguncularia racemosa* (L.) C.F. Gaertn. the most used (Fernandes et al. 2018). Among the different uses of mangrove wood are the construction of fishing weirs, using selective logging of mangrove trees such as *L. racemosa* (Voigt 2011) and illegal selling of all mangrove woods, but especially *R. mangle*, to feed the ovens of local potteries and bakeries (Fernandes et al. 2018). It is important to point out that the Chico Mendes Institute for Biodiversity Conservation – ICMBIO authorizes the cutting of mangrove trees only in special situations and upon direct request. Interested parties must describe in detail the location where they intend to cut and the specific amount of wood to be removed. ICMBio carries out a technical evaluation of this request to verify if there will be any impact on the area of the Conservation Unit, as well as that referring to the "Buffer Zone".

Throughout their lives, mangrove users spend many hours a day interacting with the mangrove ecosystem, resulting in a lot of valuable information on available resources in this ecosystem (Carrasquilla-Henao et al. 2019; Dahdouh-Guebas et al. 2021). When considering that the mangrove is a socioecological system, it is relevant to have a better understanding of the local ecological knowledge (Dahdouh-Guebas et al. 2021; Mace 2014).

Considering that the mangrove forests of the Brazilian Amazon coast are formed by a few species of trees that are the target of multiple uses and overexploitation, and that the association of wood quality with these different uses is little known. The objectives of the present study were: i) to evaluate socio-environmental factors, such as location, sex, age, which can affect users' knowledge about mangrove vegetation; ii) to characterize, through speech analysis of respondents, the uses of wood from mangrove trees; and iii) to verify the adequacy of these uses to academic knowledge (AK) based on available literature. Both TEK and AK about mangrove wood resources serve as a basis for the adequacy of their dif-

Figure 1. Photographs illustrating different mangrove uses on the Brazilian Amazon coast: (A) Stilt house built with wood of *Rhizophora mangle* and *Laguncularia racemosa*, (B) Corral fence built with wood from *R. mangle*, (C) Use of *L. racemosa* sticks for building weirs, (D) Smoke with wood from *Avicennia germinans,* (E) Cooking food with *R. mangle* e *A. germinans*, (F) Wood obtained from *R. mangle* used for charcoal production, (G) Groiled fish using wood from *A. germinans,* (H) Weir built with *L. racemosa*, (I) Clay oven for charcoal production from wood of *R. mangle*.

ferent uses and for discussing preventive conservation and management strategies, with the aim of mitigating the negative effects of these activities on mangrove forests.

MATERIAL AND METHODS

Study area

The Caeté-Taperaçu Marine Extractive Reserve (MER) covers a total area of 42,068,086 ha and is located on the Ajuruteua peninsula, Bragança, northeastern Pará State (ICMBIO 2012) (Figure 2). The vegetation cover of the peninsula is approximately 87% mangrove forests, the rest being dominated by salt marshes, *restingas* (coastal sand-dune vegeta-

tion), beaches, dunes and some patches of dry land vegetation (Behling et al. 2001; Carneiro et al. 2010). The climate in this region is hot and humid with an average annual rainfall of 2508.4 mm and an average annual temperature of 25.6°C (INMET 2022). The dry season runs from July to November, while the rainy season runs from December to June (Moraes et al. 2005). The region has a semidiurnal macrotidal regime with a range of 4 to 6 m.

The communities where the present study was carried out are located inside (Bonifácio, Castelo, and Vila dos Pescadores) and in the surrounding areas (Caratateua, Tamatateua, and Taperaçu-Campo) of the Caeté-Taperaçu MER (Figure 2). Inside and in the surroundings of the Caeté Taperaçu MER, 57 traditional communities depend directly on the ecosystem services provided by the mangrove: i) supporting and regulating services such as nutrient cycling, regulation of floods, droughts, and soil degradation; ii) provisioning services as food and water; and iii) cultural services such as leisure, spiritual, and religious (MEA 2005). Approximately 3000 to 4000 families from Bragança are beneficiaries of the reserve, whose main economic activity is artisanal fishing (ICMBIO 2012). The MER has a Management Plan that defines the norms for use, the zoning of the areas and the environmental and socioeconomic sustainability programs (ICMBIO 2012). The reserve is managed by the Association of Users of the Caeté-Taperaçu Marine Extractive Reserve (ASSUREMACATA), which is directly responsible for applying these rules, as it represents users from all communities that make up MER, i.e., 4457 beneficiaries (ICMBIO 2012).

Data collection

In order to obtain information about the different uses of wood resources available in the mangroves of the Caeté-Taperaçu MER, semi-structured interviews were carried out by using an interview guide (Additional File 1). Such interviews format represents a better balance between structured and unstructured questions, often carried out through the application of a semi-open questionnaire, that is, a script for a semi-structured interview (Oliveira 2008). Semi-structured interviews consist of questions that aimed to broaden the understanding of the object of study and access different TEK about this object (Fraser and Gondim 2004). The information obtained through the interviews with the respondents were organized in a relational database, that is, a collection of tables that allow data to be compared and processed in order to produce tangible results (Brent 1983), allowing use of coding previously established for each of the answers, or categories of answers.

Data were collected by using 108 respondents in six communities, totalling 18 respondents per community. Respondents were divided into three age categories: i) 15 to 25 years old; ii) 26 to 55 years old who are considered active producers in the labour market, in a non-excluding variable category, that is, many subjects are mangrove wood extractors and at the same time, mangrove crab fishermen and iii) over 55 years, those people who, among their beneficiary rights, are retired or do not have the same market production. In each community, respondents were chosen randomly, so there were different numbers of women and men (67 and 41 individuals, respectively). The most important criterion adopted here was not only to quantify the opinions of users, but to explore and bring significant content to better understand the various facets of the topic in question.

All respondents were asked for permission authorizing the disclosure of data. If granted, an author's signature was requested. In the first encounters, the objective of the study was explained, with the acceptance and permission of the local communities, with the addendum that the personal data of the respondents were preserved in absolute anonymity. All participants were asked if they agreed with the questionnaires, giving the opportunity to withdraw. Finally, all information provided by respondents was compared with technical-scientific knowledge available in the literature.

Data analysis

To identify the most evoked words in the interviews, highlighting the terms that best represent the use of wood in the *corpus* or set of text obtained through the verbal material transcribed from the interviews applied in the target communities (Bauer et al. 2002), three statistical analysis or techniques were used: i) the *Word Cloud*, which is a simple lexical analysis that groups and organizes words graphically based on their frequency of occurrence; ii) *Similitude Analysis*, which is based on graph theory to identify the co-occurrences between the words and indicate the existing connection between them, better describing the content of the interviewee's speech; and *Correspondence Factorial Analysis* that was used to evaluate the intersection between the words and the classes, through the frequencies and correlation values of the Chi-square (χ^2) of each word of the *corpus* (Marchand and Ratinaud 2012). The result generates a graphic representation that shows the differences between classes (Nascimento and Menandro 2006) helping to visualize the proximity between words or classes. All statistical analysis of the *corpus* was performed using IRAMUTEQ v0.7 software (Ratinaud and Marchand 2012), which uses the R platform, RStudio interface (www.r-project.org), and Python (`www.python.org`).jm.

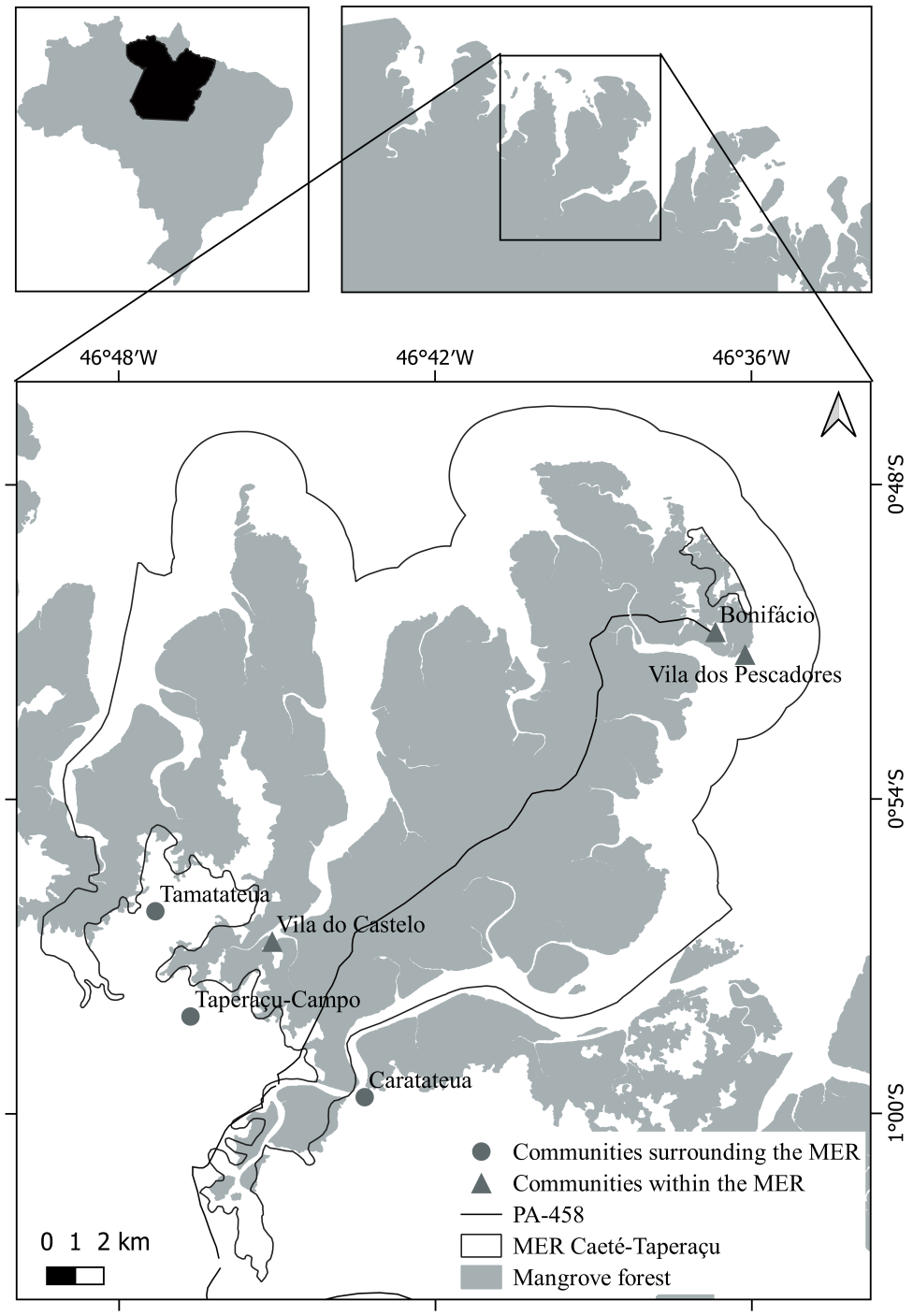

Figure 2. Location of the Caeté-Taperaçu Marine Extractive Reserve, municipality of Bragança, State of Pará, Brazilian Amazon coast. The Bonifácio, Castelo and Vila dos Pescadores communities are located within the reserve area, while Caratateua, Tamatateua and Taperaçu-Campo are located in the surrounding area.

Legal and ethical aspects

This study was submitted to and approved by the Committee for Research Ethics (CAAE: 36854519.8.0000.8187), complying with the determinations of Resolution No. 466/2012 of the National Health Council for research involving human beings. Additionally, this study was granted approval by the Chico Mendes Institute for Biodiversity Conservation (License No. 77497-1/2022) as it was carried out in

traditional communities within a conservation unit (Caeté-Taperaçu Marine Extractive Reserve).

RESULTS

The majority of respondents were men (67%) (Figure 3a). The mean age of both men and women respondents was 43 and 45 years, respectively (Figure 3b). Men were represented in all age groups, while women were not represented in the 18 to 25 age group (Figure 3c and 3d). Almost all respondents (98%) stated that wood from mangrove trees in the region is used domestically (by the family) and that knowledge about purposes and applications was taught by elderly people (57%), parents (20%), and neighbors (17%).

Considering the different uses by gender, the most frequently reported uses among men were "charcoal" (17%), "weir" (14%) and "ink" (9%), while among women were "charcoal" (19%), "fence corral" (11%) and "weir" (11%). The relationship between the uses and the community within the MER revealed associations of the words "charcoal" with the Castelo community, "charcoal" with Bonifácio and "weir" with Vila dos Pescadores. In addition, the relationship between the uses and the communities around the MER revealed associations of the words "charcoal" with the Caratateua community, "firewood" with Tamatateua and "charcoal" with Taperaçu-Campo. Charcoal" (17.9%), "weir" (12.9%), "corral" (8.6%), "stilt_house" (7.4%) and "firewood" (7.0%) are the most prominent words in the tag cloud and represent the answers about "which" use is given to each type of mangrove, while the words "resistant" (30%), "smoke" (6.5%), "hard" (6.0%), "delay" (5.0%), and "soft" best represent the "why" of these uses (Figure 4). Subsequently, three indicators were established for the traditional knowledge of the use of mangrove wood, which refer to the questions: (i) what are the uses of mangrove wood in your community? (ii) what are the preferred species for each use? and (iii) why is this species preferred for this use?

The similitude analysis identifies the existing connection between the words of the respondents' speech, i.e., a structure composed of five groups of words (Figure 5). The word "charcoal" appears as an element that describes the central nucleus and still presents important relationships and overlaps with countless elements and groups that complement and support them, intertwining in the formation of several webs of interconnected developments with the peripheral groups, whose main elements are represented by the words: "firewood", "weir", "smoke", and "stick".

In Figure 6, correspondence factorial analysis shows that the three groups are in opposite quadrants, that is, each class covers specific semantic contexts, which refers to the semantic root of the word that most interfered in the group and allows perception of the action of the attribute variables of the three groups observed. On the vertical axis, two groupings of words stand out that form factor-1, explaining 73.62% of the total variance; this refers to three semantic fields: two in the upper plane, with the contributions of the groups in blue and green, and another in opposition, on the lower plane, where the words coming from the group in red are positioned. On the horizontal axis, the groups in blue and green appear clustered, forming factor-2 that explains the remaining 26.38% of the variance (Figure **??** 7?). Factor-3 is not representative of the correlations and does not explain the variations (0.0005%). In the same figure it can be seen that in group 1, in blue, the central words are "mainstay", "charcoal", and "ink". In group 2, in green, the main words are "weir", "firewood", and "stick", while in group 3, in red, the most important words are "burn", "complement", "burn_quickly", and "scare_off".

DISCUSSION

In general, our findings show that the different uses of mangrove wood for the estuarine-coastal communities studied in the Amazon region are practiced in a similar way between men and women, as well as between locations. However, the very low number of respondents between the ages of 15 and 25 (n=5) leaves open the current discussion about the loss of traditional knowledge, already identified in community youth, whose explanation may be related to the modernization of way of life that have produced negative impacts on knowledge about the uses of natural resources (Saynes-Vásquez et al. 2013; Arjona-García et al. 2021). Other events are also associated with the distancing of young people from their traditional culture, such as the search for higher educational levels, which increases emigration to large urban centers and the greater urbanization of communities are also directly associated with the decrease in the ability to recognize, name, utilize, and manage plant resources (Cano-Ramírez et al. 2012). In addition, the characteristics of the respondents are linked to the different motivations, such as attitudes, desires, values and convictions (Schweitzer 2019) that can express the pressing needs of the *modus vivendi* in any community elsewhere.

The traditional uses and applications of mangrove wood were assessed by tag cloud technique that showed the central words in the respondents' speech ("charcoal", "weir" and "firewood"), which represent the main uses of mangrove wood in the Amazon region and are related both to family (domestic) and commercial activities. First, these uses highlight the

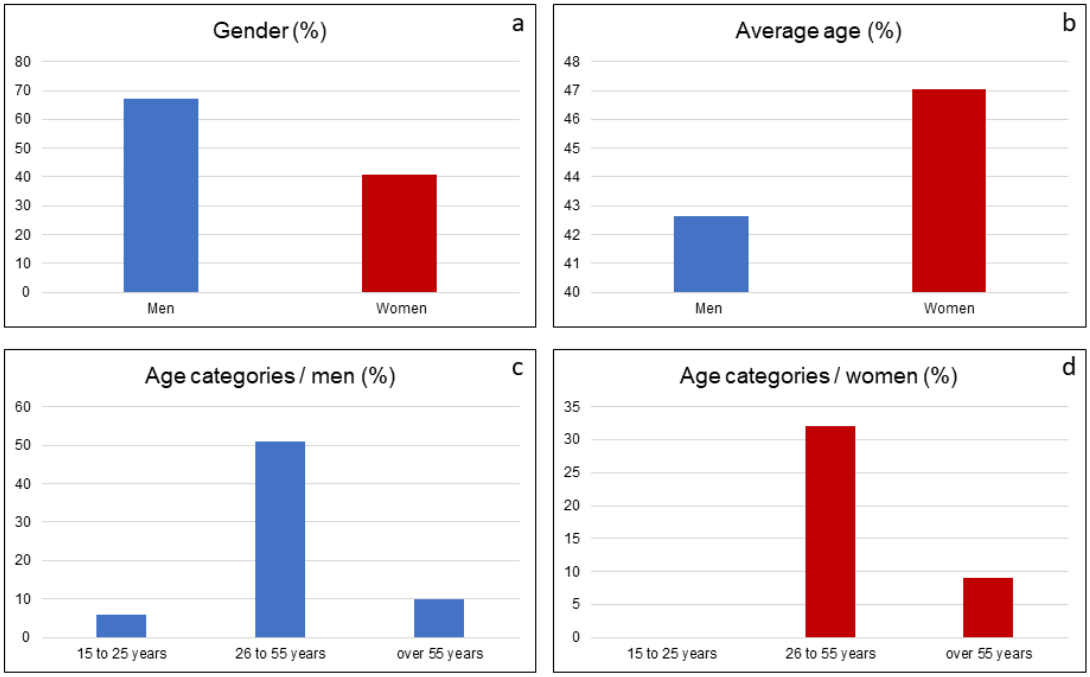

Figure 3. Percentage of people interviewed represented by gender and age.

importance of subsistence activities, such as obtaining energy to cook food (Dahdouh-Guebas et al. 2006; Atheull et al. 2009; Hamilton 2020) and artisanal fishing by building fishing weirs (Voigt 2011) among other domestic uses such as house-building and furniture (Atheull et al. 2009; Fernandes et al. 2018). All these activities related to the use of mangrove wood also provide a supplementary source of income (Iftekhar and Islam 2004), substantially contributing to cover expenses for the basic needs of these communities, whose vulnerability to poverty is considered high (Kebe et al. 2009).

The connection between words and groups of words described the main attribute variables of the respondents' speech analysis. The first major connection visualized in the central group of the analysis refers to the use of *R. mangle* wood ("charcoal"⇔"resistant"), while in the peripheral groups connections allude to the use of *A. germinans* wood ("firewood"⇔"smoke") and *L. racemosa* ("weir"⇔"stick"). In a more detailed analysis, through the correlation of words and groups of words in the *corpus*, the analysis showed that each species of mangrove tree is represented by a group of words. Thus, the knowledge of the respondents in this study about the use of wood resources in estuarine-coastal communities is certainly connected to their experiences with the mangrove areas in their surroundings. Therefore, energy, house-building, and dyeing fishing nets for *R. mangle*, smoke for repelling mosquitoes and house-building for *A. germinans*, and fishing weirs and corrals for livestock for *L. racemosa* were the most common uses recognized by the traditional fishing community that basically depends on the resources and ecosystem services delivered by the mangroves. In addition, the knowledge that respondents hold of their mangrove wetlands was a keystone to accessing these main uses, although it is important to point out that traditional knowledge can change according to the way resources are used by different types of users.

It is evident that the low diversity of tree species in the Amazonian mangroves – only six tree species (Abreu et al. 2016) - also works as a key factor for overlapping uses and overexploitation of wood in the Amazonian mangroves, since users use the three dominant species of mangrove trees for all their domestic (e.g., house-building) and productive (e.g. weirs) activities. Therefore, traditional knowledge of the respondents about typical trees in mangrove forests is not restricted to the type of use intended for this vegetation, but also involves the reason why a particular plant was chosen for a given purpose; hence, it is important to ask here whether the uses are consistent with the technological properties of these woods.

The consistency between the use of mangrove wood (traditional knowledge) and its technological properties can be identified through the correlation of words and groups of words in the *cor-*

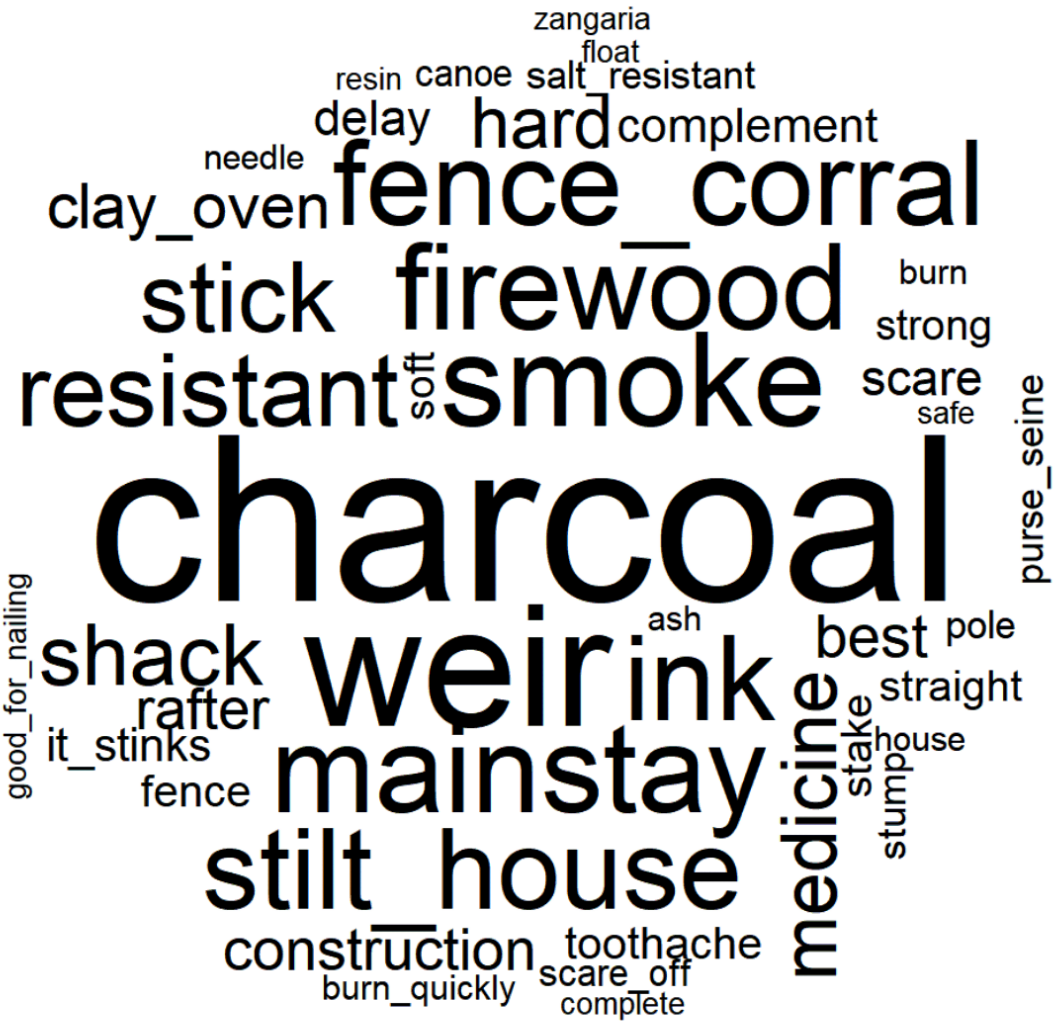

Figure 4. Word cloud of respondents' traditional ecological knowledge about the different uses and applications of wood from mangrove trees in the Caeté-Taperaçu Marine Extractive Reserve, Bragança, Pará, Brazilian Amazon coast.

pus. Results showed that each use has one or more words that represent the reasons why that wood was used for that specific purpose. In the connection between the words "charcoal"⇔"resistant" and "charcoal"⇔"good_for_nailing" for *R. mangle*, for example, the interpretation applies to the fact that *R. mangle* wood is used to make charcoal because this wood is resistant and takes a long time to burn. In fact, *R. mangle* presents wood density considered high ($= 0.83$ g m^{-3}) (Virgulino-Júnior et al. 2020) and the highest total lignin values (24.88%), when compared to the other mangrove species in supplementary material (Additional File 2). For energy production, it is desirable that the wood has properties that can influence the quality and production of charcoal (Brito et al. 1987; Brito and Barrichelo 1977; Loureiro et al. 2021), with high density (Neves et al. 2011) and high lignin content (Additional File 2). A study carried out in Ecuador with *R. mangle* showed that this species has a calorific value of 4,400 kcal kg-1, making it a high-density heat source (Doat 1977; Hamilton 2020). This mangrove species also has a lower ash content than other neotropical mangrove tree species (0.78%) (Hamilton 2020), factors which together with the high thermal stability are relevant for obtaining the highest gravimetric yield in charcoal production (Costa et al. 2014).

Different anatomical characteristics are also relevant to determine the suitability of wood use. Wood strength, for example, is associated with wood den-

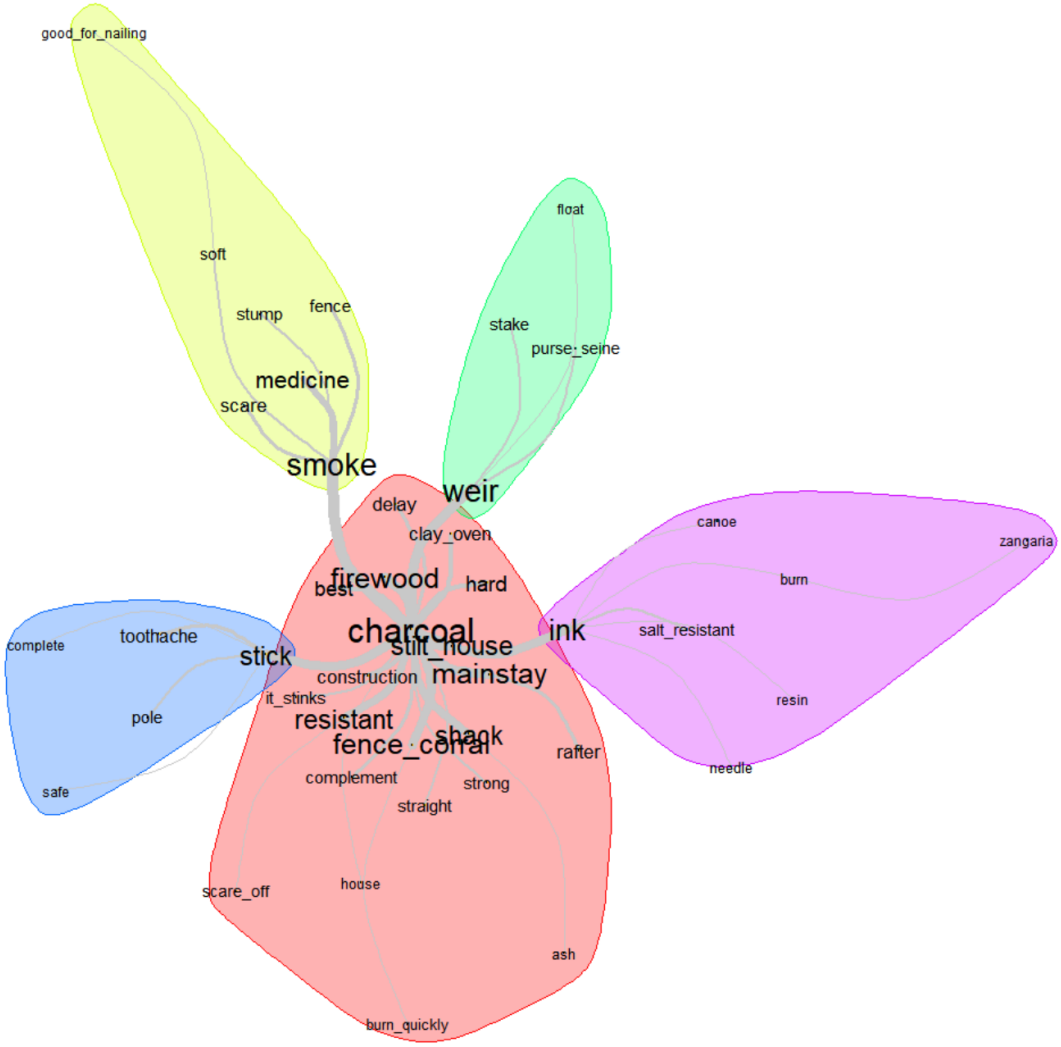

Figure 5. Similitude analysis of the respondents' traditional ecological knowledge about the different uses and applications of wood from mangrove trees in the Caeté-Taperaçu Marine Extractive Reserve, Bragança, Pará, Brazilian Amazon coast.

sity, the total diameter of the lumen area of xylem vessels, and fiber wall thickness, which may increase wood resistance to physical damage (Jacobsen et al. 2005; Martínez-Cabrera et al. 2009; Santini et al. 2012). Anisotropy is an important index to evaluate the dimensional stability of wood (Durlo and Marchiori 1992). Considering this characteristic, the species *R. mangle* presented high dimensional instability (2.85), therefore, its wood is considered bad for construction, and its applications should be restricted to temporary constructions (Motta et al. 2014). The woods of *A. germinans* and *L. racemosa*, on the contrary, presented normal anisotropic values (1.69 and 1.55, respectively) (Additional File 2), thus they can be applied in house-building with reservations. Additionally, it is important to remember that only woods that have high dimensional stability are recommended and can be used regularly for furniture manufacturing in general and house-building without reservations (Motta et al. 2014; Oliveira et al. 2010).

The wood of *A. germinans* was associated with the production of firewood to generate smoke because it has a bad smell and repels mosquitoes. Its use seems appropriate to the chemical characteristics of the wood of this mangrove species, as it has a high content of total extractives (Additional File 2), together with insecticidal compounds (Kabaru and Gichia 2001; Senthil Raja and Kathiresan 2011). The wood of this species has a density of 0.67 g m^{-3}, being suitable for use in direct burning, as in firewood for cooking food, and hardwoods (>0.73 g m^{-3}) (Vale et al. 2002). The wood of *L. racemosa*, in turn, is

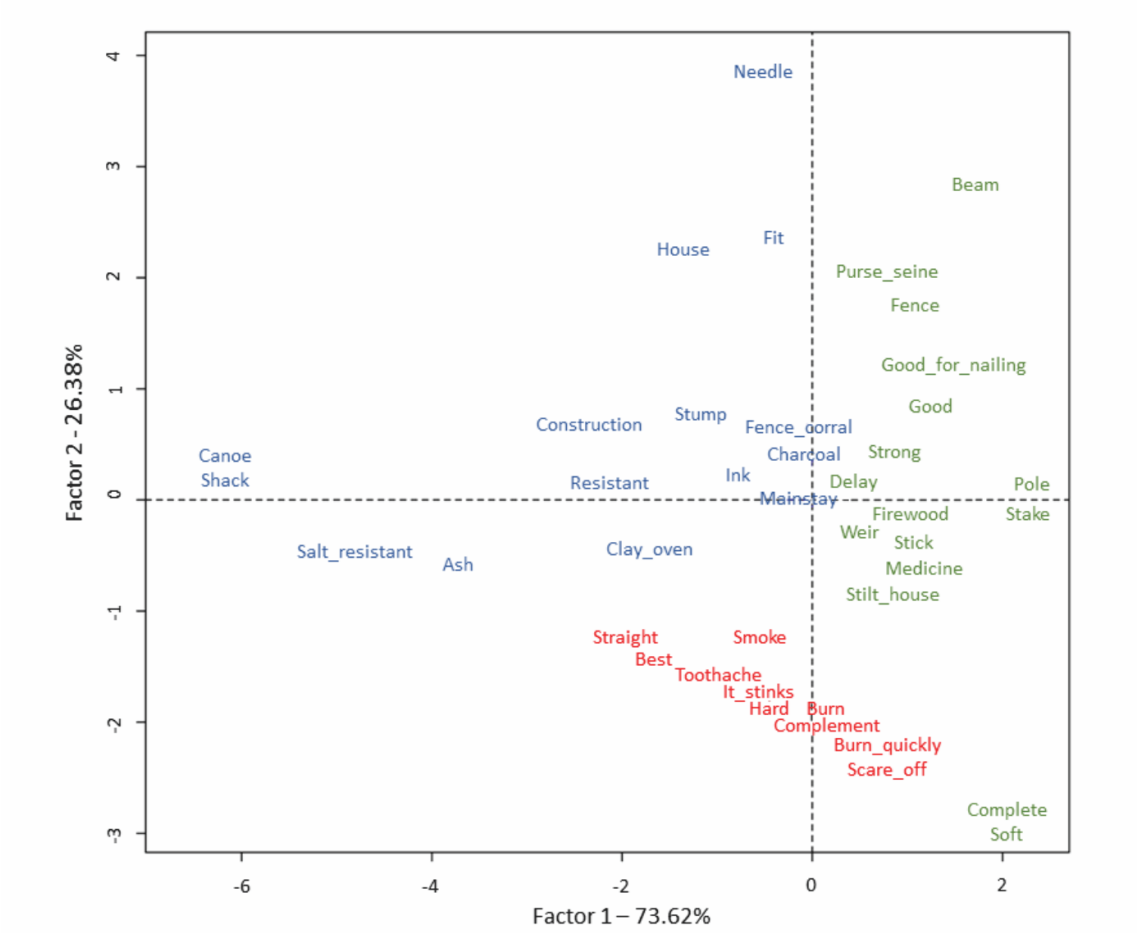

Figure 6. Factorial Correspondence Analysis (CFA) of the respondents' traditional ecological knowledge about the different uses and applications of wood from mangrove trees in the Caeté-Taperaçu Marine Extractive Reserve, Bragança, Pará, Brazilian Amazon coast.

mainly used in the construction of fishing weirs, as it is considered a "soft" wood. This characteristic of the wood can be evaluated by its density, which for this species is considered average ($0.61\ g \cdot m^{-3}$), although it presents the lowest value when compared to other species of mangrove trees (Virgulino-Júnior et al. 2020). Other important characteristics for the use of wood in fishing weirs are the appropriate shape and size, in addition to greater durability in contact with salt water. The diameter of the trunk used for this fishing component varies between 2-4 cm for the "stick" to build the "fence" component that will guide the fish to the inner part of the trap and 8-10 cm for the "pole" that is fixed on the ground to maintain the structure of the fishing weir (Voigt 2011). In addition, wood of these sizes is also used for other purposes, such as, for example, corrals for raising cattle and pigs, stilt houses, shacks and other structures (Maneschy 1993; Oliveira 2015).

The uses of mangrove wood are so many, since wood is considered a versatile resource. Therefore, well-designed management of mangrove forests is required in order to provide ecological functioning of the mangrove system, which will serve as a basis for maintaining the mangrove forests in a sustainable way (Soegiarto 2004). As a consequence, mangrove forest management can guarantee the natural regeneration process and maintain mangrove areas that can be exploited for local users according to land-use policies established between local traditional communities and governance (Masoud and Wild 2004). Mangrove management is a relevant step for creating a needed balance between conservation and economic activities (Ida 2004), and for enhancing biodiversity and maximizing fisheries production in coastal environments (Kairo et al. 2001). In addition, it will help to lessen the natural and anthropogenic impact on mangrove areas and surrounding systems, especially coral reefs and seagrass beds. The information presented here can serve as a basis for the elaboration of strategies focused on raising user awareness and on the conservation and sustainable use of mangrove resources, both

in the traditional communities that use the Amazonian protected areas and experience that can be replicated in different areas of mangrove elsewhere. In the case of the present study that was focused on users of mangrove inside protected area (Caeté-Taperaçu MER that is part of the Ramsar site Nº 2337 – Estuary of the Amazon and its Mangroves), findings are consistent with other studies in the region, which are also based on the uses of wood resources in the mangrove forests, particularly those related to charcoal production, the most recurrent activity among almost all the families of the Caeté-Taperaçu MER (Fernandes et al. 2018; Oliveira 2015), followed by artisanal fishing (Voigt 2011). This implies that logging activity is constant and can cause degradation in some places of the Caeté-Taperaçu MER, mainly due to the targeted use of young trees of *L. racemosa* that are cut down by the thousands for the restoration of dozens of weirs along the coast. These targeted uses, partly due to the low diversity of trees in the mangroves of the Amazon region, portray the dependence of local communities on wood resources from the mangroves, which may result in a significant hazard for the maintenance of their means of subsistence. Such dependence is similar to those also registered in other traditional communities found all over the world (Gallup et al. 2020; Kovacs 1999; Kusmana 2018), where a greater diversity of mangrove trees is registered. Thus, it is important to emphasize that knowledge about the technological properties of mangrove wood associated with traditional knowledge about this resource can provide alternatives that minimize or prevent the degradation of these resources.

CONCLUSION

The present study showed that the respondents, users of wood resources in the mangrove forests of Caeté-Taperaçu MER, are men and women who use mangrove wood for various domestic purposes, especially for the production of charcoal and weirs. Factors such as location, sex, and age did not have a significant influence on these users' knowledge about mangrove vegetation. However, the small number of young respondents leaves a gap in the current discussion of the loss of traditional knowledge in this specific group. Lexical analyzes of the respondents' speech revealed that wood from mangroves is widely used for subsistence purposes, playing specific roles, such as *R. mangle* mainly used in charcoal production, while *A. germinans* and *L. racemosa*, as repellent and weirs, respectively.

Our findings contribute to theoretical questions regarding the ethnobotany of mangroves on the Brazilian Amazon coast, reinforcing traditional knowledge based on scientific literature, and provide guidelines for the most appropriate use of mangrove wood. Likewise, our findings provide technical support for sustainable practices, especially in relation to the production of charcoal and weirs, which is crucial for the subsistence of these communities. However, we emphasize the need for specific studies on the technological properties of mangrove wood, filling gaps in knowledge about chemical, physical, mechanical, energetic characteristics, and natural durability. In addition, it is still necessary to fill another gap that refers to a more comprehensive understanding of the use of these timber resources, through the assessment of their environmental impact and challenges, to guarantee sustainability in the exploitation of these coastal resources.

There is still a pressing need for conservation policies aimed at the use of wood from mangrove trees in the country. Therefore, the identification of tree species in mangrove forests is of fundamental importance for recognizing the diverse uses and applications of local species. By mapping the uses of these typical mangrove species, environmental conservation policies can be directed to increase the potential for diversification in their use, so that benefits are maximized, and inappropriate uses are reduced. The transmission of knowledge about the uses of mangrove wood also suggests opportunities for educational policies that promote best practices for preserving this traditional knowledge. All these guidelines together can guide comprehensive public policies, integrating traditional knowledge with technical-scientific knowledge and promoting the sustainability of the use of wood from mangrove forests.

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DATA AVAILABILITY

The data sets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: MLG, MEBF.
Investigation: MLG, TNMR, ISS MEBF.
Carried out the data analysis: MLG.
Wrote the first draft of the manuscript: MLG.
Review and final write of the manuscript: MLG, TNMR, ISS MEBF.

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Additional Files

Add File 1. Interview guide.

1. What are the end-uses of mangrove woods in your community?
2. What are the preferred species for each end-use?
- *Laguncularia racemosa* ("Tinteiro" or White Mangrove)
- *Avicennia germinans* ("Siribeira" or Black mangrove)
- *Rhizophora mangle* ("Mangueiro" or Red Mangrove)
3 Why is this species preferred for this end-use?
- *Laguncularia racemosa* ("Tinteiro" or White Mangrove)
- *Avicennia germinans* ("Siribeira" or Black mangrove)
- *Rhizophora mangle* ("Mangueiro" or Red Mangrove)

Add File 2. Adequacy of the different uses of mangrove wood, according to the local ecological knowledge of the users of the Caeté-Taperaçu Marine Extractive Reserve and current scientific knowledge. Fr = Frequency of occurrence in the analyzed *corpus*.

Local ecological knowledge		Scientific knowledge	Source	Fitness for use
Use	**Fr (%)**			
		Rhizophora mangle		
- *"charcoal"*	17.9	- Studies carried out with *R. mangle* show that this species has a high basic density = 0.83 $g \cdot m^{-3}$ and higher values of lignin content 24.88% when compared to other mangrove species.- For the production of charcoal, it is desirable that the wood has a high basic density.- High gravimetric yield in energy production, in this context, wood with high thermal stability is sought, that is, with a high lignin content.- The low values of 0.78% ash content found bring benefits, as they will certainly result in a coal with low mineral content.- *Rhizophora mangle* has a heat value of 4,400 $kcal \cdot kg^{-1}$ at the Equator, making it a high-density heat source.- wood resistance may also be linked to the basic density, the total diameter of the vessel lumen area, the xylem vessels, fiber wall thickness, factors that can increase the mechanical resistance of the wood.	- Virgulino-Júnior et al. (2020)- Neves et al. (2011)- Costa et al. (2014)- Costa et al. (2014)- Doat (1977)- Jacobsen et al. (2005); Martínez-Cabrera et al. (2009); Santini et al. (2012)	yes
- *"mainstay"*	7.0	- For anisotropic behavior, it presented a value of 2.85, thus showing a high dimensional instability of the wood. Therefore, due to its hygroscopic character, its applications are restricted to temporary constructions.	- Motta et al. (2014); Oliveira et al. (2010)	no
- *"ink"*	7.0	- *Rhizophora mangle* has a lower percentage of extractives 4.30%, but may contain tannins that are used to dye fishing nets.	- Fernandes et al. (2018)	yes

- *"firewood"*	7.0	- The use of wood with low density for the direct production of energy in the form of heat implies a quick burning and a smaller production of energy per unit of volume, contrary to wood with higher densities.- *Rhizophora mangle* has a high basic density = 0.83 $g \cdot m^{-3}$. - The direct burning of wood for cooking food is suggested in the basic density range between medium and hard woods.	- Vale et al. (2002)- Virgulino-Júnior et al. (2020) - Vale et al. (2002)	yes
		Avicennia germinans		
- *"smoke"*	6.5	- It has the second highest average value of total extractives = 11.96% and may contain insecticidal compounds that repel insects.	- Kabaru and Gichia (200)	yes
- *"firewood"*	7.0	- The use of wood with low density for the direct production of energy in the form of heat implies a quick burning and a smaller production of energy per unit of volume, contrary to wood with higher densities.- *Avicennia germinans* has an average basic density = 0.67 $g \cdot m^{-3}$.- The direct burning of wood for cooking food is suggested in the basic density range between medium and high woods.- It has the second highest average value of total extractives = 11.96%, which may contain insecticidal compounds that repel insects.	- Vale et al. (2002)- Virgulino-Júnior et al. (2020); Vale et al. (2002)- Kabaru and Gichia (2001)	yes
- *"mainstay"*	7.0	- For anisotropic behavior, those with a value of 1.69 show a high dimensional stability of the wood, therefore can be regularly used in construction.	- Motta et al. (2014); Oliveira et al. (2010)	yes
- *"medicine"*	4.5	- It is known that mangrove woods, due to their extractives such as tannin, are used as remedies for dysentery and hemorrhages- Has the second highest average value of total extractives = 11.96%, which may contain insecticide compounds that repel insects	- Bastos (1995) - Kabaru and Gichia (2001)	yes
		Laguncularia racemosa		
- *"weir"*	12.9	- *no record*	- *no record*	?

- *"corral"*	8.6	- For anisotropic behavior, those materials with a value of 1.55 show a high dimensional stability of the wood, therefore it can be used regularly in construction.	- Motta et al. (2014); Oliveira et al. (2010)	yes
- "s*tilt_house"*	7.4	- *no record*	- *no record*	?
- *"shack"*	4.7	- For anisotropic behavior, those materials with a value of 1.55 show a high dimensional stability of the wood, therefore it can be used normally in construction.	- Motta et al. (2014); Oliveira et al. (2010)	yes