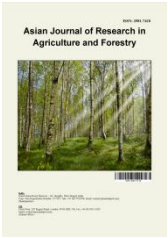

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Household Wood Requirements and the Substitution Potential of Bamboo (*Bambusa vulgaris*) Available to Peasants in Forest Areas of Cameroon: A Case Study in Ebolowa 2

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Authors' contributions

This work was carried out in collaboration among all authors. Authors EKW, LT and FC designed the study and wrote the protocol. Authors EKW, AM, WM, MN, JAO, MJE and JN collected the data in the field. Author EKW drew the map of the study area and managed the analyses of the study. Authors EKW, FC and LT wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of this study is to assess people's perceptions of bamboo's potential to replace wood.
Study Design: Introduction, methodology, results, and conclusion.
Place and Duration of Study: This study was carried out between April and July 2022 in an agro ecological rainforest zone in Cameroon, more specifically in the Ebolowa 2 Council, where there are significant bamboo resources.
Methodology: 5 villages were chosen for the study, due to their accessibility and proximity to the urban centre. A purposive sampling based on proximity to bamboo stands was applied and 75 households were surveyed using a semi-structured questionnaire, with 30% of respondents being women. In addition, observations were made directly on the field to identify the uses made of bamboo by peasants in the various villages.
Results: The results show that the collection of firewood is the second greatest anthropogenic threat to the forest after agriculture. An analysis of wood energy requirements shows that they increase with household size. 51.8% of the households sampled consume an average of 2 to 5 50-cm steres, i.e. around 1.6 to 4 m^3 of firewood/week. The landscape of the study area is marked by a strong presence of tree nurseries built using bamboo as a substitute for wood. Bamboo is used by 70.3% of the population sampled in the study area. However, the value of bamboo is still very low, given the 5 areas of use identified. Nonetheless, it is seen as a good alternative to wood by 75% of these households.
Conclusion: The results of this study provide a database that can be used to help promote and develop the bamboo sector in rural forest areas of Cameroon.

Keywords: Wood energy; Substitution; Bamboo; Forest degradation.

1. INTRODUCTION

In Cameroon, the national demand for wood energy amounts to 6,560,000 tons per year, including 356,000 tons of charcoal. This demand for charcoal represents 2.5 million m3 and 12,500 ha of natural forest destroyed every year [1]. This high pressure on forest cover is at the root of deforestation and the degradation of forest ecosystems, which in turn exacerbates the vulnerability of populations to effects of climate change. Reducing the pressure on natural forest ecosystems to meet household cooking energy needs is a major ecological challenge [2]. As part of the fight against climate change, Cameroon's Nationally Determined Contribution (NDC) sets out its contributions in terms of mitigation and adaptation to climate change. It provides for the reduction of the unsustainable consumption of firewood, for example through the sustainable management of wood energy, improved stoves and the promotion of methanisation in rural areas. The regional strategies developed are locally appropriate mitigation measures for wood-energy value chains [3]. However, access to these solutions for peasants in rural areas remains utopian. Cameroon's forests are under threat from an ever-growing population whose activities are major drivers of deforestation and forest degradation, particularly intensive slash-and-burn agriculture and timber collection [4]. For people living in forest areas, it is essential to offer sustainable solutions to meet household wood needs. For several years now, bamboo has been renowned for its many ecosystem services, including carbon sequestration and its ability to act as a substitute for wood, with very good results in the civil engineering and craft sectors [5]. Cameroon relies heavily on bamboo to restore degraded landscapes, such as the banks of the Benue. However, the use of bamboo as a solution for reducing greenhouse gases (GHGs) is still very limited, due to low levels of knowledge about the possible uses of bamboo [6]. More needs to be done to assess the potential of bamboo to help people become more resilient in the face of the challenge of sustainable management of wood resources in forest areas. It is in this context that the present study finds its purpose, with the following

research question: is bamboo a good substitute for wood to meet the needs of households in the Ebolowa 2 Council? The main objective was to evaluate the solution offered by bamboo to meet the wood needs of a population living in a forest area.

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted between April and July 2022 in the Ebolowa 2 Council, Mvila Division, South Region, Cameroon. The said area is located in the agro-ecological zone (AEZ N°5) of bimodal rainfall, between 2° 54′ North and 11° 09′ East, and in the heart of the equatorial forest and is endowed with a significant bamboo resource spread over an area estimated at 219,094.67 ha, i.e. almost 20% of the total bamboo area in Cameroon [7].

The Ebolowa 2 Council benefits from the wealth of AEZ N°5 to which it belongs. Rainfall varies between 1,200 and 2,000 mm per year. The average temperature varies between 22 and 26°C. Winds are violent during the rainy season, sometimes causing damage to crops and even housing [8]. With a population density of 27 inhabitants/km² and agriculture as its main activity, this is a forest area with a rich biodiversity of flora and fauna, which is unfortunately subject to strong pressure from the population, particularly to satisfy its wood needs.

2.2 Data Collection

Two main wood requirements are considered as major in this study, namely: "wood energy" used for cooking and "timber" understood as all service wood and including essentially poles, electricity poles and posts, to which are added a few special products such as Raphia palm stalks and bamboo [9]. Studies by Chimi *et al* (2021) demonstrated a significant presence of bamboo in Agro-Ecological Zone N°5 (AEZ 5), where the Ebolowa 2 Council is located, and the villages surveyed were chosen based on their proximity to the road and the visible presence of bamboo [10]. The villages of Adoum, Biyeyem, Assosseng, Nkoemvone, Ndengue and Biba were selected. The collection of fuel wood is the second cause of forest degradation in the Congo Basin. Notably in this study only fuel wood requirement was assessed in this study, i.e. the quantity of fuelwood used weekly by each household, which we estimated in 50 cm steres, i.e. a volume of 0.8 m³ [11] [12]. Data collection was carried out using combined two-phase approach: firstly, a questionnaire survey to assess households' perceptions and estimate their wood energy needs; secondly, field observations to identify the different uses made of bamboo by the households surveyed along

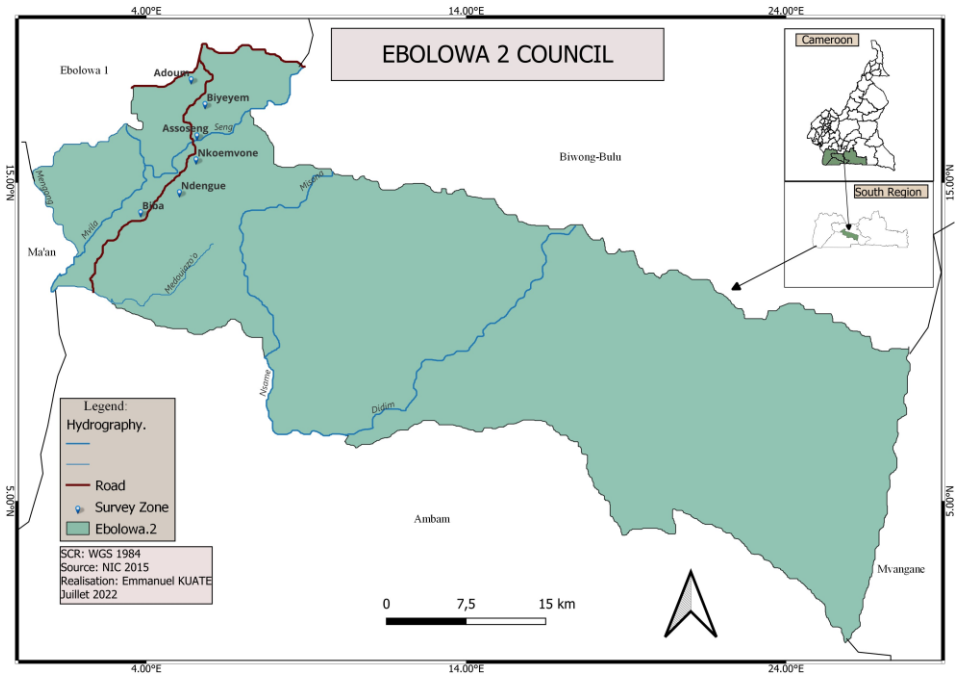

Fig. 1. Location of the study area

National Road No. 2, which crosses the Ebolowa 2 Council. A purposive sampling approach, based on the proximity of these households to natural bamboo stands within a radius of 1 km was adopted for the administration of the semi-structured questionnaire. A total of 75 households were surveyed.

2.3 Data Analysis

Data collected were analysed using Sphinx Plus[2] software, to generate diagrams for quantitative data and a Multiple Component Analysis (MCA), for qualitative data, to more assess the link between variables (household size, fuel wood quantities).

3. RESULTS AND DISCUSSION

3.1 Relationship with the Forest

Analysis of the relationship that peasants have with the forest is a major factor in assessing the pressure they exert on the forest. Table 1, which presents the results of a dynamic cross-tabulation of two qualitative variables: "Do you have an interest in the forest?" and "What are your reasons for entering the forest?", shows that of all the 75 households surveyed, 38.3% said they practiced an activity related to the forest and 24.8% said that agriculture and timber harvesting were the main anthropogenic threats to the forest attributable to local populations. This finding corroborates CIFOR's findings on the assessment of the causes of deforestation and forest degradation in the Congo Basin in 2015, which show agriculture and the extraction of energy wood as the main drivers of deforestation and the second biggest driver of forest degradation respectively [13] [14]. It should also be pointed out that most often, when peasants go to their fields in the forest, they return to the village with wood, therefore amplifying the role of this activity in forest degradation.

3.1.1 Dynamics of household wood energy requirements

Wood is the main source of energy for more than 90% of households. As Fig. 2 shows, it comes from field in the forest. The direct effect of population growth would be an exponential increase in household wood requirements over time.

Table 1. Main reasons why the peants enter the forests

Forest frequently access vs Reasons for entering the forest	Little bit	Yes	TOTAL
Agriculture	10,6%	27,7%	38,3%
Wood Supply	3,5%	21,3%	24,8%
Hunting	2,1%	12,1%	14,2%
NTFP	5,7%	17,0%	22,7%
TOTAL	22,0%	78,0%	100%

Fig. 2. Women returning from field with wood at Adoum

Fig. 3 is a diagram showing the distribution of the average quantities of wood used per week according to the size of the households below or above five < 5 >. It shows that households with more than five > 5 members use an average of 2 to 5 steres of wood per week, i.e. 1.6 - 4m³. This is proof that a population's need for natural resources does indeed increase with its size. However, the work of Balole et *al* (2015) has shown that the unsustainable exploitation of wood resources leads to a reduction and scarcity of the resource over time [15].

Generally, the wood requirements identified, i.e. fuelwood for cooking and timber used as building materials, for craft manufacture or as poles, are increasingly huge and proportional to population growth. Fig. 4 is a Multiple Component Analysis (MCA), which highlights 03 qualitative variables to show the relationship: "the size of the households surveyed", "household wood energy requirements estimated in steres [6]" and "the temporal dynamics of these requirements". The variables are represented as follows:

H: Household size (H1: less than 5; H2: more than 5)

Y: Dynamics of wood requirements (Y1: decrease; Y2: stable; Y3: increase)

W: Average number of steres of wood used per week (W1: less than 2; W2: between 2-5; W3: more than 5).

52.31% of the variance is explained by the two axes represented. It emerges that: the H2, W2, W3 and Y3 modalities are considerably closer, which explains the fact that the quantities of wood energy (W) increase (Y) according to household size (H) and generally over time [15]. Moreover, over the last decade, this phenomenon has become more pronounced, leading to the gradual unavailability of quality firewood and timber resources, to the extent that people now have to walk longer in the forest to find good firewood, which was not the case in the past. At the same time, there are fewer and fewer species available specifically for construction works. It is in this context that bamboo could offer a sustainable solution to this shortage, given its known potential.

- **Peasants' perceptions of bamboo**

Generally speaking, bamboo is a prosperous plant in AEZ N°5 (Agro-ecological Zone N°5) in Cameroon, characterised by humid forest with bimodal rainfall. In the Ebolowa 2 Council, a large part of the bamboo resource can be seen along National Road No. 3, which runs alongside these street-type villages [16], characteristic of the zone. Bamboo is therefore a plant that is familiar to farmers, as shown in Table 2, which shows that over 70% of the population surveyed have been using bamboo for at least 10 years. However, the value of bamboo is still very low, given the many uses to which it could be put [10]. Bamboo therefore has huge untapped potential and is perceived by almost everyone as an invasive species.

The ingenious use of bamboo at the local level. For many years, bamboo has been perceived by these farmers as an invasive plant that is essentially useless. This explains why even those who already use it have retained this pejorative perception, which actulaly does not encourage ingenuity.

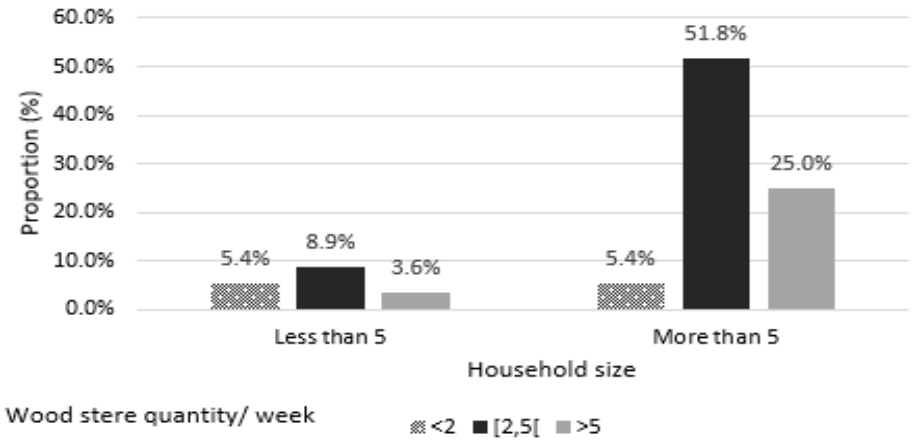

Fig. 3. Distribution of wood stere quantities/week/household

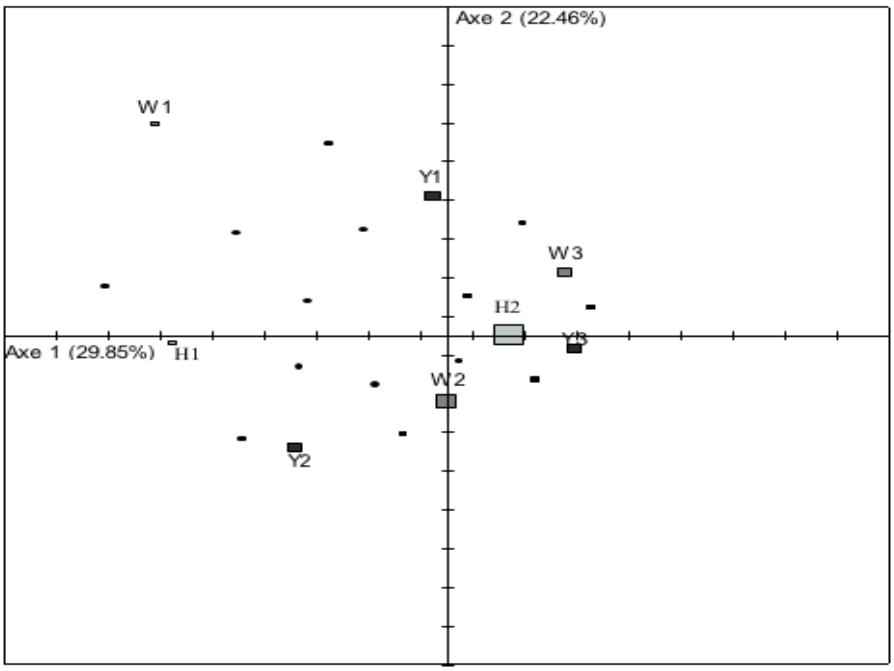

Fig. 4. Analysis of households' wood energy requirements

Table 2. Peasants' perception of bamboo according to use

Have you ever used bamboo? vs What do you think on bamboo?	Yes	No	TOTAL
Bulky	9,9%	8,8%	18,7%
Invasive	19,8%	7,7%	27,5%
Usefull	30,8%	1,1%	31,9%
Cost-effective	7,7%	0,0%	7,7%
Useless	2,2%	12,1%	14,3%
TOTAL	70,3%	29,7%	100%

3.4 Wood Substitution Potential

Thanks to its very rapid growth and solid texture [14] already known to peasants, the availability of bamboo close to households makes it an effective solution that is increasingly sought by peasants to overcome the scarcity of suitable wood resources for certain uses. Fig. 5 provides a good illustration of this reality, with the use of bamboo for the construction of shades to produce cocoa and fruit tree seedlings in nurseries, as a substitute for wood, which has become scarce.

Since rafters and panelling are expensive and not available to everyone, and acacia wood is less resistant to bad weather, bamboo generally appears to be an effective alternative for people's timber needs, mainly for the construction of shades, due to its availability and robustness [17].

However, peasants still do not use it as much for their wood energy needs, which are greater because they are more frequent due to the limited access of households to other energy sources (gas, coal) and are constantly increasing.

Fig. 6 shows a cumulative diagram grouping the five (05) different levels of use identified for bamboo: "firewood", "handicraft", "stem sales", "hedge" and "cultural" and the level of satisfaction they give peasants as an effective substitute for wood: "Yes" for good substitute and "No" for poor substitute for wood. We can see that 'poles' are the most important use for 43% of the sample, followed by 'handicrafts' (24%) and 'firewood' (21%).

The bamboo is used in the study area are of two main types: *Bambusa vulgaris and vitata*. The main use of bamboo as a "pole" can be explained by the fact that the construction of shade poles for tree nurseries is a key activity in this locality, where cocoa is the main cash crop [8]. The scarcity of wood has prompted peasants to look for other solutions. Bamboo, specifically the *Bambusa vulgaris vitata* variety, has emerged as a highly effective alternative to the general need for wood, as shown in Fig. 6.

When asked "Is bamboo a good substitute for wood?", out of the 40% of the sample using bamboo as a pole, just 13% answered "no". Similarly, in the case of firewood, only 4.5% of the 21% of the sample said "no".

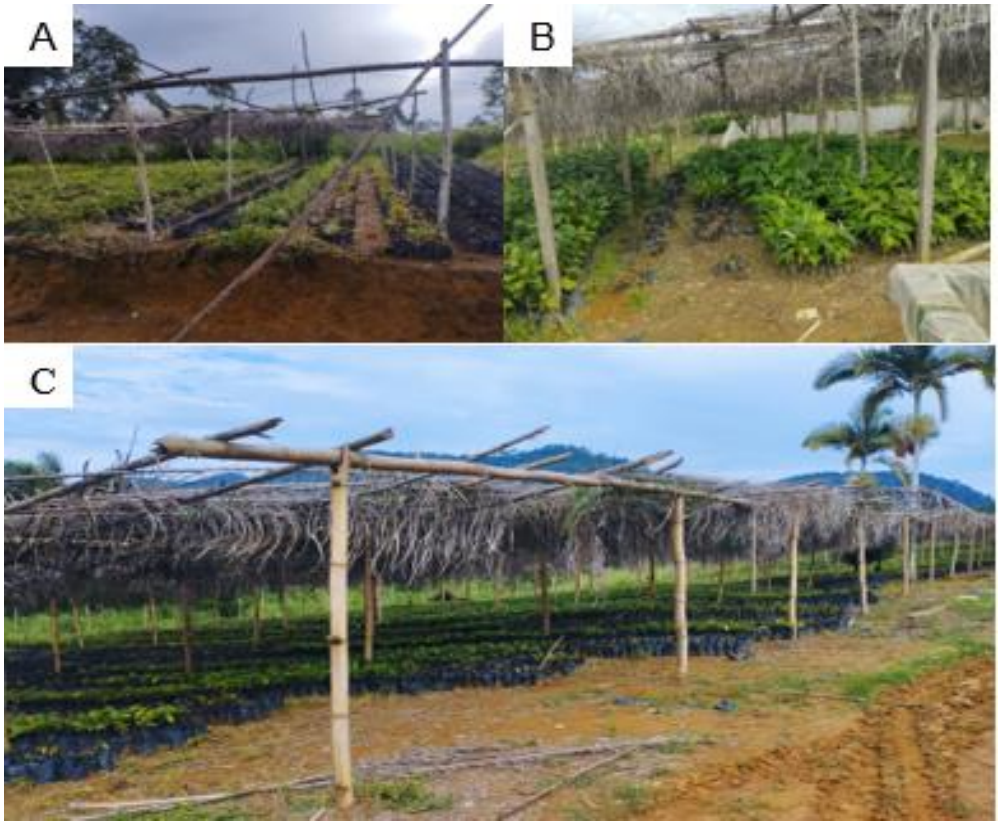

Fig. 5. Substitution of bamboo (C) for wood (A and B) in the construction of tree nurseries at Nkoemvone

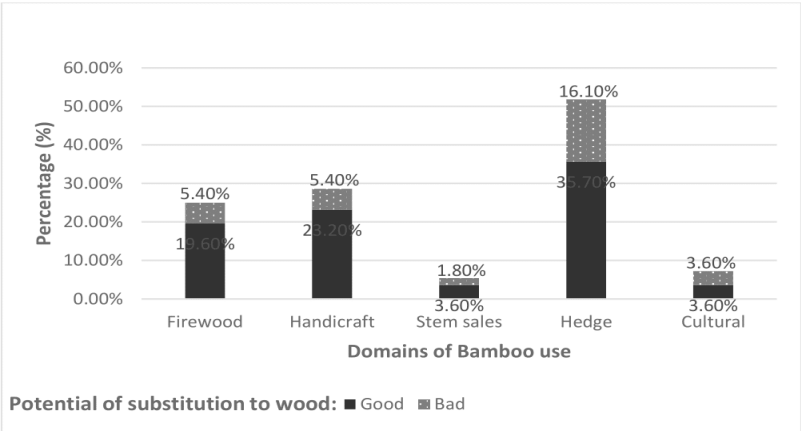

Fig. 6. Different uses of bamboo and its perception as a substitute for wood

However, it should be noted that bamboo, because of its hollow texture, meets the needs of rapid cooking only, and does not satisfy the requirements of longer cooking. In fact, bamboo stalks burn extremely quickly and during the combustion of the internodes, small explosions occur, making a frightening noise for women and children. This is an unfavourable factor for the genuine adoption of bamboo as a substitute for firewood.

On the other hand, converting bamboo stalks into biochar [3] would make it more efficient and would be an excellent sustainable solution, given its extremely rapid growth and proximity to households.

4. CONCLUSION

This study assessed the wood requirements and substitution potential of bamboo for peasants in the Ebolowa 2 Council in the South Region of Cameroon. According to the 75 households sampled, wood collection is the second biggest threat to the forest after agriculture. In terms of wood energy, 82% of households had more than 5 members and consumed the most wood, with an average of 2 to 5 steres of wood per week. Bamboo, used by 70% of the sample, is an effective alternative to wood for 75.7% of the 5 uses identified: poles 30.30%, handicrafts 19.70%, firewood 16.70%, sale of stalks 3%, and for cultural purposes 3%. However, because of its texture and the fact that it burns quickly and noisily, bamboo is unlikely to be adopted more widely by households as a substitute for firewood for long-duration cooking. The development and, above all, the dissemination of this resource are opportunities to be exploited to meet the urgent challenge of sustainable forest management in this locality and in Cameroon. This study provides a database for further investigation on potential use of bamboo.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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