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Research Article

Ecological Impact of Logging for the Production of Community Beams for Local Use in the Community of Segundo Congresso in Chipanje Chetu Program Area

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Abstract

This technical note assesses the ecological impacts of logging for beams in the community of Segundo Congresso, Niassa, Mozambique, under the Chipanje Chetu program. Dendrometric methods were used to collect diameter at breast height, commercial and total height, identification of local species, volume of standing tree, volume of logs and sawn wood, in addition to volumetric yield. Data were organized in Excel 2024 and analyzed using ANOVA in Statistix 8, with means compared by Tukey's test at a 5% significance level. From the results, it was found that the chainsaw operator lacks technical knowledge, aggravating the unsustainable exploitation, since the forest supply is critical, trees of large diameter and height are scarce and dispersed, especially *Vitex doniana* (Mpindimbe) and *Pericospi angolensis* (Muanga). The sample included 3 trees with DBH > 50 cm and total height between 16 and 21 m, generating standing volumes of 2.92–5.65 m^3 and commercial volumes of 1.07–1.88 m^3, with an average yield of 17.25 m^3 per tree. The low yield is due to the diameter, height, morphological quality of the trees and the experience of the operator. The production of beams was 35 per log, corresponding to 0.68 m^3 of sawn wood per tree, equivalent to 46.78% of commercial yield. Ecologically, the activity has positive impacts, such as the preservation of the ecosystem, as it is a semi-mechanized exploration with only a chainsaw and displacements on foot, and it also has negative impacts that are manifested in the pressure on the same large species and low availability, and the lack of technical knowledge of the operator generates operational inefficiency in the conversion of logs into beams.

Keywords

Conservation Areas, Dendrometry, Sustainability, Local Communities

1. Introduction

The miombo woodlands of northern Mozambique support a wide range of rural livelihood activities, with local communities relying heavily on timber for construction, energy, and income generation [9, 16]. In community conservation areas, such use must comply with principles of sustainability and with forestry-sector regulations to ensure ecological integrity and the continuity of ecosystem services [6, 9].

The Chipanje Chetu Community Conservation Program represents a participatory management model that requires strict application of dendrometric and ecological criteria during timber harvesting. However, limited technical assistance often leads to inadequate tree selection particularly regarding

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diameter at breast height (DBH) and commercial height removal of immature individuals, and felling techniques that damage the residual stand and soil. Such practices compromise natural regeneration, reduce future productivity of timber resources, and conflict with legal provisions governing conservation areas [12]. The extraction of timber for the production of 1,943 beams intended for local use by the Segundo Congresso community is a representative example of this type of intervention. Assessing its impacts is essential to understanding the ecological changes induced by harvesting activities and to identifying factors that influence the resilience of the miombo ecosystem [11]. This analysis also supports the establishment of technically appropriate management thresholds, such as minimum DBH, minimum commercial height, and recommended stump height to promote resprouting.

Therefore, this study aims to analyze the ecological impacts associated with timber harvesting for beam production in the Segundo Congresso community, contributing to the improvement of community-based forest management practices in the Chipanje Chetu area.

2. Methodology and Technical Assumptions

2.1. Characterization of the Study Area

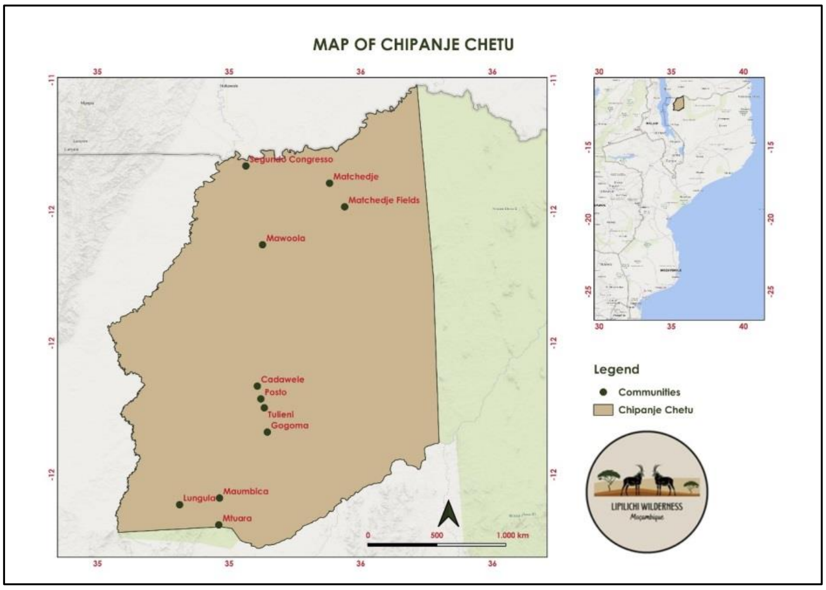


Figure 1. Geographical background of Chipanje Chetu.

The present study was conducted in the northern region, in the community of Segundo Congresso, in the miombo forest of the Chipanje Chetu community program conservation area in the northern district of Sanga, Niassa province, northern Mozambique (Figure 1). The average annual temperatures of the Sanga district range from 20 to 23 ℃ in the southern zone, while in the low-lying areas of the district along the Rovuma River, temperatures reach 23 to 26 ℃ [11].

2.1.1. Demography

The area has an estimated population of 7,860 inhabitants (approximately 1,800 households) in five community clusters (see Table 1). These communities are geographically dispersed and have relatively distinct areas of use of local villages, each with its own characteristics and social and economic dynamics.

Table 1. Demographic distribution.

Communities	Household	Est. Pop.	Population%
Segundo Congresso	575	2 633	33%
Maumbica	574	2 331	30%
Nova Madeira	347	1569	20%
Matchedje	164	744	9%
Lilumba	139	584	7%
TOTAL	1 799	7 860	100%

Source: [18]

2.1.2. Vegetation

The study area is home to a rich and structured forest community, representative of the natural vegetation of the Miombo. This formation is characterized by the clear predominance of several species of the genus Brachystegia, namely *Brachystegia longifolia, Brachystegia spiciformis, Brachystegia boehmii, Brachystegia utilis, Brachystegia bussei* and *Brachystegia manga*.

In addition to these, the forest is composed of other important tree species that contribute to its diversity and structure, such as *Uapaca zanguebarica, Uapaca nitida, Uapaca kirkiana, Pterocarpus angolensis, Diplorhynchus condylocarpon, Parinari curatellifolia, Pericopsi angolensis, Burkea africana, Pseudolachnostylis maprouneifolia* and *Monotes africanus*.

2.1.3. Wildlife

Chipanje Chetu is home to several vulnerable and endangered species, as classified by the IUCN [18]. Among these species are the lion, the African wild dog, the African elephant, the pangolin, the white-headed vulture, and the hornbill.

In addition to these, the region is also home to other species with more robust populations, such as the leopard, the sable, the kudu, the eland, the zebra and the African buffalo. Also noteworthy are several species of birds, including the hornbill and the white-headed vulture, as well as the Mozambique forest warbler, known as the long-billed avocet, who's only known locality is within Chipanje Chetu.

2.1.4. Agriculture

The local communities of Chipanje Chetu depend on subsistence farming practices, using a rainfed regime in smallholder farms with average dimensions ranging from 2 to 4 hectares. The focus of agricultural production is on corn, beans, rice, cassava and sesame crops. Agriculture in the region is characterized by being itinerant, with cycles of 1 to 2 years for the opening of new fields, due to the infertility of the local soils for agriculture. In addition, the communities also carry out domestic breeding of chickens, goats, ducks, pigeons and sheep.

2.2. Data Collection

2.2.1. Chainsaw Operator Information

Information was collected from the chainsaw operator through a non-structure interview, to find out his origin, years of experience of using the chainsaw, brand and model of the chainsaw, similar services in the Chipanje Chetu area, condition and condition of the chainsaw, and how much he charges for labor.

2.2.2. Dendrometric Parameters

For this study, the following were collected: pair of coordinates, species name (scientific and local), circumference and breast height (CCH) in centimeters, total height and commercial height in meters (m). The trees were initially identified by the local name in the local language *"Yao"* and then translated into scientific names using a pre-existing nominal list. The coordinates of the tree felling sites were captured using EarthRanger Mobile.

Circumference at Chest Height - CCH

The CCH was obtained using a 50m tape measure and its value was later converted to diameter at breast height (DBH) in centimeter units (cm) using formula (1).

$$DBH = \frac{CCH}{\pi} \tag{1}$$

Where: DBH – Diameter at breast height (cm); CCH – Circumference at chest height (cm), π – Pi = 3.14.

The height variable was estimated using the application called Trees, available on the Play Store. This application has a statistical accuracy level of over 90%, with a root mean square error of 1.15.

In comparison, a traditional hypsometer has an error of 0.98. However, the differences between these measurement methods are not statistically significant, according to the results of the research carried out by [8, 15].

Tree Volume Determination

The volume of the standing tree was calculated using formula (2).

$$Vol_{(tree)} = \frac{\pi * DBH^2}{4} * h * ff \tag{2}$$

Where: Vol_{tree} – Volume of the standing tree (m^3); π – 3.14; DBH – Diameter at chest height (cm); h – total height of the tree (m); ff – Form factor (0.7).

Determination of roundwood volume (Log volume)

The volume of the logs was determined using formula (3), known as the Smalian method.

$$Vol_{(log)} = \frac{g_b + g_t}{2} * h \tag{3}$$

Where: g – Cross-section ($g = d_b^2 * \left(\frac{\pi}{4}\right)^3$); Vol log – Volume of the log (m^3); db – Diameter of the base (m); dt – Diameter of the top (m); h – Length of the log (m).

Volume of sawn wood

The study focused exclusively on the splitting of logs to obtain beams, whose fixed dimensions were 3.20 meters length, 7.50 cm wide and 5.0 cm thick. During the unfolding process, it was observed that, although the initial dimensions were fixed, there were variations that always manifested themselves in increments, which could increase up to 0.8 cm in each of the variables.

To calculate the volume of sawn wood, formula (4) was used.

$$Vol_{beam} = L * W * T \quad (4)$$

Where: Vol_{beam} – Beam volume (m^3); L – Beam length (m); W – Beam width (m); T – Beam thickness (m).

Volumetric yield coefficient

The estimate of the volumetric yield coefficient of sawn timber per log was calculated using the following formula (5).

$$VYC\ (\%) = \frac{\sum Vol_{beam}}{Vol_{(log)}} * 100 \quad (5)$$

Where: VYC (%) = Percentage volumetric yield of the processed logus; $\sum Vol_{beam}$ - The sum of the volumes of the beam (m^3); $Vol_{(log)}$ – Volume of the log (m^3).

Cutting cycle

The cutting cycle technique was estimated using formula (6). The value of the Average Annual Increment (AAI) was 1.36, as cited by [17] for the northern region of Mozambique. Taking into account an average annual rainfall variation of around 1000 to 1200mm for the district of Sanga [6], the model of Clementi (1979) can also be used, according to [17].

$$CC_{(years)} = \frac{Vol_{sw}}{AAI} \quad (6)$$

Where: Vol_{sw} – Volume of Sawn Wood (m^3/ha); AAI – Average Annual Increment (1.36 m^3/ha/year).

2.3. Data Analysis and Processing

The collected data were recorded and organized in an MS Excel 2024 spreadsheet. After this stage, the data were submitted to an analysis of variance (ANOVA) and to the comparison of means using Tukey's test, with a significance level of 5%. To perform these analyses, the statistical program called Statistix 8 was used, using a completely randomized design (CRD).

3. Results

3.1. Chainsaw Operator Information

Table 2. *Chainsaw Operator Information.*

Name	Wazir Rachide
Age (years)	42
Residence	Lichinga City
Years of experience using chainsaw	+13 years
No of helpers	01
Chainsaw holder	Jackson Iassine – II Congresso

Table 2 shows the data of the chainsaw operator, responsible for cutting the trees, pre-processing (tracing and delimbing) and final processing (sawn wood production).

The operator in question is Wazir Rachide, 42 years old, residing in the city of Lichinga. He has more than 13 years of experience in the use of chainsaws and has an assistant to carry out the work. The chainsaw used is owned by Jackson Iassine, a resident of II Congresso.

Figure 2. *Chainsaw operator and his helper.*

According to the operator, he was hired by Jackson Iassine to provide sawn wood production services, with the aim of meeting the requests made by members of the community of II Congresso. They requested from the Natural Resources Management Committee (NRMC) of the same locality a total of 1943 beams for local consumption, intended for the coverage of residences. The NRMC, in turn, communicated the request to Lipilichi Wilderness (Chipanje Chetu area operator), which authorized the use of the resource.

Each member of the beneficiary community paid the amount of 100.00 Metical (MT) per requested beam, and the total amount was collected and delivered to Jackson Iassine. He was responsible for hiring the operator and his assistant (a young man from the community of II Congresso), as well as for the costs associated with the food of both, fuel, oil and maintenance of the equipment.

The chainsaw used is a Husqvarna 272 XP model, with a weight of 6.3 kg. At the moment, the equipment is not in good working order, with frequent breakdowns, especially related to the teeth of the chain. Its maintenance has been carried out in the community of Mkenda, located in the cross-border area of Tanzania. Thus, for this type of work, it is important that the operator has cumulative experience in the use of the chainsaw, as his experience influences the yields of the sawn wood.

3.2. Current Supply Situation

Based on the findings in the field, the exploration team was composed of 01 chainsaw operator, 01 chainsaw operator's assistant, 01 community ranger and 01 ranger from the Lipilichi Wilderness anti-poaching unit. The Community Ranger, responsible for indicating the areas where the logging should take place, because he is the one who knows the region best and knows where certain species can be found. The inspector of the anti-poaching unit, representing the company Lipilichi Wilderness, is responsible for verifying and ensuring compliance with the quantities of wood requested and ensuring that they are delivered to their respective beneficiaries.

However, when moving to the exploration area indicated by the community inspector, a distance of 10 to 15 km was covered in relation to the community of II Congresso. Arriving at the site, although the species was frequent, it had a lower density and with relatively smaller diameters than expected, and to find trees of the desired species with a large diameter (without a defined value, empirical knowledge) it was necessary to move further, which could vary from 100 to 200m in distance to find an ideal tree for felling.

According to local knowledge, there are species whose trees are not ideal for the production of beams. A certain species could be indicated for the production of beam, but it would not be ideal for the production of boards, according to empirical knowledge, they assume that the physical properties of wood, such as density and volumetric ratio (anisotropic coefficient) do not offer dimensional stability for wood for external use, such as for doors, windows and frames, for example. In this case, it has been more difficult to find timber species for board production than for beam production, corroborating [1].

3.3. Dendrometric Description

Standing tree volume

In the field, three (3) trees were felled and processed, two of *Vitex doniana* and one of *Pericopsi angolensis*, presenting different dendrometric values, and due to the commercial height (from the base in relation to the ground to the first bifurcation, see Figure 3), the tree could provide two or only one trunk, considering the length of 3.20m (Table 3).

It is evident that the usable commercial volume depends critically on a specific combination of morphological factors, and not only on the general size of the tree. The data reveal fundamental relationships between diameter at breast height (DBH), total height (TH), commercial height (CH) and the number of trunks obtained, with profound implications for the efficiency of forest exploitation.

Table 3. *Standing tree volume.*

Scientific name	Local name	DBH (cm)	CH (m)	TH (m)	N° of logs	Volume in standing (m^3)	Commercial volume (m^3)
Vitex doniana	Mpindimbe	57,6	7	16	2	2,92	1,28
Vitex doniana	Mpindimbe	56,9	6	19,5	1	3,47	1,07
Pericopsi angolensis	Muanga	70	7	21	2	5,65	1,88

Where: DBH – Diameter at breast height; CH – Commercial height; TH – Total height; cm – Centimeter; m - Meter

The tree with the highest standing volume (5.65 m^3) and commercial volume (1.88 m^3) was *Pericopsi angolensis*, which had the largest DBH (70 cm), the largest TH of 21 m and a HC of 7 m, allowing it to yield two trunks. The first *Vitex doniana*, with DBH of 57.6 cm and CH of 7 m, also produced two trunks, resulting in a commercial volume of 1.28 m^{3}from a total volume of 2.92 m^3. However, the second *Vitex doniana*, despite having a DBH of 56.9 cm, TH of 19.5 m, its commercial height of only 6 meters was the decisive limiting factor, restricting its use to a single trunk and a commercial volume of only 1.07 m^3, the lowest in the sample, despite having the second largest total volume (3.47 m^3).

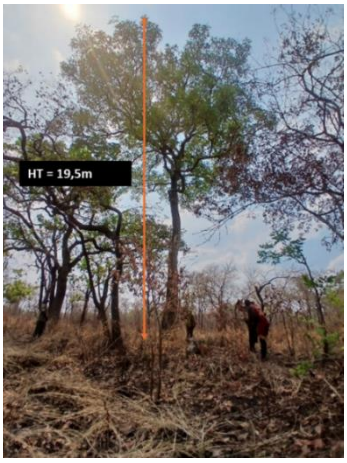


Figure 3. *Measuring the volume of a standing tree.*

Therefore, for sustainable and efficient forest exploitation, priority should be given to the selective harvesting of individuals that combine an appreciable DBH with a high commercial height. This practice maximizes the volume of useful timber harvested per tree, while minimizing the ecological impact of felling, as less disturbance is created in the canopy per cubic meter of product obtained. Selection based on morphology, favoring trees with clean and high stems such as *Pericopsi angolensis*, is fundamental to harmonize timber production with the conservation of forest ecosystems.

Roundwood volume

According to the results presented in Table 4, it is observed that the species *Pericopsi angolensis* obtained a greater volume of logs, corresponding to the log of the 1st section of the tree with 1.01m^3, a similar scenario was repeated for the two *V. donianas*, where the trunks of the 1st section presented greater volume, and the logs of the 2nd section the volume decreased significantly, confirming the expected pattern of decrease in diameter and, consequently, in volume, as the height of the shaft is raised. It should be noted that the dimensions of the logs were standardized (Length = 3.2m; Width = 7.5cm and Thickness = 5cm) (Figure 4).

Table 4. *Roundwood volume.*

Species	**N° of log**	**D_{base} (cm)**	**D_{top} (cm)**	**D_m (cm)**	**Volume of log (m^3)**
Vitex doniana	1º	66	53	59,5	0,89 b
	2º	53	40	46,5	0,54 d
Vitex doniana	1º	63	50	56,5	0,80 bc
Pericopsi angolensis	1º	71	56	63,5	1,01 a
	2º	56	54	55	0,76 c
CV%					4,37
General average					0,800

Where: D – Diameter of the logs of the base or top (cm); CV – Coefficient of variation; % - Percentage. Means followed by the same letters horizontally did not differ statistically from each other at 5% by Tukey's test.

Figure 4. *Measurement of length and thickness in logs (C = Length; E = Thickness).*

The coefficient of variation of the volume of the torus was very low (4.37%), indicating high precision of the experiment and low variability between the volume data, with the general average being 0.8m^3 per logus. The difference in volume between the logs is directly explained by the influence of diameters, both at the base and at the top. The medium diameter (Dm) is an indicator of the resulting volume, and the torus with the highest Dm (63.5 cm of *P. angolensis*) produced the largest volume (1.01 m^3), while the one with the smallest Dm (46.5 cm of the 2nd section of the first *V. doniana*) produced the smallest volume (0.54 m^3).

Volume of sawn timber

Based on the analysis of the results of the volume of sawn timber (Table 5), there is a directly proportional and consistent relationship between the size of the log, the number of beams produced and the final volume of sawn beams obtained. Tukey's test of comparison of means at 5% significance confirmed statistical differences between logs, with an experimental accuracy considered average, reflected in a coefficient of variation (CV%) of 10.94% for the volume of beams, indicating a moderate but acceptable variability in the data.

Table 5. *Volume of sawn timber.*

Species	N° of log	N° of beams	Volume of beams (m^3)
Vitex doniana	1º	37,00 b	0,443 b
	2º	22,00 d	0,264 c
Vitex doniana	1º	28,00 cd	0,336 bc
Pericopsi angolensis	1º	50,00 a	0,600 a
	2º	35,00 bc	0,408 b
CV%		8,32	10,94
General average		34,400	0,410

Where: Vol – Volume; m^3 – Cubic meter; CV – Coefficient of variation; % - Percentage. Means followed by the same letters horizontally did not differ statistically from each other at 5% by Tukey's test.

The species *Pericopsi angolensis* (Muanga) stood out again, with the 1st section log generating the largest number of beams (50 units) and the largest volume of sawn wood (0.600 m^3). This superior performance is directly linked to the higher initial volume of the log (1.01 m^3), confirming the premise that larger logs, characteristic of the first sections of the trunk, allow a more significant use (Figure 5).

Figure 5. *Beams generated after splitting.*

The pattern is repeated for the two *Vitex doniana* trees (Mpindimbe), whose 1st section logs produced 37 and 28 beams, with volumes of 0.443 m^3 and 0.336 m^3, respectively. On the other hand, the logs of 2nd section, of lower volume, resulted in fewer beams, 22 units (0.264 m^3) for the first *V. doniana* and 35 units (0.408 m^3) for the second section of *P. angolensis*.

The general average obtained in the experiment points to 34.4 beams and 0.410 m^3 of sawn volume per log. The analysis of variance supports the conclusion that this average value (approximately 35 beams per logus) can serve as a base estimate, but will always be subject to variations. These fluctuations depend critically on two key morphological factors, the diameters of the log (which determine the gauge of the beams and the number of beams per cross-section) and the commercial height of the tree (which defines how many logs of usable size can be obtained from a single individual) [13].

Therefore, sawn efficiency and final yield in sawn timber are maximized when trees are selected that combine a high diameter at breast height (DBH) with a significant commercial height, thus ensuring that a greater number of first-section logs are obtained, which offer the highest return in volume of processed product.

Volumetric yield coefficient

Regarding the volumetric yield coefficient, Tukey's mean comparison test at 5% of significance (Table 6) shows that the log of the 1st section of *P. angolensis* had high yield in sawn wood, with 59.2% of utilization, not differing statistically with the other sections of *V. doniana*, expecting for the second *V. doniana* which had a 41.9% success rate. In general, the analysis of variance points to an overall average of 50.8% yield for all sections of the logs, with a variability and average experimental accuracy.

Table 6. *Volumetric yield coefficient.*

Species	N° of log	Vol of log m^3	N° of beam	Vol of beam m^3	Yield %
Vitex doniana	1º	0,89 b	37,00 b	0,443 b	49,8 ab
	2º	0,54 d	22,00 d	0,264 c	48,6 ab
Vitex doniana	1º	0,80 bc	28,00 cd	0,336 bc	41,9 b

Species	N° of log	Vol of log m³	N° of beam	Vol of beam m³	Yield %
Pericopsi angolensis	1º	1,01 a	50,00 a	0,600 a	59,2 a
	2º	0,76 c	35,00 bc	0,408 b	53,7 ab
CV%					10,71
General average					50,821

Where: Vol – Volume; m³ – Cubic meter; CV – Coefficient of variation; % - Percentage. Means followed by the same letters horizontally did not differ statistically from each other at 5% by Tukey's test.

In this context, the superior and statistically validated performance of the 1st torus of *Pericopsi angolensis* (59.2% yield) acquires crucial ecological importance. This species demonstrated superior efficiency, converting a greater proportion of its extracted biomass into final product. In forestry practice, this means that, in order to meet a specific demand for sawn wood, it would be necessary to cut a smaller number of P. *angolensis* individuals compared to other trees with lower yields.

Consequently, the pressure on the population of this species in the forest is reduced, allowing a higher in *situ* conservation rate and a lower disturbance of the canopy and habitat per volume of product obtained. Its better performance is probably associated with intrinsic characteristics such as rectilinear stem, uniform wood and low incidence of defects, attributes that reflect a good phytosanitary and growth status, making it a key species for a lower impact exploitation.

In contrast, the performance of 2nd *Vitex doniana* (41.9% yield) represents the worst-case scenario from a conservation point of view. This drastically lower yield indicates that this particular log, probably due to the production of only a single log in the tree due to the greater presence of natural defects (knots, cracks, deformations), required a much larger amount of forest biomass to be removed to generate a low yield.

The exploitation of trees with these characteristics implies a greater disturbance of the ecosystem per cubic meter of useful wood produced. It means more openings in the canopy, more interference with the soil and greater generation of waste at the farm site for the same benefit of local consumption, which is unsustainable in the long term. According to [4] that establishes the use of sawn wood, defining 35% less of the volumetric yield coefficient, it can be obtained individually by species or by the set of species most processed in the timber industries, so the results found here are within this limit and for [2], yields between 45 and 55% are considered normal for broadleaves.

Relationship between volume and yield

The analysis of the volumetric results, confirmed by the non-significant statistical difference in the commercial volume and in the volume of sawn wood (beam) between the species (Tukey's test, 5%), shows a severe impairment in the efficiency of the wood value chain.

Table 7*. Relationship between volume and yield.*

Species	Volume (m3)			Yield%	
	Standing	Commercial	Beam	Standing	Commercial
Vitex doniana	2,92 c	1,28 a	0,71 a	24,24 a	55,46 a
Vitex doniana	3,47 b	1,07 a	0,34 a	9,69 c	31,77 b
Pericopsi angolensis	5,65 a	1,88 a	1,01 a	17,83 b	53,72 a
CV%	0,83	40,96	84,15	4,73	1,81
General average	4,01	1,41	0,68	17,25	46,78

Where: m³ – Cubic meter; CV – Coefficient of variation; % - Percentage. Means followed by the same letters horizontally did not differ statistically from each other at 5% by Tukey's test.

This inefficiency manifests itself in two critical points. The first and most relevant in terms of gross volume is the low volumetric conversion rate from the standing tree to the final product. The volume of beam represents only 17.25% of the total volume standing, indicating that more than 80% of the potential biomass is lost or discarded during slaughtering, sectioning and delimbing operations.

This loss, classified as crop residue, suggests that cutting specifications and commercial inventory techniques are underestimating or excluding large portions of the stem that could be used, establishing the main absolute limitation to total productivity. The second point of inefficiency, of an industrial nature, lies in the low Volumetric Yield Coefficient (VYC) obtained in the sawmill, which is only 46.78% in relation to the commercial volume processed.

A VYC of less than 50% means that the waste in the splitting (53.22%) is greater than the volume of useful product generated, as a result of factors such as excess cutting thickness (sawdust), inadequate log geometry (taper, curvature) and, above all, the sub-optimization of the cutting plan used. Finally, the results demonstrate that productivity is limited by a double and structural inefficiency: the maximum volume loss occurs in the field (harvest), and the subsequent processing is highly deficient.

3.4. Number of Trees for the Production of Beams

Based on the requirements of the Segundo Congresso community, which needs 1943 beams with standardized dimensions (3.20 m length, 5 cm thick and 7.5 cm wide), it is essential to carry out a technical analysis that integrates dendrometric parameters, processing efficiency and forest sustainability criteria. Each beam has an individual volume of 0.012 m^3(calculated by $3{,}20 \times 0{,}05 \times 0{,}075$), resulting in a total required volume of 23.32 $m^3$of sawn wood.

Considering the average sawing yield of 50.8% (previously referenced value), the gross volume of logs needed to produce this volume of sawn wood is approximately 45.91 m^3($\frac{23{,}32\ m^3}{0{,}508}$). Adopting an average volume of 0.8 m^3per log (based on experimental data), it is estimated that 57.4 logs are required (rounded to 58 units). This calculation assumes that the logs have ideal characteristics: suitable diameters (base and top), low taper and absence of defects such as tortuosity or rot, factors that directly influence the yield.

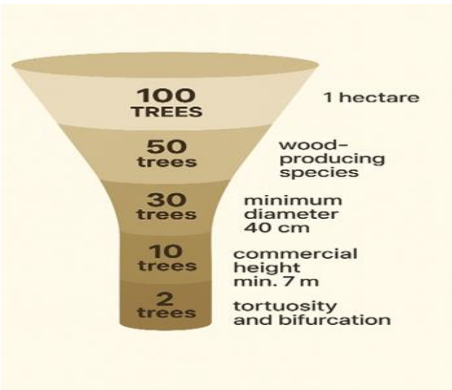
The relationship between the number of logs and trees depends critically on the commercial height and the quality of the stem. Assuming that trees with a commercial height greater than 7 m and a minimum diameter at breast height (DBH) of 40 cm allow the production of two usable logs (due to the standard length of 3.20 m per log), approximately 29 trees would be required ($\frac{58\ logs}{2\ logs\ per\ tree}$). However, it is essential to incorporate natural variability and operational losses. Trees with low taper stems (reduced diameter variation along the stem) maximize the number of beams per cross-section, while tortuosity or defects can drastically reduce utilization.

From a silvicultural point of view, the selection of trees should prioritize individuals with adequate morphology, DBH ≥ 40 cm, commercial height ≥ 7 m, cylindrical shape (taper less than 1 cm/m) and absence of thick branching or damage. This criterion ensures greater efficiency in unfolding and reduces waste.

To meet the demand of 1943 beams, it is recommended to cut down approximately 30 to 35 trees with optimized morphological characteristics, ensuring a technically efficient and environmentally responsible exploitation. This dimensioning should be accompanied by *in situ* evaluation for adjustments, considering the variability between individuals and specific conditions of the stand, considering the height of 30 to 90cm of stumps [10].

3.5. Selection Process for Wood-producing Species

The process of selecting trees for lumber production follows a pyramid or funnel selection approach, as illustrated in Figure 6. This method ensures that only specimens with the ideal technical characteristics are harvested, maximizing the yield and quality of the final product, while ensuring the sustainability of the forest ecosystem.



Tree selection

To maximize yield, it is recommended to select trees with:

- DBH (Diameter at Chest Height) ≥ 40 cm
- Commercial height ≥ 7 m
- Taper ≤ 1 cm/m (reduced diameter variation)
- Straight shaft (minimum tortuosity)
- Absence of defects (cracks, rot, thick knots)

Figure 6. *Felling Tree Selection Hopper.*

The selection begins with a base population of approximately 100 trees per hectare, representative of a mature forest stand. The first filtering criterion is the species, reducing the universe to about 50 trees. Only wood-producing species with proven commercial value and superior technological characteristics are selected, thus excluding non-commercial or low-quality species.

The second filter applied is the minimum dimension, focusing on the Diameter at Breast Height (DBH). Only trees with a DBH equal to or greater than 40 cm are considered, a criterion that ensures that each individual has enough volume to be economically viable. This stage reduces the number of candidates to about 30 trees.

The third filter assesses the commercial height, requiring a minimum of 7 meters. This parameter is crucial to ensure that logs with useful lengths can be obtained for the production of beams and other value-added products. After this screening, there are approximately 10 trees per hectare left.

The final and most rigorous filter concerns the quality of the stem. In this phase, advanced dendrometric criteria are evaluated, such as taper, tortuosity and the presence of defects. The ideal taper should be equal to or less than 1 cm per meter of height, indicating a reduced diameter variation and a cylindrical stem, which maximizes the yield in the split. The tortuosity should be minimal, favoring straight shafts. Finally, the tree must exhibit high health, with the absence of significant defects such as cracks, rot or thick knots that compromise the quality of the wood. The rigorous application of these quality criteria results in the selection of only 2 trees per hectare, the true elites of the stand.

3.6. Ecological Impacts of the Exploitation of Community Beams

The exploitation of timber in miombo forests, in the area of Segundo Congresso, when carried out by local communities, without commercial purposes, and with simple methods, such as the use of a single chainsaw and displacement on foot, represents a model of low-impact forest management. This type of activity, usually aimed at building houses, is a traditional way of using natural resources, deeply connected to the reality and needs of communities. Although this practice has environmental impacts, it can also generate relevant positive effects for the conservation of biodiversity, depending on how it is conducted.

Positive impacts

Because it is a selective, low-intensity extraction carried out manually, most of the forest remains intact. The removal of a few trees per hectare does not significantly alter the structure of the canopy or the forest microclimate, which are essential factors for the maintenance of fauna, flora and ecological cycles [3, 14].

Unlike mechanized logging, which causes the opening of roads and clearings, walking and punctual cutting allow the ecosystem to maintain its ecological continuity, favoring natural regeneration and the persistence of species that are more sensitive to light, temperature, and humidity. As the wood is only used for the construction of houses and not for commerce, the volume extracted is reduced and occurs at long intervals (once a year or every two years). This natural rhythm of use gives the forest time to recover between extraction periods, maintaining the balance between removal and regeneration.

As the cut is dispersed (on average, one tree every 200 meters), the impact on the population structure of the species is minimal. The remaining trees continue to produce seeds and fruits, ensuring the diversity of plants, birds, insects and mammals that depend on them.

Negative impacts

The trees chosen for felling are usually the largest, straightest and of good quality, exactly those that fulfill crucial ecological functions. Adult trees shelter nests of birds, bats, bees, store a large amount of carbon and regulate the microclimate. Their removal, even if occasional, can cause small disruptions in ecological connectivity, creating "voids" between habitats used by fauna [5]. Resulting in the loss of key trees and reduced ecological connectivity.

By repeatedly selecting the same timber species of structural value (*Vitex doniana* and *Pericopsi angolensis*), the community can unwittingly gradually reduce the abundance of these species over time. If the most productive trees are always cut down before they fully reproduce, there will be fewer seeds available for regeneration, which can alter the floristic composition of the forest, according to [14].

One of the biggest challenges of community management is to maintain the balance between need and availability. As the population grows or communities become more reliant on timber, there is a risk of increasing the frequency or volume of logging. Let's see, if all five communities within the Chipanje Chetu ask for beams at least once for no, even though the exploitation is semi-mechanized (Chainsaw), this exploitation is not ecologically sustainable in the long term.

3.7. Cutting Cycle

According to [17], the Niassa region has an AAI of 1.36 m^3/ha/year, which means that annually in an area of 1 hectare, its volume grows by up to 1.36m^3. Thus, with a farm of 45.91m^3, to recover this volume, it would take 34 years, if the farm took place in the same area of 1 hectare. Thus, 2-5 years cutting cycle and a maximum limit of 25m^3 of sawn timber are proposed for all five communities with a defined number of trees per species to be harvested, based on the annual productivity of miombo forests in the North of Mozambique.

4. Conclusions

This technical note evaluated the ecological impacts of logging for the production of 1,943 community beams in the

Chipanje Chetu Program Conservation Area, in Sanga district, northern Mozambique.

Farm volume and yield

1). Standing volume – The trees analyzed (*Vitex doniana* and *Pericopsi angolensis*) showed average volumes of 4.01 m^3 per tree, with significant variations depending on the diameter at breast height (DBH) and commercial height (CH). Trees with DBH ≥ 40 cm and CH ≥ 7 m produced the highest commercial volume (up to 1.88 m^3 per tree).

2). Log volume – The average volume per log is 0.8 m^3, with first-section logs (base of the tree) showing higher volumes (up to 1.01 m^3) due to larger diameters.

3). Volume of sawn wood – A log produces an average of 35 beams, equivalent to 0.410 m^3 of sawn wood per log. The total volume required to meet the demand of 1,943 beams is 23.32 m^3, requiring approximately 58 logs (equivalent to 30–35 trees).

4). Volumetric yield – The average yield coefficient in splitting is 50.8%, indicating that almost half of the log volume is lost in sawdust, ribs and slats. The total conversion of standing volume to lumber was only 17.25%, highlighting significant inefficiencies in the production chain.

Ecological impact

Timber exploitation, being for local and non-commercial use, is intended exclusively for community consumption, which reduces commercial pressure and allows natural regeneration cycles. Selective and semi-mechanized harvesting contributes to the preservation of forest structure and biodiversity. However, the removal of vigorous trees compromises long-term ecological resilience, and repeated exploitation of the same species (*Vitex doniana* and *Pericopsi angolensis*) threatens their natural regeneration and genetic diversity.

The low efficiency in processing, with losses of more than 80% of the original volume of the standing tree, makes this exploitation unsustainable, since it requires an excessive number of trees to meet demand. In addition, population growth in communities represents a critical risk factor, as it progressively amplifies the pressure on the timber resource, increasing the minimum volume needed per community over time.

Technical recommendations

Based on the results found in this document, the following is recommended to Lipilichi Wilderness:

1). Train members of the natural resource management committee of each community and community inspectors in matters of criteria for identification, selection and registration of trees for exploitation, because, for each exploitation activity at the community level, it is necessary to record the coordinates, species, dendrometric data, product generated, numerical quantity and in volumes, final destination, among other relevant parameters.

2). Establish cutting cycles based on the Average Annual Increment (AAI) of 1.36 m^3/ha/year and the natural regeneration capacity. Delimit rotational exploitation areas, with fallow periods of 2-5 years to allow the recovery of the exploited species.

3). Expand the list of usable species to include alternative varieties with similar technological characteristics but less ecological pressure, based on the classes of timber species (Precious, 1st class to 4th class).

4). Prepare a forest management plan for timber products that will include the permitted species, minimum cutting diameter, commercial height, defined exploitation areas, maximum volume per community, ideal period for exploitation and type and conditions of permitted equipment. The same plan should include alternative uses of farm waste and reforestation initiatives, if necessary.

Abbreviations

AAI	Average Annual Increment
CH	Commercial Height
cm	Centimeter
CONAMA	Conselho Nacional Do Meio Ambiente [National Council for the Environment]
CV	Coefficient of Variation
VYC	Volumetric Yield Coefficient
DBH	Diameter at Breast Height
ha	Hectare
IUCN	International Union for Conservation of Nature
m	Meter
m^3	Cubic Meter
TH	Total Height

Author Contributions

Fanuel Garai Albino Muiambo is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Araujo, H. J. B. (2020). Characterization of the wood material. In Environmental Education – Sustainable Development in the Globalized Economy (ISBN 978-65-5109-002-8) (Forest Engineering, M.Sc., Researcher at Embrapa Acre). Embrapa Acre.

[2] Biasi, C. P., & Rocha, M. P. (2007). Yield in sawn wood and quantification of residues for three tropica species. Floresta, 37(1).

[3] Chapagain, U., Chapagain, B. P., Nepal, S., & Manthey, M. (2021). Impact of disturbances on species diversity and regeneration of Nepalese Sal (Shorea robusta) forests managed under different management regimes. Earth, 2(4), 826-844. https://doi.org/10.3390/earth2040049

[4] Conselho Nacional do Meio Ambiente (CONAMA). (2016). Resolution No. 474, of April 25, 2016. Establishes procedures for inspection in industries that consume or transform native forest products and by-products. Federal Official Gazette, Brasília, DF, ed. 80, seção 1, p. 61. Available at: https://conama.mma.gov.br/?option=com_sisconama&task=arquivo.download&id=585 Accessed on: 10 nov. 2025.

[5] Electricidade de Moçambique, E. P. (2023). Environmental and social impact assessment report: Construction and operation of a 40 MWp solar photovoltaic power plant in Chiúta District, Tete Province, Mozambique. Electricidade de Moçambique, E. P.

[6] Januário, J. M. (2023). Analysis of the Nonduece River Basin in the Administrative Post of Unango – Sanga.

[7] Forest Law. (2023). Law on the Protection, Conservation and Use of Forest Resources Law on the Protection, Conservation and Use of Forest Resources). Maputo, Moçambique.

[8] Lima, L., Machado, A., & De Figueiredo, L. (2025). Mobile Apps for Estimating Tree Height in a Commercial Teca Plantation. VII MENSUFLOR, September 24 to 26. Federal University of Lavras – UFLA. Available at: https://mensuflor.ufla.br/index.php/evento/article/view/132 Accessed on: 10 nov. 2025.

[9] Mbanze, A., Dias, C. R., Munome, A., Massingue, Y., Joaquim, R., Ferrão, R., Laisse, Y., Cassido, I., Manuel, M., Abbas, M., Mbanze, J., Soares, V., Ribeiro, P. F., Lasse, N., Buramuge, V., Canadas, M. J., Novais, A., & Lima-Santos, J. (2025). Conservation with people inside the protected areas: How to address local people's needs with no zero-sum game. IntechOpen. https://doi.org/10.5772/intechopen.1012328

[10] Mohit Gera, Buvaneswaran, C., Murugesan, S. and Sasidharan, K. R. (Eds.) (2018). Towards Resilient Ecosystems: The Role of Forestry Research -Synthesis and A Way Forward Proceedings of National Conference onTowards Resilient Ecosystems: The Role of Forestry Researchheld on 8 - 9 May, 2018 at Institute of Forest Genetics and Tree Breeding, Coimbatore. Pp. 1-204.

[11] Natasha, R., & Buramuge, V. (2024). Assessment of tree species composition and diversity across disturbance gradients in miombo woodlands of Chipanje Chetu Community Conservation Area. Available at: https://omrmz.org/livros/research-report-assessment-of-tree-species-composition-and-diversity-across-disturbance-gradients-in-miombo-woodlands-of-chipanje-chetu-community-conservation-area/ Accessed on: 10 nov. 2025.

[12] Nesi, M. (2011). Identification of risks associated with semi-mechanized cutting of eucalyptus and pine in forest exploitation. University of the Extreme South of Santa Catarina, Specialization Course in Occupational Safety Engineering, Criciúma, August.

[13] Parante, P. R. F., Amaro, M. A., Lima, Q. S. de, Lobão, M. S., & Carvalho, C. A. de. (2024). Volumetric yield coefficient for timber species obtained in sawmills in Acre. Scientia Naturalis, 6(2), 779-800. https://doi.org/10.29327/269504.6.2-15

[14] Poudyal, B. H., Maraseni, T., & Cockfield, G. (2019). Impacts of forest management on tree species richness and composition: Assessment of forest management regimes in Tarai landscape Nepal. Applied Geography, 111, 102078.

[15] Rodrigues, L., Barreto-Garcia, P., Cerquera, D., Araújo, A., Rocha, I., & Dos Santos, D. (2025). Height estimates of eucalyptus using the Trees® app and the Haglöf® hypsometer: a comparative study. VII MENSUFLOR, September 24 to 26. Federal University of Lavras – UFLA. Available at: https://mensuflor.ufla.br/index.php/evento/article/view/213 Accessed on: 10 nov. 2025.

[16] Salomão, Alda e Matose, Frank (2007) - Towards community based forest management of miombo woodland in Mozambique. CBNRM.CIFOR. Available at: https://www2.cifor.org/miombo/docs/CBNRMMozambique290607.pdf#page=18.99

[17] Uetela, A. E. (2014). Dynamics and production prognosis of a miombo forest using transition matrix. Curitiba. Available at: http://www.floresta.ufpr.br/pos-graduacao/defesas/pdf_ms/2014/d687_0180-M.pdf Accessed on: 10 nov. 2025.

[18] Yambone's Annual Impact Report (2024): A Year of Transformative Change in Chipanje Chetu.

iAAI = 0.05129 + 1.08171 * P^2; AAI – average annual increase in m^3/ha/year and P – precipitation expressed in meters.