Analysis on wood requirements, production and marketing for small-scale farmers in Phalombe District (Malawi)

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Lancement et suivi de programmes concrets de développement

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Introduction

Inter Aide is a French development NGO created in 1980. This organization works in different sectors in rural areas, such as agriculture, water and sanitation and health. It has been working in Malawi since 1991 and currently has 8 projects. Since 2020, Inter Aide has been running a pilot agroforestry project in Phalombe to help families produce their own firewood and improve their livelihoods.

Wood production is an important activity for families, as they use it as a source of energy and for construction. It is estimated that 77% of the country's population uses firewood as their primary energy source and 89% in rural areas (Mvula, Office, et Chiundira 2020). Today, a vast majority of rural households are not producing enough wood to meet their needs and different copping strategies to access to this resource, such as using crop residues or harvesting wood from natural forests, etc. This high demand for fuelwood puts pressure on natural resources and leads to heavy deforestation on the hills and in the Mulanje escarpment. Planting trees can help families become more self-sufficient in this resource and to generate additional household income. In addition, wood production around plots can reduce erosion, improve soil fertility and increase crop yields.

The aim of this study is therefore seeks to deepen Inter Aide's knowledge in order to better understand 1/ the household's wood needs and strategies to meet them, 2/ the wood production strategies and techniques put in place by smallholder farmers (other than eucalyptus) and 3/ the level of incomes that can be generated from trees. Finally, it was also important to understand how the wood markets (firewood and timber for construction) operate and who the players are in the Phalombe district. This knowledge will enable Inter Aide to better support and respond to families' needs.

1. Context

1.1. The importance of wood harvesting for rural households and its environmental impact

In the early years following Malawi's independence (1964), forest plantations were established to ensure the country's self-sufficiency in timber. At the same time, the National Tree Planting Program, based on the promotion of fast-growing exotic species in rural areas, was set up. In 1994, following the transition from dictatorship to democracy, Malawians had virtually free access to timber resources in public forests (Mauambeta et al. 2010). This led to the destruction of plantations and accelerated deforestation (Abadia 2016). Indeed, in 20 years (2002-2022), the country has lost 11% of its primary humid forest and 15% of its plant cover (Global Forest Watch 2023). In addition, the high population growth rate has led to an increase in fuel energy demand. World Bank estimates that only 5.6 % of the rural population had access to electricity in 2022 (The World Bank Group 2024).

As firewood is becoming increasingly scarce and expensive, households also use crop residues to replace it, especially after the harvest, during the dry season (Abadia 2016). In Lilongwe, Inter Aide already estimated that about 63% of firewood is used during the rainy season. At the end of the dry season, families have used up their crops and crop residues, and firewood becomes an essential resource for cooking and generating income (Aceves Cardenas 2022). Household use of wood fuel is the largest consumer of wood in Malawi, well ahead of building materials and brick making (Drigo et USAID 2019).

Traditionally, women are in charge of cooking. They are therefore the primary consumers of firewood in rural areas. In addition, when cooking, they are more exposed to various diseases (respiratory, cardiopulmonary or neurological) caused by the burning of low-quality wood and crop residues

(Aceves Cardenas 2022; Aggarwal et Steckel 2022). Wood combustion emits fifty times more domestic pollution than gas stoves (Taulo, Mkandawire, et Gondwe 2008).

Wood is also used as construction material in the villages, mainly used during the dry season. During the dry season, demand is higher (Aceves Cardenas 2022). Other sectors also consume wood such as "*lime production, poultry industry, tobacco curing, brickmaking, fish smoking/drying, boarding schools, tea drying, restaurant and resort*" (Drigo et USAID 2019). Only rural household consumption and wood for construction (poles/timber and brick making) are studied in this report.

1.2. Study location: Phalombe district

The study took place in the Phalombe district, characterized by a warm temperate climate (Cwa on the Köppen-Geiger classification). This corresponds to hot, humid summers (from November/December to March) and a dry winter. The average temperature is 20°C and the average annual rainfall is around 1159 mm (Climate-data 2023; The Globe program, s. d.).

The district corresponds to an area of 163,300 hectares, of which 124,500 hectares (76.24%) are arable, mostlye cultivated and inhabited. The rest of the area is covered by marshes at Lake Chilwa and Mpoto Lagoon and forest reserves like the Michesi Forest and part of Mulanje Forest reserve. The forest area corresponds to 11,806 ha (7.23%) of which 1826 ha are plantations with 452 ha planted with pine trees and 423 ha with eucalyptus (Taulo, Mkandawire, et Gondwe 2008).

Families depend on agriculture as their main means of livelihood. The main crops are maize (76.4% of arable land), rice, sorghum, groundnut, cassava and sweet potato. 55% of producers have less than 0.5 ha and 75% cultivate less than 1 ha (Taulo, Mkandawire, et Gondwe 2008). Environmental risks such as droughts and floods impact a very fragile food security, especially since Phalombe is the poorest district in Malawi with 83% of households living below the national poverty line. The district has been also heavily impacted by climate hazards over the past two years. Indeed, it was hit by Cyclone Freddy in March 2023, which caused heavy flooding, the destruction of houses and the death of some trees (Government of Malawi 2023). The 2023/2024 season was affected by El Niño, which was responsible for the late arrival of rains and the prolongation of dry spells. This had a major impact on crops, with a 16% drop in maize production nationwide (Department of Disaster Management Affairs 2024).

The survey was carried out in the T/As of Nkhumba (villages: Chilombo, Namukongwa, Nachipo and Nachanje), Nyambalo (villages: Namitanga, Kanula and Nagome) and Kaledzela (villages: Gomani, Mwanyenga, Suluwati), in the villages of Namphwalala and Phunduma and in the entire district for markets.

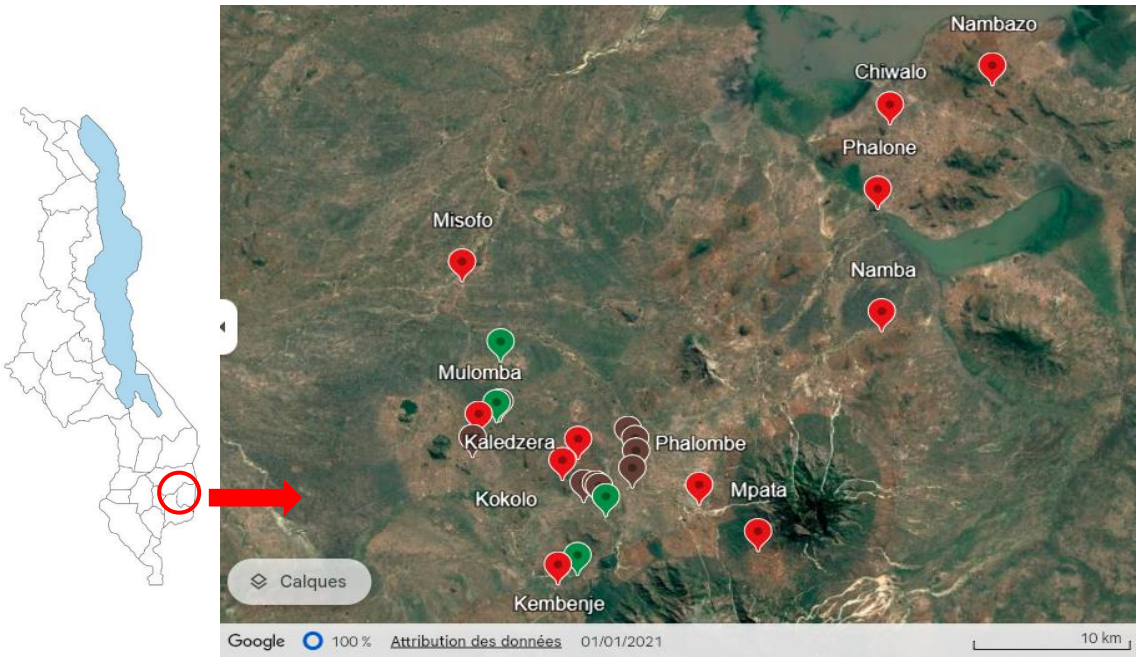

Figure 1: Map of villages where interviews were conducted; Green: village where wood producers were interviewed, Brown: village where interviewed for wood needs were conducted and Red: markets places where interviews took place

2. Presentation of the study and its methodology

2.1. Presentation of the study

Wood production can be an interesting activity for households, as it can be used as a source of energy and for construction. Wood is therefore in high demand, putting puts pressure on natural resources. Planting trees can help families become more self-sufficient in this resource. This activity can also generate additional incomes for households. In addition, wood production around farm lands can also limit erosion, improve soil fertility and increase crop yields. However, it is important to better understand the demand, production and marketing of wood in order to better adapt the project. This study aims to assess the potential of agroforestry as a means of meeting the energy challenges faced by rural households in Phalombe, as well as improving their access to building materials and additional income. This study focuses on wood production, both for firewood and poles/timber and on understanding families' needs and their approaches to meeting them. The presentation of the study results is divided into 3 different chapters. **The first part** aims to understand household biomass fuel and wood requirements for heating and construction, including brick making for houses. It identified the main sources used according to the time of year, the quantities needed and the time required to access these resources. It also aims to identify the different strategies families use to access wood, while identifying the practices they would like to change. **The second part** consists of gaining a better understanding of wood producers' practices and potential economic values of the productions by species group and season. **The last part** is devoted to a deeper understanding of wood marketing at the district level and the economic margins generated by the main actors.

2.2. Methodology: a systemic and qualitative study

This study is based on a systemic and qualitative analysis. The aim is to understand the complexity of a situation by taking into account the point of view of the various stakeholders. The information is collected during semi-directive interviews in order to understand through active listening. The sample is reasoned and small. Evidence is obtained through information saturation, triangulation of

information from multiple sources, and consideration of systemic coherence. Information saturation is achieved when a survey provides no new data. Triangulation and systemic coherence make it possible to check the data obtained and identify major divergences, convergences and inconsistencies. Surveys was based on interview guides and was anonymous. Interviews were conducted in pairs to translate from Chichewa to English. Translation is one of the main limitations of this study. Throughout the study, four different people carried out the translation, which could lead to bias.

Moreover, to fully understand the quantities really used by respondents and their wood's needs, a weekly follow-up with nine households was set up from March or April (depending on the household) to mid-October. This follow-up enabled us to deepen the data collected during the interviews and to weigh the actual quantities used for cooking. Households were selected after an initial analysis of the surveys and the definition of a typology.

A total of 30 households were interviewed for wood needs (87% of respondents are women), 12 for wood production (58% of respondents are women), 40 people for markets (collectors, retailers, carpenters, etc.), 30% women and 3 key informants belonging to government institutions and non-governmental organizations (detailed in Appendix *1*). For wood needs and production, families were identified by Inter Aide's field officers. who were given the task to select producers with different profiles (from the most vulnerable to the most well-off). However, it turned out that the profiles selected did not always achieve this diversity, which may have biased the study. Lastly, as it was very difficult to identify families owning sufficiently old trees and who exploit them, only twelve families were selected for the wood production survey. All small scale farming families surveyed for wood need and wood production were at point supported by Inter Aide to raise seedlings and plant trees. Some families were supported from 2016 to 2019 and others started collaborating with Inter Aide between 2020 and 2023. It is important to mention that all these families have also other trees, planted before Inter Aide's intervention.

We present here below some particularities of the methodology used for each chapter, or sub-study.

For the wood demand study, we first conducted an individual interview with the 30 selected beneficiaries. These interviews were used to define the different strategies and to select 9 families for weekly monitoring. At each visit, the amount of wood and crop residues used for a meal was weighed on a scale and the number of meals per day was asked. This allowed the quantities used for a week to be defined and annual consumption calendars to be established. As it was not possible to collect data for a whole year, the quantities used during the months of November to February were estimated on the basis of what the families told us. A spreadsheet was also distributed to each household to record the date, amount, quantity and duration of each wood purchase. A test was carried out in April with about ten families, and then the table was distributed to all families from May to mid-October.

For the wood production study, we conducted interviews that allowed us to estimate the technical itineraries and working times for each task performed. The total number of trees was also counted and it was possible to weigh the amount of wood cut for four families. The quantities of wood produced, consumed and sold were estimated from this weighing and from data on firewood requirements. The data was also analysed from an economic point of view to understand changes in cash flow calendars over the course of a year and to understand strategies based on needs and quantities produced. To this end, GVA (Gross Value Added) was calculated as an approximation of the wealth created. It can be expressed in terms of the number of trees to give the productivity of a tree, or in terms of hours worked to give labour productivity. GVA is obtained by subtracting intermediate consumption (IC) from gross product (GP).

GVA = GP - IC

Gross profit is the sum of sales and the value of products for own consumption. Intermediate consumption is the total cost of purchased inputs such as fertiliser and seed.

For the wood market study, economic margins and simple value chain analysis, we conducted interviews that allowed us to obtain sales prices, purchase prices (in the case of resale) and various charges. This allowed us to define net margins. In fact, the net margin is defined by:

$$\textbf{Net margin} = \textbf{Sales price} - \sum \textbf{Expenses}$$

As firewood prices are not set by weight but by bundle, weighing was also carried out using a weighing scale, which made it possible to establish prices per kg and therefore costs and margins per kg of wood sold. In the case of timber, the boards were measured.

Finally, the results were presented to the families interviewed and supported by Inter Aide in six presentations. A total of 429 people attended the presentations. This allowed the results of the study to be verified.

3. Wood needs of households supported by Inter Aide

3.1. Biomass fuel needs and strategies used by families to meet them

Families use a wide range of biomass fuel resources for cooking, from wood to crop residues. The different resources and quantities used to cook a meal (mainly *nsima*) are shown in the table below.

Table 1: Average quantities (in kg) used to cook a meal for a household of 5.5 people (CR = crop residues, Fw = Firewood, PP = pigeon peas); in bold: the largest quantities between traditional and improved cooking stoves

		Average quantity used per meal (kg)	**Average quantity used per meal with a traditional cooking stove (kg)**	**Average quantity used per meal with an improved cooking stove (kg)**
Wood	**From the mountain**	3.7	**3.9**	3.6
	From riverbank/fields	2.1	**2.3**	2.0
	Purchased	2.9	2.5	**3.0**
	Gifted from a friend/relative	2.3	**3.5**	1.9
	From roof poles	2.9	2.3	**3.5**
	From own trees	2.6	**2.7**	2.6
	Wood mix with residues	1.6	1.4	**1.8**
Average wood (no mix)		**2.8**	**2.9**	**2.8**
Crop residues	**Maize stalks**	2.0	Unknown	2.0
	Maize residues	1.8	1.8	1.8
	Sorghum stalks	2.8	2.2	**3.1**
	Pigeon pea stalks	2.3	**2.5**	2.2
	Tobacco stalks	Unknown	Unknown	Unknown
	Maize stalks mixed with CR or Fw	1.0	1.0	Unknown
	Maize residues mix with firewood	1.6	**2.1**	1.0
	Sorghum mixed with other CR	1.6	**1.6**	1.5
	PP mixed with other CR	1.8	**2.1**	1.6
Average crop residues (no mix)		**2.2**	**2.2**	**2.3**
Charcoal		1.0	1.0	1.0

On average, a family uses 2.8 kg of dry wood biomass to cook a meal, and only 2.2 kg of dry biomass if they use crop residues. Surprisingly, we found out that families using a modern cooking stove don't use significantly less firewood than families using a traditional stove[1]. Of the thirty households surveyed, sixteen use a traditional cooking stove, eleven an improved cooking stove and three use both. Although there was no significant difference in terms of quantities, nine of the eleven families bought an improved cooking stove in 2023 after Cyclone Freddy, in an attempt to save wood.

Figure 2: Cooking stove; left: traditional, right: improved

Some households may also use other materials for cooking when they have no other options, such as paper or clothes. This is not commonly used, but only as a last option, as it produces a lot of ash and it smoke gives the food a bad taste.

Not all families use all these resources. They have different strategies depending on their needs, availability, accessibility and financial means. The following chapters present four kind of different strategies:

- **Families who go to the mountain/hills to collect firewood mainly for their own use.** These families belong to the poorest categories and are involved in casual work (*ganyu*) for 6 months of the year, some of it in Mozambique. A third of these households are headed by single women. These families have few productive trees on their farm, averaging 48 trees, most of which are young.
- **Families who go to the mountain/hills to collect firewood, mainly for sale.** These families have a very similar profile to the first category and are also among the poorest. They are involved in casual work (*ganyu*) for 6 months of the year, some of it in Mozambique, have more children than the other 3 types of families and are the most food insecure.
- **Families who don't go to the mountain/hills but collect firewood locally (no purchase)**. These families don't have any outstanding characteristics in comparison with the other 3 types of families. Apart from the fact that 40% of these households are headed by women, they seem to be an average type of family.
- **Families who don't go to the mountain/hills but often purchase firewood**. These families are clearly the less disadvantaged and more food secure. They have 4 times more trees, and at a more mature stage, than the other 3 types of families. Among them, 90% own a business. As we will see later, some of these families prune their trees (type 4a), while others do so very rarely (4b), because they have means to purchase firewood.

[1] We acknowledge that these findings are contrary to the literature and research conducted to assess the efficiency of improved cookstoves and must be taken with caution as the methodology used was not designed to assess the efficiency of cookstoves. Therefore, these results are a by-product of the study and the reasons for the lack of significant difference have not been explored as they may be very technical and related to the type of materials used, cooking methods, household size and amount of food cooked, etc.

The family profiles are shown below:

Table 2: Typical profile of families according to their strategies for meeting their firewood needs (We have highlighted the most notable values in green.)

	Collect firewood in the mountain for own use (Type 1)	Collect firewood in the mountain for selling (Type 2)	Source firewood locally (Type 3)	Purchase firewood (Type 4a and 4b)
Number of households	10	6	5	9
Number of people in the household	4.5	6	4.5	5.3
Number of adult	1.7	1.8	1.5	1.9
Number of children	2.7	4.2	3	3.4
Number of single women household	3/10	1/6	2/5	1/9
Number of plot	3.3	2.4	2.5	3.8
Number of trees	48	39	48	175
Number of months with maize	6.1	5.2	7.4	8.6
Number of months doing *ganyu*	6.1	6.6	2.8	2.8
Number of months doing *ganyu* in Mozambique	1.6	1.6	0	0.6
Number of household owning a business	3/10	1/6	1/5	8/9

The Mulanje Mountain and village hills are the main source of biomass fuel for two categories of families: the type 1 and type 2. Because of their proximity to Mulanje Mountain, many families choose to collect wood from the mountain. In fact, sixteen of the thirty beneficiaries surveyed go to the mountain (53 %). They are mainly located in T/As Nhumba and Nyambalo. Only three families, located in T/A Kaledzela, do not go to Mulanje but collect wood from the surrounding hills. Among these sixteen families, two different strategies can be identified: some families collect wood only for their own needs and others collect to sell some in order to get money to buy necessities.

3.1.1. Type 1: Families who go to the mountain/hills to collect firewood mainly for their own use

Families collect and use wood from the mountains or hills during the rainy season. Collecting can take place before the rainy season, in October and November, or during the rainy season. Collecting before the rainy season helps the wood to dry better. It is then used during the rainy season because it is harder to find alternative resources and this period coincides with the lean season, making it difficult for families to buy wood. On average, families go to the mountain four times a month (five to six time a month for the hills), and this activity is mostly carried out by women. Generally, one woman per household goes with friends or neighbours, mainly on Saturdays. They collect a heavy bundle large enough to cook for one or two weeks. In the case of Mulanje Mountain, families have to pay a forestry fee of MK 200 to be allowed to collect dead wood. For the three families who go into the surrounding hills, collecting wood is more difficult. Indeed, they are not allowed by the chiefs to collect wood, even dead branches. The hills are well patrolled and the chances of families returning home without firewood are high. If a forestry officer catches them in the hills, he will take the wood away from them.

To avoid that, they put in place some strategies, such as going there during lunch hours or very early morning, when the forestry officers are usually not yet at work.

Wood from the hills and mountains is not the only source used throughout the year. They all use crop residues during the dry season. They use using maize residues and stalks in April and May. They can mix it with firewood if they have some. Then they use pigeon pea and sorghum stalks, sometimes together and sometimes separately, from July up to October/November. The number of months varies according to the quantity of residues available.

They also collect dead branches around their house or at the riverbank when they need firewood and when no other options are available. Some prefer to collect these dead branches during the rainy season and other during the dry season. For example, one farmer said that she is doing it mostly in June because her crop residues are not ready yet, it is a cold month and the mountain is slippery. When they cannot find dead branches around, then they may buy firewood if money is available. In this case, they buy small bundles from 200 to 500 MK. They finish these bundles in one meal or one day (2 meals).

Half of the families use wood from their eucalyptus trees. They are not yet using trees planted by Inter Aide because they are too young. The wood is harvested either during the dry or rainy season according to their needs and preference. Some prefer to harvest in October to be sure the wood will dry properly. On average, they harvest wood from ten trees (small, because recently planted) per year.

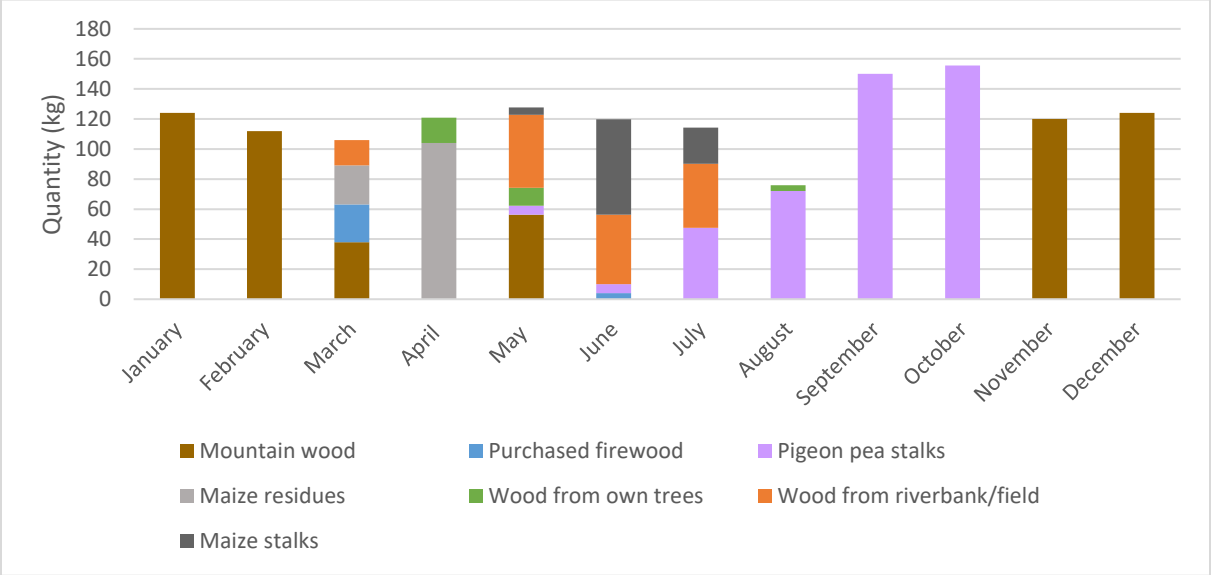

Figure 3: Calendar of biomass fuel use for families who go to the mountain to collect firewood for their own use (Type 1)

Over the year, the household consumes a total of 1,318 kg of dry matter for cooking, with an average of 125 kg per month. The main source of biomass fuel is pigeon pea stalks with a 437.2 kg (33%) followed mountain wood with a 394.2 kg (30%) and wood from riverbank/field with 154.2 kg (12%).

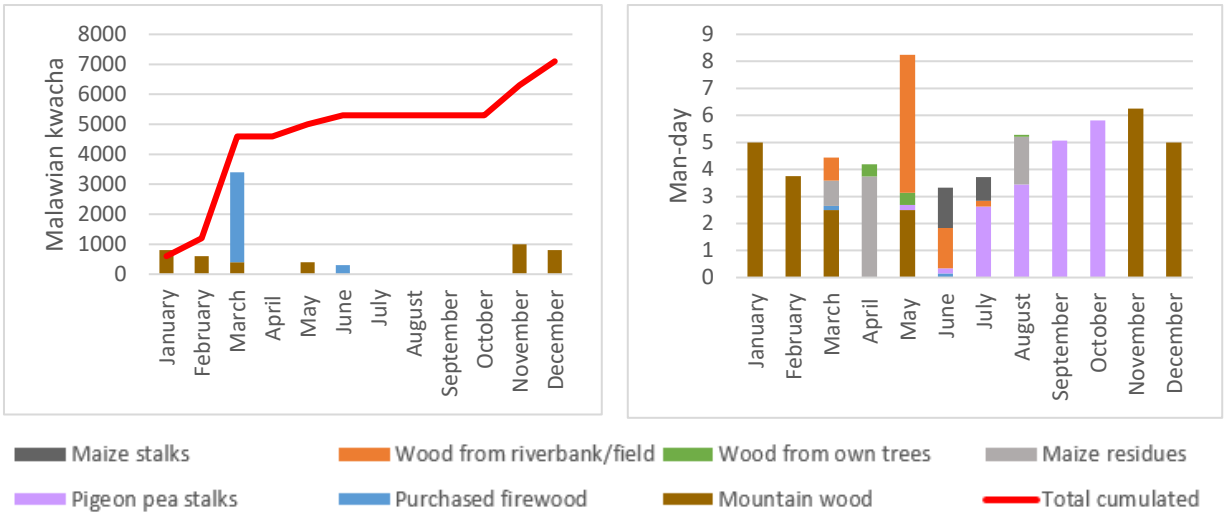

Figure 4: Calendar of expenditure for families who go to the mountain to fetch firewood for their own use (Type 1)

Figure 5: Work calendar for families who go to the mountain to fetch firewood for their own use (Type 1)

For an average household using this strategy, it spends MK 10,500 per year on firewood, of which MK 3,300 corresponds to the purchase of wood and MK 7,200 to spending on collecting wood in the mountains. The family spends an average of 60 man-days a year collecting resources for cooking (2 full months), including 25 man-days collecting wood from the mountains (42% of the time) and 26 man-days collecting crop residues (17.3 man-days for pigeon pea stalks, 8.8 man-days for maize residues and stalks, 43% of the time). Wood collection takes a lot of time because women walk long distances, usually 8 to 12 hours per trip. Crop residues collection is also time consuming, as most women collect them on a daily or weekly basis, in small quantities at a time.

3.1.2. Type 2: Families who go to the mountain/hills to collect firewood for their own use and sell part of it

As seen above, families go to the mountain before (from August to November) or during the rainy season in order to obtain wood during this season. However, some families do it also to sell part of the wood they collect to earn money to buy basic necessities. They usually go to collect when they need money. They usually go several time per month, from one time per week up to six times per week. They keep a small part of it for their own use and they sell the rest, usually in their village. The selling price varies from one farmer to another and according to the size. A bundle can be sold for between 300 and 2,000 MK. They usually sell at home or by the roadside, and they communicate with their neighbours to let them know they sell firewood.

They also use other sources like firewood from their own trees, mostly eucalyptus or *Senna siamea*. Some prefers to prune during the rainy season (3) and others during the dry season (2). They prune between three to thirty trees per year according to their size and age. During the dry season, households use crop residues (maize, sorghum and pigeon pea) collected from their own fields or from other people's fields. They do not always ask for permission to collect in other people's fields, even if it is not allowed to collect pigeon pea and sorghum stalks from someone else's field. The use of crop residues allows the families to reduce the consumption of firewood. Some tobacco growers may also choose to use tobacco residues for cooking purposes.

If they do not have firewood or crop residues, they can buy some firewood. They buy only when they do not have other solutions and when they have money. However, they prefer to use money to buy food than firewood. When they buy, they buy small quantities like bundle at 300, 400 or 500 MK that

will last for few meals. They do not go to the market but they buy from people who are coming back from the mountain, relatives or neighbours.

If they cannot go to the mountain or to buy firewood, they may also collect dead branches around their house, usually on a day to day basis, whenever needed and according to what they can find.

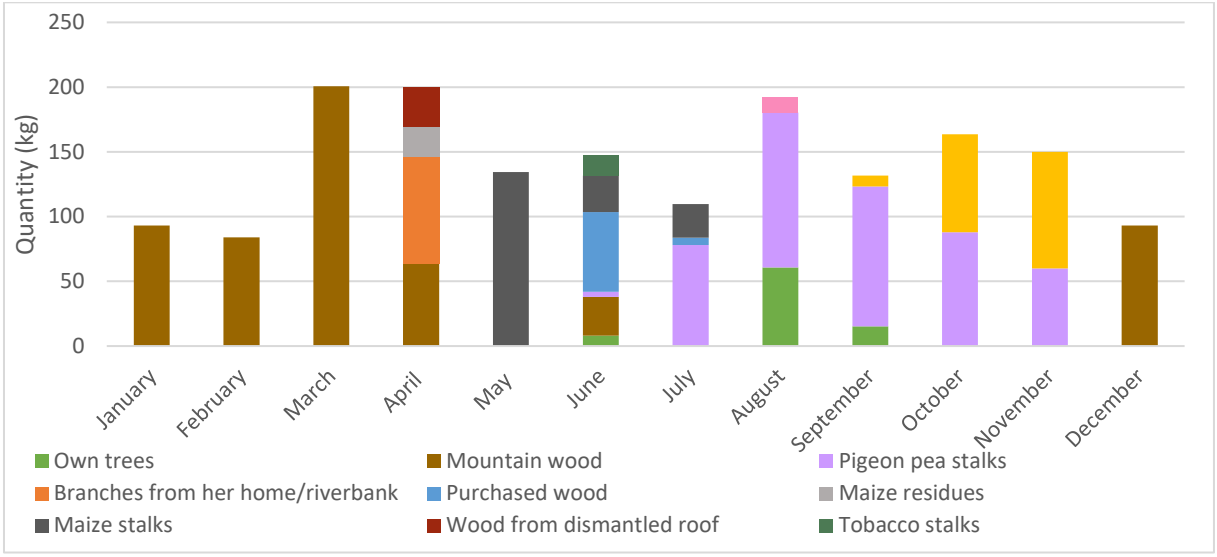

Figure 6: Calendar of biomass fuel use for families who go to the mountain to fetch firewood to consume and to sell it (Type 2)

Over the year, the household consumes a total of 1,700 kg of dry matter for cooking, with an average of 146 kg per month. The main source of biomass fuel is mountain wood, with a use of 564.5 kg (37%), followed by pigeon pea stalks with 457.5 kg (26%), maize residues and stalks with 188,4 kg (11%) and sorghum stalks with 174 kg (10%).

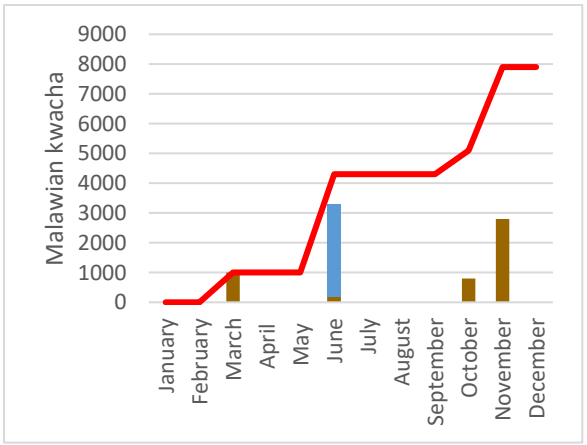

Figure 7: Calendar of expenditure for families who go to the mountain to fetch firewood mainly for selling (Type 2)

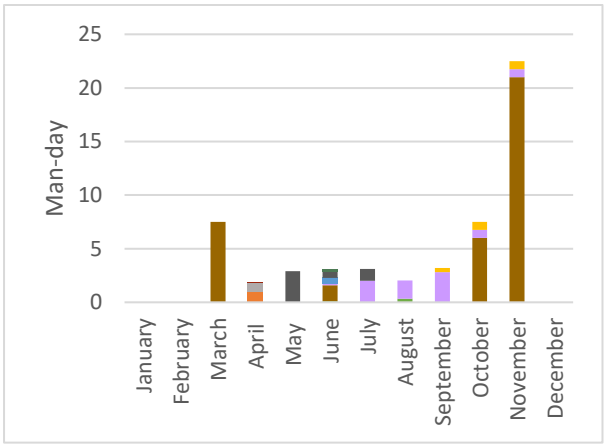

Figure 8: Work calendar for families who go to the mountain to fetch firewood mainly for selling (Type 2)

In the case of this household, it spends MK 7,900 per year on firewood, of which MK 3,100 corresponds to the purchase of wood and MK 4,800 to spend on wood collection in the mountain/hills. Families spend an average of 54 man-days a year collecting biomass fuel sources for cooking, including 36 man-days collecting wood from the mountains (67% of the time) and 15.7 man-days collecting crop residues

(8.1 man-days for pigeon pea stalks, 5.3 man-days for maize residues and stalks and 1.9 man-days for sorghum stalks, 29% of the time).

Compare to the families of type 1, this strategy allows them to earn some cash but they spend more time collecting wood in the mountains. In fact, they spend 36 man-days in this case compared with 25 man-days in type 1, i.e. 1.4 more time.

The following two chapters describe the characteristics of the types of families who don't go to Mulanje mountain or hills to collect firewood.

3.1.3. Type 3: Families who don't go to the mountain/hills but collect firewood locally (no purchase)

Some families do not have the possibility to go to the mountain to fetch firewood. Sometimes, they live too far from the Mulanje mountain and the hills are too heavily guarded. Some other people are too old to go to the mountain because it demands a lot of strength. Moreover, some families make the choice not to go to the mountain and try to use firewood from their own trees or from the surroundings (riverside and fields).

They use their own trees to have firewood and they prune trees during the dry season, around September or October. Wood dries faster during these months and it can be used at the end of the dry season and the beginning of the rainy season. They prune between five to ten trees per year. Some families may also cut down some eucalyptus trees to have more firewood. They also collect dead branches around their house and the riverbank, especially when they do not have any solution. Dead branches are easily found in the fields during the dry season while they are found mainly during the rainy season in the riverbanks due to the strong current that carries more wood.

As with the two previous types, they use crop residues (maize, sorghum and pigeon pea). The residues, often mixed together during cooking, come from their own field or from a neighbour's land, and it can be mixed with wood to reduce cooking time. These families say that using crop residues is not ideal and it produces a lot of smoke and ashes.

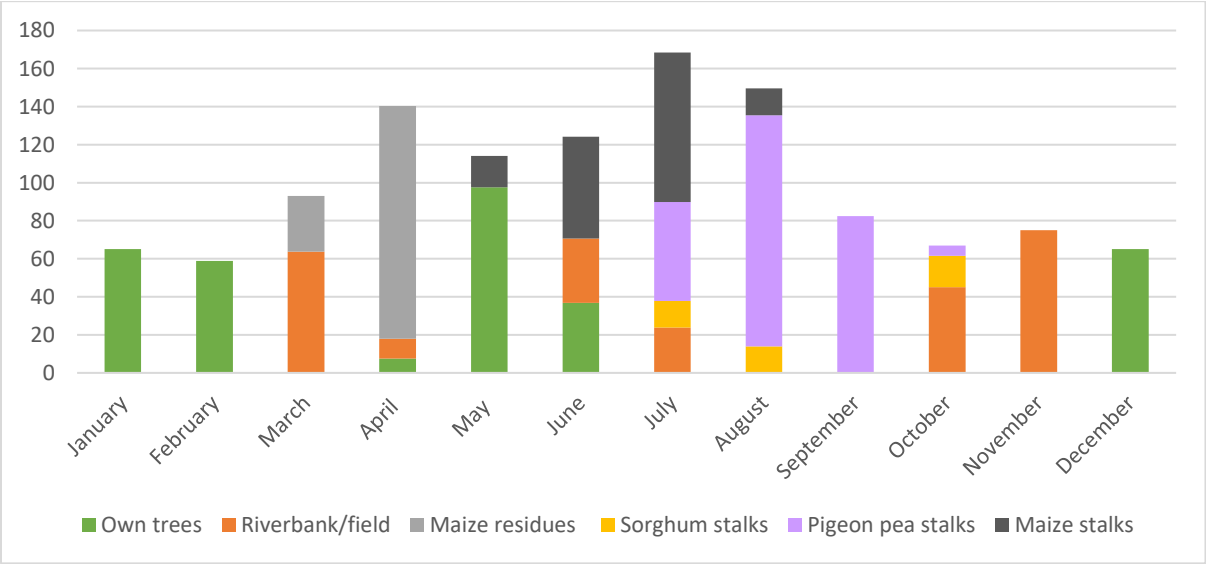

Figure 9 : Calendar of biomass fuel use for families who mainly collect firewood locally (Type 3)

Over the year, this type of family consumes a total of 1,203 kg of dry matter for cooking, with an average of 100 kg per month. The main source of biomass fuel is wood from their own trees, with the

use of 331 kg (27.5%), followed by maize residues and stalks with the use 316,2 kg (26 %), pigeon pea stalks with 261.5 kg (22%) and firewood from the riverbank/field with 252 kg (21%).

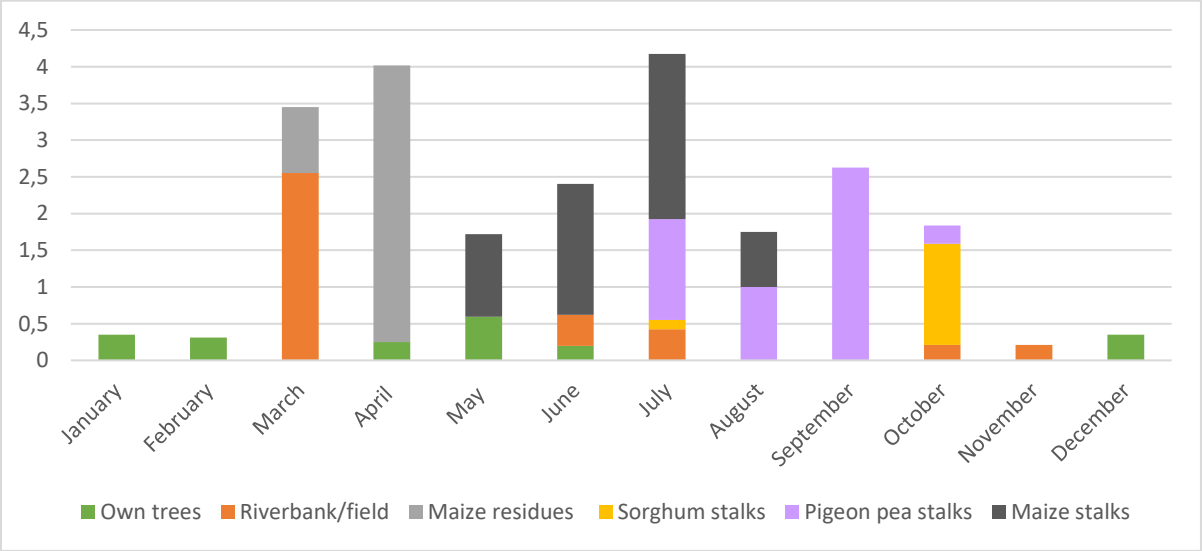

Figure 10: Work calendar for a family who mainly collect firewood locally (Type 3)

This type of households does not spend any money for firewood because they have enough biomass that can be collect locally. The family spends an average of 23.2 man-days a year collecting biomass fuel for cooking, including, 15.82 man-days collecting crop residues (5.25 man-days for pigeon pea stalks and 10.57 man-days for maize residues and stalks, 68% of the time), 3.8 man-days collecting wood at the river or in the fields (16.4%) and 2 man-days collecting wood from their own trees (8.6% of the time). **In this case, the total working time for fuel biomass collection is divided by almost 2.5 compared with Families who go to the mountain to collect wood Therefore, compared to the 2 previous types of families, they have at least 1 month less work per year that they can use for other purposes.**

3.1.4. Type 4a and 4b: Families who don't go to the mountain/hills but often purchase firewood

Families of type 4 don’t go to the mountain or hills. They are generally wealthier (they own a business) and have more trees. If their trees are old enough, they mostly use them, but also buy firewood at the market or from their neighbours.

Almost all families from this type, but not all, use firewood from their own trees. They mostly use them during the rainy season. Some prefers to prune in October to be sure the wood will have time to dry before the beginning of the rainy season. Other prefers to prune and use the wood during the rainy season. They use four to ten trees according to the number of grown trees they have. The number of trees required depends on the age of the trees and the frequency of pruning. **These families have more trees and the trees are older and/or less frequently pruned than the previous types.**

As they do not have enough biomass fuel from their own farm, these families buy additional quantities of firewood to meet their yearly needs. They can buy during the rainy season, from January to March but also at the beginning of the dry season, from May to July. They mostly buy to the market that are closer to their house (Mulomba, Nyambalo…) or from neighbors. Sometimes, they can also go to market closer to the mountain like Phalombe or Kambenje because the wood is less expensive there but they need to have a bike or hire someone to transport the wood. Some of them buy big quantities

because they need some woods for their business (baking). The quantities used for business have not been studied.

As with the other types, they use crop residues (maize, pigeon pea and sorghum). When the families do not have any other options, they go to their fields to collect dead branches. They do not have specific month or a specific frequency. They go when they do not have crop residues, firewood or money to buy some firewood. They have to go once or twice a day. Some also choose to use some poles of their house or from their barn.

For this type, it is possible to observe two different kinds of profile, that we will name 4a and 4b types:

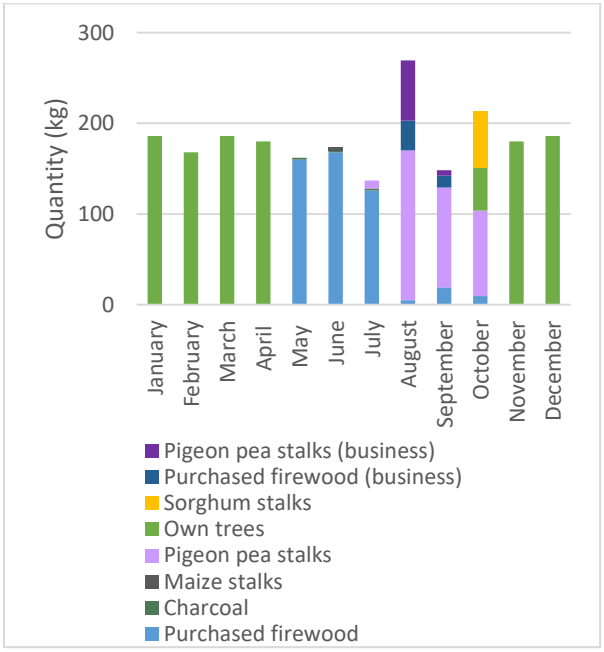

Figure 11: Calendar of biomass fuel use for families (4a type) using their own trees during the rainy season (not sourcing in the mountain/hills)

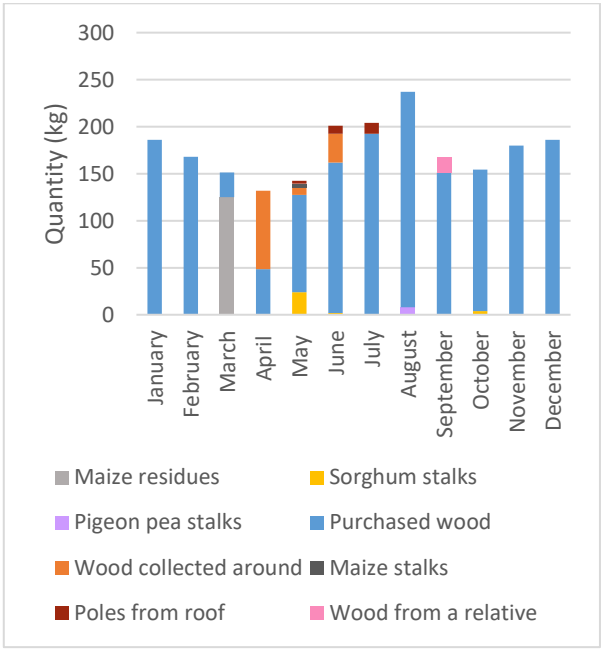

Figure 12: Calendar of biomass fuel use for families (4b type) buying firewood all year round (not sourcing in the mountain/hills)

These two type of households use 2,071 and 2,109 kg of dry matter per year, i.e. 172.6 kg and 175.7 kg per month on average. In the first case (4a), the main source of biomass fuel is their own trees with a consumption of 1,137 kg (55 %), followed by the purchased wood with 487.8 kg (24%) and pigeon pea stalks with 378.3 kg (18%). In the second case (4b), the main source of biomass fuel is the purchased wood with 1,780.7 kg (84%), followed by maize residues with 125 kg (6%) and wood collected in the fields or by the river with 122.2 kg (6%).

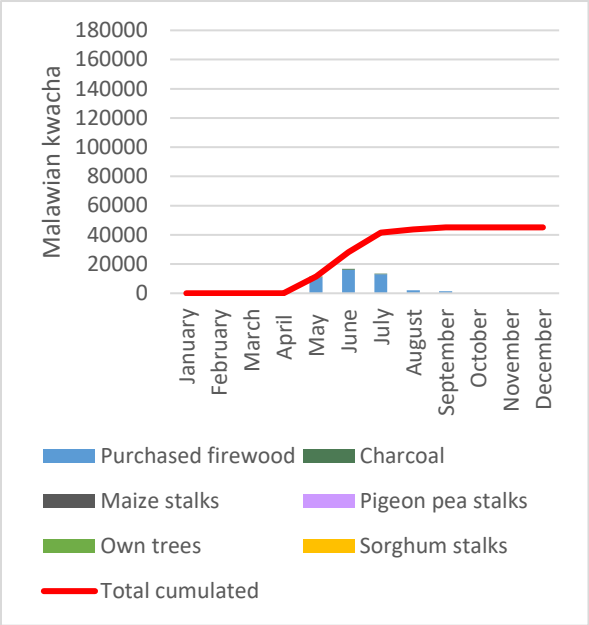

Figure 13: Calendar of expenditure for families using their own trees during the rainy season (not sourcing in the mountain/hills)

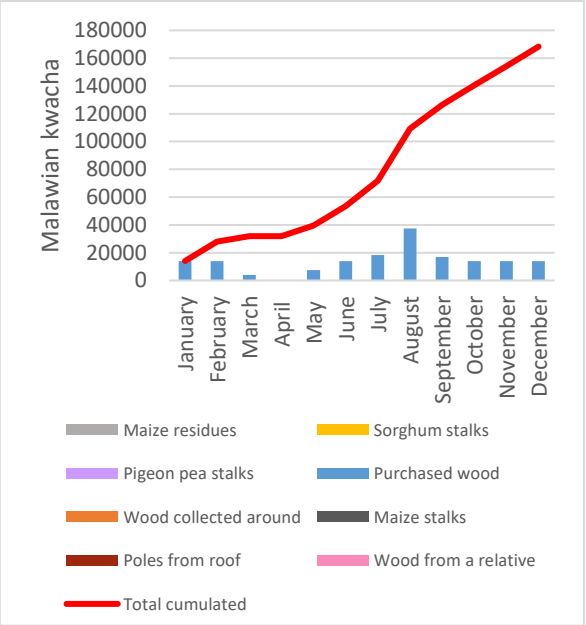

Figure 14: Calendar of expenditure for families buying firewood all year round (not sourcing in the mountain/hills)

These households therefore spend more than the 3 other types. **The type 4a spends MK 45,100, including MK 43,300 on wood and MK 1,800 on charcoal**. **The type 4b spends MK 168,300 a year on firewood (without taking into account the wood used by business)**. For type 4b, the figures also include transport costs, as they were the only families to mention having incurred these additional costs. For these families, it may be necessary to travel to more distant markets and therefore to pay people to bring the wood home. In the case of type 4a, most wood is bought at nearby markets or from neighbours. It is important to note that as we did not assess the amount of wood used for business purposes, the high amount invested in wood purchase by type 4b is not related to possible business needs. **These two families spend respectively 4.9 and 18 times more money than families who go to the mountains.**

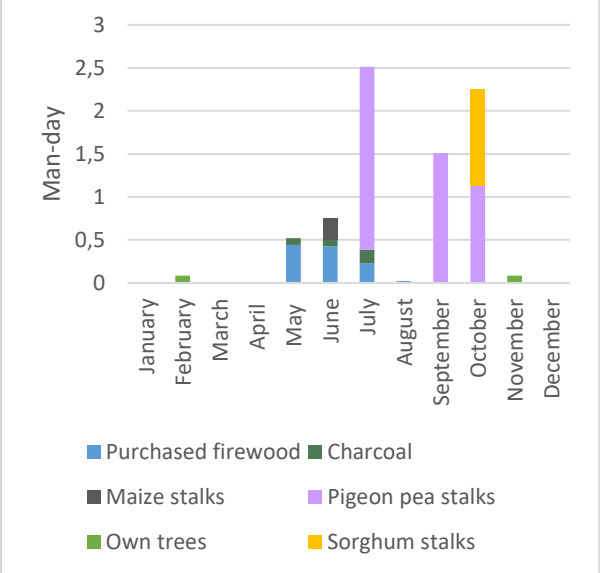

Figure 15: Work calendar for a farmer who uses his own tree during the rainy season (4a type)

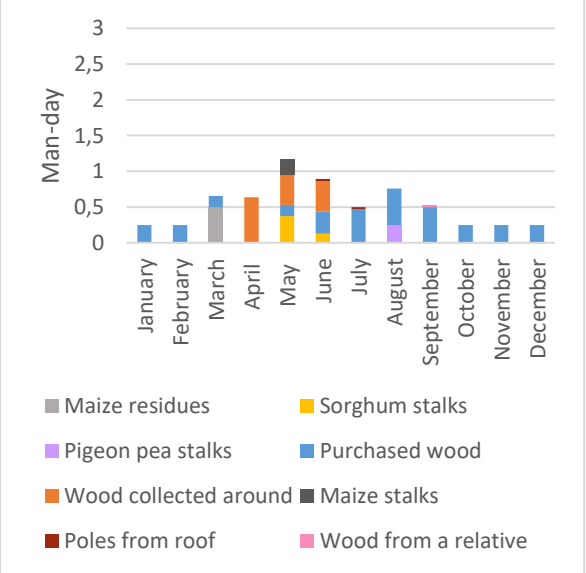

Figure 16: Work calendar of a farmer who is buying firewood all year round (4b type)

These two households spend respectively 8 and 6.4 man-days per year harvesting/buying their biomass fuel, that is more or less 1 full week only. For the 4a type, crop residues require the most time with 6.1 man-days (4.75 man-days for pigeon pea, 1.1 for sorghum and 0.25 for maize, 76%), followed by the purchase of wood with 1.1 man-days (14%) and tree pruning with 0.2 man-days (2,5%). For the 4b type, purchasing wood requires the most time, 3.3 man-days (52%), followed by wood collection with 1.4 man-days (22%) and maize residues with 0.5 man-days (7.8%). Families of this 4b type spend the least time collecting their energy sources. In fact, **they spend 7.9 times less time than families who go to the mountains, and 3.2 times less time than families who collect their wood locally**.

3.1.5. Families' goals for changes in biomass fuel sources

Firstly, only two families (7 %) expressed their wish to stop using wood, one saying he would prefer to use charcoal and the other preferring to use electricity. **Eleven families out of 25 want to stop buying wood so they can use the money for other needs (44%)**. Moreover, twenty-two families say they have no preference for a species, seven prefer *Senna siamea*, three Eucalyptus and one *Lonchocarpus capasa*. They have no desire to change species.

Regarding crop residues, twenty-two families (73 %) do not want to stop using crop residues and only six of them (20 %) would like to stop using maize residues. Crop residues, especially pigeon pea and sorghum stalks, seem to be a good alternative to firewood and allow families to save firewood. In addition, four people (13%) do not want to leave crop residues on their fields because they do not know that they can incorporate residues into the soil to improve soil fertility. However, the remaining eight people (27 %) would like to stop using crop residues because they are more difficult to cook with, and it is necessary to stand by while cooking because they do not last long on fire. Furthermore, they have a strong smell and can produce a lot of ash that can end up in the food when it is windy or when cooking pots are not handle carefully. Only one person wishes to leave crop residues on his fields in order to improve soil fertility.

Of the sixteen people who collect wood in the mountains, thirteen (81%) wish they could stop this activity. It's extremely cumbersome, tiring and time-consuming. "*Sometimes I leave in the morning on an empty stomach, and when I come back in the afternoon, there's nothing to eat at home*". Moreover, the Mulanje forest is more and more well monitored and wood can be confiscated by community patrols or forest guards. The three people (19 %) who wish to continue going to the mountains say that their objective is to continue selling wood and to have incomes from this activity, but also to have enough wood for the whole year.

Eight families out of eleven also want to stop collecting wood from the river or fields (73 %). This activity is time-consuming, the wood harvested is not always of good quality, and there is a high risk of encountering snakes in the river. However, three families wish to continue this activity, as they already go to the river every day and want to be sure of having enough wood.

3.2. The wood needs for construction

3.2.1. Brick burning

Moulding and burning bricks in kilns is a common activity for building new homes or repairing damaged ones. Of the thirty families interviewed, only three (10 %) had never burned bricks, including two young people aged 22 and 24 who use mud bricks, and one older person whose house was built by his children. The frequency of this activity varies from person to person, depending on the state of their home and their plans. On average, they burn bricks every ten years. However, it is important to note that houses were heavily impacted by Cyclone Freddy in 2023, and that half of the families had plans to burn bricks this year. For the most part, these plans had to be postponed due to this year's poor harvests. Bricks are moulded and burned during the dry season, from May to October, with a peak in August and September, when the weather is warmer and drier.

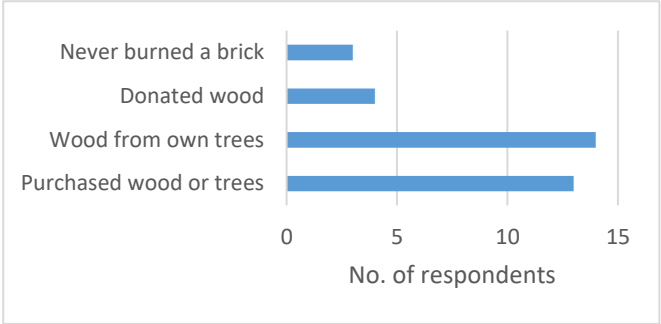

Figure 17: Origin of wood for brickmaking

The bricks are first moulded and then sun-dried. Once dry, the producer builds a kiln to burn them. For this, a significant quantity of wood is used. The quantity varies according to the number of bricks produced. Families can produce between 3,000 and 23,000 bricks, depending on their project. **One large tree may be enough to make 5,000 bricks**, but if trees are very young and small, up to 150 trees may be needed. However, on average, 10 trees are needed to burn 5,000 bricks. So it takes about 2 trees to burn 1,000 bricks. Wood can therefore come from a variety of sources, mostly trees from the owner's farm or purchased trees. Families may also receive wood from their relatives. The species most commonly used for this purpose is eucalyptus (44%), followed by mango (13%) and *Senna siamea* (10%).

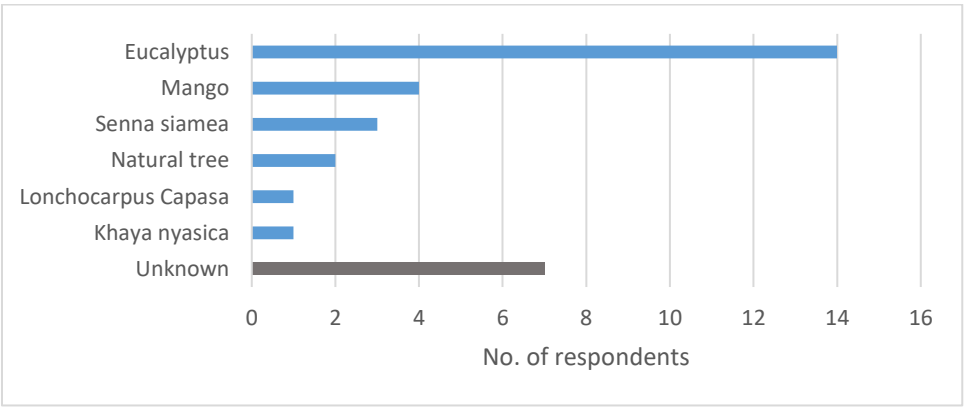

Figure 18: Species used for brick burning

Study case for a family who burned 10,000 bricks this year

Of the nine families monitored weekly, only one was able to carry out his brick-burning project this year. This activity was carried out over four months, from June to September. Trees had to be cut and pruned, bricks had to be moulded, the oven had to be built, wood had to be transported... They used one of their own trees and bought thirty-five eucalyptus trees.

Figure 19: Brick burning activity

This activity represents a significant cost for the household. It requires labour and the purchase of additional trees. The thirty-five eucalyptus trees costed MK 60,000. In addition, the family had to hire two people for the moulding, for a total of MK 45,000 for nine days' work. They also hired a tractor to transport the bricks, making thirteen trips for a total of MK 234,000 (MK 18,000 per trip). They had to hire two people to cut the eucalyptus for a total of MK 10,000 and finally they had to hire an oxcart to transport the wood from the house to the kiln for a total of MK 14,000 (MK 2,000 per trip). This represents a total cost of **MK 363,000 (210 USD[2])** to mould and burn **10,000 bricks to prepare the bricks for the construction one standard average house.** This is the equivalent of about one year's net farm income for an average family of smallholder farmers[3].

The family plans to buy poles and build the house next year.

3.2.2. Poles

Wood in the form of poles is also used, mainly for roofs. Poles are mostly used during the dry season, from August to December. At this time of year, families repair their roofs before the rainy season. The frequency of roof repairs varies from person to person. It depends on the quality of the wood, weather conditions and the type of roof. A thatched roof needs to be repaired more frequently than an iron roof. Families need to repair their roofs and use poles after one to over ten years and **they need 6 to 50 poles to repair or build his roof**. For example, a farmer in the weekly monitoring program bought poles this year. She bought three large poles at MK 1,000 each and 37 smaller poles at MK 700 each, for a total of MK 28,900.

[2] Exchange rate of October 2024 (1 USD = 1,742 MWK), valid for the entire document

[3] We have based our estimates (in USD) on the IFPRI 2020 net farm income figures that are found in their report "Employment options and challenges for rural households in Malawi." (Benson et De Weerdt 2023)

The most commonly used species for poles is eucalyptus (52 % of the respondents), well ahead of Mulanje Cedar and *Senna Siamea*. Eucalyptus is popular because it grows fast, produces straight poles and is readily available. According to a farmer: "*Eucalyptus is a society thing, everyone uses it!*". However, this species does have its disadvantages. It is heavily attacked by termites. As a result, twelve out of twenty-five families, i.e. almost half, would like to use another species. **Nine would like to replace it with *Senna siamea* (36%), as the wood is said to be stronger and more resistant to termites and it is already used by some families**. Others would like to use *Khaya nyasica* (three people), *Albizia lebbeck* (one person) or *Melia azedarach* (one person). One person would even like to try using *Gliricidia sepium* and *Fairdhebia albida*.

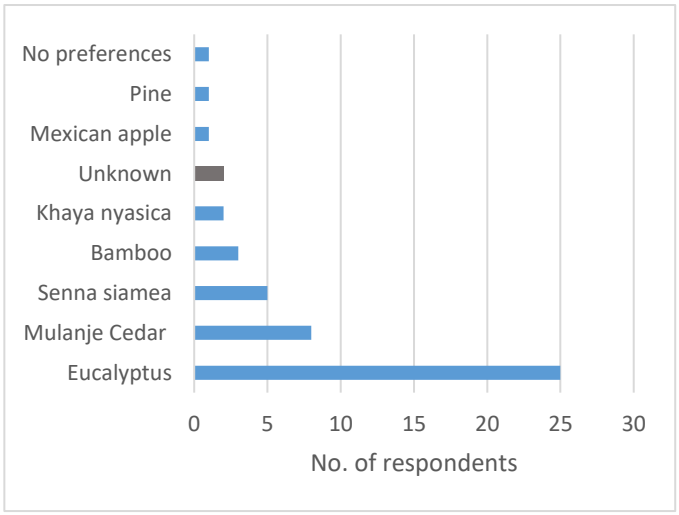

Figure 20: Species used for poles

The second most popular species is Mulanje Cedar (*Widdringtonia whytei*). Its wood is strong and termite-resistant; therefore, poles can last longer. However, Mulanje Cedar is on the IUCN red list of endangered and the use of its wood is illegal. It is therefore more expensive and harder to find. Half the families who use it are among those with better financial capacities, who do not go to the mountains and who buy most of their firewood. Six out of ten families would like to continue using this wood in the future.

Most poles are purchased. Although many families have eucalyptus trees, they do not have enough trees to meet their needs. Twenty families buy them from neighbours who have trees suitable for poles. Eleven use their own trees and five receive trees from relatives. If someone is elderly, their children can buy poles for them. There are also cases where, in the event of a death, family members can collect the poles or timber that is still in good condition. Of the 20 families who buy, 14 buy 100% of the wood for the poles, while 6 sometimes buy the poles themselves and sometimes use their own trees or poles from relatives.

3.3. Conclusion on biomass needs for fuel and construction

3.3.1. Biomass needs for fuel

All the families use biomass for cooking. None of the household have access to gas or electricity. Collecting this biomass requires time and money from the families. However, the amount of time and money spent on collection varies greatly depending on the situation of each family and the strategy used. **Households who go to the mountains (types 1 and 2) spend an average of 57 man-days per year on this, or 2 full months. Households that do not go to the mountains and do not buy (type 3), on the other hand, spend an average of 23 man-days (almost 1 month) per year collecting these resources**. Finally, households that do not go to the mountains and that mainly buy wood (type 4) spend only 7 man-days per year (i.e. one week) collecting these resources, **which is eight times less than for types 1 and 2 and three times less than for type 3 households.** On the other hand, families of this type (4) spend more money than other households. They can spend between MK 45,000 and MK 170,000 per year, while type 1 and 2 households spend between MK 5,000 and MK 30,000 per year, i.e. **1.5 to 34 times less**. Type 3 households do not spend any money on firewood.

The table below summarizes the collection times, expenses and quantities of the total biomass used and the total quantities of wood used for each type.

Table 3: Collecting times, expenses and quantities of biomass used by households according to their strategies (Type 1: collect firewood in the mountain for use; Type 2: collect firewood in the mountain for use and sale; Type 3: collect sources locally; Type 4a: collect sources locally and buy during the rainy season; Type 4b: collect sources locally and buy all year round)

	Type 1	Type 2	Type 3	Type 4a	Type 4b
Collecting time per year (Man day)	60	54	23	8	6.4
Expenses per year (MK)	10,500	7,900	0	45,100	168,300
Biomass use per year (kg)	1,318	1,700	1,203	2,072	2,109
Firewood use per year (kg)	610 (46%)	840 (49%)	583 (48%)	1,622 (79%)	1,942 (92%)
Crops residues use per year (kg)	708 (54%)	860 (51%)	620 (52%)	444 (21%)	167 (8%)
Equivalent value of firewood use per year (MK)[4]	50,630	69,720	48,389	134,626	161,186

This shows that the quantities used by families vary greatly from one type to another. Depending on their vulnerability, **families do not eat the same number of meals per day**. For types 1 (go to the mountain for own use), 2 (go to the mountain for own use and sale) and 3 (collect locally), families eat one meal a day during the lean season, mainly from November to March. However, depending on the year's harvests, the lean season for can start much earlier these households, and some families have been eating once a day from time to time since June this year. In the case of types 4a and 4b (collecting locally and buying firewood), the interviewed families managed to maintain two meals for almost the entire the lean season. This explains much of the difference in the quantities consumed.

It is clear that **for type 4 households, firewood (regardless from its origin) is the most important source of biomass**. It can therefore been see that these households are less dependent on crop residues. These families can therefore choose whether or not to use some of their residues. Some families choose not to use maize residues. The residues can be buried in the soil as organic manure. They may also choose to store them on case they are needed at another time, such as during the rainy season. **Households of types 1, 2 and 3, which are much more dependent on crop residues, may be limited by the size of their farms and by quantity of crop harvested**. When harvests are poor, the quantity of residues is reduced. Some households have relatives who use less of their residues (type 4, or they are absent), which gives them access to their residues. However, some families also choose to remove residues from other families' fields, often without telling them, in order to meet their needs because they have no other option. Even though crop residues appear to be less efficient for preparing a meal, the majority of families want to continue using this resource. **This is why they must be included in the objectives when support families to produce wood on their farms**.

Finally, with regard to the restitution of the results to the families in the villages, conducted in November 2024, it appeared that the two most common types are type 3 and type 1 (69%). Of the 6 presentations organized, 3 were made in areas close to the mountains and 3 in areas far from the mountains. **In areas away from the mountains, type 3 is the most common**. This is because the hills are more heavily guarded than the mountains. There are no permits to harvest wood in the hills**. In**

[4] The average price of firewood in the villages (83 MK/kg) was used.

areas close to the mountains, type 1 is more prevalent. It is easier for families to travel to the mountains to collect wood during the rainy season. **We can conclude that the majority of families in this area use an average of 1,509 kg of biomass as fuelwood per year, of which 507 kg comes from firewood (40%) and 912 kg (60%) from crop residues. The annual amount of firewood they use is worth a value of 42,000 MK**. Types 2 and 4 are the least common. Type 4 corresponds to better-off families with more diversified sources of income. In the case of type 2, selling wood is more time-consuming as it requires more frequent trips to the mountains, and most families prefer to ensure that they have enough wood for their own needs.

Table 4: Percentage of families identifying themselves by type, total of 356 respondents (Type 1: collect firewood in the mountain for use; Type 2: collect firewood in the mountain for use and sale; Type 3: collect sources locally; Type 4: collect sources locally and buy)

	Type 1	Type 2	Type 3	Type 4	TOTAL
% total	34%	16%	35%	15%	100%
% for area close to Mulanje mountain	41%	17%	30%	12%	100%
% for area far from Mulanje mountain	4%	12%	56%	28%	100%

However, it is important to note that during the presentations, some families (17%) did not raise their hand to identify themselves in a category, some saying they were too lazy or ashamed to do so. It is therefore possible that more households go to the mountains or the hills and/or that more households sell wood from the mountains.

A typical household that we met during our wood production survey (the wood producers) is more likely to correspond to type 3, because it neither goes to the mountain nor buys firewood. However, they are totally dependent on their trees and crop residues (although some of them have stopped using maize residues) and no longer go to the fields or the river to collect wood. In addition, they are generally better-off households than the standard ones presented in Type 3 and their profile is more similar to those presented in Type 4a, but they do not buy wood. We hope that in the future, more households will be of this type.

3.3.2. Biomass needs for construction

Building houses and livestock pens are activities that also require large quantities of wood. Families use wood both for poles and for burning bricks.

The poles have to be replaced on average every 3.6 years (from 1 to 10 years) because of termites and weevils. On average, a family changes 22 poles each time, or 6 poles per year. Considering that the poles come from eucalyptus trees and that a tree has 8 coppicing shoots, this equates to 0.75 trees per year (i.e. 2.75 trees every 3.6 years). **This represents an average annual cost of MK5,100 (USD2.91)**.

For bricks, families carry out this activity on average every 10 years, producing an average of 7,200 bricks (ranging from 3,000 to 23,000). That's 720 bricks per year. Given that on average a household uses two trees to make 1,000 bricks, this equates to 1.5 trees per year (2.7 trees if felled and 0.9 trees if pruned, as trees pruned for brick production are usually old). On average, a tree can be sold for MK 2,750 (the price of a tree can vary greatly depending on its size and age), so 1.5 trees cost MK 4,125. What's more, brick production can be labour intensive. Brick production can therefore represent an annual cost of between MK 4,125 (using family labour; USD 2.35) and MK 25,941 (using non-family labour; USD 14.79). **Thus, the use of wood for construction can represent an average annual cost of MK 9,225 (USD 5.36) to MK 31,041 (USD 17.69), which must be put into perspective with the minimum of MK 50,000 per year required for wood biomass.**

4. Wood production on small scale farms in Phalombe District

4.1. Overview of the surveyed producers

Small scale wood producers are scarce in the villages and it was very difficult to identify a good number of them. In total, twelve wood producers were identified and interviewed. They are located in the villages of Phunduma, Nyambalo, Suluwati, Kazembe, Gomani and Namphwalala. Eleven were Inter Aide beneficiaries. Producers located in the villages of Phunduma, Suluwati and Namphwalala were supported by Inter Aide to raise seedlings with other families and to plant from 2016/17 to 2020. Families in Gomani and Kazembe were supported from 2020 to 2024. The Nyambalo farmer has never been accompanied by Inter Aide.

They all have more than 100 trees, with an average of 354 trees on two to four plots[5]. On average they have 282 afforestation trees. The number varies greatly from farm to farm, ranging from 27 to 1,017 trees. For the farms that do not have a lot of afforestation trees, they have a lot of Eucalyptus. This tree can also be used as firewood or poles and timber.

Table 5: Number of trees by age per farm; in purple: families produce enough for consumption and to sell (scenario 1), in blue: families produce enough for consumption only (scenario 2), in yellow: families do not produce enough (scenario 3), in green: families do not produce enough but sell (scenario 4)

	Number of afforestation trees by age					All trees	Percentage		
	0 - 1	1 - 3	4 - 6	6+	Total	Total	Afforestation	Fruit trees	Eucalyptus
Farmer 1	0	91	140	4	**235**	**334**	70%	22%	5%
Farmer 2	0	100	0	283	**383**	**416**	92%	6%	2%
Farmer 3	0	644	27	346	**1017**	**1190**	85%	6%	8%
Farmer 4	16	0	6	102	**124**	**216**	57%	42%	0%
Farmer 5	1	26	0	0	**27**	**114**	24%	24%	53%
Farmer 6	0	1	14	155	**170**	**205**	83%	13%	5%
Farmer 7	0	0	66	226	**292**	**314**	93%	2%	5%
Farmer 8	0	0	2	496	**498**	**539**	92%	3%	5%
Farmer 9	0	0	0	129	**129**	**161**	80%	3%	17%
Farmer 10	0	83	210	3	**296**	**311**	95%	5%	0%
Farmer 11	0	0	27	145	**172**	**255**	67%	9%	24%
Farmer 12	0	22	0	21	**43**	**191**	23%	0%	77%
Average	**1,4**	**81**	**41**	**159**	**282**	**354**	**72%**	**11%**	**17%**

Producers choose whether to plant their trees at their homestead or in their fields. 53% of the trees are planted at the homestead. This simplifies access to the trees and reduces the risk of theft. 27% of the trees are planted in the plot closer to their house. 15% are planted in more distant plots. Only 2 families have a woodlot out of the twelve surveyed.

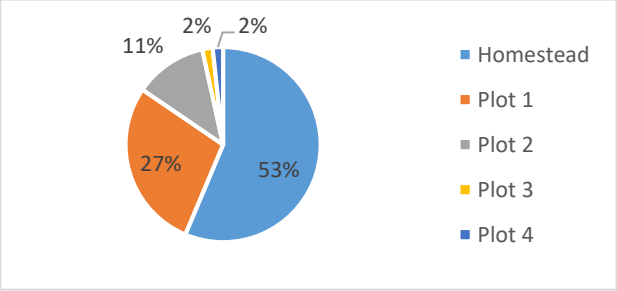

Figure 21: Distribution of trees on plots

Eucalyptus represents 17% of the trees and fruit trees 11%. Among the afforestation trees, there are mainly four tree species present on the farms, all of them promoted by Inter Aide. *Senna siamea* is the dominant species, followed by *Lonchocarpus capasa* (*Mpakasa* in Chichewa). This tree is part of the

[5] All trees were physically counted during the surveys

Miombo ecosystem and grows naturally in fields when families protect it, which explains its high numbers. However, it takes a little longer to grow. They are followed by *Gliricidia sepium* and *Albizia lebbeck.* Other species include *Senna spectabilis*, *Acacia polyacantha*, *Faidherbia albida*, *Leuceana leucocephala*, *Khaya nyasica*, *Jacaranda mimosifolia*, *Neuclea nyasica* (also named *Burttdavya nyasica), Grevelia robusta* and others.

Table 6 : The main species and their average distribution on farms

Main species	Distribution
Senna siamea	32%
Lonchocarpus capasa	17%
Gliricidia sepium	16%
Albizia lebbeck	11%
Other species	24%

Senna siamea and *Gliricidia sepium* are fast-growing species. According to families, they can be pruned after 3 and 2 years respectively. *Albizia lebbeck* is a little slower-growing, as they can start pruning it after 4.5 years. *Lonchocarpus capasa*, on the other hand, is a slow-growing species. They can start pruning the tree after 8 to 10 years. Another species is now on high demand in villages, although families do not have yet a lot of experience on it: *Burttdavya nyasica*. It is an indigenous species from Southern Malawi (but not naturally present in Mulanje) mainly used for timber production. Its wood is also said to be termite-resistant but we did not find people who could give a lot of insight on it due to its recent introduction in the area.

Nine of the twelve growers interviewed said they had no preference for a particular species. For them, each species has its own advantages. They said that *Albizia lebbeck* produces good charcoal, *Gliricidia sepium* improves soil fertility, *Senna siamea*, *Khaya nyasica* and *Melia azedarach* are good for timber. However, three families said that they prefer some species. One said he prefers *Melia azedarach* because it produces good and strong timber. Two prefers *Senna siamea* because it improves soil fertility and it produces good poles.

4.2. What motivates families to plant trees?

Producers had several reasons for planting trees. The first was the difficult access to firewood. As mentioned in precedent chapters, firewood is widely used in the area. Population density and deforestation have therefore led to a reduction in wood availability, especially for villages far away from Mulanje mountain. This was underlined by a producer located in Namphwalala: "*I started planting trees in 2007. I planted trees because I knew the importance they have for the environment. Before 2007, it was easy to find firewood, because of the hills next to my house. However, people cut down all the trees and there was not wood available. In addition to the massive deforestation of the hills, the village chief and forestry officer put in place strong rules to control access to the hills. As a result, we could no longer go up the hills to collect firewood.*" The presence of trees on their farms ensures that families have access to firewood.

Respondents also say that trees are source of shade at the house and in the fields. This allows families to rest in the shade while working in their fields. Families can also earn money by marketing wood and firewood. This enables them to supplement their income to buy basic necessities or pay for their children's schooling. Trees are also seen as playing a role in mitigating the effects of climate change, particularly in terms of rainfall. They can also improve soil fertility, especially for trees located in plots. Five out of eleven families said they had been encouraged by the school and by messages from the

government. Finally, they are also a source of wood for building houses (poles, timber and firewood for brick burning).

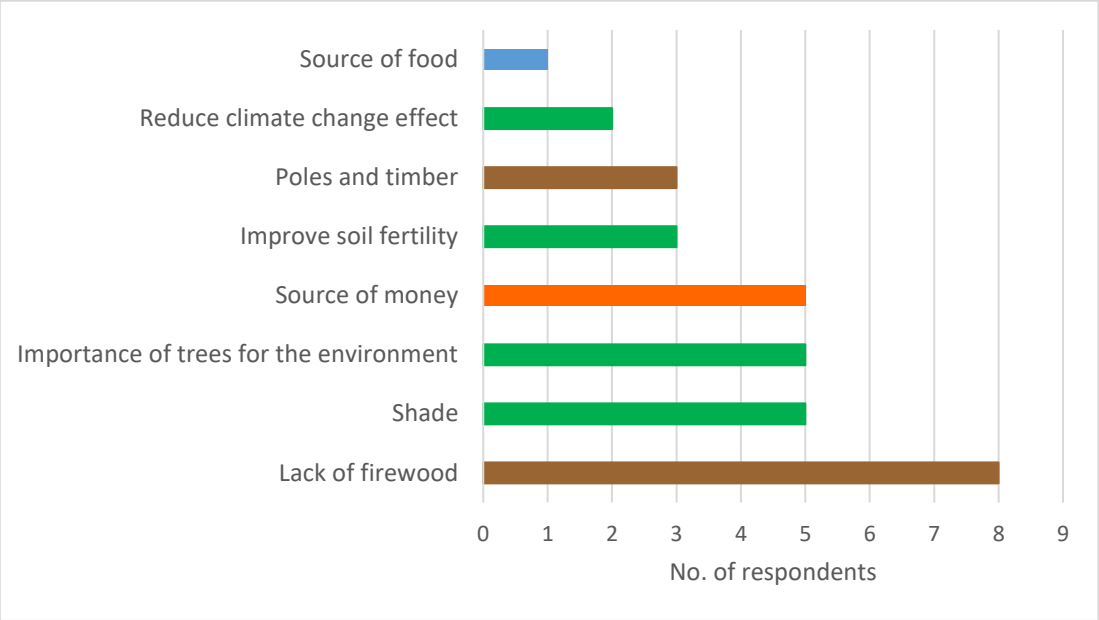

Figure 22: What motivates families to plant trees? We highlighted in green the environmental reasons, in brown the practical use for households' use, in orange the financial reasons and in blue the other reasons.

4.3. Wood production techniques

All families mostly perform the same tasks to look after their trees. Tree management depends on the age of the trees. Indeed, the tasks carried out for newly planted trees are not the same as for a mature tree. Three categories have been identified: trees from 0 to 1-year-old, trees from 1 to 3 or 4-year-old and trees over 3 or 4-year-old. Tasks differ according to these three periods.

4.3.1. Tree management from planting to 1 year

During the first year, families have to transplant a seedling or to sow seeds. The period of planting varies according to the period of rainfall. This 2023-2024 season, the rains came late and trees were planted at the end of December, beginning of January. To transplant seedlings, they have to dig a pit (30 cm deep and 30 cm wide) separating top soil and sub soil and then to sow the seedlings. **It takes them around ten minutes per tree**.

Figure 23: A young tree with a basin

While planting, a basin can be built around the tree. The basin helps to collect water and to retain moisture in the soil. The basin helps the tree to grow better. It takes them between 20 and 30 minutes per tree. To prevent the basin from being damaged too quickly by heavy rain, they may choose to put bricks around it. This reduces the frequency of maintenance. They do not make basins for indigenous species, such as *Lonchocarpus capasa*. They also need to protect their newly planted trees from livestock and children. Young trees can easily be damaged and die quickly. For newly planted trees, they can use a basket or a fence made of sticks or bricks. It takes them about **45 minutes to build a fence**. Some prefer to buy a basket that can be bought between 250 and 1,000 MK. There are some people in the villages who make and sell them.

Figure 24: Tool for protecting young trees against livestock; left: a basket, right: a small brick fence

To avoid fire damage, families have to weed during the dry season (August and September). Indeed, some people set fire to the bush after the harvest period to hunt mice. Some families also weed during the rainy season to reduce competition for nutrients and to reduce the risk of pest or disease. Others do it at the end of the rainy season because weeds are not yet dry and can be incorporated in the soil as green manure.

The work schedule is shown below. Working time is expressed in man-days, where one man-day equals eight hours of work. **The model has been developed for a family planting 135 trees, as this was the average number of trees planted by a family participating in the Inter Aide programme in Phalombe during the 2023-2024 season**. This does not take into account the mortality rate, as it would have been too difficult to do and too confusing to present.

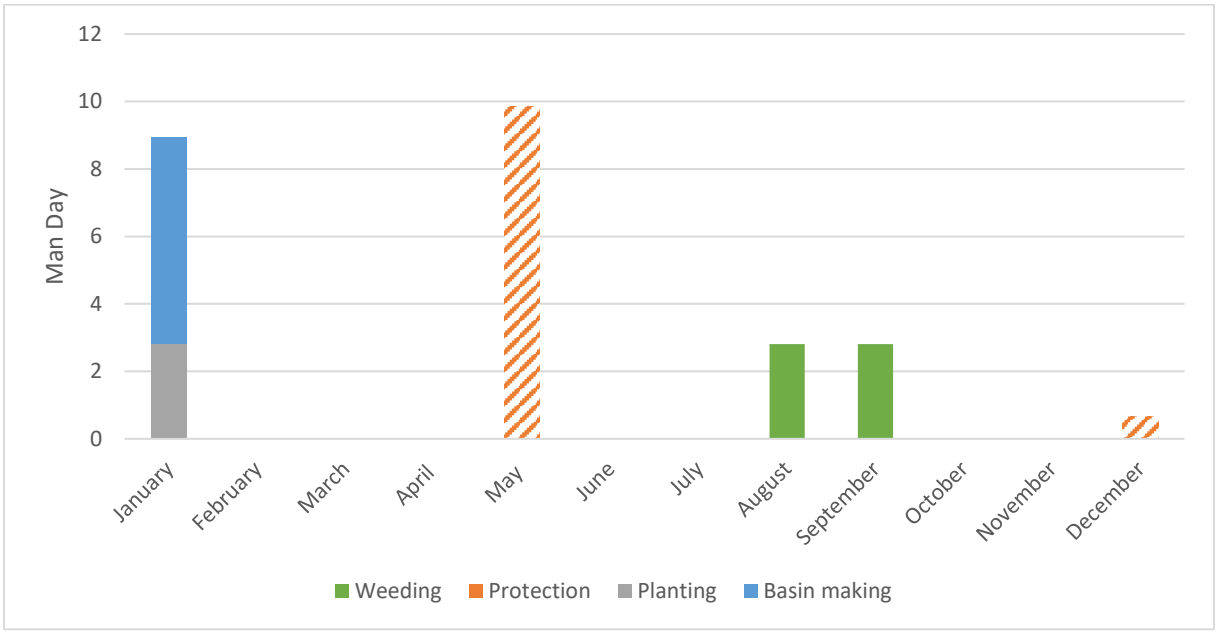

Figure 25: Working calendar for trees aged 0 to 1 years (model for 135 trees planted and managed)

Some families can also apply manure to their newly planted trees to help trees grow faster. Others can also water their trees during the first year. These activities are only done by very few families; hence they have not been taken into account. The application of manure and watering is generally only carried out for fruit trees. For 135 trees planted and managed, the first year requires a total of 26.5 man-days if trees are protected with bamboo and brick fences and only 16 man-days without tree protection. **When trees are not protected individually, most of the work required is done in January (64 %) and the rest (36 %) is only weeding in July and August**. This peak of 10 days of work in January explains why some families have difficulties to plant trees early in the season and at the right moment (e.g. after good rains), because at this time farmer are busy fertilizing, weeding and banking their crops (

Appendix 2).

4.3.1. Tree management from 1 to 3-4 years

At that age, trees still need to be protected from livestock but they are still too young to be productive and pruned for firewood.

When crops are harvests in the farms, goats are free to range and families have to protect trees to avoid damages. They can use the fence or basket they used during the first year. They can also use empty sacks or animal dung, as its smell repels livestock. If they use sacks, they need one to three sacks to protect a tree. They can use old sacks or they can buy some at the market, bought for 250 to 500 MK per sack. To promote good growth, protections are removed in December when the livestock no longer roam. Some species are more sensitive than others, namely *Albizia lebbeck*, *Gliricidia sepium* and *Melia azedarach*. Four of the families interviewed protect these species with goat dung even when they are big.

They also maintain the basin during these periods. On average, they maintain the basin once a year, at the end of the dry season or at the beginning of the rainy season for it to be ready during the rainy season. They may also have to repair it during the rainy season after heavy rains.

Most families still weed their trees in August and September. They also start pruning some trees to be sure they will grow straight (if they want to make poles) and to prevent them from shading for the crops. They do this at the beginning of the rainy season and it takes about five minutes per tree.

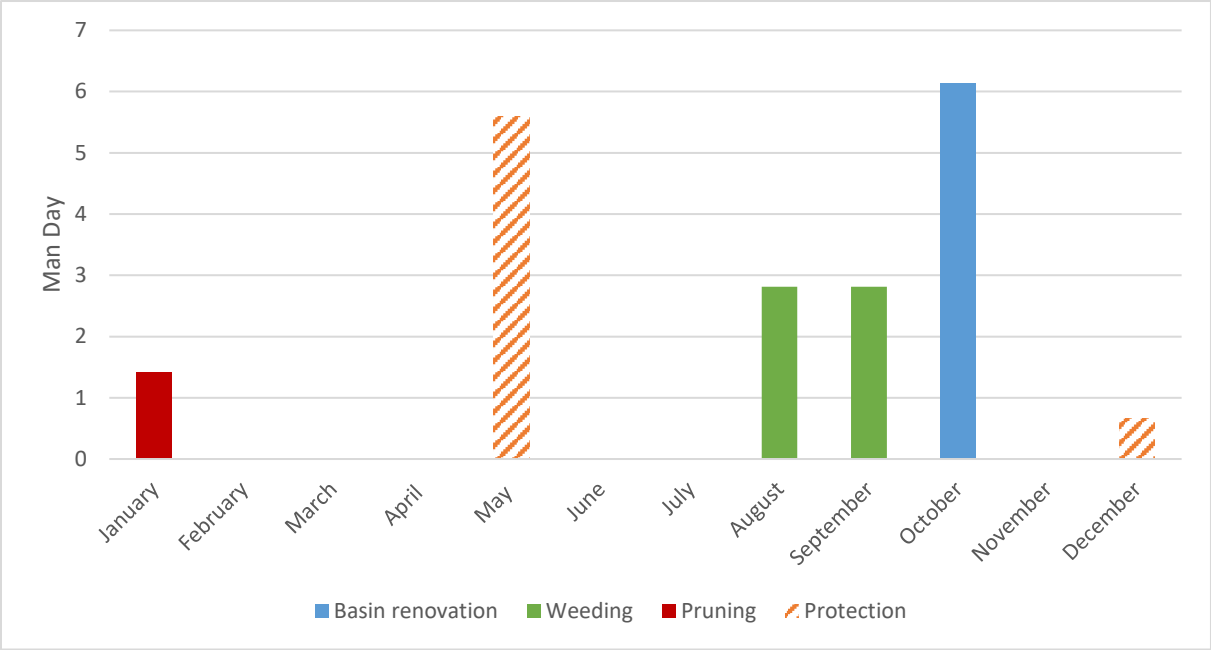

Figure 26: Working calendar for trees aged 1 to 3-4-year-old (model for 135 trees)

We kept the model working with 135 trees again because even if there is usually 40 to 50 % of mortality in the trees planted the first year, most families plant again consecutively during 2 or 3 years and will have indeed that number of young trees to managed in their farm. This example of 135 young trees require 19.4 man-days of work per year (almost 3 full weeks), and 13.2 man-days (almost 2 full weeks) if the trees are not protected. Assuming that basins are maintained, **the peak of work is in October with the renovation of the basins, corresponding to 46% of the work (6 days, without doing tree protection)**, when most families are busy with land preparation for the cropping season (

Appendix *2*).

4.3.2. Tree management after 3-4 years

This category corresponds to productive trees. They do not protect their trees because they are usually strong and tall enough. They do not make basins because trees are now well established. Weeding is usually still done to prevent fire, pest and diseases.

These trees are mostly pruned for firewood. They usually prune lower branches with a panga knife (machete). Some rare families also use an axe or a saw. The frequency of tree pruning varies from farmer to farmer. Four out of twelve families (33%) prune their trees every year, one family prunes her trees twice a year (8%). Others (58%) prefer to wait two or three years between each pruning to harvest bigger branches. Trees are pruned mainly during the end of the dry season, September and October, that is the beginning of the hot season. According to the respondents, this prevents damages from rain or cold weather and it allows families to store enough wood for the rainy season. The warm and sunny weather also allows the wood to dry faster. **To prune a tree, it takes about 30 to 50 minutes**. For trees pruned in the plots, the cut wood is left in place for a few days for it to start drying, usually between four days and two weeks. This makes it easier to transport the wood. Then they take it home. If the quantities are too large, they can hire an oxcart (about 4000 MK per trip). It is usually men who are responsible of pruning or cutting the trees.

They coppice some trees when they need money or when they need wood to burn bricks, to make poles or timber, usually in June or July. Depending on the age and size of the tree, it takes them

between 15 minutes and 1 hour to coppice one tree. The most common species coppiced are *Senna siamea* and eucalyptus.

Most families think that tree management is not too complicated. However, they can face challenges such as a lack of equipment, especially for pruning. **Half the families questioned would like to have access to a suitable tool. The second biggest challenge is theft, as 4 out of 12 families pointed out**.

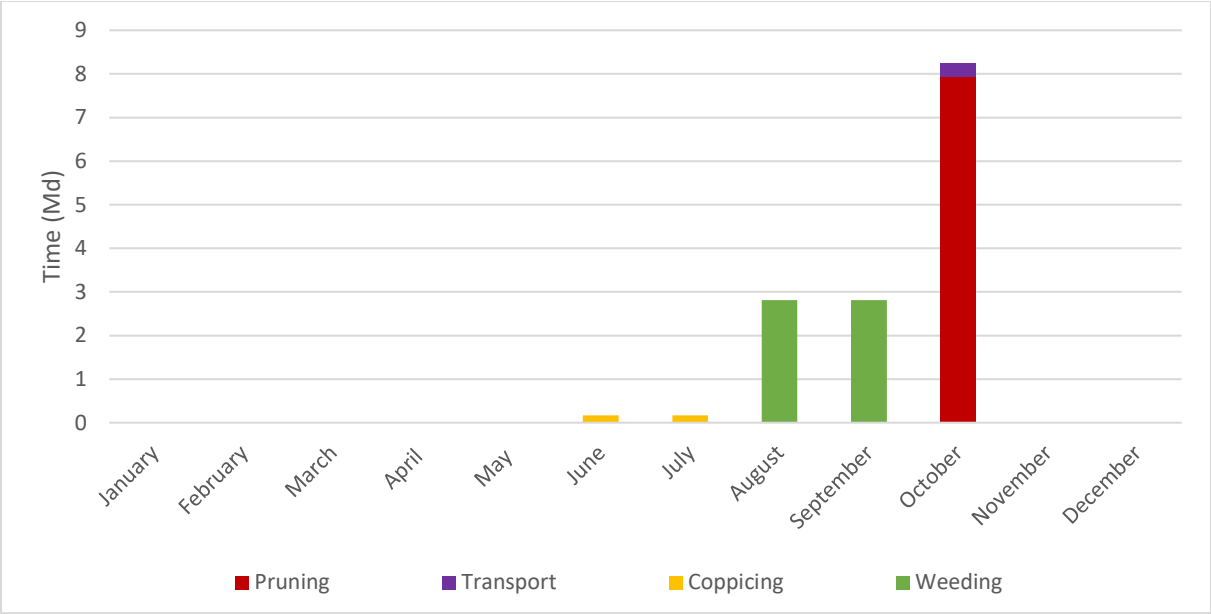

Figure 27: Working calendar for trees over 3-4 years-old (model for 135 trees, out of which 80 are pruned on an annual basis)

Productive trees require 14 man-days per year, with a peak of work at pruning time (October in the model, but it can be earlier), corresponding to 8 man-days. **This means that 57% of the annual workload takes place when the families are busy with the preparation of the land** (

Appendix 2). However, it is important to remember that the families surveyed have never been trained in advanced tree pruning and management techniques, and if they were to implement these techniques, it would probably increase their workload.

In four of the families followed, we weighed the **exact amount of wood cut per tree during pruning in August and October**. The weight per tree was estimated from the number of trees cut and the total amount of wood.

Table 7: Quantity of dry wood obtained by tree after pruning

Species	Age	Quantity per tree (kg)
Lonchocarpus capasa	12 years	24
Natural tree	13 years	45
Senna siamea	5 years	18
Eucalyptus	1.5 years	13

In order to obtain a comprehensive average figure by species and by age, we recommend that a further in-depth longitudinal study should be carried out on the weighting of biomass in wood production.

Some families face problems with pests such as aphids, weevils and termites. Some use ashes but it does not really work. Some also mentionned diseases they did not know the name of, like *Senna siamea* branches curling up or *Moringa oleifera* trees drying up. They have no solution and in general no access to chemicals. Some cut down diseased trees and they burn them to prevent the spread of the disease. In general, they a lack knowledge about pests and diseases and they do not know how to fight them.

Figure 28: A branch of Senna siamea *that curls*

4.4. Use of tree products

Not all producers have the same wood consumption and marketing strategy. It all depends on the quantity produced. Some produce enough to market and consume, while others do not produce enough wood to meet their needs. After surveying the respondents and analysing the data collected, we were able to group them into four different categories, according to the way they use they wood production. In the economic calculations of the four scenarios presented here below, eucalyptus sales are not.

4.4.1. Scenario 1: The wood produced is sufficient to meet household needs and any surplus is sold

Only two of the twelve families (17 %) sell part of their production while keeping enough wood to meet their household needs. They use their own wood throughout the year, supplementing it with crop residues in April, May, July, August, September and October. On average, they have 530 trees over 6 years old, 17.5 trees are exploited per year. These are respondents n°3 and 12[6].

These families do not sell their tree products at the market, but from their homes. They place a few branches on the roadside to indicate that they are selling firewood. Customers come straight to them. They do not have specific customers; they sell to anyone who wants to buy wood. They mainly sell to people from the village or neighbouring villages. They sell mainly during the rainy season, in January, February or March. The wood is sold in bundles of 200 to 1000 MK, with an average price of 83 MK/kg.

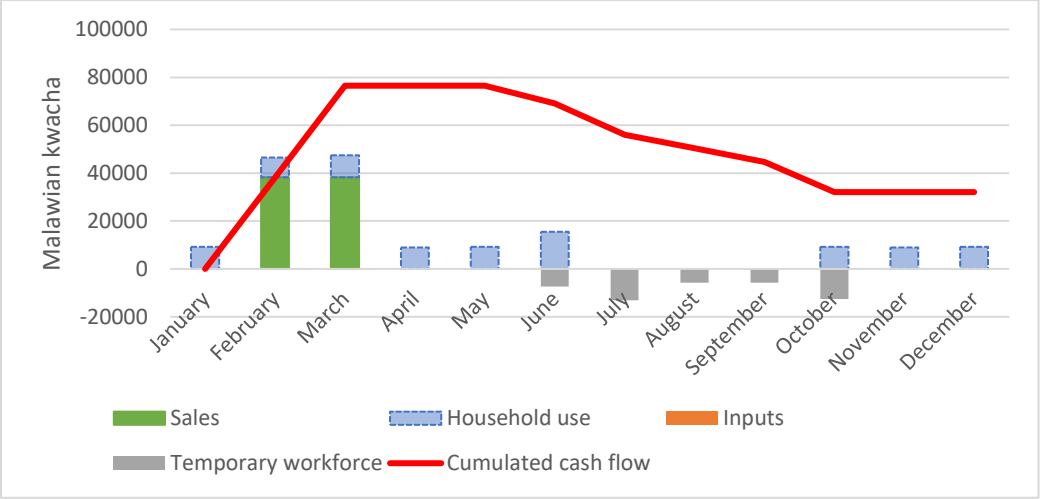

Figure 29: Cash flow calendar of the farmer n°3 (on Table 6 page 24) who produces enough firewood to sell and consume (200 trees over 6 years old, of which 17.5 are used)

The graph above shows the cash flow schedule of a farmer marketing his firewood from his farm with 200 trees of more than 6 years old (among which he chooses about 17.5 trees for harvesting and selling). A model was used to simplify the data by cross-multiplying (rule of 3) the figures collected from a grower with 1,190 trees. The number of trees pruned per year is an average of the number of trees pruned over the last two years. He earns MK 85,000 (USD 48.45) a year. Expenses correspond to temporary labour employed for weeding, pruning and transporting the firewood. Including their own consumption (1,529 kg per year), this activity has a gross added value of **119,667 MK** (USD 68,21). This corresponds to **MK 598 per tree** and **MK 5,384 per man-day**.

[6] This producer said he produces enough firewood to meet these needs and to sell. However, it can be seen that he has few trees (other species than eucalyptus) over 6 years old, so he has to sell firewood from these eucalyptus trees.

4.4.2. Scenario 2: The wood produced is sufficient to meet household needs and there is no surplus

Five of the twelve families interviewed (42 %) produced enough for their own needs. These are respondents n°1, 2, 4, 5 and 7. Firewood is therefore entirely consumed by the household and is not marketed. This may be due to the age of the trees, which are still young and not very productive. It may also be a choice on the part of the producer as some people want to keep their trees for environment benefits, but also the shade and the protection against the wind they provide.

Wood production is sufficient throughout the year. However, families continue to use crop residues. Some have opted to stop using maize residues, which are incorporated into the soil as fertilizer, but this is not the case for the majority of families.

If they do not have any personal projects, they can choose to sell trees that will be used as poles, timber or to burn bricks. The number of trees can vary greatly, depending on the year and the project. They mainly sell *Senna siamea* and Eucalyptus. Buyers come directly to the farm. It is up to them to cut the trees and transport them. The producer does not intervene at this level. On average, an entire tree is sold for MK 5,000. However, the price can vary greatly depending on the size of the tree. In the model below, the farmer sells four *Senna siamea* trees.

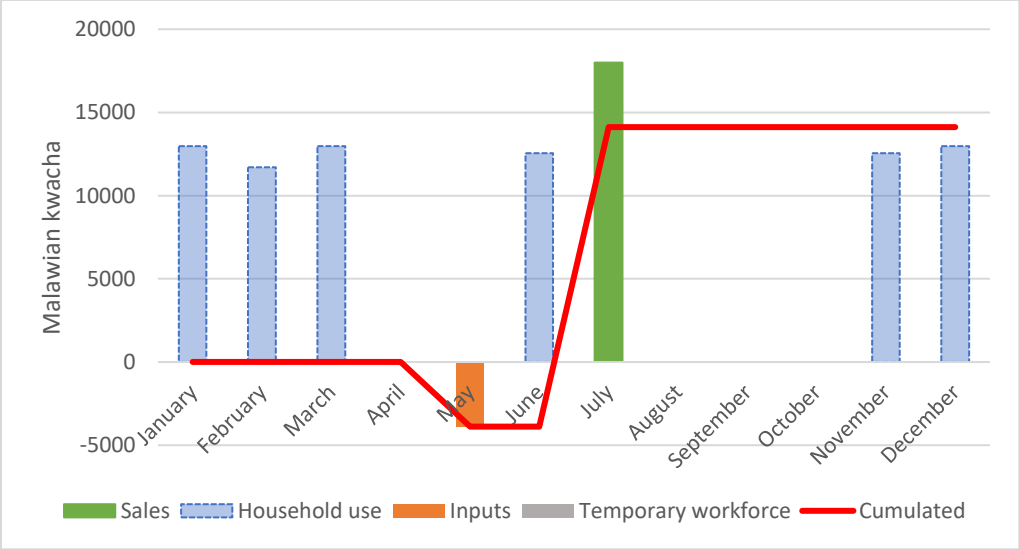

Figure 30: Cash flow calendar of a farmer who produces enough firewood to consume but not to sell (135 trees over 6 years old , of which 80 trees are used)

The data from the families in this scenario was not reliable enough, but it was possible to model a typical farm. The model is based on cross-referencing data from the 5 families surveyed to ensure that the data is sufficiently complete and realistic. In this case, the farmer earns MK 20,000 (USD 11.40) a year. Expenses correspond to the purchase of bags to protect young trees. While valuing self-consumption, this activity has a gross added value of **89,835 MK** (USD 51.21). This corresponds to **MK 447 per tree** (USD 0.25) and **MK 4,963 per man-day** (USD 2.82).

4.4.3. Case 3: The wood produced is not sufficient to meet household needs and there is no firewood sold

Three of the twelve families surveyed do not produce enough wood for their own needs. These are respondents n°6, 8 and 10. Consequently, they do not sell firewood. Their production is insufficient, either because most of their trees are still small, or else because families are still in the early stages of their activity and they still try to figure out the right number of trees to prune per year. Sometimes,

both reasons are combined. For example, one family said he was still not sure how many trees he needed to prune to meet his needs. Last year, he pruned 60 trees, but that was not enough. This year, he wants to prune 80 trees to see if it is enough for of his household.

To meet their household needs, these households have to find other sources of energy for cooking. They may therefore collect branches from their plots or from a river, or buy wood at the market, and they all continue to use crop residues.

However, **these families can still sell whole standing trees. Selling trees is a way of meeting cash needs.** It can be used to pay for children's schooling or other necessities. Trees are not cut down every year. It depends on the family's need for wood or cash. In the model below, the farmer cuts trees about every two years. Some of the trees are used to meet his own needs for poles, timber or bricks, while others are sold. The trees are sold "standing", which means the whole live tree is sold to a buyer who is responsible to cut and transport the wood. In the model below, 1.5 trees are sold per year. The trees are mainly used and sold during the dry season, in June, July and August.

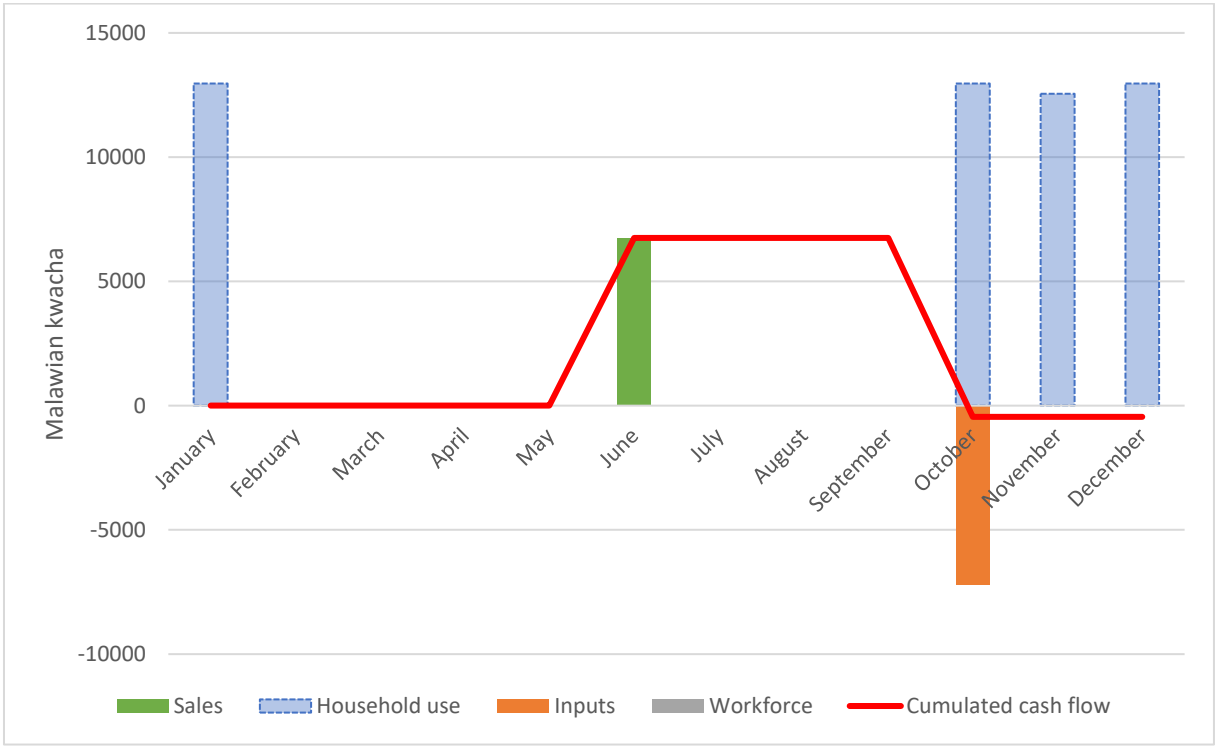

Figure 31: Cash flow calendar of the farmer n°8 (on the Table 6 page 24) who does not produce enough firewood to satisfy his household needs and who does not sell (250 trees over 6 years old, of which 60 trees are used)

In this case, the actual data provided by farmer n°8 was used as it was sufficiently reliable and representative. The farmer earns MK 7,500 (USD 4.27) a year. Expenses correspond to the rent of an oxcart to transport the firewood from his fields to his house. While valuing self-consumption (689 kg), this activity has a gross added value of **51,003 MK** (USD 29.07). This corresponds to **MK 204 per tree** (USD 0.12) and **MK 963 per man-day** (USD 0.55).

4.4.4. Case 4: The wood produced is not sufficient to meet household needs, but part of it is sold to meet other needs

Two of the twelve families surveyed (17 %) do not produce enough wood to meet their needs. However, because of financial needs, they sell some of their wood. This enables them to buy food. **This**

category includes more vulnerable households such as single women. They are the respondents n°9, and 11.

Few trees are exploited - in the case of the model, 20 trees are exploited for 172 trees that are over 6 years old. **These households are more vulnerable, as they do not have enough manpower to prune more trees (single women)**. This explains why these households have many trees unexploited. In fact, it is mainly men who are responsible for pruning or cutting trees, which makes the activity more difficult. In addition, some trees can be used for other purposes such as poles or shade.

These producers sell their wood at home to anyone who wants to buy firewood and the quantities sold are quite small, around 120 kg (to be compared with the 1,445 kg in the model presented in case 1). They sell firewood at the beginning of the rainy season, in December, January and February. The wood is sold in bundles of 200 to 500 MK. To meet their own firewood needs, they keep some of the branches they have pruned. They also collect branches from the surrounding area and continue to use crop residues.

To supplement their income, these producers can also sell whole standing trees. In the case of the model below, the producer sells four trees at 4,000 MK each. As in the previous model, he sells standing trees and buyers are also responsible for cutting and transporting the wood.

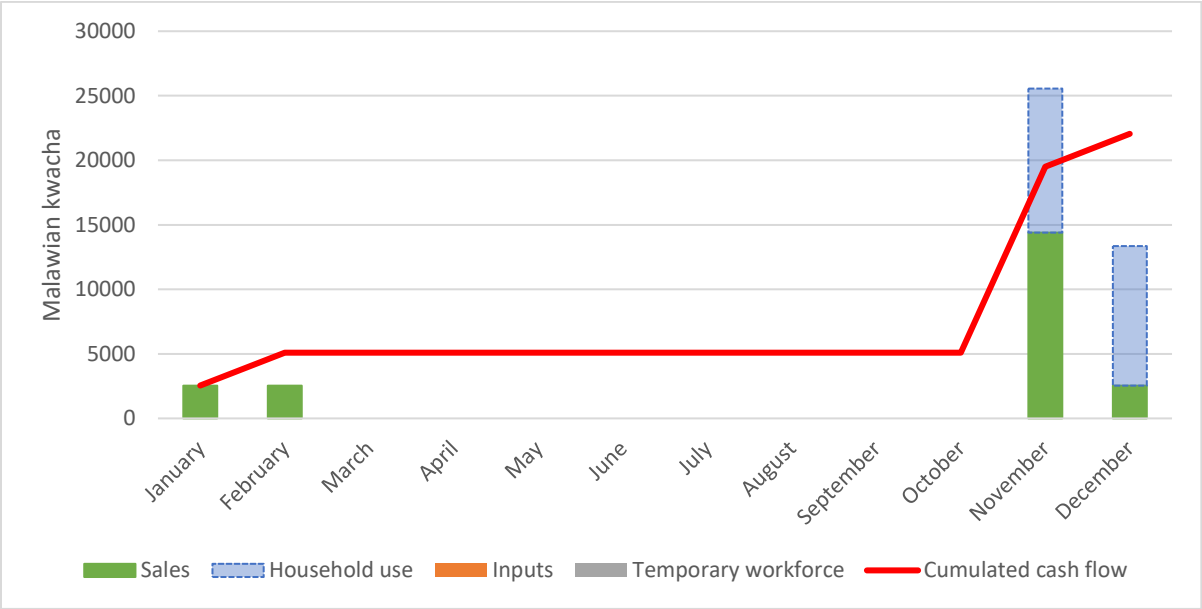

Figure 32: Cash flow calendar of the farmer n°11 (on Table 6 page 24) who does not produce enough firewood to satisfy his household needs but sells some firewood to meet his cash needs (172 trees over 6 years old, of which 20 trees are used)

In this case, the actual data from farmer n°11 was used because it was sufficiently reliable and representative. The farmer earns MK 24,500 (USD 13.96) a year. He does not have any expenses because he does not hire temporary workforce or oxcart and he does not buy empty sacks. While valuing self-consumption (342 kg), this activity has a gross added value of **44,010 MK** (USD 25.09). This corresponds to **MK 256 per tree** (USD 0.15) and **MK 2,406 per man-day** (USD 1.37).

4.5. Element of comparison and conclusion on wood production in small family farms.

The GVA per tree is higher for farms that produce enough wood for consumption than for those that do not produce enough wood for consumption. In fact, as trees get older, they need less pruning in order to get a bigger amount of firewood. For example, in the first scenario, where the farm that

produces enough firewood from old trees to meet the household needs and also to sale, the family managed to produce 2,741 kg of wood by pruning 17.5 trees in one year (but one tree was over 50 years old). In the third scenario where wood production from young trees is insufficient and no sale is done, the farmer produces 576 kg of wood by pruning 60 trees, i.e. 4.8 times less by pruning 3.4 times more trees.

The income from trees is a source of money that complements incomes from various crops (pigeon peas, soybeans, sunflower, green gram, rice, cow peas, groundnuts, sweet potatoes and/or tobacco). For all scenarios, the data collected shows that the **benefits from crops are 2 to 44 times higher than those from wood. It is only in the case of the poorest households (scenario 4) that the income from wood comes close to half the level of the crop income**.

Table 8: Comparative table of earnings from the sale of trees and crops (figures for crops have been roughly estimated with families and are for guidance only); GVA = Gross value added, Md = Man day; scenario 1 = enough to meet needs + sale, scenario 2 = enough to meet needs but no sale, scenario 3: not enough to meet needs and no sale, scenario 4 = not enough to meet needs + sale

	Scenario 1 (Self sufficient + sales)	**Scenario 2** (Self sufficient + no sales)	**Scenario 3** (Not self sufficient + no sales)	**Scenario 4** (Not self sufficient + sales)
Household profile	Better-of households	Average type of households	Better-of households	Most vulnerable household, e.g. single women
Plantation profile	Large number of trees, 42% of trees are over 6 years old	Mostly young trees (55% of the trees are less than 6 years)	Old trees but producer still looking for the right number of trees to prune (case 1) or trees are too young (case 2)	Old trees (92% are over 6 years old) but lack of manpower
Quantity of firewood sold	1,445 kg	0 kg	0 kg	119 kg
Number of trees sold	0 tree	4 trees	1.5 trees	4 trees
GVA (MK)	107,341	86,416	42,577	40,564
GVA/tree (MK)	537	445	177	236
GVA/Md (MK)	4,829	4,940	817	2,217
Earnings wood (MK)	85,000	20,000	7,500	24,500
Earning crops (MK)	591,444	194,250	333,000	55,000
% of crops value	14%	10%	2.3%	45%

It can be noticed that for vulnerable households, wood accounts for almost 50% of crop-related income (scenario 4), whereas for the better-off households, it accounts for a more minimal share (10 to 14%). In the third case, families are also not among the most vulnerable, but they are still at the beginning of their activity, the trees are still young and/or they still try to figure out the quantities they need to be self-sufficient. Even if the amounts are not very high for some families, selling wood therefore remains an additional source of income for these households. In particular, it provides them with a source of income during the lean season, at least for the families in scenario 1 and 4. **For families in scenario 2 and 3, despite not benefiting from wood incomes during raining season, the figures 31**

and 32 show that they heavily rely on their wood production during the rainy season, which is also a way to avoid expenses to buy firewood. Firewood can be used to buy daily necessities, while the sale of trees can be used to pay for more major expenses, such as children's school fees. It is important to note that not all of these families' wood harvesting practices are sustainable. Some cut down the whole tree and others use inadequate pruning techniques.

Besides being a source of income, trees play other important roles on the farm. Some species, such as *Gliricidia sepium*, can improve soil fertility by fixing nitrogen. Four producers have witnessed changes in their crops production. They grow better, greener and stronger, even without the use of fertilizer. Although one farmer also reported an improvement in soil texture, seven report no change. Some say their trees are still too young, while others say it is difficult to see any change following two seasons affected by climate hazards (cyclone Freddy and El Nino). However, one pointed out that the shade the trees provide for the crops is preventing them from developing properly (he has 205 trees, including 23 around one plot).

Producers can, also face a number of difficulties. They have to deal with theft, as people can enter the plots to steal the wood as it dries, or they may prune or even cut trees without permission. This happens a lot with indigenous trees. They also have to deal with pests and diseases, and they have no solutions to prevent them or to treat the trees. Tree management can cost time and money. It can compete with the time needed to cultivate crops. Lack of equipment can also make the task even more difficult. Indeed, families have little access to polytubes, certain seeds, chemicals and other materials such as gloves, watering cans, pruning saws...

In spite of these difficulties, all the families surveyed want to continue planting trees. The majority would like to continue using polytubes for planting. However, they all have in common an unfulfilled and redundant objective: **they would like to plant more fruit trees**.

5. Short analysis of the wood value chain in Phalombe district

5.1. The firewood value chain in Phalombe District: a sector heavily dependent on natural forests

The firewood value chain is an important sector in Phalombe district. For the sake of this study, we mainly focus on the wood value chain connected with the use of firewood by rural households. There are two main actors in this sector, the collectors and the producers.

Collectors is a person who goes into natural forest to collecting firewood and sell it at specific markets There are two types of collectors. The first are women, sometimes very young (16 to 53 years old), collecting wood and carrying it on their heads (about 40 to 45 kg). They come from villages close to the natural forest. There are also men, generally older (30 to 69 years old), who collect larger quantities (60 to 150 kg) and transport the wood on a bicycle. They may live in villages further away from the resource. There are two main natural sources of firewood in Phalombe District: Mulanje and Michesi mountains on the one hand, and forests of Mozambique, on the border with Malawi, on the other. On average, a collector collects 8,152 kg of dry wood per year. Of the 14 collectors interviewed, nine are going to collect specific species. **They mainly collect *Percopsis angolensis*, *Pterocarpus angolensis*, *Combretum molle*, *Combretum zeyheri* and *Acacia nilotica*** because they are common in the forest and in high demand on the market. In fact, they are good firewood species because they burn for a long time when cooking., which means that less wood is needed for a meal. Wood can be sold directly to consumers or to retailers. The latter resell the wood in markets or villages further away from the mountains or the Mozambican border.

Producers, on the other hand, are families who produce enough firewood to sell some on the market. **On average, a producer sells 1,291 kg per year. They mainly sell *Senna siamea* and eucalyptus wood**. They can also sell some firewood to transporters who go to sell in Blantyre. Transporters cannot buy from collectors because it is illegal to collect firewood in natural forests. If they are stopped on the road, they risk being fined and having their wood confiscated.

The functioning of the fuelwood sector in Phalombe District is illustrated in the diagram on the next page, in the figure 34.

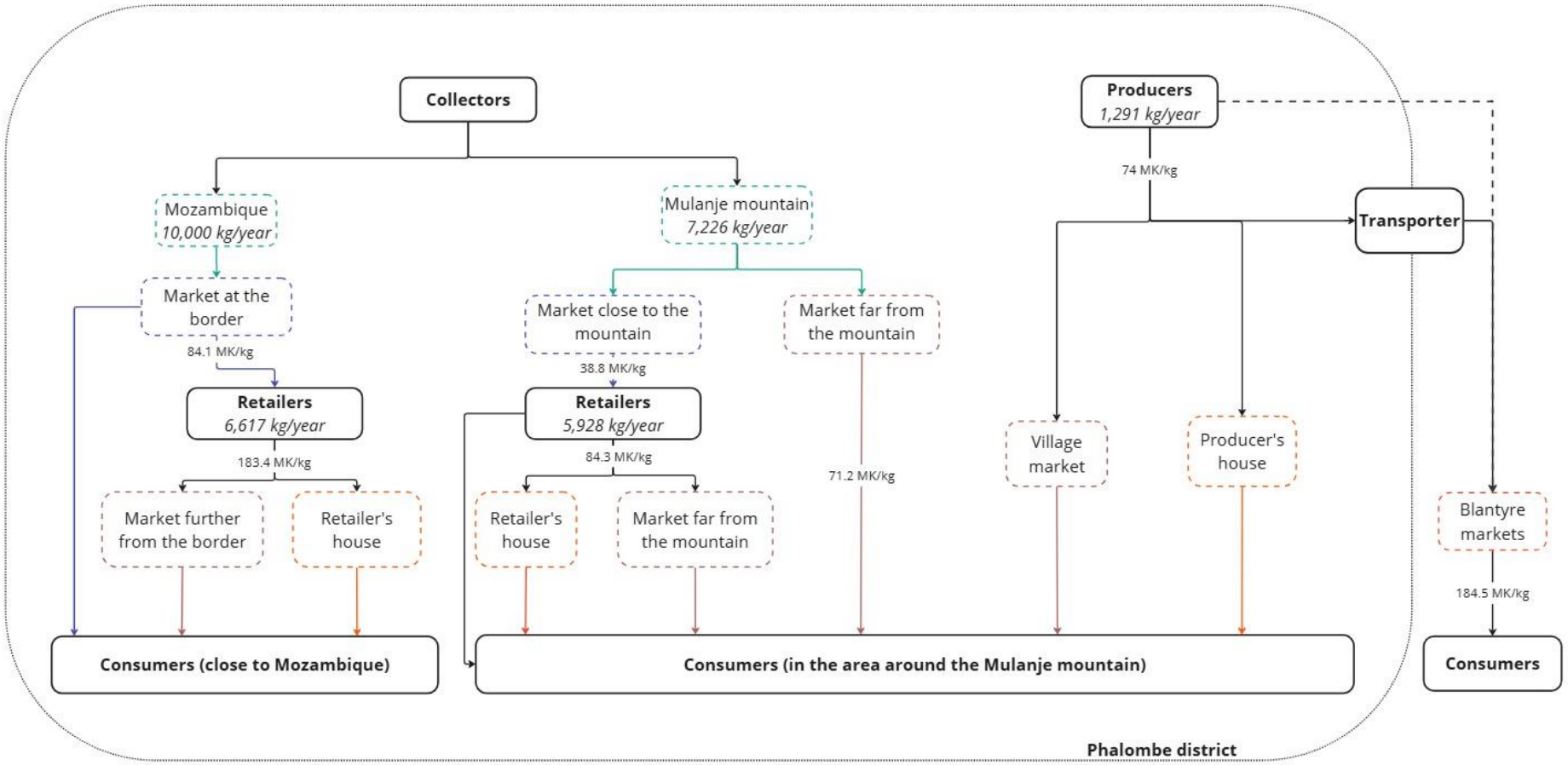

Figure 33: The firewood sector in Phalombe district

According to value chain players, demand for firewood is highest at the beginning of the rainy season, in December, January and February. This is due to the fact that households have already finished using crop residues, and that harvesting wood in the fields when crops are in place is more challenging. As the lean season is not yet too far advanced (December/January), they still have the resources to buy firewood. Demand is also high in June. In fact, during this month, families have already finished maize residues, but sorghum and pigeon pea residues are not yet ready for use. In addition, it is common to have light rains on the mountain during this month, making it slippery and difficult to harvest firewood. Several actors also pointed out that patrols by forest guards are more important at this time of year.

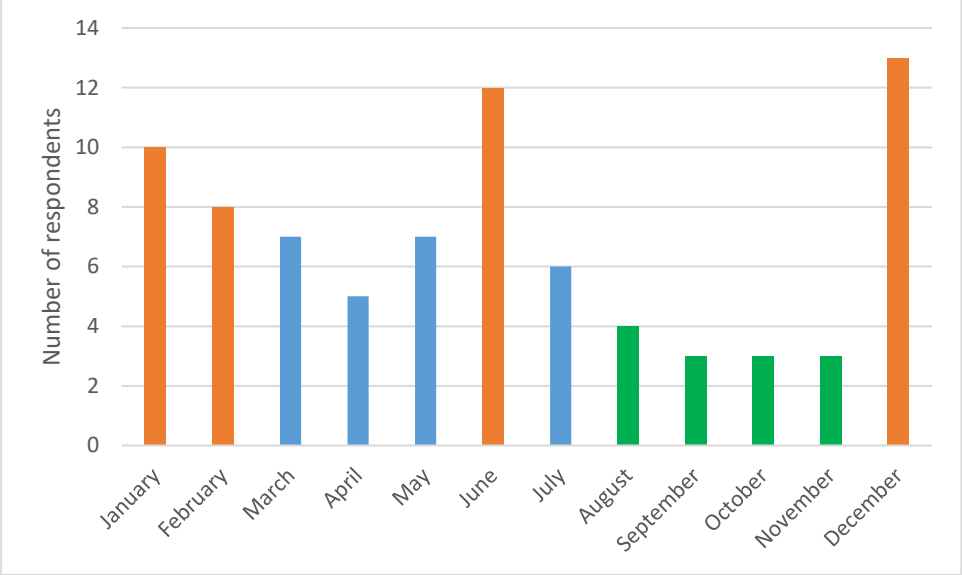

Figure 34: Period of high demand for firewood according to market players interviewed

For the vast majority of firewood used by rural households in the study area, we have identified 2 main sources: the natural forests and the production on small scale family farms. Although we have not been able to estimate the proportion of each source, it was easy to notice that t**he closer we get to Mulanje Mountain and Mozambique, the less firewood produced on the farm is used and sold**.

5.1.1. Firewood from natural forests and sold in markets

Firewood collectors are the main actors in wood marketing. In fact, it is easy to start this business because it does not require an important capital. They do it to earn money to buy food and other necessities. "*It is poverty that made me start selling firewood. I chose firewood because it doesn't require a capital. I'm just going to the mountain to collect it."* On average, collectors are about 34 years old, but some of them may be also really young, around 16 or 17 years old. This activity can help them to pay their school fees. *"I decided to sell firewood because I couldn't pay my school fees. I'm doing it only to pay my school fees. I'm in secondary school."* Others are older; the oldest person interviewed was 69 years old and he is the chairman of the firewood sellers at Mulomba market. This activity increases when agricultural harvests are poor in order to supplement household income.

For collectors based in Phalombe, Kambenje, Mulomba, Mpata, Kokolo or Kaledzera, they collect wood in Mulanje or Michesi mountain. These mountains are protected areas, as the Mount Mulanje was declared a forest reserve in 1927 and was included in the list of world biosphere reserves in 2000 (Kayembe 2021). To collect firewood, one must pay a fee to the forestry office. Fees start at MK 100 and worth MK 200 per headload (40 to 45 kg). The permit only allows them to collect dead branches and it is prohibited to cut branches or trees. Collectors in Nambazo or Namba, near the border, they

go to collect firewood in Mozambique. To collect firewood there, they have to pay for a forest pass and are expected to give a small bundle (equivalent to 200-300 MK) when crossing the border.

Although wood harvesting is not capital-intensive, it remains a difficult business. The distances involved in collecting wood are very long. It takes an average of 7 hours to travel from their home to the forest, to collect one large bundle and return. The roads and paths are in bad condition and they may sometimes encounter dangerous animals such as snakes. The NGO Mulanje Mountain Conservation Trust is one of the main historical stakeholders that has been organizing patrols with the police and communities for more than a decade. If a collector does not have a permit or cuts down a tree or branches, the wood and their panga knives can be confiscated by these patrols. The Phalombe District's Department of Forestry has been collaborating since 2022 with the NGO WeForest Malawi. WeForest funds the patrols carried out by the Department of Forestry and the police, and works with communities around Mulanje mountain to restore the *miombo* ecosystem and reduce the harvesting of indigenous trees by actively promoting the planting of agroforestry trees on farms. Finally, it is worth noting that collectors also mentioned that they may sometimes encounter "fake" forestry officers who ask them for money.

Depending on the origin of the wood, it was possible to define three sales scenarios. **In the first case**, **the collector comes from a village close to the Mulanje mountain**, for example Phalombe or Kambenje. He collects wood all year round, almost every day. He sells it at the Phalombe or Kambenje market to private individuals or retailers. If he sells to a retailer, the latter will resell the wood in more distant villages. **In the case of the second scenario, the collector comes from a village further away from the mountain**, such as Mulomba or Kalezera (10 to 15 km as the crow flies), where Inter Aide worked to support agroforestry families in recent years. He sells directly to individuals in his village or in the trading center near his village. He goes to Mulanje mountain almost all year round, about two to four times a week. **In the last scenario, the collector is located near the Mozambican border**, in Namba or Nambazo (4.5 km from the border). He collects the wood in Mozambique and sells it either to private individuals or to retailers who can sell the wood in more distant villages such as Chiwalo or Phaloni. He can also sell it to fishermen on Lake Chilwa. The collector goes to Mozambique almost all year round, usually two to four times a week.

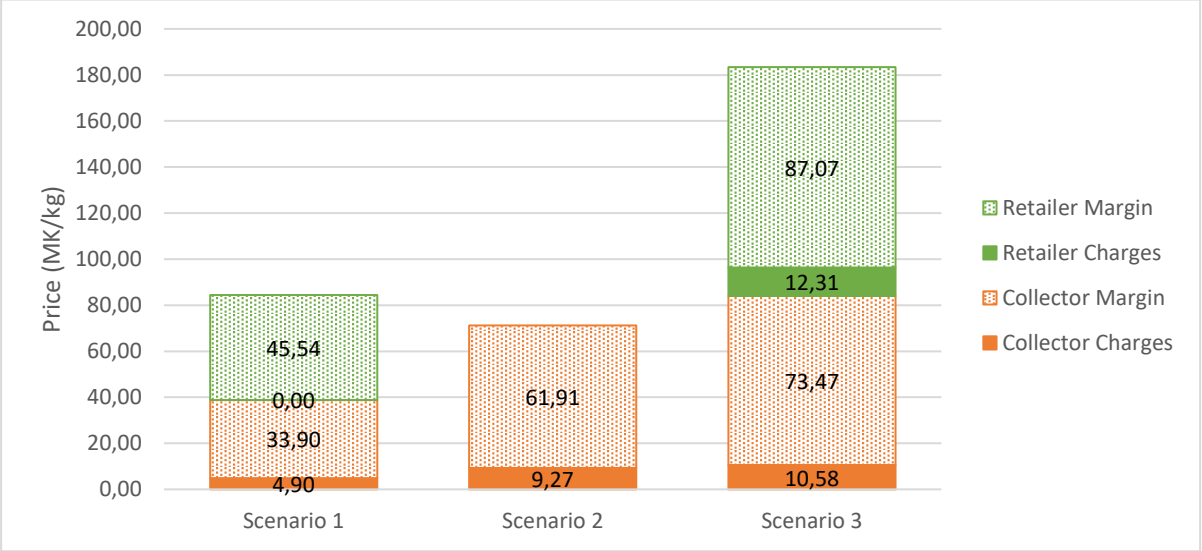

Figure 35: Cost structure for different sales scenarios for collectors; scenario 1: the collector sells firewood to a retailer in a market close to Mulanje Mountain; scenario 2: the collector sells firewood from Mulanje mountain in a market far from the mountain; scenario 3: the collector goes to Mozambique to collect firewood and sells it to a retailer in a market close to the border; personal realization

The price depends on where the firewood is collected and sold. Firewood from the Mulanje mountain fetches lower prices than firewood from Mozambique. **Indeed, Mulanje firewood is sold on average at 55 MK/kg (0.03 USD) (all markets combined), while Mozambique firewood is sold at 84 MK/kg (0.05 USD) at the collector's level**. This difference is due to the fact that it seems more complicated to get wood from Mozambique. In addition, the cost is higher because of customs duties and frequent informal taxes.

It can also be seen that **firewood is sold at lower prices in markets close to the mountains than in those further away**: 39 MK/kg (0.02 USD) versus 71 MK/kg (0.04 USD). This is because there is more competition in markets close to the mountain and transporting the wood requires more effort from a collector in a distant village. In markets close to the mountain, firewood is sold in bundles at 1,000 MK (0.57 USD) for 23 kg, or in bundles at 1,500 MK (0.85 USD) for 40 kg. In more remote villages, bundles are smaller, usually sold at MK 500 (0.28 USD) for 9.7 kg, MK 400 (0.23 USD) for 6.9 kg, MK 300 (0.17 USD) for 4.1 kg and MK 200 (0.11 USD) for 2.1 kg. Prices are set according to the size of the bundle, the place of sale, the costs and the quality of the firewood (well dried, good species…).

Table 9: Summary table of firewood bundle prices and weights (larger bundles are sold close to Mulanje Mountain, while smaller bundles are sold in villages/markets further away from the mountain)

Price of a bundle (MK)[7]	Weigh (kg)	Price per kg (MK)	Price per kg (USD)
1,500	40	37.5	0.022
1,000	23	43.5	0.025
500	9.7	51.5	0.029
400	6.9	58	0.033
300	4.1	73	0.042
200	2.1	95	0.055

Figure 36: Firewood bundles; , large bundles at Phalombe market (left); small bundles at Kalezera market (right)

On the Figure 35, expenses include the mountain pass, market fees, storage costs and customs duties. Collectors go to the mountain by foot or by bicycle, so transport costs are minor and have been neglected (bicycle maintenance, etc.). If they use a bicycle, they need to leave it entering the forest reserve.

In the first and third scenarios, collectors sell to retailers. Retailers buy the wood and transport to markets further away from the mountain and from the border. Like collectors, retailers have taken up

[7] The data was collected on the markets in March 2024. However, at the time of writing (November 2024), prices had changed. Families reported during presentations that bundles previously sold at MK 200 are now sold at MK 500.

this activity because it does not require large amounts of capital. In fact, they have few expenses. They only have to invest in buying wood. They buy wood almost all year round, about two or three times a week, between three and four large bundles. However, it is not always easy to buy firewood and to transport it. They use bicycle but if their bicycle has an issue, they cannot go to purchase the wood.

"I used to sell fish. Unfortunately, my husband was sick and I used capital from the fish business to pay hospital fees. Now, I just have a small capital. I'm selling firewood to get more capital and to start selling fish again."

In the first scenario, retailers do not have any charge because they sell at their house and not at the market. In the case of the third scenario, retailers sell at the market. They have to pay market fees. If they do not sell everything during a market day, they have to store the wood near the market. They pay 200 MK to store the wood between two market days.

Wood is sold in small bundles at 200 MK (0.11 USD) for 2 kg, 300 MK (0.17 USD) for 3.2 kg and 500 MK (0.28 USD) for 4 kg. The price is set according to the purchase price, the size of the bundle, the quality of the wood and the market. He must ensure that he always makes a profit. In scenario 1, the retailer gets back 57.1% of the margin and in scenario 3, the retailer gets back 54.2% of the margin.

However, it is not always easy to sell firewood. Some customers leave with the wood without paying, while others negotiate prices that are too low. Demand also varies according to the month. At certain times, it is difficult to sell because there are not enough customers (August, September, October) or to too many sellers. To limit competition, sellers can agree on selling prices based on quantities, as it is the case in the Phalombe market.

5.1.2. Firewood produced on small scale family farms and sold in the villages

There are also some families in the area who sell the firewood they produce. It was difficult to find some families in the markets. Of the 22 actors interviewed in markets, only two were producers. They were found at the Misofo market and only sold *Senna siamea* wood. Most of the producers sell their wood at home by putting a few branches on the side of the road to indicate that they sell firewood. This enables them to sell it to their neighbors or to people in a neighboring village. Producers sell their firewood mainly during the rainy season, in December, January and February.

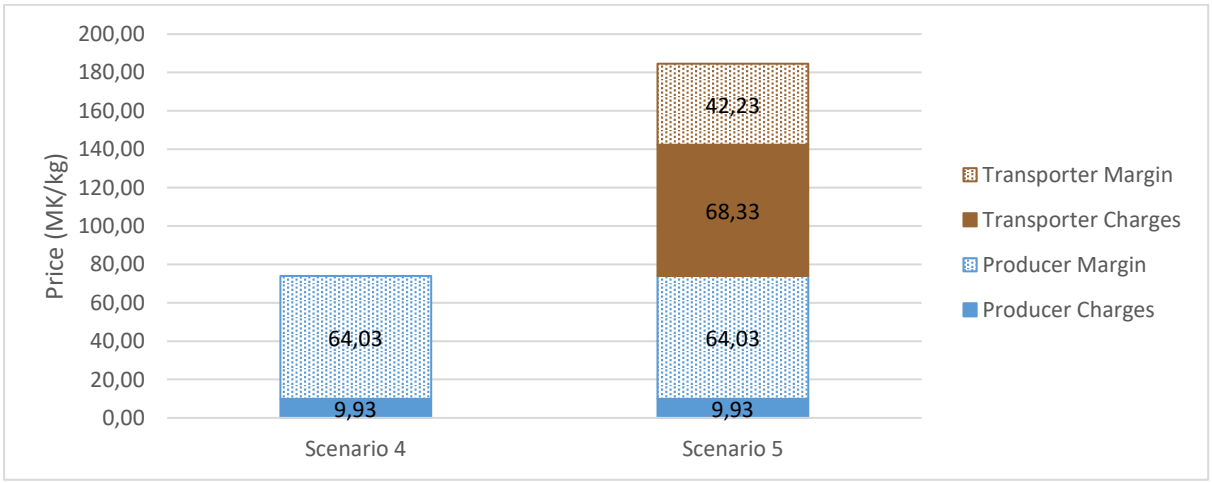

Figure 37 : Cost structure for different sales scenarios for producers ; scenario 4: the producer sells directly to customers; scenario 5: the producer sells to a transporter who sells the wood in Blantyre (not representative, only one respondent); personal realization

Producers can sell their firewood at 74 MK/kg (0.04 USD). It is sold as small bundles of 2 to 3 kg at 200 MK (0.11 USD). From an expenditure point of view, they have no intermediate consumption because they do not buy treatments, fertilizers... However, if they prune a lot of trees or large trees, they may need to hire extra labour. They may also need to hire a means of transport such as an oxcart to bring the wood back to their home. This represents a cost of 8.09 MK/kg (0.005 USD). Biological amortization[8] of afforestation trees is almost negligible, at 1.84 MK/kg (0.001 USD). The scenario 4 represents a producer who is selling directly at his homestead. If producers decide to sell at the market, they can also include an additional cost. They have to pay the district council or to the owner of the place for their space (200 MK per market day).

We found a rare case of producers selling firewood to a transporter, as presented in the scenario 5. It was difficult to interview transporters. Only one who was found who was willing to answer our questions. **The data presented for scenario 5 is for only indicative and cannot be representative**. Transporters buy firewood from families in Phalombe district and sell it in Blantyre. They do not collect or buy wood from Mulanje Mountain because this is illegal and would have high chances to have having the wood confiscated and to be fined. The transporter interviewed buys only eucalyptus, *Senna siamea* and *Gmelina arborea*, as these species can be sold legally and are in high demand in town. She bought wood throughout the year to sell it in December, January and June. She sells it at 185 MK/kg (0.11 USD) in Blantyre market.

Transporters have a lot of charges: they have to hire a truck with other transporters, to pay for accommodation in Blantyre, pay market fees and they need between one to five days to sell their firewood. The transporter who was interviewed was no longer selling wood. She did only this temporarily to pay for her daughter's schooling.

5.1.3. Comparisons between producers and collectors

The results presented above show that the wood producers supported by Inter Aide and the collectors of mountain wood selling in the villages far from the mountains sell at similar prices. On average, small scale producers sell at 74 MK/kg and collectors at 71 MK/kg. **Producers are therefore able to compete with collectors' prices**. Similarly, the margins and costs of these two actors are similar, with a margin of 64 MK/kg for producers versus 62 MK/kg for collectors, and 10 MK/kg expenses for producers versus 9 MK/kg for collectors. In addition, producers' costs are mainly related to temporary labour. A farmer with limited financial resources can therefore reduce these costs by carrying out all the tasks himself, with the help of family members. However, this requires more labour.

The following graph on the next page shows the working time required to collect or produce 1 kg of firewood, excluding the time spent to sell the firewood.

[8] Biological amortization takes into account the investment made by a farmer to care for a tree that is not yet productive (less than 3 - 4 years old). This takes into account the labor required, as well as intermediate expenses (purchase of seedlings, baskets to protect against livestock, etc.). This sum is then divided by the number of productive years of the tree.

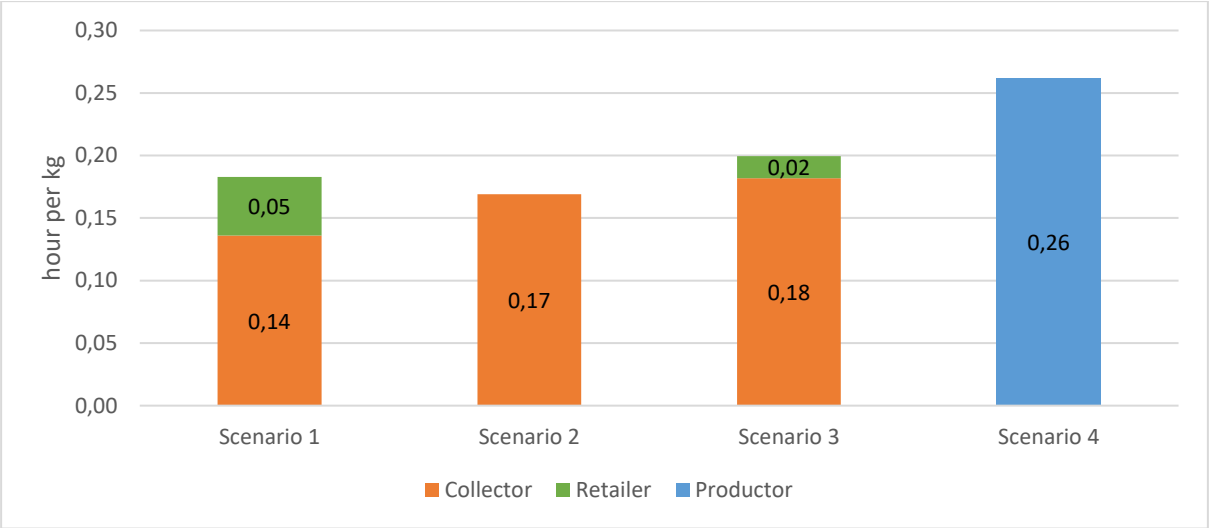

Figure 38: Working time to collect or produce 1 kg of firewood - sales time is not taken into account; scenario 1: the collector sells firewood to a retailer in a market close to Mulanje Mountain; scenario 2: the collector sells firewood from Mulanje mountain in a market far from the mountain; scenario 3: the collector goes to Mozambique to collect firewood and sells it to a retailer in a market near the border; scenario 4: the producer sells locally, directly to customers.

On average, it takes a collector 10 minutes per kg to collect and transport 1 kg of firewood. The time varies according to the distance he has to travel to collect the wood, so the time is longer in the scenario where the collector travels to Mozambique (scenario 3) or sells the wood in villages far from the mountains (scenario 2). However, it can be seen that the production of 1 kg of wood requires more working time (all the tasks carried out over a year (pruning, weeding, transporting the wood to the house) are taken into account, the wood is sold at the house, there is no transport time to sell it). In fact, a producer has to work 16 minutes to produce 1 kg of wood, i.e. 1.7 times longer than a collector. However, the work is spread over several months of the year and is less physically demanding.

Despite the fact that production is more time-consuming than firewood collection, producers sell their wood to collectors at similar prices. This keeps them competitive and enables them to sell off their stock. To be competitive on the market, producers should also offer high-quality wood. Indeed, quality is one of the main factors in the purchasing decision and in the selection of mountain species.

An important question is whether producers would be able to replace collectors on the market and meet demand. To answer this, we need to look at the quantities sold and the number of each operator on the market. While it is not difficult to meet and find collectors in markets and even in some villages, wood producers are currently very scarce. Regarding the average quantities involved, **a collector collects and sell 8.2 t of firewood per year, while the producers surveyed produce and sale an average of 1.3 t of firewood per year**. **The conclusion is that it would take 6.3 producers to replace the amount of output sold by one collector and that many more wood producers would be needed to achieve this, with all the transport and marketing constraints for small scale producers that we mentioned earlier**.

5.2. Poles and timber market

Firstly, it was not possible to find any actors selling poles on markets in Phalombe district. In fact, poles are sold directly by small scale producers. A person who wants to buy poles needs to go directly in a village and buy from a farmer (eucalyptus or *Senna siamea*).

However, it was only at the Phalombe market that is was possible to meet timber production and sales operators. Some actors produce and sell timber directly from their homes. As in the case of firewood

production and sales, the Mulanje and Michesi mountains play an important role in timber production. There are two types of actors: timber producers who collect timber illegally from the forest (unlike firewood, there is no forest permit for timber production). There are also timber producers who buy trees from families or estates (Mulli brothers for example). In the second case, few people are involved in this activity, as it requires more investment. It was difficult to meet people involved in this sector, because people who collect wood in the mountains are reluctant to answer questions due to their illegal activity. Only seven people were interviewed, all men aged between 40 and 60 who have been in the business for between ten and thirty years.

The main users of timber in the districts are the carpenters. They use the wood to make furniture for homes, such as doors, windows, tables, beds, chairs... Some people may also buy timber to build or repair the roof of their house. This is less common, but there may be traders who buy timber in larger quantities for resale in larger trading centers or in cities such as Blantyre.

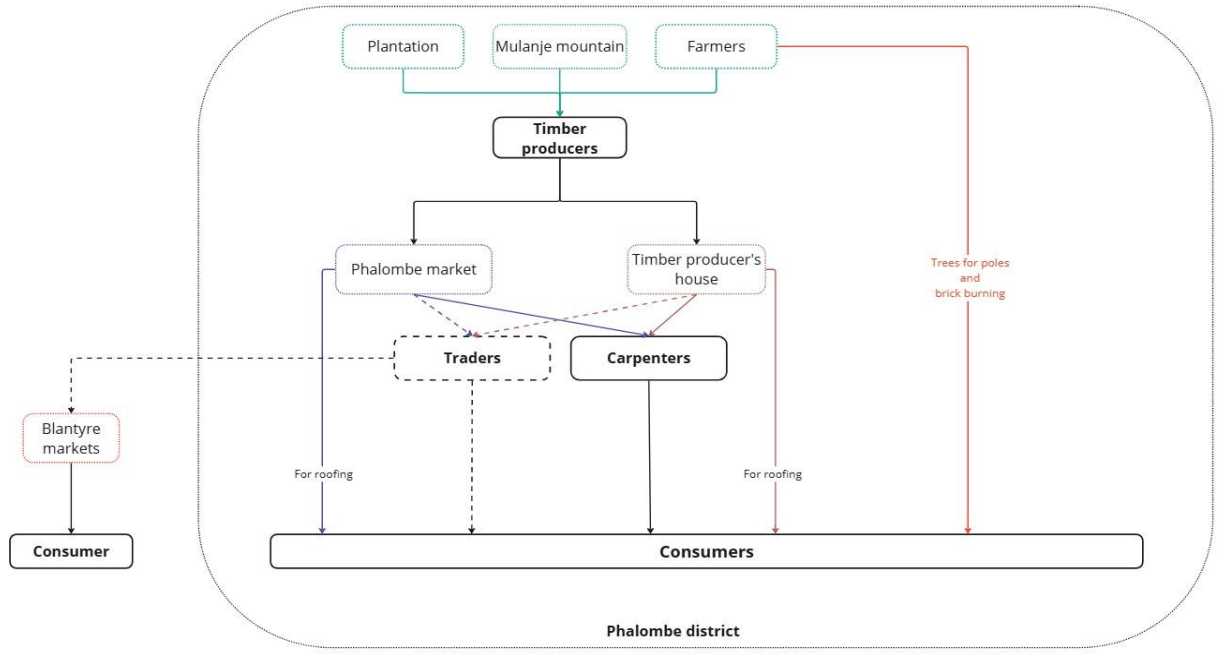

Figure 39: Wood construction sector in Phalombe District (for timber, poles and brick burning)

Demand is highest for poles and timber during the dry season, from April to August, when houses are being repaired.

5.2.1. Poles marketing

Poles are usually sold from the owner's home. The consumer is responsible for cutting and transporting the tree. Cutting is done under the owner's supervision to ensure that the tree is not damaged. Preferred species are *Senna siamea* and eucalyptus. Prices vary according to tree size and species. In fact, some families use bamboo for their roofs because it's cheaper, but less durable.

Table 10: Prices for poles by species

Species	Price (MK/coppicing shoot)[9]	Price (USD/coppicing shoot)
Eucalyptus	450 to 7,000	0.26 to 1.99
Senna siamea	400 to 8,000	0.23 to 4.56
Bamboo	100	0.06

[9] Poles can even be sold at higher prices, but we were unable to obtain precise data.

5.2.2. Timber marketing

There are 2 types of timber producers, in both case they cut an entire tree and produce planks from it. **The first type (timber retailer)** does not go to the mountain but buys trees from a plantation or from families. **The second type (timber collector)** goes in the forest to cut down trees, transport it and make their own timber at home. Timber retailers prefer to buy certain species such as **eucalyptus, *Melia azedarach*, *Senna siamea*, *Khaya nyasica*, *Neuclea nyasica*, *Toona ciliata* and *Gmelina arborea***. These species are well suited to timber production. Consumers prefer *Gmelina arborea* because it produces good timber, followed by *Khaya nyasica*, *Toona ciliata* and eucalyptus. Those who collect in the forest prefer Mulanje Cedar, but this species is now difficult to find, so they have to look for alternatives.

Trees must be over 12 years old for timber production. Trees are therefore sold at higher prices, ranging from MK 5,000 to MK 100,000 depending on size and species. ***Khaya nyasica* and *Toona ciliata* are the most expensive species**. These species can indeed produce a lot of planks and branches that can also be used as firewood. *Gmelina arborea*, on the other hand, is the least expensive because it produces less planks. Typically, they buy between 10 and 15 trees a month during the peak of demand (April to August) and may buy between 5 and 2 trees a month for the rest of the year. They can produce between 5 and 80 planks from one tree. They are obliged to buy from a large number of families, as each farmer has one or two trees suitable for his needs.

Those who go to the mountains collect wood 4 to 25 times a month in the peak season, and one to three times a month in the low season. Before taking down the timber to their home, they cut down the tree in the forest and then saw it into smaller pieces that they can carry it on their heads.

Figure 40: Cost structure for timber collectors and timber retailers

The figures presented above are for information only. Being very small, the sample (6 persons, 3 timber retailers and 3 timber collectors) makes it impossible to obtain representative figures. However, it can be seen that planks produced from trees purchased from families is sold at higher prices. This is because the timber retailer has more work to do: he has to buy the tree, pay labour to cut it down and hire transport to bring the wood back to his workshop. He then has to process the timber into planks, which is sometimes done by hiring external labour. Labour accounts for 70% of expenses and transport for 24%.

Figure 41: Planks from timber at Phalombe market; 1: Gmelina arborea*, 2:* Toona Ciliata*; 3: Eucalyptus*

Producers who collect the wood have few expenses. In fact, they may have expenses related to storage (when not all of their production is sold at the market), market fees and transport. In fact, they can rent an oxcart or a bicycle to transport the wood to the market. The margin generated by this actor is almost double that of the producers who buy the wood. However, fetching wood from the forest requires a lot of energy and he runs the risk of having the wood confiscated, being fined or going to prison (maximum penalty in 2024: 10 years' imprisonment, 10 million kwacha (Ministry of Forests and Natural Resources 2019).

5.2.3. Carpenters: timber's largest users

Carpenters buy large quantities of timber, especially during the dry season. They buy between 10 and 60 planks a week, depending on capacity and demand. Demand is high during the dry season from April to October, with a peak after the harvest when families sell their produce and therefore have more cash.

Carpenters buy various species such as *Khaya nyasica, Pterocarpus Angolensis, Gmelina arborea, Toona ciliata, Albizia lebbeck*, Mulanje Cedar*, Uapaca kirkinia*, eucalyptus, pine and other mountain species. They generally prefer *Pterocarpus angolensis, Gmerina arborea, Khaya nyasica* and Mulanje Cedar. The latter, however, is becoming increasingly difficult to find. If a carpenter takes the risk of using wood from the mountains, he can also have it confiscated and fined. Purchase prices for certain species are given below:

Table 11: Prices for planks from forest and non-forest timber

Species	Source	Dimension	Prices (MK)
Pterocarpus angolensis	Forest	6 feet x 8 inches	8,500
		7 feet x 9 inches	9,500
Gmelina arborea	Non-forest	6 feet x 8 inches	3,500
		9 feet x 8 inches	4,000
Toona ciliata	Non-forest	6 feet x 8 inches	5,000
Eucalyptus	Non-forest	6 feet x 4 inches	1,700
Senna siamea	Non-forest	6 feet x 6 inches	2,000
Albizia lebbeck	Non-forest	6 feet x 8 inches	6,000
		7 feet x 8 inches	9,000
Khaya nyasica & K. anthotheca	Forest and non-forest	6 feet x 8 inches	7,500
		7 feet x 8 inches	9,000

Planks from eucalyptus and *Senna siamea* fetch lower prices than the other species. The planks are then used to make numerous products sold at prices ranging from 2,000 to 600,000 MK. The products are sold in carpenter workshops or in markets such as Phalombe, Mulomba or Phaloni.

To be able to exercise their profession, carpenters must pay for a business license. The Phalombe carpentry association gathers several carpenters of the district.

6. Conclusion on wood requirements, production and marketing for small-scale families

Families depend entirely on firewood and crop residues for cooking. Firewood is mainly used during the rainy season, while crop residues are mainly used during the dry season. As families do not have enough trees to meet their firewood needs, they rely heavily on the natural trees available in their area, i.e. Mulanje mountain, hills and river banks. Even those who can afford to buy wood also depend on these indigenous resources, as the wood comes mainly from the mountains. **On average, our study found that a family needs 1,455 kg of dry matter to cook all year round [1,203 – 2,109 kg]** and that **47% of this amount comes from crop residues** and **32% from indigenous wood from Mulanje mountain and hills** [0 – 84%]. **If a family was only using wood from pruned trees to meet their needs, this would represent 61 twelve-year-old *Lonchocarpus capasa* trees, 32 thirteen-year-old natural trees such as *Pterocarpus angolensis*, 81 five-year-old *Senna siamea* trees and 112 one-and-a-half-year-old eucalytpus trees**[10]. This is worth 120,765 MK[11]. However, families use an average of 684 kg of crop residues per year, so they need about 771 kg of wood, that is, for each species, 53% of the number of trees mentioned here above[12]. According to studies already carried out by Inter Aide in Lilongwe District, it was estimated that a rural family of 5 living in this district uses between 1,900 and 2,250 kg of biomass per year (Abadia 2016; Aceves Cardenas 2022), that is 20% more than what we found out in Phalombe. We don't have an explanation for why this might be the case, but the higher levels of chronic food insecurity in Phalombe, which contributes to limiting the number of meals families have, could be part of the answer.

Buying wood can represent a significant cost for households. **On average, families travelling to the mountains spend MK 13,800 a year on wood collection**. This can vary greatly from one family to another, ranging from MK 1,800 to MK 27,700. **Families who do not go to the mountain spend an average of MK 66,740 per year** [MK 40,000 and MK 180,000]. There is also a category of families who do not go to the mountains and who do not buy wood. This means that **families that do not go to the mountains spend on average 4.8 times more money than households that collect wood in the mountains**. Collecting wood in the Mulanje mountain significantly reduces household expenditure, as the money can be used for other purposes, such as buying food during the lean season or other necessities such as soap, utensils, clothing, etc. This indirectly confirms that poverty and lack of access to sustainable energy sources, such as firewood produced on the farm, is a key driver of deforestation in the area.

Trees are also used for construction, as poles and as firewood for burning bricks. On average, families have to change their poles every 3.6 years because they mainly use eucalyptus, which is heavily attacked by termites and weevils. On average, they change 22 poles, or 2.75 eucalyptus trees (0.76

[10] These figures were obtained using the quantity of wood weighed per tree pruned. The average annual quantities were divided by the quantity produced by one tree in order to define the number of trees required.

[11] The average selling price in the villages is MK 83/kg.

[12] That is 32 twelve-year-old *Lonchocarpus capasa* trees, 17 thirteen-year-old naturel trees, 43 five-year-old *Senna siamea* trees and 59 one-and-a-half-year-old eucalytpus trees. This is worth 63,993 MK.

trees per year). In addition, on average, a family burns 7,200 bricks every 10 years, which corresponds to 27 trees cut down (2.7 trees per year) or 9 old trees pruned (0.9 trees per year). **Thus, the use of wood for construction can represent an average annual cost ranging from MK 9,225 (USD 5.36) to MK 31,041 (USD 17.69)**.

Regarding the labour constraints, trees generally require little work on the part of the families. A young tree requires a lot of work at the time of planting, especially as families are busy planting crops at this time of year. It also requires work if the tree is protected from livestock and the basins are maintained to encourage soil moisture. Once mature, they need to be weeded during the dry season and pruned/coppiced before the rainy season. The peak workload corresponds to the period when the land is being prepared for cultivation. Our results show that, depending on the age of the tree and the intensity of its protection (individual fence, …), it takes between 0.8 and 1.5 hours per person per year to manage 1 tree. **If we extrapolate this to 50 trees, we get between 5 and 10 man-days per year**, and double that for 100 trees. However, we agree that the families surveyed are not yet taking optimum care of their trees, and most of them do very little maintenance pruning. Unless they have access to new types of time-saving tools (saws, pruning shears, …), it is highly likely that families practising good regular pruning of mature trees will see their workload increase, but to the benefit of an increased production.

The trees can be sold whole or in the form of firewood, depending on the cash requirements of the families and their production. **They can represent a significant source of income for families, ranging from MK 7,500 to MK 85,000, representing between 2% and 45% of income from crop sales**. Firewood is sold progressively during the rainy season, while trees are sold during the dry season, usually all at once. The sale of trees helps to meet major cash needs, such as school fees or emergencies. **District markets only sell firewood from natural forests, usually from Mulanje Mountain or Mozambique, while wood produced on small farms is only sold at home, in rural villages.** Producers have no problem selling in this way because demand is high and there are few producers.

The results showed that the families are currently offering competitive prices. In fact, they sell the wood at an average price of MK 74/kg, compared to MK 71/kg and MK 84/kg respectively for collectors selling in markets far from the mountains and for retailers. However, most of the producers interviewed were located in villages far from the mountains (Namphwalala, Gomani, etc.) and the price varies greatly depending on location, with wood sold at MK39/kg in markets close to the mountains (Phalombe, Kambenje, etc.). A producer closer to the mountains would probably not be able to achieve such high margins to remain competitive in the market. **The main question is whether on-farm wood producers, once they have more trees on their farms and are able to market their wood, will be able to market in the same way.** And if not, how will they fit into the market? Since the species available in the villages have little or no market presence, it is important to ask whether these species will be able to compete with indigenous species. Families therefore need to sell wood at competitive prices while remaining profitable. As quality is the primary purchasing criterion, it is also important to favour species that can produce quality wood on the farms.

Timber is more difficult to find in the district markets. Most poles are sold direct from the producer. This market is largely dominated by eucalyptus, although other species such as *Senna siamea* seem to have good potential. Timber is sold at the Phalombe market mainly in the form of planks. The wood comes either from illegal collection on Mulanje mountain or from a farmer or plantation. The planks are mainly sold to carpenters. The planks that come from the purchase of trees are sold at a higher price, but the people who process this wood (timber retailers and carpenters) can do so without fear of being arrested. In fact, most of the timber from the mountain is worked at night for fear of being inspected.

7. Recommendations

The study showed that most families want to stop buying firewood and going to the mountains and hills. They want to save time, money and energy. Going to the mountains takes a lot of time - between 8 and 12 hours to collect wood for a week. Women also run the risk of being arrested, injured or abused if they collect wood illegally. In addition, the devaluation of the Malawian kwacha has increased the price of wood in the markets, making it less affordable for families. The vast majority of families also wish to reduce the use of crop residues, especially maize, which is more difficult to cook with. **Reducing the use of crop residues would allow families to leave them on the plots to restore some of the organic matter and thus increase soil fertility, at least for maize residues**. However, during interviews and monitoring, many families reported collecting crop residues from other families' plots without their permission, which is not allowed by local communities for sorghum and pigeon pea stalks. It is therefore important to find solutions to help families achieve these objectives, in particular by suggesting tree species that are well suited for firewood production and a sufficient number of trees.

From a production point of view, families are motivated to plant trees in agroforestry to be more self-sufficient in wood, to have shade but also to improve soil fertility for the tree planted around or in their plots. However, families do not always use sustainable techniques to harvest firewood and they may even cut down a tree instead of pruning it. **It is therefore important to train families in more sustainable and species-appropriate techniques and to consider pruning frequencies to maximize production**. It may also be important for families to have access to more appropriate tools for tree pruning (group purchases, schemes to borrow equipment at village-level, etc.). Furthermore, the vast majority of project beneficiaries are women, although surveys have shown that it is men who are more responsible for tree maintenance, particularly pruning and coppicing. **It is therefore crucial to include men in tree management trainings, while at the same time looking for solutions to ease the work for women who are interested to get more involved in tree pruning**.

Trees can be an additional source of income for households, especially for the poorest. It is therefore important to explore strategies to support families who wish to do so in marketing tree products. In fact, most families sell the wood from their homes. They therefore wait for customers to come and ask them if they are selling wood. **As a result, customers do not necessarily come when the family wants to sell. This also leaves the families little room to negotiate prices**. Finding solutions for families to sell their products directly at markets may be tempting, but it is important to consider the additional time this requires for wood producers who are also farmers. In addition, as the sale of wood is seasonal, it may be interesting to market both products: firewood mainly during the rainy season and construction wood mainly during the dry season. Finally, it may also be in the interest of the families' financial security to keep some trees for wood production to be sold during major economic shocks and to meet major financial needs (school fees, emergencies, etc.).

Construction also requires large quantities of wood, and in particular clear-cutting whole entire old trees. Poles used are mainly from eucalyptus, but many families complain that this wood is heavily attacked by termites. Alternatives to eucalyptus are discussed in another of our studies, "*Study on the importance of eucalyptus for smallholder farmers in Phalombe district (Malawi)*" (Guihéneuf 2024). Brick production also requires an extremely large quantity of wood, leading families to cut down older trees and even fruit trees such as mango and Mexican apple trees. It may be worth investigating the promotion of wood-efficient kilns or alternative types of bricks.

The interviews revealed that *Senna siamea* is an important species for households. It is a fast-growing species, suitable for the production of firewood and poles, and could be a potential alternative to eucalyptus. It would therefore be interesting to carry out a more detailed study of the

technical and economic aspects of this species: its productivity, best techniques suited to harvesting its wood, production time to grow a mature pole and income that can be generated from this species. In addition, it is important to better understand the resistance of this wood (poles) to termites and weevils, and to research and test solutions to this important problem for families.

Finally, in the context of wood production, some of the families interviewed made requests to development partners such as Inter Aide. In particular, they are interested in receiving training on tree management (45%), access to materials such as pruning saws, polytubes, watering cans, gloves, etc. (36%) and long-term refresher training on related topics (19%).

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Appendix

Appendix 1: Number of respondents by type of interview

Actors	Number of respondents
Families for wood needs	30
Families for wood production	12
Firewood transporters	1
Firewood collectors	14 (10 in Mulanje mountain & 4 in Mozambique)
Firewood producers (at the market)	2
Firewood retailers	6 (4 in Mulanje mountain area & 2 in Mozambique area)
Timber retailers	3
Timber collectors	4
Carpenters	6
Seedling producers	4
Institution & organization	3 (Department of Forestry, Mulanje Mountain Conservation Trust, We Forest)

Appendix 2: Work calendar for crop production