

Mission Report

**Diagnosis of agrarian dynamics on the Eastern slope of Mount
Namuli**

&

**Analysis of agricultural practices into deforestation dynamics
and definition of an agricultural accompaniment**



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Vocabulary

1) Agronomic vocabulary :

- ◇ Agrarian system : "Theoretical expression of a historically constituted and geographically located type of agriculture, composed of a characteristic cultivated ecosystem and a defined productive social system." (Mazoyer and Roudard, 1997)
- ◇ Production system : ""A combination of land, power and means of work for crop and animal production, common to a group of farms. A production system is characterized by the nature of the production, the labour force, the means of work implemented and by their proportions." (Reboul, 1976)
- ◇ Crop system : "All the technical modalities implemented on plots treated in an identical way. Each crop system is defined by : the nature of the crops, their order of succession and the technical itineraries applied to these different crops, which implies the choice of varieties." (Sébillotte, 1976)
- ◇ Technical itinerary : Logical and orderly combination of the farming operations implemented on an agricultural plot in order to obtain a production.
- ◇ Plot : a piece of field homogeneous by its environment and agricultural practices supported.
- ◇ Crop rotation : succession of cultures that can be repeated over time.
- ◇ Fallow : "State of a plot between the harvest of a crop and the establishment of a next crop. " (Sébillotte, 1976)
- ◇ Agricultural income : difference between the farm gross product (value of final output, ie final quantities produced multiplied by the unit price of each product) and all fixed and variable costs for a given period (a year in this context).
- ◇ Activity income : same as agricultural income but considering all the activities that bring money to the household (not just farming activities).

2) Specific vocabulary in the context of the study :

- ◇ "Highlands" : this term refers to the lands located on an altitude plateau (above 1.700 meters), locally called the "Murretxa". This is where the ever-green forest threatened by deforestation is located and potato cultivated.
- ◇ "The living area" : as opposed to the "highlands" this term refers to the lower floors of the mountain where dwellings and food crops are located.
- ◇ "Lean period" : in this particular context, the expression refers to the period during which families, running out of food, have to buy cassava and maize (usually from November to March).

1_ Context, goals and methodology of the study

The aim of this section is to present the context of the study, the specific problems identified, the questions it seeks to answer and the methodology followed to achieve this result.

1.1. General context of the study

1.1.1. General presentation of Mount Namuli

Mount Namuli, altitude of 2.419 m (Timberlake et al., 2009) is the second highest peak of Mozambique. It is part of a massif associating other granite peaks located near the town of Gurué, in the province of Zambezia, in north-central Mozambique.

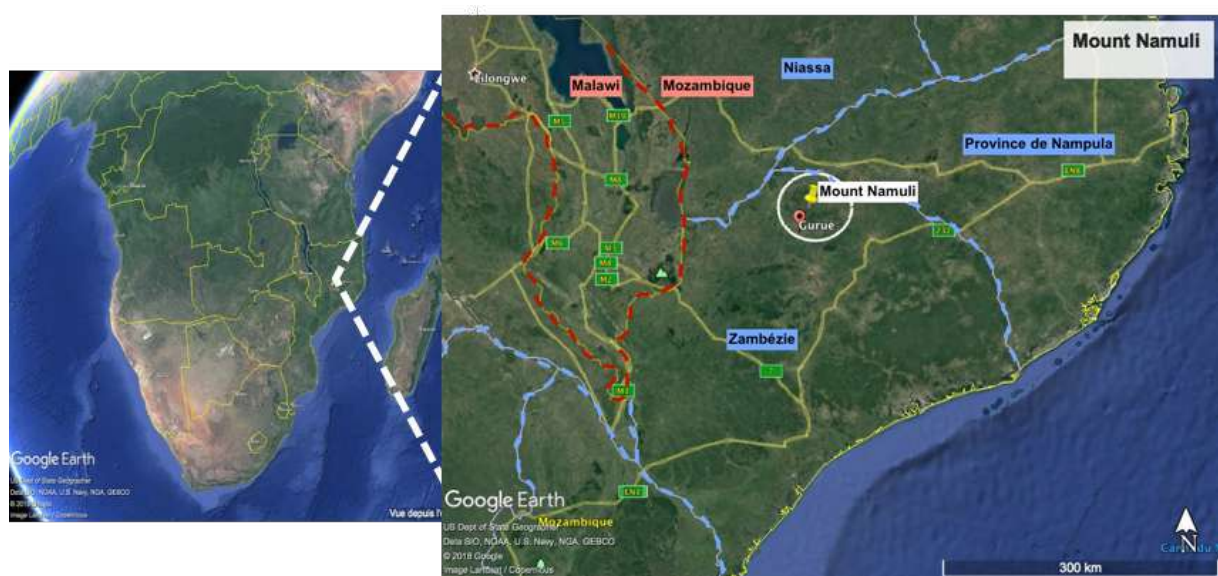


Figure 1 : Mount Namuli's geographic localization (at the scale of the southern African continent on the left, and of Northern Mozambique on the right), (adapted from Google Earth images)

Administratively, the Namuli massif is part of the district of Gurué. It is divided into eight “povoados” (local administrative division units) : Carico, Mucunha Sede, Mujaua, Nicaú, Nawitela, Murruí, Murabué, and Gurué Sede. Each “povoado” is then divided into “celulas” (for example Muiyarana, Muharana, Macuwa, Matxua, Marabué Sede, Chipi, Curuca and Rere for Murabué’s “povoado”) (see Figure 2).

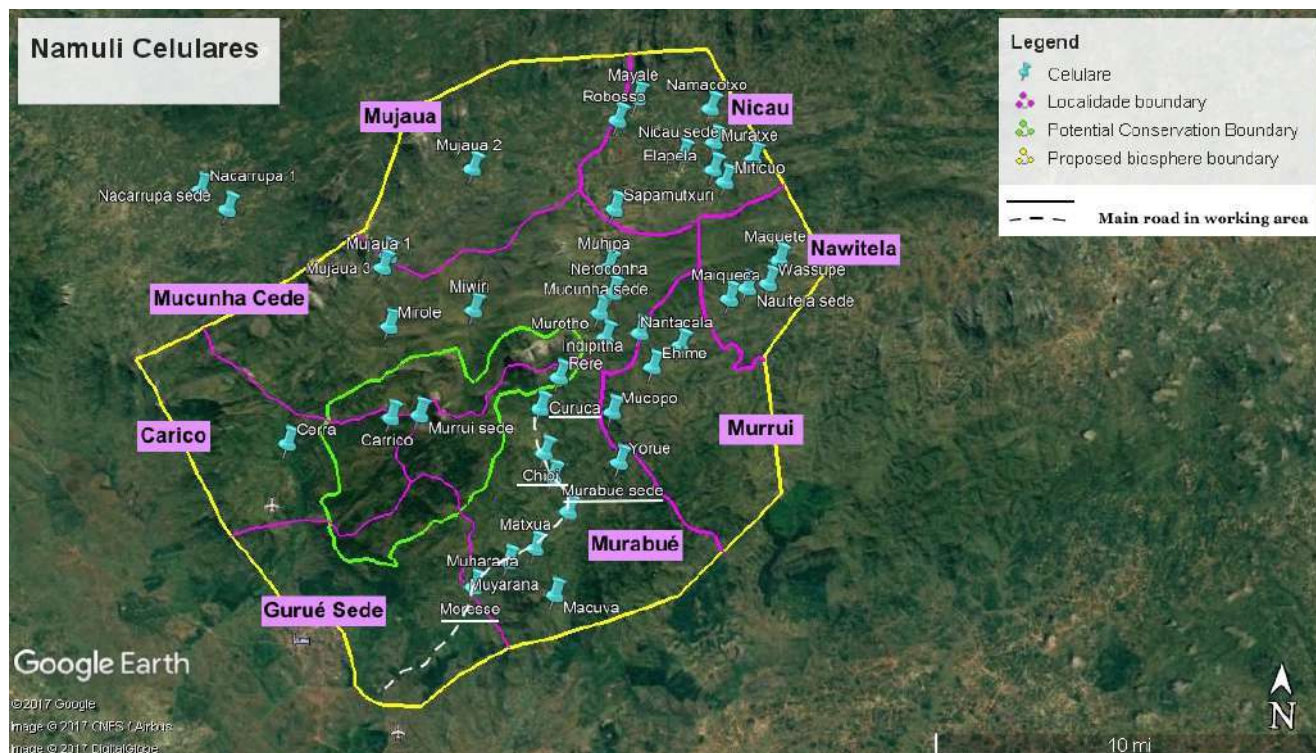


Figure 2 : Administrative division of the Namuli Mountain area. In pink the "povoados", in white the "celulas" (source: Legado, adapted from a Google Earth image).

Climatic data for the Namuli massif itself are not available. The only data available is for the town of Gurúé, which is located at the south of the area of study and at 750 meters above sea level. (see Figure 3). Considering that difference of altitude, the data presented in Figure 3 is not totally representative of the climate of the mountain (temperatures recorded in the city are significantly higher and rainfall significantly lower).

| | Janvier | Février | Mars | Avril | Mai | Juin | Juillet | Août | Septembre | Octobre | Novembre | Décembre |
|--------------------------------------|---------|---------|------|-------|------|------|---------|------|-----------|---------|----------|----------|
| Température moyenne (°C) | 24.1 | 24 | 23.3 | 22.3 | 20.3 | 18.1 | 18 | 19.3 | 22.5 | 24.8 | 24.7 | 24.6 |
| Température minimale moyenne (°C) | 18.5 | 18.5 | 18 | 17 | 14.7 | 12.3 | 12.4 | 12.9 | 15.1 | 17 | 17.6 | 18.4 |
| Température maximale (°C) | 29.8 | 29.6 | 28.7 | 27.6 | 26 | 23.9 | 23.6 | 25.7 | 29.9 | 32.7 | 31.9 | 30.8 |
| Précipitations (mm) | 323 | 323 | 355 | 167 | 54 | 48 | 37 | 37 | 20 | 40 | 169 | 284 |

Figure 3 : Rainfall and temperature data for Gurúé (source : climate-data.org)

Under a tropical climate, Gurúé is the coolest and rainiest region of Mozambique. The average annual temperature and rainfall are respectively 22.2 ° C and 1857 mm. The year is divided in a hot and rainy season and a dry and cool season. The hot and rainy season lasts from mid-October to mid-March. The average temperature is 24.3° C and the precipitation is above 300 mm over the three wettest months (January, February and March). In the cool and dry season, mean rainfall and temperatures are respectively 236 mm and 20° C. In June and July (the coldest months) the temperature drops below 12° C at night. In September (the driest month) there is only 20 mm of rain.

1.1.2. A key agricultural area

The cool and moist/humid climate of the slopes of Mount Namuli provides the region with exceptional agricultural potentialities”

The current agricultural landscape is inherited from the history of the region. Establishment of Portuguese tea plantations, implementation of grazing areas to the detriment of the long-established farmers that were forced to leave their family land, civil war, development and liberalization of trade and markets... all these elements have, over time, modified the agricultural activities and the distribution of rural populations.



Figure 4 : Gurué in the road network of northern Mozambique (adapted from a Google Maps image).

But beyond the benefits of the local market, the dynamism of local agriculture is strongly due to its connection to the market thanks to the proximity of the city of Gurué which is well connected to the capitals Quelimane and Nampula owing to the good concrete roads (Figure 4).

1.1.3. Majors environmental challenges

Mount Namuli has been of particular biological interest for many years. In fact, it supports extensive areas of forest and grasslands (Figure 5) where scientists recorded many rare and endemics species of plants, birds, mammals, reptiles and amphibians (Timberlake et al., 2009).



Figure 5 : The moist evergreen mountain forest (on the left side) and grasslands (on the right side), both in the highlands.

The moist evergreen mountain forest, commonly called “Murrettxa forest”¹, covers approximately 949 ha (Nitidæ, 2019) and is located on an 1700 meters altitude plateau (in dark green on Figure 6). It is an essential habitat for Namuli’s biodiversity. In addition, its trees, thanks to their root systems, help the infiltration of rainwater into the soil. So they play a key role in mitigating rainfall variations and regulating the flow of Licungo and Malema, two rivers that take their source in the mountain before traveling hundreds of kilometers across the country. Finally,

¹ It is actually a metonymy. For locals, the elevated plateau is divided into many areas. Each one has its own name. "Murrettxa" (name of a plant whose fiber is used to make traps for hunting) is regularly the specific name of a grassland area without trees. By extension, the term can today designate, in everyday language (and in this document), the altitude plateau and its forest as a whole.

trees play a key role in soil support (and thus in erosion prevention) and in the renewal of their fertility.

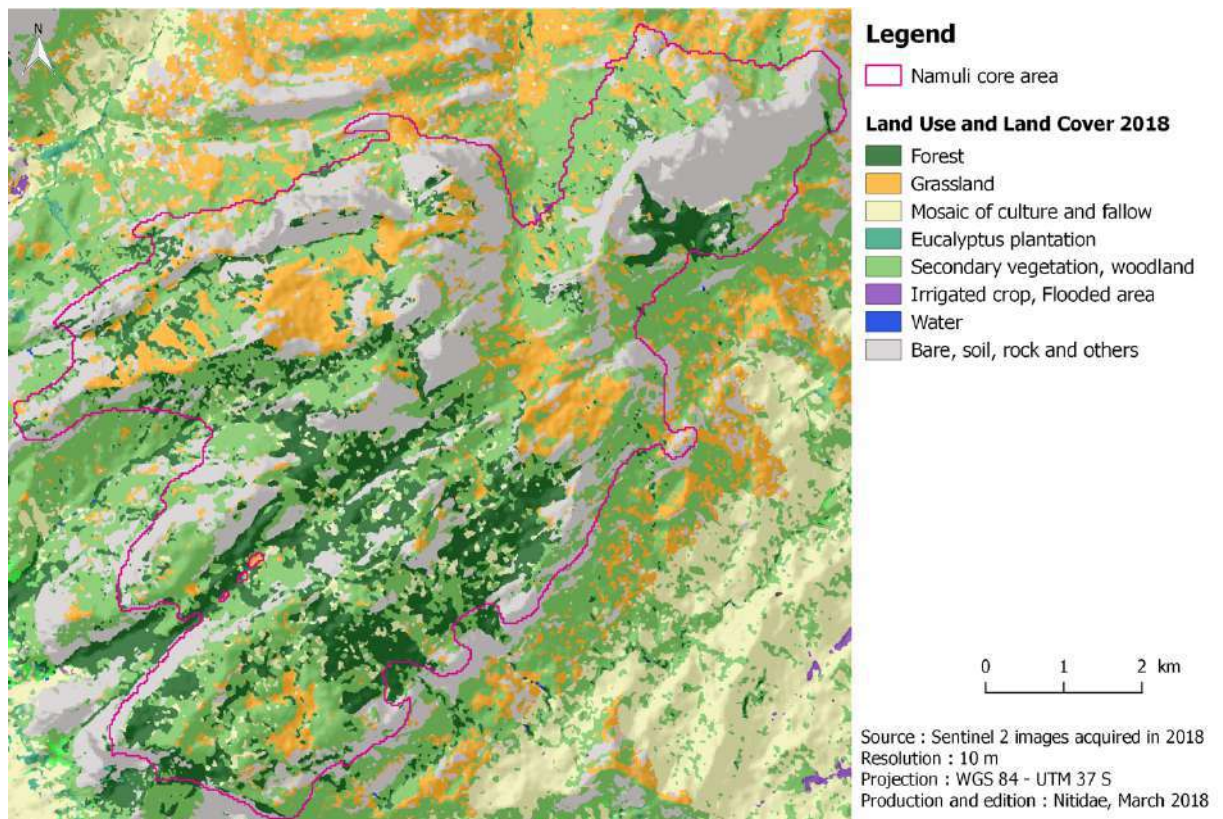


Figure 6 : Land Use and Land Cover in Namuli's core area, 2018 (Montfort, 2019).

Currently, growing population and expansion of rural markets have pushed local people to seek arable land further and further up the mountain side. Formerly set aside for hunting local communities began to use the highlands for agricultural purposes during the colonial era, especially to cultivate a potato called "Nacional" brought from Portugal by the settlers. In the 2000s, the cultivation of the potato in the highlands, encouraged by a dynamic market, exploded. Today, while agricultural practices are seriously threatening the balance of natural ecosystems, the potato has become the primary source of income for the majority of the local households.



Figure 7 : A potato plot in the Murrettxa forest (January, 2019).

In this context, the American NGO, Legado, has been acting in the area since 2015 in order to develop a “community-based sustainable management system around Mount Namuli” (source : Legado). This program is supposed to bring together many stakeholders : farmers, local leaders, scientists, conservation experts, and NGOs such as Lupa², and more recently Nitidæ.

² Associação para o Desenvolvimento Comunitário

The current challenge is to support local farmers to develop local agriculture and limit its impact on forest resources. To shed light on this question, Nitidæ commissioned this study.

1.2. Goals of this study

This study contributes to the conservation project of Mount Namuli forest and biodiversity, implemented in partnership with the Mozambican NGO LUPA, the US NGO Legado and Nitidæ. The objective of this study is to propose agricultural accompaniment measures adapted to local producers' strategies regarding the deforestation problematic, Nitidæ commissioned this agrarian diagnosis. Its specific goals are :

- 1/ **To improve our knowledge about current agricultural dynamics, including their impact on the evolving deforestation phenomenon.**
- 2/ **To anticipate the impacts that our intervention could have on agricultural and deforestation dynamics.**
- 3/ And finally to **propose agricultural accompaniment measures** (measures that aim to increase the standard of living of rural households) by specifying their predictable impact on the forest.

This work sheds light on deforestation issue through its link with agriculture. It aims to feed a more general reflection and search for solutions, which must be carried out on a territorial scale.

1.3. Methodology of work

This mission was accomplished through two stages : a field phase (from January the 3rd to April the 3rd 2019) and an analysis and writing phase (from April the 2nd to the date of submission of this report) in France. It was conducted by the agronomist Margaux Béringuier, supported by Nitidæ's multidisciplinary team (agronomy and agricultural value chain, landscape reading and cartography, rural development and regional planning, environment and conservation) and Lupa's technical team in the field.

1.3.1. The field phase

The specific objective of this first phase was to answer the following questions : Who are the farmers living on Mount Namuli ? What do they grow in their fields ? How and why ? More specifically, who are the farmers practicing agriculture in the highlands ? Why do they do it ? In response to what constraints and opportunities?

The study area was chosen taking into account the first information collected by Nitidæ's colleagues on the field as well as maps of deforestation (Hansen and al., 2013), fire frequencies (Nitidæ, 2018) and annual land productivity trends (Nitidæ, 2018b). It was decided to focus on the "celulas" of Muresse, Murabué Sede, Chipi and Curuca, where the farmers are currently growing on the Murretxa's plateau.

The agrarian system is considered as a dynamic entity, inherited from a history and in constant changes under the effects of external factors. To better understand these dynamics it was decided to investigate into the evolution of the farming practices and the re-investment strategies of the people involved (one week in Muresse, two weeks in Curuca and Chipi).

Finally, “focus groups”, bringing together between three and twelve farmers, were also organized to validate, with farmers, models based on qualitative comprehension and quantitative data collected during the field interviews.

◇ *3rd step : investigating into agricultural practices on the scale of the plot and enlarging the view a little further*

After two months of work, it was considered necessary to go down to the plot scale to better understand farmers' practices and identify their technical itineraries. Thus, interviews were held with farmers right on their plots. Each time, GPS readings, surface measurements were done as well as soil samplings sometimes.

A little work in Nicau (interviews with ten producers) was also carried out. Indeed, it is in this “celula” that the producers from Curuca, Chipi and Murabué Sede buy their sprouts of potato Nacional before planting them on the Murretxa plateau. Finally, producers who once lived in the mountains but bought a house in the town and now live there, were also met.

A total of one hundred and twenty two interviews were held with farmers (some people were seen twice). Figure 9 specifies the distribution of these interviews between the five “celulas” where the study was made. In addition, forty interviews were held with traders from Gurué, Nampula, Mocuba and Quelimane, including thirty tomato traders, following the path of their products from Murabué to Gurué, Murrimo, Namarripe as far as Magige along Cuamba’s road.

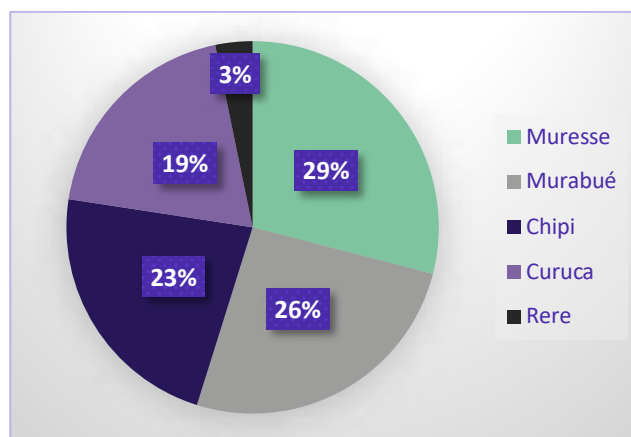


Figure 9 : Repartition of interviews between the “celulas” where the study was made.

1.3.2. The analysis phase

After the field work, an analysis of the data collected was necessary. It was done in France, in April and May. This paragraph presents the progress of the analysis work that will also be the plan followed in its restitution.

◇ *A typology of farmers*

Not all the producers in the region have the same history and means of production. Thus, they do not have the same practices, goals and strategies of evolution. With the data collected in the field, a work has been done to highlight these differences through a typology of farmers (with emphasis on those who practice agriculture in the highlands). The aim is to show that all the farmers cutting trees in there do not have the same goals, and are confronted to different constraints and opportunities.

In this typology, each type is a model, ie a simplified representation of reality. To present this typology to readers, specific analytical tools have been chosen, such as cash flow schedules or graphs representing the contribution of each crop/activity to the global income.

◇ *Confronting agricultural and deforestation dynamics*

It is essential to understand that a farm is a system where all the different activities are related to one another. Thus, the problem of agricultural deforestation may have several origins. That is why the problematic cannot be tackled by making only the potato cropping responsible for it. So, the link between the forest and each component of the production system must be questioned. This analysis led to identify "drivers" (an activity that in itself justifies cutting trees), "accelerators" (an activity that is not the first cause of deforestation but contributes positively to it) or "brakes" (an activity that has a downward impact) to deforestation.

Of course, the links between each activity and deforestation dynamics depend on the different farmers. This is why the reflexion is declined for the different profiles of producers identified.

◇ *Accompanying measures*

This work analysis allowed then to identify :

- Levers that could be used to encourage the development of agricultural activities in the area, called "accompaniment measures",
- The potential impacts that they would have on the forest (a relevant measure to improve the rural household incomes may lead to an intensification of deforestation when applied alone, without any measure of compensation),
- Concrete technical action tracks, related to production or markets, that would make it possible to concretize these measures, called "activities".

1.3.3. *Steps to follow*

After having identified accompaniment measures and proposed concrete activities some other steps need to be followed :

- Testing of the relevance of the propositions, on the ground, with the farmers : are they interested ? Do these propositions answer a problem they are facing ? What difficulties we didn't think about could it imply ?
- Making a feasibility study with the local teams,
- Sizing the accompaniment measures and...
- Moving on to their practical implementation

2_Picture of local agriculture

The purpose of this section is to give the reader all the keys to understand local agricultural dynamics related to deforestation.

2.1. Most important crops for farming households

What are the main crops and livestock activities in the region and what are their strategic importance for rural households?

2.1.1. Tuber crops

◇ Potato ("batata")

In the region, three varieties of potatoes are cultivated :

- The Nacional (or Portugal), locally also called "a preta" ("the dark one") brought by the Portuguese during the colonial period,
- The Angonha, "a vermelha" ("the red one"), a Mozambican variety,
- The CCM, "a branca" ("the white one") brought in the 90s by a religious delegation (the Conselho Cristiano Moçambicano).

By far the most cultivated variety is Angonha. Although smaller than the Nacional, it is appreciated for its taste but first and foremost it is better accessible to farmers. Indeed, they manage to reproduce their own sprouts from one year to another by doing an intermediate cycle in the living area (see Figure 10 below). This is not (yet) possible with the Nacional potato (see below). Producers have therefore to buy sprouts for planting it in the highlands. This causes heavy spendings between April and August, which limits the production capacity of many households. CCM is less popular among consumers and is sold at lower prices. Farmers, however, continue to cultivate it to spread the risks of production. The reproduction of sprouts from one year to another is also possible for this variety.

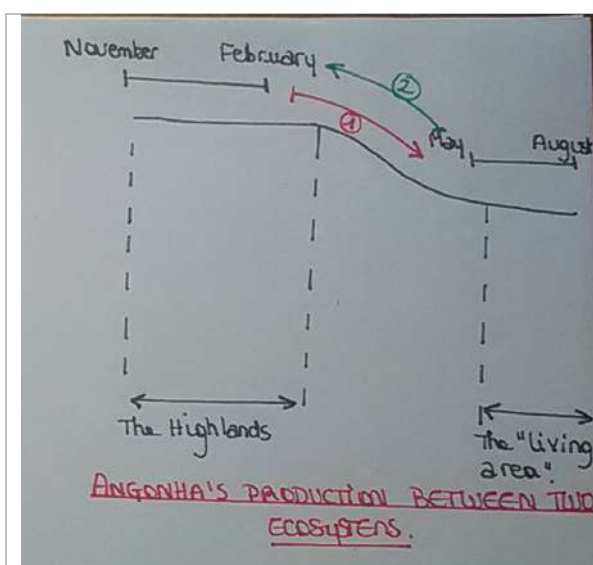


Figure 10 : Reproduction of Angonha sprouts between the living area and the highlands.

The most important cycle of potato Angonha for farmers is done during the rainy and hot season (from October- November to February) in the highlands. After harvesting, the producers keep the smaller sprouts for planting (**way 1**). But these sprouts cannot be kept until the next season. That is why farmers do an intermediary cropping cycle, in the living area. The smaller highland sprouts are planted there during the cold and dry season in May. Each plant produces, in the living area, more tubers but much smaller in size. They are harvested in August, kept for pre-germination, and planted again in October-November in the highlands (**way 2**).

Although grown in the highlands, these three potatoes should not be planted in the same agroecological environments or at the same time (see above). By cultivating different varieties, in different environments, at different dates, farmers help spread climate and economic risks (volatility of yields and market). If potato prices are locally relatively stable and the market relatively safe, crops are, however, at the mercy of climatic hazards, pests (especially *Agrotis ipsilon* locally called “Rilé” in Lomwé) and even thieves.

Potatoes, mainly those grown in the highlands, are the main cash crops for many³ local households. It represents between 25% and 50% of the annual activity income of households producing it. However, the levels of production can be very unequal between households, as well as evolution dynamics and productive strategies (see below). Potato pays more when it is sold in town (gains of about 9.1 Mt/kg, 0,14 US \$/kg⁴). But that means a motorcycle is required to transport the tubers (115 kg carried by trip for a man on average). Otherwise, many traders assault the mountain during the sales period (especially from December to January) to buy and resell the productions of those who cannot move.

◇ *Cassava (“mandioca”)*

Cassava is the basis of the local people diet. Planted (by cutting) in January (with sweet potato) or in August (possibly associated with maize and/or cowpea and/or *Mucuna Pruriens*) it can remain between eight months and two years in the soil, depending on the planted surface, the tuber yields, the maize production (another starchy basis of the diet), the number and the needs of the people eating in each household.

In the area, loamy and clayey soils are compacted by rainfalls. Under these conditions, the tubers hardly grow. In addition, many plots are infected with the cassava mosaic virus. Finally, between November and January, the soils become waterlogged and tubers sometimes become unfit for consumption. All of these factors (low yields and period of consumption) explain why many households have to buy the cassava they eat from November to March (lean season).



Figure 11 : Cassava infected with cassava viral virus, Chipi, March 2019.

◇ *Sweet potato (“batata doce”)*

Sweet potato is grown in the region almost exclusively for self-consumption. In fact, the local variety is not sellable on Gurué’s market, people prefer other varieties.

Planted (by cutting) from January, on ridges with cassava, it will be consumed from May for lunch or for morning snacks (“mata bicho”). The leaves, rich in vitamins and minerals, are also cooked to accompany cassava or corn flour.



Figure 12 : Sweet potato and cassava on ridges, Curuca, January 2019.

³ All households in Curuca and Chipi, about half of Murabué and Muresse households (rough approximation)

⁴ Exchange rate used (May 22, 2019) : 1 Mt = 0,0157 US \$

◇ *Yam and taro ("Nhame" and "Matumbe")*

From what people say, these two crops would not be traditional in the region. Farmers started growing them, for self-consumption and sale, after the civil war (in the 1990s). The main production area was Muresse. Until the 2000s, these crops grew under the banana trees, in the "baixas". The proximity with Gurué also facilitated access to market.

But for fifteen years, these crops have become scarcer and scarcer. Interviews conducted with farmers allowed to formulate various hypotheses to explain the causes of this rarefaction :

- The first explanation given by producers is the decline of soil fertility. This is very possible in a general context of increasing population density, intensification of land use (especially in Muresse), all with a climate that favors erosion. Moreover, instead of giving up these crops, many farmers (especially from Muresse) have relocated them to more fertile areas : the Murrexta's plateau, the middle floor of the Malema's plateau, or plots in the "pantano" of Murabué (see below). As many farmers complain about tuber rot on their plots of the living area, an increasing fungal and/or bacterial pressure in the soils may also be considered as an explanation.
- The closing of the market is another argument commonly given. It would be linked, in particular, to changes in consumption patterns in the city (more bread, less yam or taro). This hypothesis is also probable, but not entirely satisfactory. In fact, yam or taro producers interviewed said they keep on selling their production (although in smaller quantities). In addition, during the mission, traders rising on the way to Muresse to buy yam or taro were seen. Thus, the market does not seem to be so closed ... What is more likely is that yam and taro have much less advantages (as cash crops) than potato. Besides, is it a coincidence that the decline of one is concomitant with the explosion of the other ?
- Yam and taro are two cultures with very long cycles. They stay on the plots for a minimum of nine months and thus compete with other crops for space. The producers have also to wait a long time before getting his money. Finally, potato prices are more favorable. These factors may explain why yam and taro remained in the dietary habits of the families of the main old production area (Muresse) but were dethroned by the potato as a cash crop.

2.1.2. Cereals

◇ *Maize ("milho")*

Maize is the main local food crop after cassava, also prepared in the form of cooked flour balls served with "caril". The main crop cycle runs from August/September to February/March. Maize is often associated with tomatoes (if farmers have seeds). A second cycle is carried out during the dry season (from May to November). Maize is then combined with potatoes (sprouts for the highlands) and green cabbage. During the dry period, the quantities cultivated are often minor and corn is often eaten still fresh, before it has time to dry. But it helps to delay the arrival of the lean season.



Figure 13 : A farmer in his maize plot (tomato already harvested), Chipi, January 2019.

In the region, long-cycle local varieties are grown. Some producers are trying to seed hybrid varieties with shorter cycles. Seeds are bought in town. But in the specific climatic conditions of Mount Namuli, the potential of these genomes does not seem to be well expressed.

◇ Rice ("arroz")

Rainfed rice is cultivated on a small scale in the "baixas" or slopes below the Muyarana's pass (making the border between the "celulas" of Muresse and Murabué Sede). Above, in fact, temperatures are too cool to allow its growth. In the narrow baixas of Muresse, rice is grown in rotation with common beans. It is grown only for self-consumption.

◇ Sorghum ("mapira")

A few people continue sowing a local variety of dwarf sorghum called "Nageli" in Lomwé. Yet, before the war, sorghum was still the family's main food grain, ahead of maize. Here again the reasons for its gradual disappearance are still obscure. Farmers say that sufficient yields can only be obtained on young plots, slashed and burned the same year.



Figure 14 : A paddy field in Muresse, March 2019.



Figure 15 : A field of Nageli, Murabué Sede, February 2019.

2.1.3. Legumes

In the past, there were numerous varieties of beans cultivated on the slopes of Mount Namuli. Today this diversity has considerably reduced. Only common beans, cowpea and *Mucuna Pruriens* associated with cassava are found.

◇ *Common bean ("feijão Manteiga")*

The main bean cultivated in the region is the common bean, the market of which is stable and profitable. The main production areas are Mucunha Sede and Nicaú. In comparison, from Curuca to Muresse yields are very uncertain (land availability, soil fertility, exposure to wind and rain...). As a result, this crop does not come first in land allocation. But if the production of common beans is not considered as a safe bet, some farmers rely on its trade. In March, provided they have a motorbike and sufficient money, they make daily round trips between Mucunha Sede and Gurué to transport and sell nearly 150kg of beans (up to 1000Mt (15,75 US \$) of profit per day).



Figure 16 : A field of common bean invaded by weeds (filicophyta), Murabué Sede, January 2019.

2.1.4. Vegetables

◇ *Green cabbage (Brassica oleracea gelaga : "couve")*

This variety of cabbage, not very demanding in water (compared to headed cabbage, see below) is the main cash crop during the dry season. It is grown in combination with maize (the second cycle we refer to above) and potato (production of sprouts for the highlands). Sown in a nursery, this cabbage is regularly transplanted in May. For three months, it continuously produces leaves, which are cut as they grow. From May to August everyone is cultivating "couve", even children in small dedicated plots. It is sold in town (by foot or motorcycle), in bunches of 10 to 20 Mt.



Figure 17 : A field of green cabbage with potato (no maize on this plot), Chiipi, march 2019.



Figure 18 : A nursery of green cabbage, Murabué Sede, February 2019.

◇ *Headed cabbage (Brassica oleracea capitata : "repolho")*

This cabbage is more difficult to grow than the previous one, most of all because of its much higher water needs. Therefore, as mainly cultivated during the cool and dry season, it is mainly spread in the "pantano" of Murabué or the cool "baixas" in the highlands.

This crop is also difficult to access. Firstly cultivated varieties difficultly go to seed. Secondly seeds are rare and very expensive on the market. Thus, only some growers can afford to grow it. In addition, this cabbage is compact and heavy. Its transport is therefore much more difficult.

2.1.5. Fruits

◇ *Tomato ("tomate")*

Formerly only cultivated for self-consumption, its trade has been soaring since the early 2000s. The success of local tomato is linked to the originality of Namuli's climate. Indeed, in the mountain, the rains are much earlier. Thus, tomato production is possible between August and January, while it is impossible everywhere else because of the lack of water. As a consequence, between the end of November and the beginning of January, the producers of mount Namuli are the only ones in Zambezia and Nampula provinces to sell tomatoes, while the demand (festive season) is at its highest. As a result, buyers from all major cities around (Nampula, Mocuba, Quelimane ...) rush to the mountains at this period. Local production has evolved to gradually meet the demands of the market. For example enhanced self-pollinated varieties, appreciated by buyers, have substituted local ones.

Just after the Mugarana's pass, on the border between Muresse and Murabué, is the key place of the regional tomato trade : the "Eucalyptus' market". This former small hamlet welcomes today the buyers every year. They stay there a whole week, the time to gather the necessary stocks to make their commercial trips profitable. The producers, for their part, bring their tomatoes there as they are harvested.

A real economy is created every year around this annual meeting. As many people are gathered, many locals profit to sell small productions : "cabanga" (corn bran or sorghum fermented beverage), "caxaço" (distilled beverage made from sugar cane), bread ... Some of them also rent bamboo hangars to buyers, so they can stock their tomatoes and spend the nights. The market even has an authority to maintain order : three representatives in charge of resolution of conflicts.



Figure 19 : The "Eucalyptus' Market", Murabué, January 2019.

But, as with any perishable product, the local tomato market is very unstable. Prices vary day by day. In general, they are higher at the beginning of the season (November) and in January, when the rains damage the fruits in the fields. Although the tomato can yield, the market volatility makes it an unsecured cash crop (compared to the potato) for many farmers. But all of them keep on cultivating it to diversify their production, spread the risks and also because it brings money early (even before the Nacional), at the beginning of the lean season.

◇ *Pineapple ("ananas")*

Pineapple is not used to the cool climate of high altitude. Moreover this fruit is not easy to transport. For these two reasons (climate and proximity to the market), pineapple is only grown in Muresse (also in Murabué, but to a much smaller extent). In Muresse it grows in the light and dark soils of the slopes around the living area.

Local farmers grow a variety called “Lisboa” relatively low in sugar but very juicy. The pineapple plants usually produce one fruit per year (if all the offsets⁵ are cut) from the second year after planting. The size of the fruits is maximum during the first two seasons. The offsets are planted during the rainy season. The fruits begin to appear in August and ripen from October to January.

There are two distinct types of plantations in Muresse :

- Small plantations (0,1 to 0,3 ha), extensive in inputs and labour. Pineapple is grown for self-consumption and for daily sales. In fact, the crop has the enormous advantage of having a production spread over several months. Thus, the sale of fruits in town (5-10Mt depending on their size) makes it possible to meet the daily needs of families, including during the lean period. The plants are almost never renewed. Some still produce while they are over 20 years old.
- Bigger plantation (more than 0,3 ha) which are also more intensive in work and inputs. Hired labour is often needed during the harvest. Sales can be done in town or right on the plot when, in December and January, buyers go up to Muresse to buy pineapples (also priced at 5-10Mt). It seems that they sell the fruits mainly on the local market or in the province of Niassa, as Nampula’s and Quelimane’s markets are already supplied by other productive regions. The plants are renewed every three to five years and yields are therefore better.



Figure 20 : A field of pineapples with the tea plantation in the background, Muresse, January 2019.

◇ *Banana (“banana”)*

Banana grows everywhere in the region. But we find it especially in Muresse, closed to the urban market. Some banana systems are intensive in inputs (mainly weed killers or products to accelerate ripening). But the vast majority of families cultivate bananas on a small scale, in small plantations that surround houses or are dispatched in the agricultural landscape.

The banana is harvested almost all year round, helping families in their daily expenses. It’s mainly the women’s job to go down to town with baskets of bananas so that they can buy what they need with the money (salt, oil, soap...).

◇ *Avocado (“pera abacate”)*

Gurué area is the first avocado supplier of Zambezia. The local market is completely full between January and April. It attracts traders from Quelimane or Nampula. If at the beginning of the season, they can buy the fruits in town (Gurué is full of avocado trees), they must go gradually further and further, including in the locality of Mucunha.

⁵ The pineapple plant doesn't reproduce from seeds, but instead new plants form from the roots of the main plant or from the crown of the fruit. These small plants, growing off the main plant and which can then grow into mature plants are called “offsets”.

◇ « caxaço »

The "caxaço" is a distilled beverage made from sugar cane and corn bran. The first manufacturing region is Murabué. There is a small production in Muresse too, but on a smaller scale because the land planted with sugar cane are often smaller. However, in Chipi and Curuca, its manufacture is very limited for religious purposes.

The same as for the tomato, the "caxaço" benefits from the specific local climate, which allows cycles of production to be shifted and thus confers advantages on the markets. In fact, in the plain, the canes start producing in March, at the end of the rainy season (when the quantity of water contained in the sap falls down and the sugar concentration increases). Canes produce until drying in September, beginning of hot dry season after a few months of dry season. But in mount Namuli, the rains fall earlier and last longer. Producers can only start distilling in June. However, they can produce cane until February, as the canes do not dry. Thus, local yields are maximum in September when the prices begin to increase (see Figure 22).



Figure 21 : Alambic for the distillation of "caxaço", Murabué, February 2019.

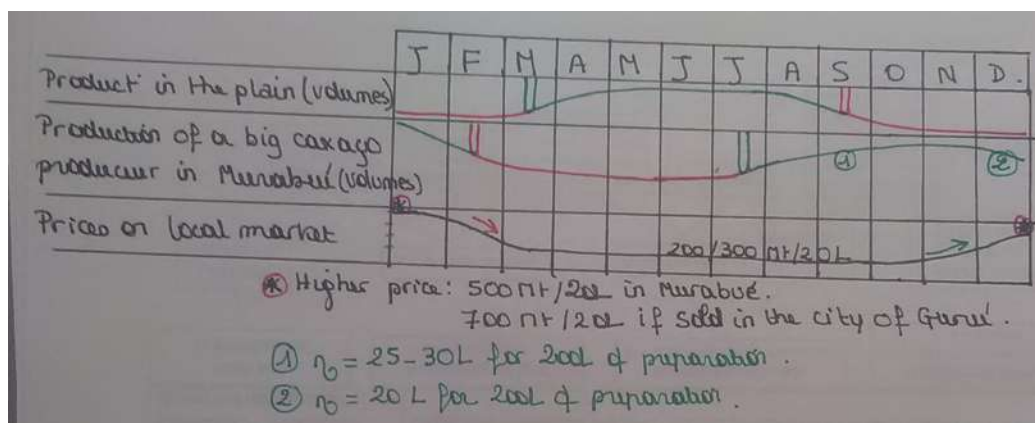


Figure 22 : Evolution of local caxaço production (difference between the plain area and mount Namuli) and prices.

Last but not least, there are among local producers of "caxaço", big differences in terms of production capacity (cane surfaces, material, punctual labor available), degree of specialization and productive strategies (see below).

Finally, producers who distill are very dependent on the wood resource that is becoming increasingly rare in the region. In Murabué, families mainly stock up along the Malema River where trees remain. Firewood collection is an activity undertaken by women.

◇ *Breeding*

The region is also a historical breeding area. Most of the farmers of Mount Namuli used to be breeders in the past. In the colonial period, each family used to raise a few goats (which were grazing in the highlands), chickens and pigs.

In the 1960s Portuguese settlers, who raised bovine cattle, established a large area of pasture in the mountain, depriving many families of their land. This cattle, like the tea-processing factories, later fell into the control of the independent state. After the civil war (and being heavily decimated by RENAMO soldiers or local populations for their survival), what was left of the cattle became the property of a private company. It was not until the late 1990s that, due to peasant protests, talks began between the population, the district governor and the breeding company. The cattle was finally moved to more remote and less populated areas. At all times, and still today (although on a smaller scale), it has employed many farmers in the region, to look after the animals.

Domestic livestock activities continued at the level of the whole population until the 2000s. In the 1990s, a foreign development project also distributed animals to many local households. Goats, in particular, used to graze in the highlands, still more occupied by hunters than by potato growers. In the 2000s, however, with the boom in potato cultivation on the Murretxa's plateau, tensions began to appear between pastoralists and farmers. At this period many animals were stolen. Facing this situation, many farmers sold their goats, re-investing the money earned in potato sprouts for highland planting.



Figure 23 : Photos of a local goatfold. On the left side : with a little horticultural plot just below. Above : seen from inside.

Today (apart from the few goats owned by some Muresse families and breeders on the Malema's plateau), there are only six goat breeders left between Murabué and Rere, who share three goatfolds. Each has an average of twenty-five animals including two billy-goats, between two and five years old. Females can be in heat twice a year. There are thus two birthing periods : one between January and March, and another between August and November. In the absence of treatments and vaccines, lambs mortality is very high. Lambs born in August are sold at the age of five months between 2000 and 5000 Mt. January lambs take much longer to grow and are usually sold at ten months. Goats are kept year-round in highland pastures (uncultivated areas) and sometimes sleep in raised goatfolds. This system makes it possible to collect the fèces which are then spread over small horticultural plots (the only ones where onions have been seen growing : see Figure 23).

2.1.6. Link between agricultural practices and agroecological environments

In this section, agroecological environments are sometimes referred to by their local names. The indications in italics and index refer to the months of sowing or plantation.

Local agriculture is exclusively rainfed. Therefore, the main factor determining the localization of agricultural activities in the landscape is the distribution of water. However, in this region, the constraints related to water are numerous, from the lack of it during the dry season, to its excess in the middle of the rainy season (remember that Namuli is the rainiest region of Mozambique). To describe the distribution of agricultural activities in the landscape we will also follow the water, going from the top of the slopes, down to the bottom of the valley. The purpose of Table 2 is to summarize the main ideas of the following paragraph. Figure 24 and Figure 25 above are also here to illustrate.

In the highest parts of the landscape are the sloping agricultural fields (with a drop of 10 to 40 meters per plot). They are particularly vulnerable to soil loss by erosion (because of rain and wind). Moreover, there is no possibility of retention or access to water nearby. As a result, farmers often cultivate on these plots the least delicate crops or those that need well-drained soils (cassava and common bean). They also make ridges in the direction of the slope to help the evacuation of surface waters. The same characteristics (relative soil unfertility and unavailability of water) make these plots not very suitable for market gardening.

Down the slopes, along the water streams are "baixas", lands without level difference. In these lands, the conditions of access to water are very different. A stream always runs nearby all year long or at least from November to July. At the bottom of the valleys, these lands benefit from the surface waters as well as from the erosion products from the slopes nearby. Thus, the soils are more loaded with organic matter and have a better water retention capacity. This makes "baixas" the ideal lands for off-season crops (green cabbage, potato, maize). In high season, they also allow early planting compared to the arrival of rains (tomato transplanted in August for example), advantageous scenario for market access and crop protection.

| Agroecological areas | Agroecological conditions | Crop systems observed |
|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| "As elevações" ("Whothithimanavó" in Lomwé) | The slopes Height difference Erosion (rain and wind) No proximity to a source of water or possibility of retention. | <ul style="list-style-type: none"> - (Common bean + maize)^{November} - (Cassava + maize (+cow bean and/or <i>Mucuna pruriens</i>))^{August} - (Cassava + sweet potato)^{January} - Pineapple (in Muresse) |
| Intermediate zone | Intermediate conditions | <ul style="list-style-type: none"> - (Tomato + maize)^{September} - (Maize + potato + green cabbage)^{May} - (Common bean + maize)^{November} |
| "As baixas" ("Whohithithimanavó" in Lomwé) | No level difference Along the thalwegs Presence of a nearby river Relative humidity and fertility of soils | <ul style="list-style-type: none"> - (Tomato + maize)^{August} - (Maize + potato + green cabbage)^{May} |
| "Os pantanos" ("Intxapó" in Lomwé) | Flooded area Fertile soils | <ul style="list-style-type: none"> - (Maize + tomato (+cabbage))^{July/August} |
| Rivers banks | Steep banks, rocky outcrops | <ul style="list-style-type: none"> - Banana trees |

Table 2 : Summary of the link between crop systems and agroecological environments.

In the mountain there are also, although few, flooded areas, where the soils are waterlogged all year round. Locally called “pantano”, they present particular opportunities and constraints for agricultural practices. For example, before cultivating, the drainage of the plots is necessary. Therefore farmers dig small canals with hoes about two months before sowing. Furthermore, ambient humidity is often responsible for micro-climate. The cold often prevents the cultivation in the dry season before July.

Finally, there are steep slopes and rock outcroppings on the landscape where nothing grows, except for some banana trees when a stream flows nearby.

A farmer's land is often divided into many small plots, scattered throughout the landscape. The more diverse is the covered environment, the more diverse the crop production systems are. The plots located in “baixas” have the highest added value.

In the highlands there is also a diversity of agro-ecological environments to which farmers adapt their practices. As the potato Nacional fears rains (which begin to be strong in November : Figure 3), it is the first potato to be planted, in August. To respond to the water needs, farmers grow it in “baixas”, where the soil, despite the dry season remains wet. The anticipation of the cycle allows also to harvest in December, and enjoy the best prices. Angonha and CCM, more moisture-resistant and heat-sensitive, are planted later, with the first true rains. In general, producers make two plantations : one in October and one in November. Thus the harvest is spread from January to March. To facilitate the evacuation of rainwater on the plots, these potatoes are planted on the “elevações”.

Figure 24 and Figure 25 illustrate the distribution of activities in the landscape.

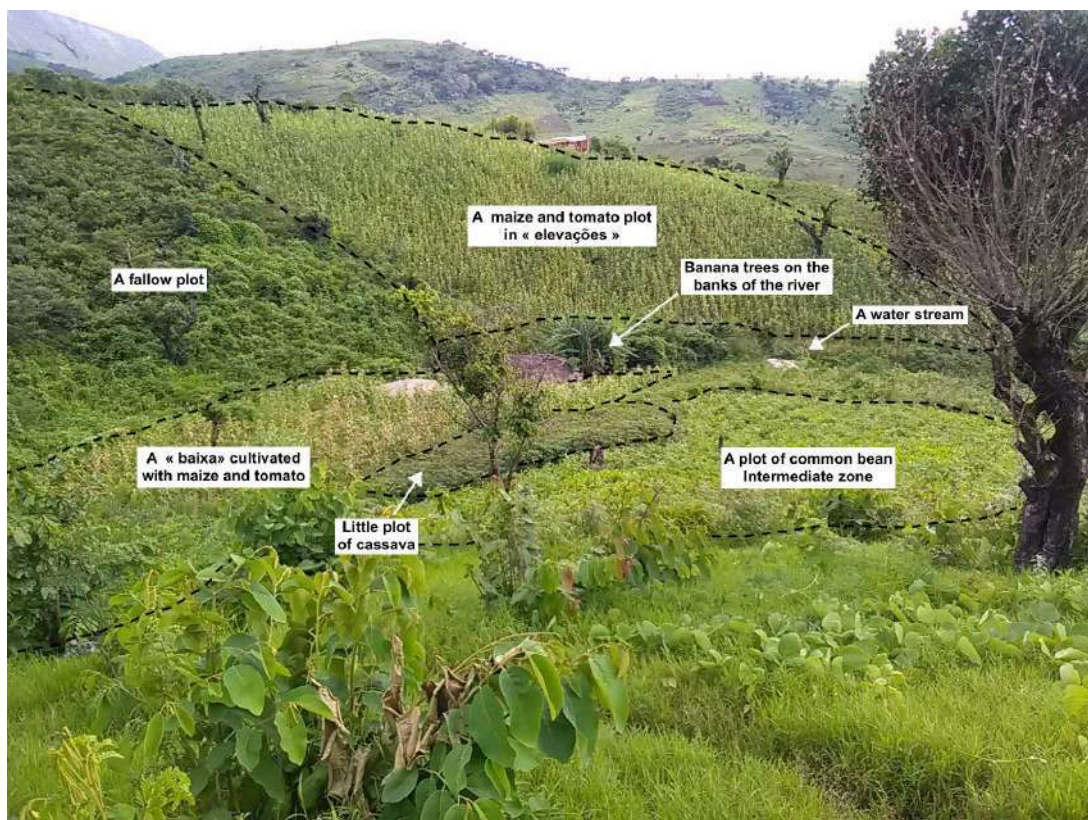


Figure 24 : Illustration of the distribution of agricultural activities in the landscape, Curuca, January 2019.

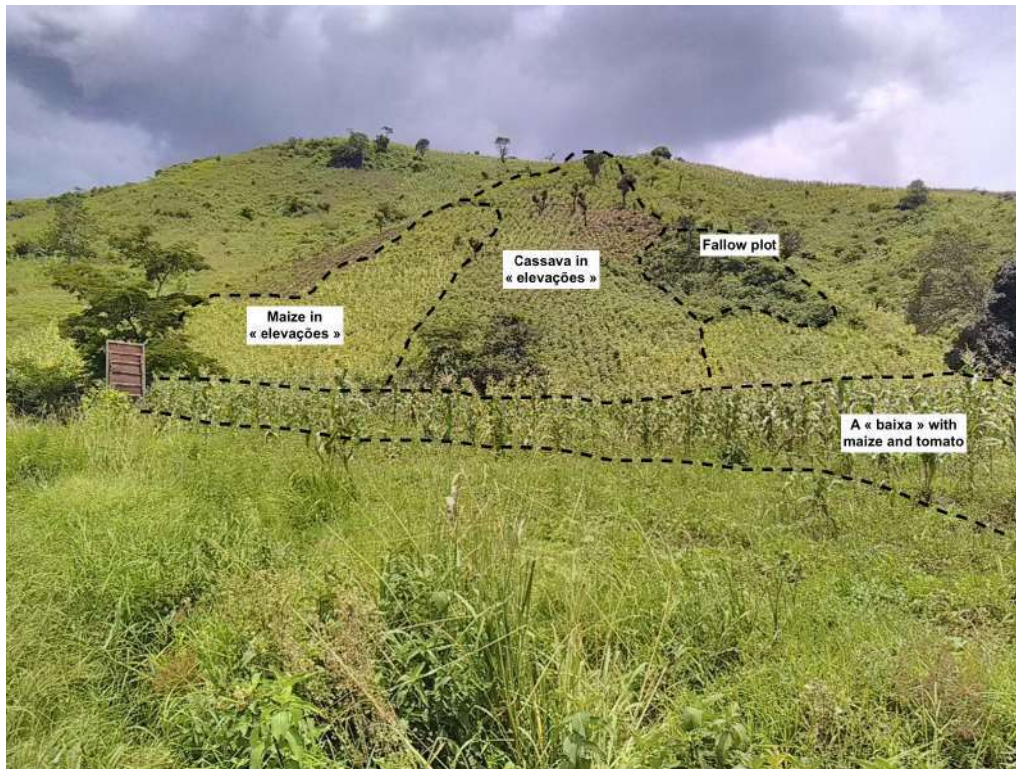


Figure 25 : Illustration of the distribution of agricultural activities in the landscape, banks of Malema's river, January 2019

Moreover, each “celula” presents sometimes specific conditions that explain particular agricultural orientations :

2.1.7. Specific agroecological and socioeconomic environments of each « celula »

◇ Muresse

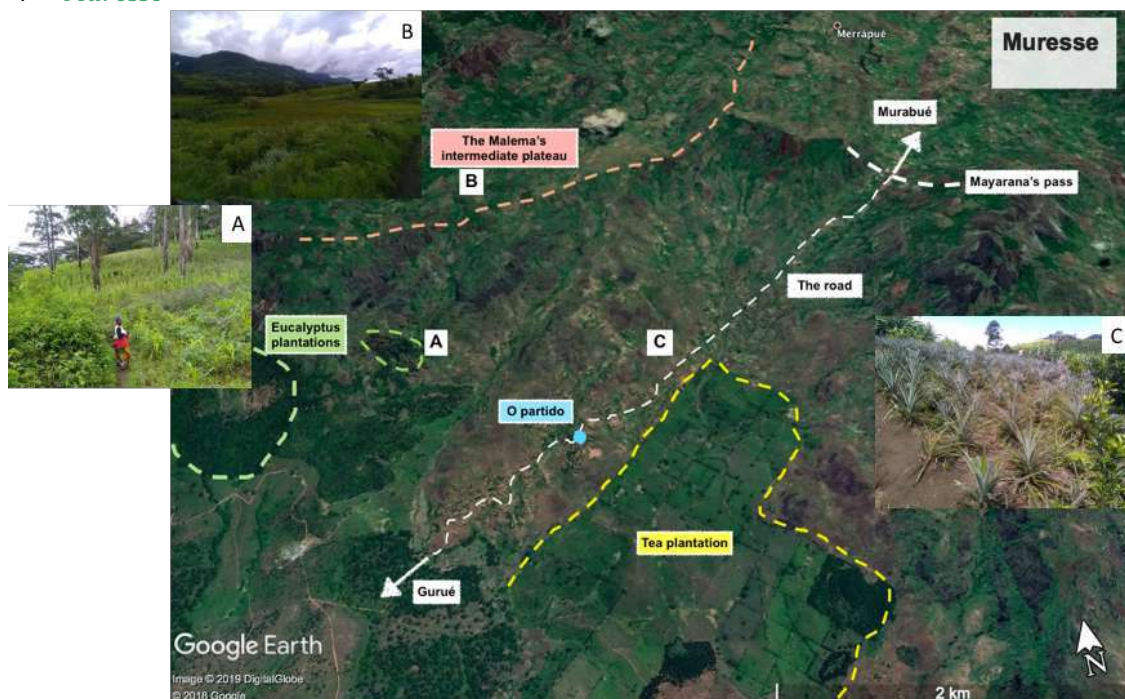


Figure 26 : Aerial photo of Muresse (adapted from a Google Earth image)

Muresse is the closest “celula” to the city of Gurué and therefore to the market. Buyers can even ride trucks to the “partido” level (see on Figure 26). This facilitated transport of goods explains why fruit crops are particularly developed : banana, avocado and pineapple which grows on slopes with light and dark soils (picture C).

Muresse is located on the edge of the tea plantation (“UP 5⁶”). It belongs today to a private company which employs many members (mainly men but sometimes even women) of the local households. The most common work consists in harvesting tea leaves. Harvesters mainly work all year long and are paid according to what they pick.

There are still some Eucalyptus plantations around the tea plantation. Since the colonial era these trees have been used to feed the leaf dryers. Today, the pressure for land use is such that some farmers have opened fields in these Eucalyptus plantations, improvising agroforestry systems (picture A). They are now tolerated by the tea company provided they control fires.

Muresse households, because of very strong local land constraints, have the most fragmented agricultural land of the region. Many grow their maize, cassava, tomato and potato far away from their houses, in old pasture areas that where progressively liberated after the war. It is the case of the main plain of Murabué (which returned to farmers in the late 90s) or the Malema plateau (liberated earlier, at the end of the civil war). Malema’s plateau (photo B) is named after the river that has it source there. It is an intermediate floor between the living area and the Murretxa’s forest.

◇ Murabué

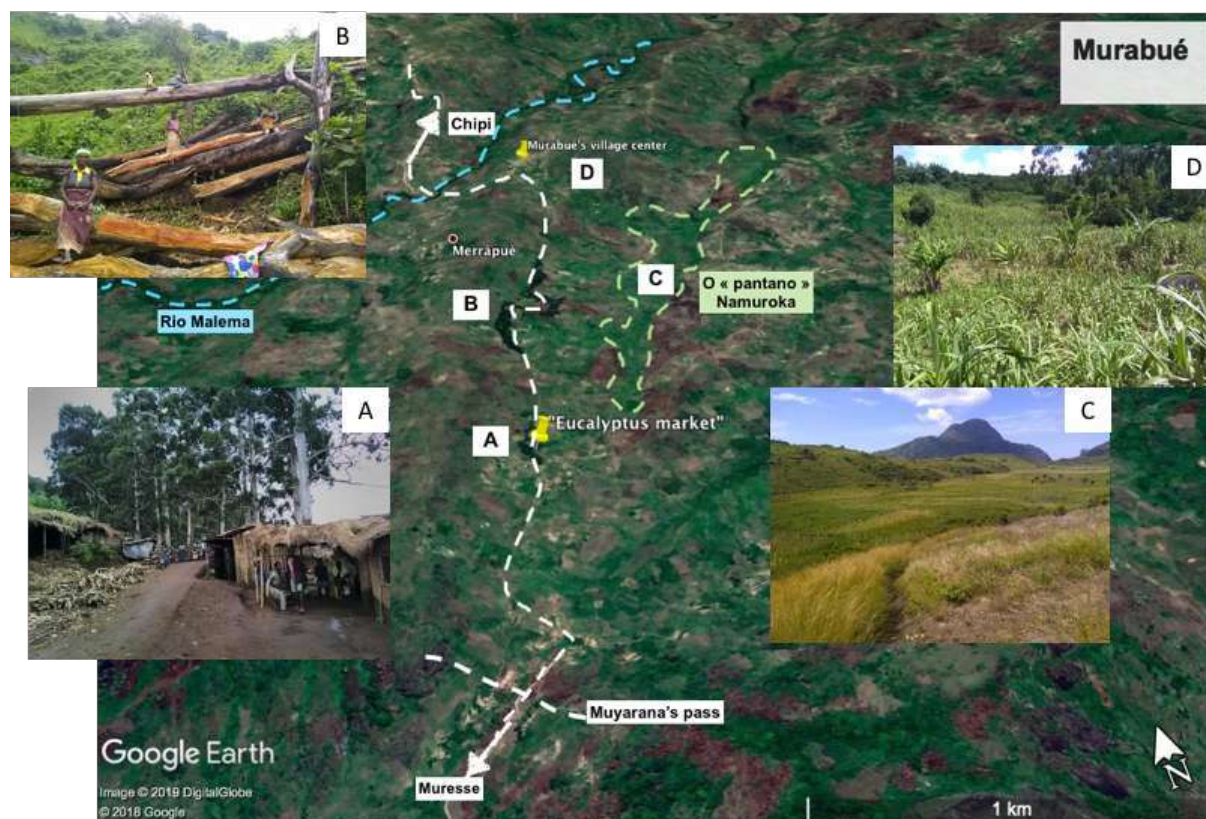


Figure 27 : Aerial photo of Murabué (adapted from a Google Earth image).

⁶ “Unidade de Produção 5” : “fifth production unit”

Murabué is located just after the Muyarana pass, on the top of Muresse. On the road, there is the “Eucalyptus’ market”, major commercial crossroad for local tomato (photo A). Every year, buyers from the provinces of Zambezia and Nampula stay there weeks long to buy tomatoes that cannot be found elsewhere. The market was named after the colonial eucalyptus that surrounds it. These trees are still found further along the road. Since wood resources are scarce, women take advantage of the trunks of trees that fell during thunderstorms (photo B).

Murabué is also characterized by a specific agroecological zone : a “pantano” called “Namuroka” (photo C). It is a flooded area where moisture is responsible for a microclimate. During the dry season it can freeze, so that it is not cultivable before July. The crop cycles are therefore a little different there. Drainage arrangements (“valetas”) are also necessary. Many farmers from Muresse, because of the lack of land in their “celula”, have their corn and tomato plots in Namuroka.

Murabué’s farmers are the first producers of sugar cane of the region (photo D). This crop is mainly grown to make “caxaço”, a distilled beverage which pays more. Firstly, unlike Curuca and Chipi, Murabué is predominantly Catholic. Thus, the consumption and manufacture of “caxaço” is not prohibited. Secondly, unlike Muresse, the valley in Murabué is open and the baixas are relatively wide. So, there is no space constraints to grow cane.

◇ Chipi

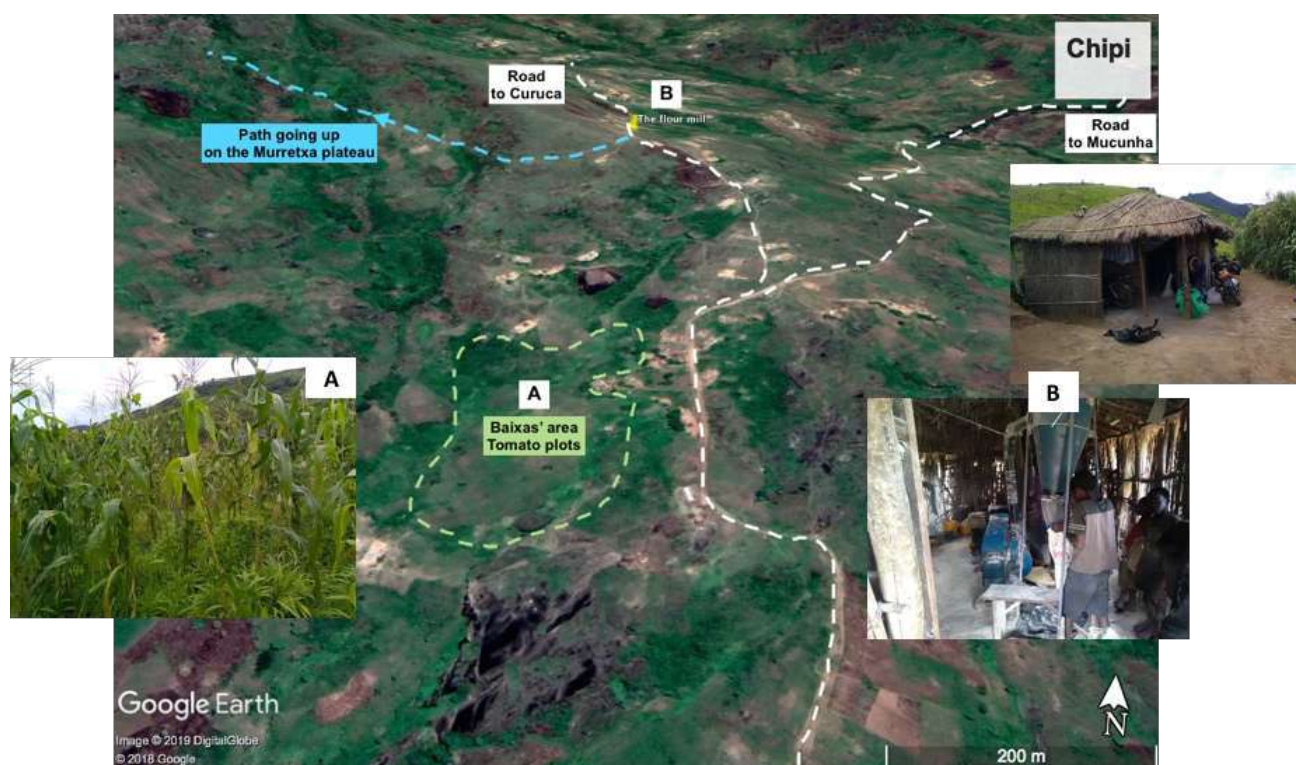


Figure 28 : Aerial photo of Chipi (adapted from a Google Earth image).

As we get closer to the Murrettxa, the proportion of potato producers among the population increases considerably. In Chipi there is only one farmer who has no fields in the highlands. However, unlike to Curuca, the valley bottom in Chipi is relatively wide. The river, fed by high-altitude streams, has also a steady flow. Thus, there are many more plots suitable for horticultural

crops (such as tomato) or maize (photo A). Early seedling (in August for tomato for example) are also possible without major risk of dried-up crops.

Chipi is under the authority of the same communitarian leader as Curuca. The two “celulas” share a school and a flour mill (photo B) located on their border and that is also used by the inhabitants of Murabué since their own mill broke down.



Figure 29 : Aerial photo of Curuca (adapted from a Google Earth image).

Curuca is the closest “celula” to the Murretxa (see the path above). Everyone there (except the elderly) grows potatoes in the highlands. This is where the potato cropping began, especially encouraged by the Portuguese. The dependence of the agricultural households on highlands crops is reinforced by hostile conditions in the living area. In fact Curuca is the most windy and rainy area among the four visited. The bottom of the valley is also much narrower, and water supply by streams not constant throughout the year. The area is therefore less suitable for growing tomatoes, corn, or beans.

2.1.8. Agricultural seasons

Table 3 presents the local crop calendar for the main annual crops depending on where they grow. Each production circle is framed by two symbols. They present the constraints that prevent farmers from planting/sowing earlier or later.
































| | |  | | |  | | | | |  | | | |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---|---|-------------------------------------------------------------------------------------|---|---|---|---|-------------------------------------------------------------------------------------|---|---|---|
| Crops | Growing environments | J | F | M | A | M | J | J | A | S | O | N | D |
| Potato Nacional | ? Baixa in the highlands  | | | | | | | | P | | | | H |
| Potato Angonha + CCM |  Elevação in the highlands  | | H | H | | | | | | | P | P | |
| All potatoes |  Living area  | | | | | P | | | H | | | | |
| Tomato |  Pantano  | | | | | N | N | T | | | H | H | |
| | ? Baixa  | | | | | ? | N | N | T | | | H | H |
| |  Elevação  | H | | | | | | P | P | T | | | H |
| Green cabbage |  Pantano  | | | | | N | N | T | H | H | H | ? | |
| | ? Baixa/elevação ? | | | N | N | T | H | H | H | | | | |
| Headed cabbage |  Pantano ? | | | | | | | S | | | H | H | |
| | ? Baixa ? | | | | | S | | | H | H | | | |
| Maize |  Baixa rainy season  | | H | H | | | | | S | | | | |
| |  Elevação rainy season  | H | H | | | | | | | S | | | |
| |  Baixa/elevação dry season  | | | | | S | | | | | | H | H |
| Common bean |  Baixa  | | H | | | | | | | | S | | |
| |  Elevação  | | | H | | | | | | | | S | |
| Sweet potato | ? Elevação ? | C | | | | H | H | | | | | | |
| Sugar cane | Baixas | P+H | H | | | | | H | H | H | H | H | H |

Table 3 : Cycles of the main annual crops (N = "Nursery", S = "Seedling", P = "Plantation", C = "Cutting", H = "Harvest").

| | | | |
|-------------------------------------------------------------------------------------|---------------|-------------------------------------------------------------------------------------|--------------|
|  | Drought |  | Too hot |
|  | Too much rain |  | Too cold |
|  | Flooded soils | ? | Undetermined |

After this brief description of cropping and breeding systems as well as their links with the agroecological environments and the seasons, it is time to take a closer look at who practices them : the farmers.

2.2. Who are the farmers of Mount Namuli ?

The objective of this section is to present the diversity of the local production systems through a typology. It consists of different profiles, model portraits of producers, among whom some cultivate potatoes in the highlands and others do not.

2.2.1. Who produces Irish potato in higher altitude ?

In this study, four profiles of farmers cultivating in the highlands were identified : the "small farmer with a diversified self-subsistence strategy", the "large potato producer in the

highlands”, the “innovative farmer living from tomato” and finally the “innovative farmer living from the forest”.

◇ *The small farmer with a diversified self-subsistence strategy*

It is a small farmer whose level of production hardly allows the subsistence of the family and the renewal of production means. This is the most vulnerable profile. The main factors which limit the development of the production system are agricultural labour (only carried out by the members of the household), investment capacity in inputs (seeds, potato sprouts, phytosanitary products...) and access to market (no motorized means of transport).

The producer adopts a diversification strategy in order to spread agroclimatic risks, agricultural work and incomes throughout the year. He produces a little bit of everything (including common bean, crop which is often set aside) in small quantities, even if yields and markets are instable (sign of his vulnerability)⁷. Farm income is balanced between the highlands and the living area (see the graph over-head). The farmer optimizes his use of the ecosystems.

Nacional and Angonha potatoes, tomato and common bean allow to meet the needs of the family during the lean season from October to March (in gray color on the cash flow schedule). During the dry season, there is no lack of maize (harvested in March) or cassava but the household is running out of cash to buy basic supplements (salt, oil, soap ...). They can only rely on leafy vegetables sales (green cabbage mainly because of the lack of seeds of headed cabbage). In addition, the farmer makes daily paid works between May and July, to help clear plots of other wealthier farmers , in the highlands or the living zone.

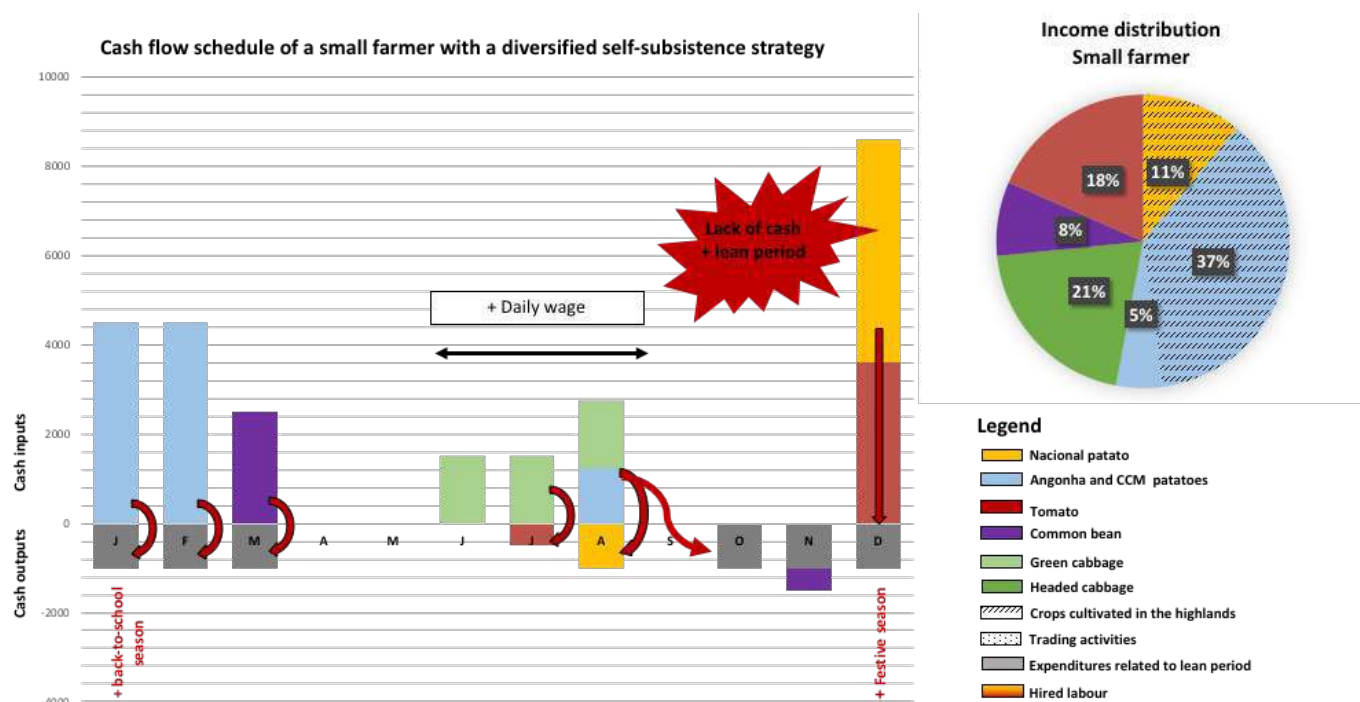


Figure 30 : Description of the small farmer with a diversified self-subsistence strategy.

⁷ In Murrabué and Muresse, the farmer can often count on additional little cash crops, such as pineapple, banana or sugar cane transformed in “caxaço”.

Agricultural labour force is a limited (and thus limiting) production factor. The farmer and his wife often fall behind with their own plots, which has repercussions on his yields. To make the most of their work, they usually add cassava to all "classic" crop associations. Once again, it leads to yield reduction, if crops are considered separately from each other. For the same purpose, the farmer often associates highland potato with maize and/or common bean for his own consumption.

After daily expenses, farmer's income is regularly reinvested in potato cropping. Therefore, the production system evolves towards an intensification of potato production in the highlands (see next profile). In Murrabué, however, potato producers sometimes specialize in "caxaço" production (a less painful and income-generating alternative) at the expense of potato (and potentially tomato) production (the competition of work schedules).

◇ The large potato producer in the highlands

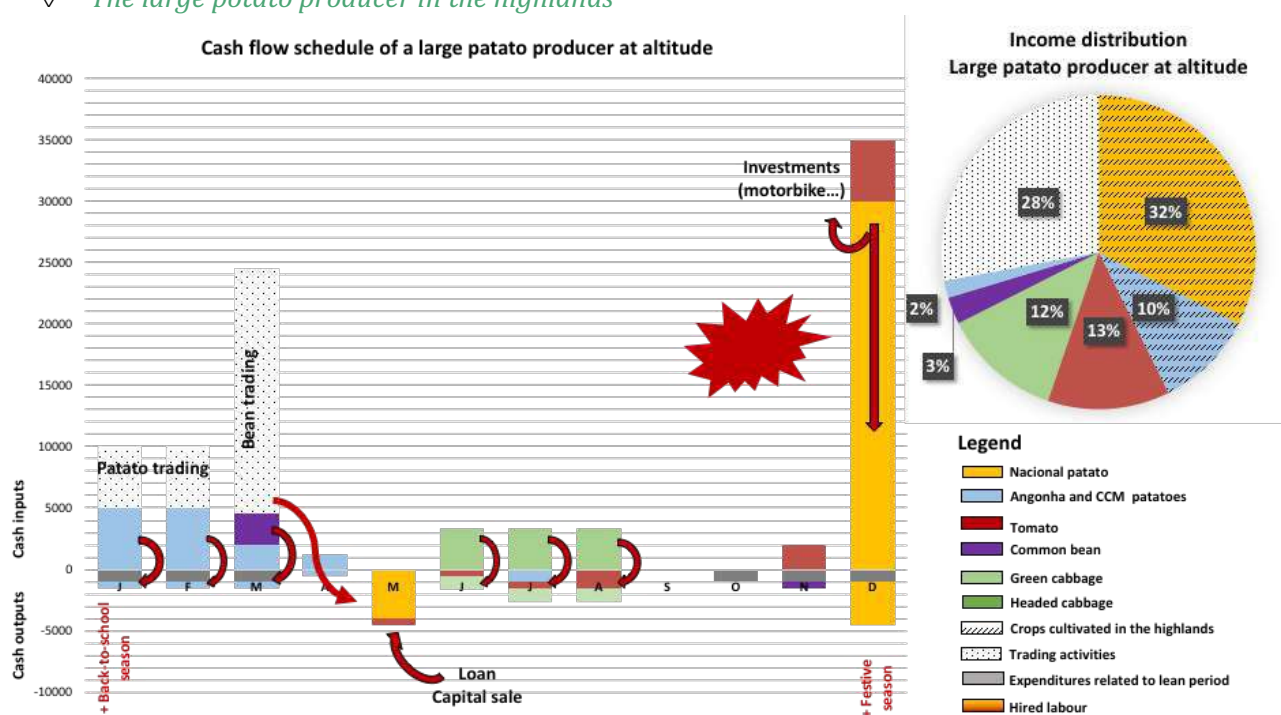


Figure 31 : Description of the large potato producer in the highlands.

Unlike the previous profile, this type of farmer has the means to intensify his crops systems in labor and inputs, particularly to produce potato Nacional. Every year, the farmer invests heavily in Nacional's sprouts (about 150 kg, three to four times more than for the previous profile) he buys in Mucunha Sede or Nicau between May and July. In June/July, he also manages the competition for the allocation of work between plots in highlands and in the living area by employing seasonal workers. Delegating the cleaning of tomato plots to salaried workers, he works personally in his highlands' plots of potatoes (its strategic priority) even if the labour is a much harder. Thus, he can both plant larger areas of potatoes and ensure a small tomato production, without delaying its seedlings. Work intensification is also visible at the commercialization stage: the farmer takes advantage of his motorcycle to sell his potato in town,

and thus achieve a better price (a margin of approximately 10Mt/kg (0,16⁸ US\$) for Nacional potato).

This production system mainly depends on potato cropping in the highlands (45% of activity income), and is consequently, one of the most vulnerable. Potato is given the priority for the allocation of the means of production. In comparison, other crops (like tomato) are just considered as subsistence crops.

Apart from agriculture, the farmer also carries out trading activities (thanks to his motorcycle and a more substantial cash flows), common bean trading between Mucunha Sede (or Nicaú) and Gurué in March (around 30% of his annual activity income).

These systems evolve towards an increasing intensification of potato cropping. Once they reach economic stability, producers begin to remove the obstacles specific to others crops in order to diversify their production. Thus, they become less vulnerable but not necessarily less dependent on the forest (see below).

◇ *The innovative farmer living from tomato*

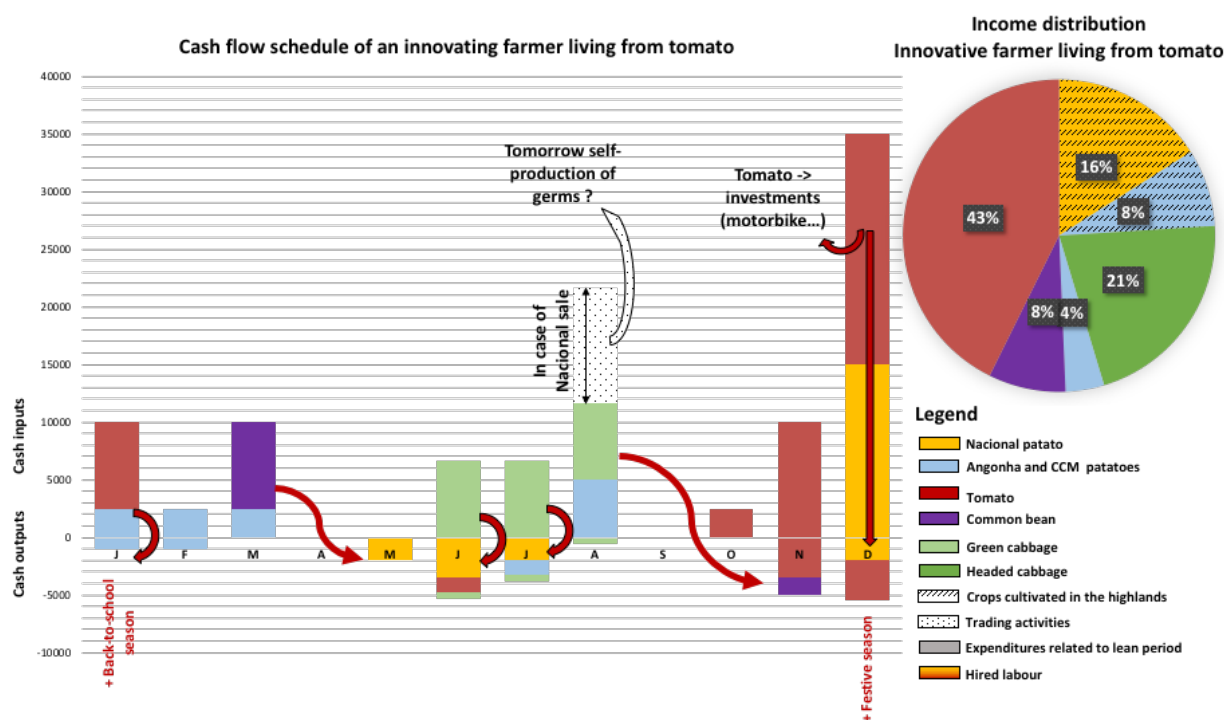


Figure 32 : Description of the innovative farmer living from tomato.

This farmer distinguishes himself by the quality of its agricultural land in the living area. In this context, the quality of the land is linked to its size (the larger the area available, the longer the fallow period and the better the fertility of the soil) and its localization in the landscape (better production in "baixas" as seen before). Therefore this profile is most of all represented in Chipi (wider bottom valley).

Often enriched by potato, the producer reinvests in tomato production. Unlike the previous profile, he employs seasonal workers to work in the highlands, while he personally works in his tomato plots (the heart of his production strategy), a far less arduous work. He thus manages to

⁸ 1Mt = 0,0161 US \$

valorize his large agricultural land. The intensification of the tomato crop system is also done through inputs : the farmer regularly invests in enhanced seeds (open-pollination varieties like "Rio Grande", "Roma", "Italiana", "Cal J") bought in town and in phytosanitary products (to fight against *Agrotis ipsilon*). Through these investments, in addition to the spreading of the seedlings, the producer manages to obtain better yields.

As he produces tomato in larger volumes, and as the market is the main cause of volatility of the profitability of the crop, the farmer has to innovate in its commercial strategy. He creates trade agreements with big city negotiators in order to increase his margin on prices. Thus, when volatility of yields and prices are mastered, tomato becomes a real source of income, which can spread throughout the lean season when spreading the seedlings (see the cash flow schedule on Figure 32). In this case tomato becomes THE first cash crop of the production system on which the farmer aims to make investments (including a motorcycle). Last but not least, as the tomato is associated with corn, the household suffers only from a very short lean period.

But tomato crop system is not the only one to be enhanced. Availability of land and labor and access to inputs (seeds, pesticides...) also allows the intensification of production of common bean and green cabbage (see the cash flow schedule above). Thus, 75% of the activity income is achieved in the living area. Therefore this type of farmer is the least dependent on forest resources⁹. But this production model is far from being accessible to all. A land potential in the living area is necessary. Only the families who were the first to set up locally have this privilege.

As long as he has free access to highlands, there is only one step for this farmer to diversify his production for market purposes, using its resources in hired labour. It would so move towards the following profile (see below).

◇ *The innovative farmer living from forest*

Unlike the previous profile, this producer does not necessarily have large agricultural land in the living area. It explains why this last profile is particularly present in Muresse, where the land pressure is very strong, or among families of Curuca who were displaced in the stony areas when Portuguese raised bovine cattle.

This is once again an innovative profile. But unlike the "tomato producer", the farmer does not depend on the market to sell his production, but produces accordingly to the market. In other words, he starts by identifying outlets in order to define his crop rotations and calendars (production of cabbage in off-season for example). As a land reserve which allows a particular seasoning of the productions, Murrexta's plateau is widely exploited to serve this "market strategy". In addition to the traditional Nacional, Angonha and CCM potatoes, the farmer grows, in the forest, maize, common bean, headed and green cabbages during the off-season as well as his sprouts of potato. If the diversification of production in the highlands makes the production system less fragile, it also increases its dependence on the forest (more than 50% of the activity income). This type of farmer also cultivates twice as many plots as the others each year in the highlands, and thus exerts more pressure on the ecosystem.

Cultivation of highland fields is almost entirely ensured by hired labour that clears the plots, digs ridges, plants, sows and harvests. At the cost of heavy expenses (see Figure 33) the farmer thus spares an arduous work. The time saved is invested in trade. Moreover, the producer has the

⁹ As all the producers who have a motorcycle, he also trades potato (unrated income) during the festive period, but not common bean, as he is occupied in his own plots

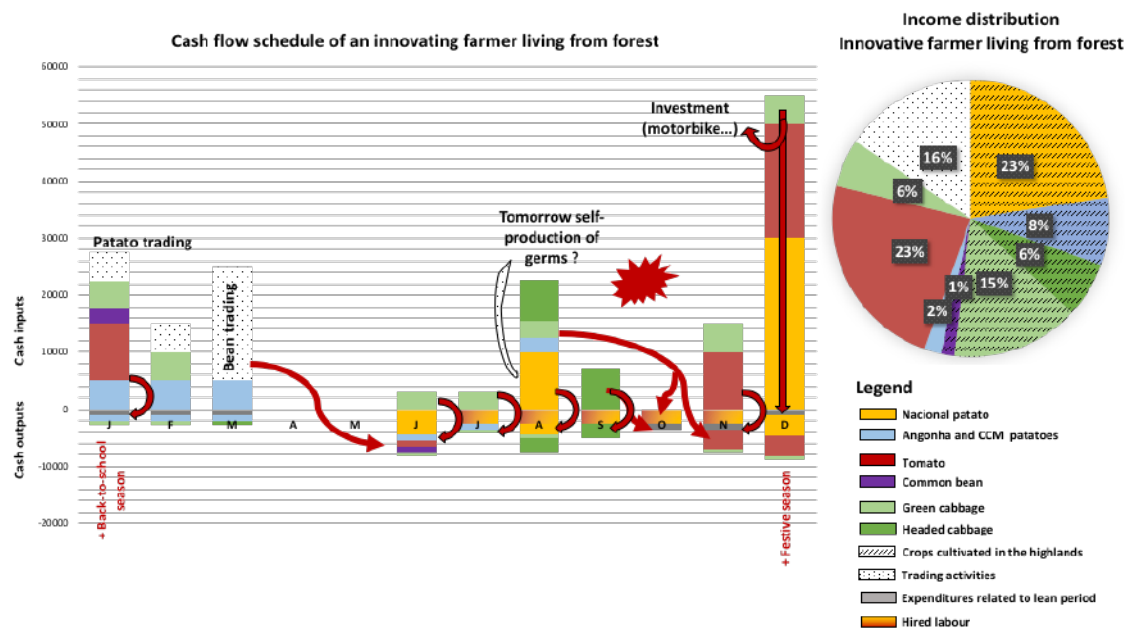


Figure 33 : Description of the innovative farmer living from forest.

plan to buy a house in the city, to live there from his commercial activities, continuing to use hired labour to exploit its plots in the mountain.

As a conclusion, there is a big diversity among the producers who practice agriculture on the Murretxa's plateau. All of them do not go there with the same goals and strategies. Some work alone, for their subsistence, trying to spread their incomes and agricultural task throughout the year, when others can count on hired labour, follow commercial objectives and have almost become "farmer-traders". Not surprisingly, all these production systems do not have the same level of agricultural income (Figure 34).

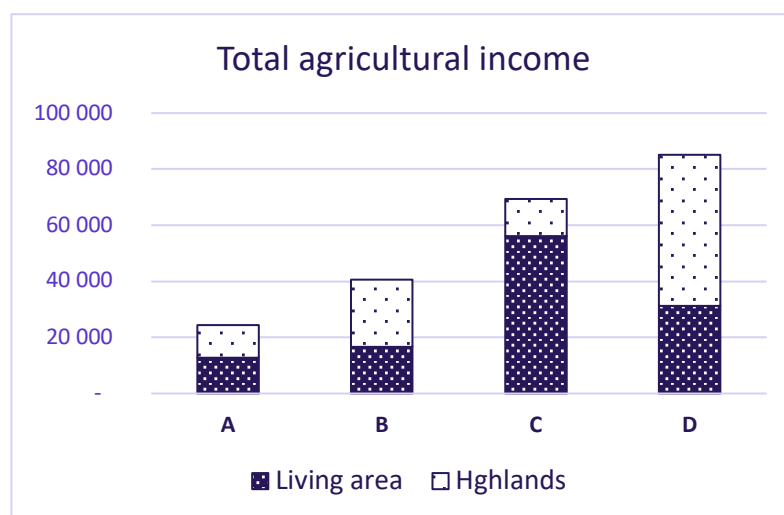


Figure 34 : Agricultural income of the four production systems presented. A : the small farmer self-subsistent ; B : the large potato producer ; C : the innovative farmer living from tomato ; D : the innovative farmer living from forest.

2.2.2. Who does not produce Irish potatoes in the highlands ?

Why did some local production systems evolve towards potato growing in the highlands and some not ? The difference of evolution is explained by both geography and history. In fact, the households living close to Murretxa's plateau (Chipi, Curuca, Rere) were more likely to develop potato cropping systems in the highlands. On the other hand, in response to particular constraints (families displaced and/or expropriated who have encountered problems of land availability) or opportunities (paying jobs) some families could not or did not need to turn towards growing potatoes at highlands. Facing this diversity of scenarios, they developed alternative strategies of production. In many cases, these alternatives are far from being default options. Indeed, many households see growing potato in the highlands as a forced labour and deliberately made the choice to reduce the hardness of their task, even if it is less paid.

What are these alternatives to the production of potatoes in the highlands ? This study identified some, represented below by Figure 35. Each possibility corresponds to a farmer's profile, some of which (written in bold on the figure) are described in the paragraphs below. The colors indicate the hypothetical risk for each profile to turn to the production of potato in the highlands in the future.

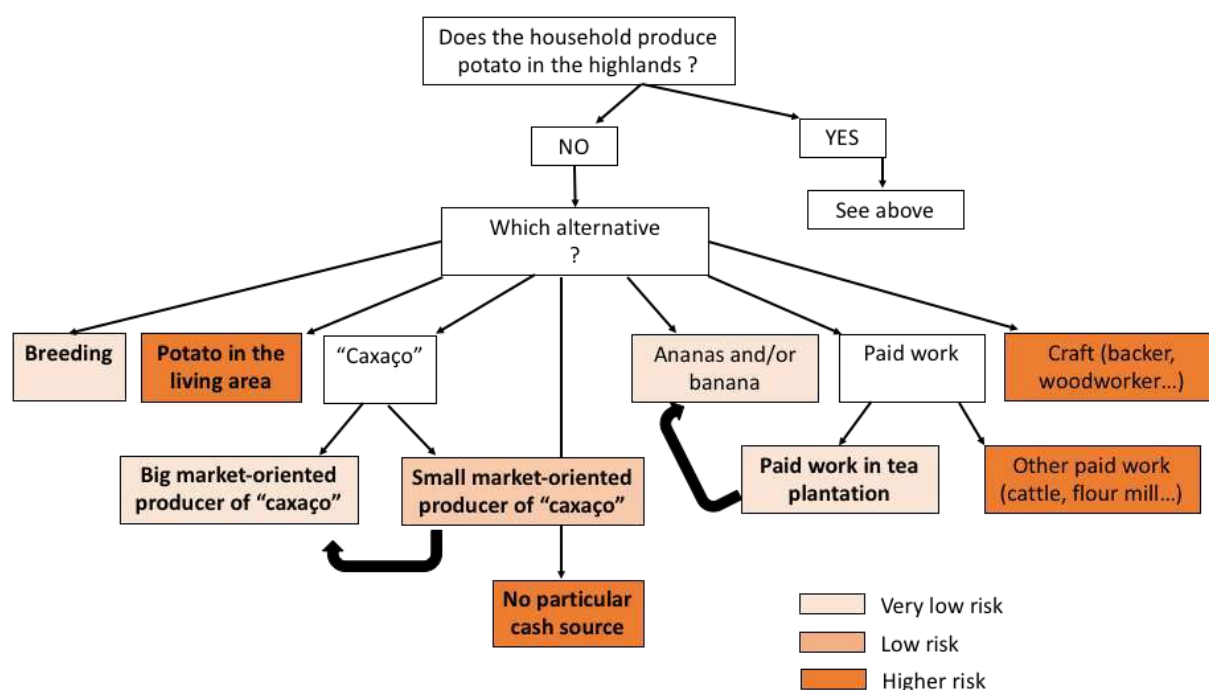


Figure 35 : What do producers who do not grow potatoes in the highlands do? What risk would they have to turn to the forest?

◇ The farmer employed in the tea plantation

Locally, the first employer is the tea plantation. The "fifth production unit"¹⁰ (as it is called in the area) employs men (and sometimes, though more rarely, women) of many (maybe about 50%) of the families of Muresse.

The main work which requires labour is the harvest of the leaves (all the year with a peak of workload from December to March). Workers work from Monday to Saturday, from 6 am to 13 pm. They are paid by performance, according to the weight of the leaves they manage to harvest

¹⁰ UP5 : "Unidade de Produção 5"

in the month. Thus, this paid job is flexible and adaptable to agricultural calendars. The farmers are free to allocate their work force as they prefer, according to their priorities, between the tea plantation and their own fields.

These households are characterized by a reduced availability of the family labour force (often that of the man). For this reason (it is mostly men working in the mountain) they did not (and still do not) seek to grow potatoes at high altitudes. Moreover, many have no land on Murretxa's plateau. Instead, the households have developed cropping systems that value well work and land (another common limiting factor in Muresse) : fruit crops (banana and pineapple), two businesses often run by women.

For many families (those whose cash schedule is presented above), bananas and pineapples are grown on a small scale. The production cycles are spread over several months (all the year round for banana, four months during the lean season for pineapple) and therefore constitute a major income supplement to meet daily expenses. However some young farmers are moving towards a gradual intensification of these systems using more and more inputs (renewal of plants, weed killers, hormones to accelerate the ripening of bananas).

Due to Muresse's land-related constraints, the food crop systems of these households are often far from their place of residence. Maize is often grown on the middle plateau of Malema, or in Namuroka's area in Murabué (see above).

Finally, there is still, in Muresse, a lot of small breeds among households working in the tea plantation (around 3 to 10 goats per family). The selling of animals (between 800 and 2000 Mt) helps to solve cash flow problems (it is not represented on the cash flow schedule above).

It does not appear that these agricultural households will evolve towards potato cropping in the highlands. The salary issued from tea harvesting is a safe and regular source of income, which falls every month, regardless of the weather hazards. The tea harvest is also very less arduous than growing potato on the Murretxa (which, in Muresse, is 4 hours walk from the living area). On the contrary, when households sometimes stop receiving the salary (retirement, death, disability ...), an extension (provided they find land available) and/or intensification of the fruit production was often noticed. Thus, in Muresse, there are households that grow for example more than 0.5 ha of pineapple and employ wage labor for harvesting it.

◇ *The "caxaço" producers*

We speak of producers in the plural because, as seen above, there are differences in terms of capacities/levels of production, strategies and degrees of specialization among the producers of "caxaço".

First of all, there is a very specialized type of producer, for whom caxaço represents almost 70% of the activity income. This producer is relatively well equipped (often more than three fermentation tanks and stills). He also has a large area of sugar cane (more than 0,3 hectares) that provides him all year round. During the off-season (February to June) he distills only to buy his salt and oil, and the production workshop runs under-regime. The volume produced is then adapted to the evolution of the market and prices. In September, when the canes are ready for harvest and the prices increase, the producer doubles his production and doubles it again in December when prices are at their highest. To cope with this peak of work he employs hired labour (paid in alcohol).

Then there is an intermediate profile : a less specialized producer ("caxaço" represents 45% of the activity income) but whose strategy is always oriented towards the market. The farmer

produces in smaller quantities but always adapts his volumes to the evolution of prices. He also often does not have a sufficient stock of sugar cane in the field to produce all year round and the production often stops between January and June.

Finally, many producers distill in only small quantities, for self-subsistence purposes. Caxaço is for them, like any other culture, a way of diversifying their source of income and reducing their vulnerability. The areas planted with sugar canes are limited (0,1 ha) and so is the equipment available (often the producers have to borrow). They have no market strategy : the production does not follow the evolution of prices but the daily needs of the family. It begins in June, as soon as the canes are ready. In December, when prices go up, the producers often do not have any more sugar cane in their fields to take advantage of it.

These production systems evolve towards the intensification of the production of “caxaço” by planting more surfaces with sugar cane (if land is available), investing in more equipment (tanks, stills), paid labour, or means of transport (motorcycle) to be able to sell directly in the city and benefit from better prices. The caxaço brings money during several months, in particular during the lean period, if the stocks of sugar cane is sufficient and well managed. As a result, it is an interesting alternative to high potato production. In addition, if the manufacture of caxaço requires a lot of work (including wood collection, task often done by women), it remains much less painful than growing potatoes in the highland (by the way, women often do the job). Furthermore, sugar cane is a relatively insensitive crop, with relatively stable yields, which requires no major investment. Finally, with the closure of old tea production units in the region, equipments (piping) are available locally to manufacture stills. The caxaço is therefore a safe sector that offers perspectives of evolution. It pays well, at the right time (lean period), for less risks and a very less hard task. For all these reasons, it appears that households who produce caxaço are very unlikely to turn to potato production in the highlands. It is actually the opposite that occurs : households that once produced potatoes in the highlands and are progressively turning away from the highland crop systems by developing a caxaço production workshop.

◇ *The small farmer without particular cash source*

This profile is very common in Murabué and Muresse. It brings together all the households that (like the small self-subsistent producers of potato and caxaço by the way) are the most vulnerable. They are the landless peasants, the young, the old, the widows and widowers, the single women, the foreigners recently arrived in the area, the handicapped ... These fragile production systems tend to evolve (when it is possible) towards :

- Potato production in the highlands, trying to borrow land and/or money to buy sprouts,
- Caxaço production, planting sugar cane around the house and borrowing a tank and a still,
- Fruit production (in Muresse), cleaning a little plot for pineapple or bananas.

Of course, any additional income is welcome : small-scale trade (taking advantage of the arrival of traders during the potato or tomato selling season for example), small crafts (fabrication of bamboo mats or clay bricks...), food and beverage processing (bread, “cabanga¹¹”...), sale of wood, salaried agricultural work...

¹¹ Traditional fermented local drink made from corn bran or (more rarely) sorghum.

A picture of the diversity of local production systems was presented. Figure 36 represents the distribution of these different profiles in the sample of surveys that was made, according to the “celulas”. But during the field work, the choice of the farmers to investigate has often been oriented by specific needs. It was not done randomly. As a consequence, the indications given by Figure 36 are certainly not completely representative of the distribution of the agricultural profiles among the entire population.

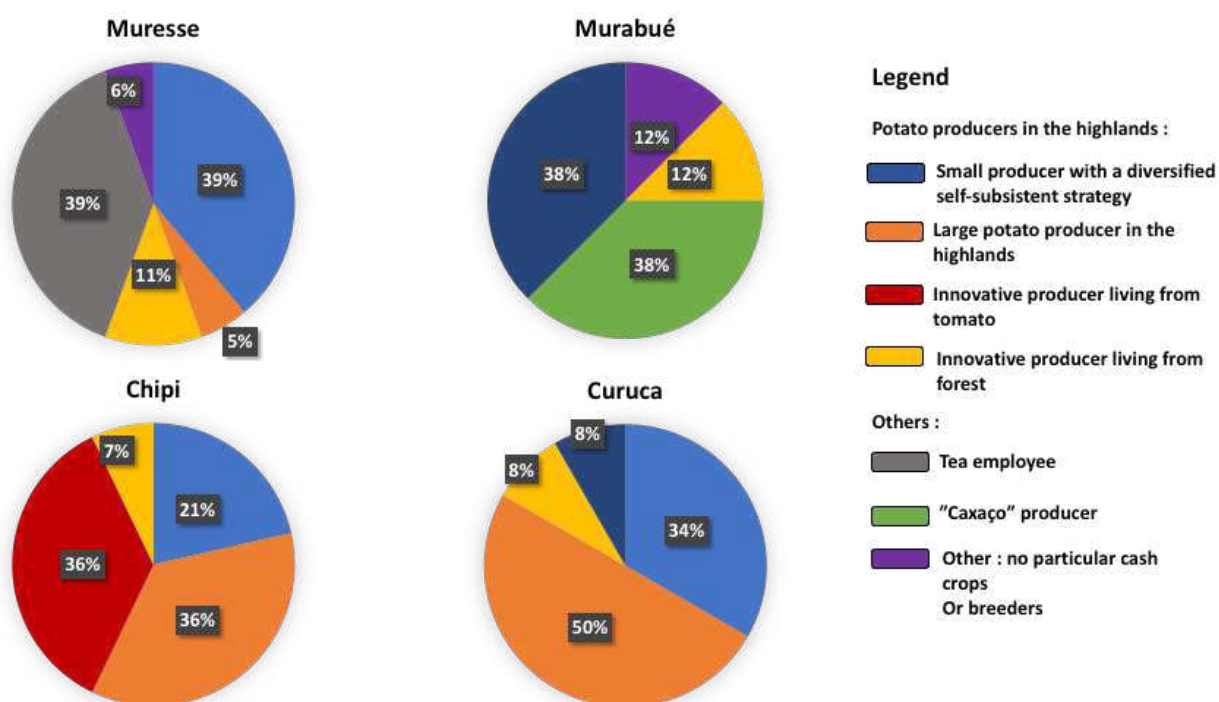


Figure 36 : Distribution of the different producer profiles by “celula”.

3_ Local agriculture in deforestation dynamics

This study shows the economic importance of Murretxa's forest for many¹² agricultural households in the area : between 25 and 50 % of their annual income (see above) is made in the highlands. **How does local agriculture take part in evolving deforestation dynamics ?**

3.1. Two clearly identified “drivers” of deforestation

Not surprisingly, the two main “drivers” of deforestation dynamics are the Nacional and Angonha¹³ potatoes. They represent between 25% and 50% of the income of the households, which practice agriculture in the highlands and which are, therefore, highly dependent on these crops.

3.1.1. Why do farmers grow potatoes in the highlands ?

Even though it is physically very hard, many farmers climb up to the highlands to grow their potatoes, in response to various constraints and opportunities :

◇ *A question of space*

In the living area, because of the population growth, agricultural land is fragmenting and shrinking. Unlike the Murretxa's plateau, there are strong land constraints in the living area. If the potato was grown there, it would compete with the allocation of the fields with other cash/subsistence crop systems (maize associated with tomato for example).

◇ *A question of yields*

Many farmers speak about the difference in size between the Angonha potato grown in the highlands and in the area. To identify the causes of these differences, a more in-depth study on this specific issue would be necessary. At this stage, however, hypotheses can be formulated :

- The temperature conditions : the temperature is always cooler in the highlands than in the living area, and potato is not a crop that appreciates hot weather,
- The soil texture : sandy soils of the highlands are more adapted to tuber growth than compacted, clay and loamy soils of the living area.
- The soil fertility : young forest soils are richer in organic matter and more fertile than leached soils of the living area.

◇ *A question of calendar*

Highland conditions allow planting potatoes between August and November (regularly in May in the living area). Thus, they are sold between December and March, during the lean season (when the households have to buy their maize and cassava), which is moreover a festive and back-to-school season (synonymous with exceptional expenses for families). Moreover, this calendar allows to start to sell the potato when prices are at their highest (in December). For example

¹² Almost all the households of Curuca and Chimi, around 50% of the households of Muresse and Murabué.

¹³ CCM is often grown with Angonha. To facilitate the understanding, both cultures will be assimilated in this paragraph.

Nacional's price in town is 30 Mt/kg (0,48 US \$)¹⁴ in December and only 12 Mt/kg (0,19 US \$) in January.

◇ *A question of risks*

Any agricultural household, dependent for its survival on crops with volatile and uncertain yields and markets, try to limit climatic and economic risks by cultivating in different environments, different varieties at different seasons.

3.1.2. Nacional and Angonha : two distinct “drivers” of deforestation

It is essential to understand that these two potatoes are distinct and independent “drivers” of deforestation. In fact :

- They are grown neither on the same type of plots nor at the same time. Thus, they do not compete for the allocation of land and labour.
- They do not meet the same needs. The Nacional is grown to meet an opportunity given by the market. It is harvested and sold in December, when prices are at their highest. Sometimes, because of lack of cash, farmers start harvesting the potato before wilting its leaves, while the maturation of the tubers is not finished yet. However the harvest of Angonha (and CCM) is much more spread out. Farmers sometimes leave the potato in the ground several weeks after the fall of the leaves, and harvest it as cash is required. So the role of this second potato is completely different. Far from a punctual and opportunist sale it supports families in the long term, throughout the lean season.

3.1.3. Towards an intensification of the potato cropping in the highlands ?

Due to land constraints in the living area, the forest offers the best the much evolution prospects for potato producers. Even though Murretxa's territory is now completely divided among families, many pieces of forest have not yet been deforested. If land and labour (many producers employ salaried workers) are not limiting the potato production, and if potato is such an attractive crop, what is preventing its expansion on highlands today ?

The main obstacle which is still limiting potato production is the farmers' inability to reproduce their own Nacional's sprouts from one year to the next. They must therefore buy them every year, which causes heavy production costs, and inevitably limits the quantities planted.

◇ *Theoretical scenario of reproduction of Nacional potato sprouts*

Farmers grow Nacional potatoes in highlands between August and December. This period is imposed by market and climatic constraints. After harvesting, the smallest tubers are kept for planting in the living area during the dry and coolest season (“**way 1**” in Figure 37) in May. During the harvest, in August, the idea would be to plant the new tubers in the highlands (“**way 2**”). This is the theory, and it is difficult to apply in practical terms.

¹⁴ Exchange rate used (May 22, 2019) : 1 Mt = 0,0157 US \$

◇ *Obstacles encountered*

In the **first way**, farmers face difficulties in conserving their sprouts. In fact, at harvest (in August), the rains have already begun and humidity damages the tubers. Moreover, when the farmers are running out of cash, the potato is sometimes harvested even though it is still immature which affects its keeping quality. In addition, conditions of conservation are often unsuitable. Consequently sprouts very often rot before May (planting time in the living area).

In the **second way**, the delay between harvesting in the living area and planting in the highlands is too short and potato sprouts do not have time to pre-germinate. The vegetative rest period¹⁵ observed on Nacional's sprouts is indeed longer than Angonha's.

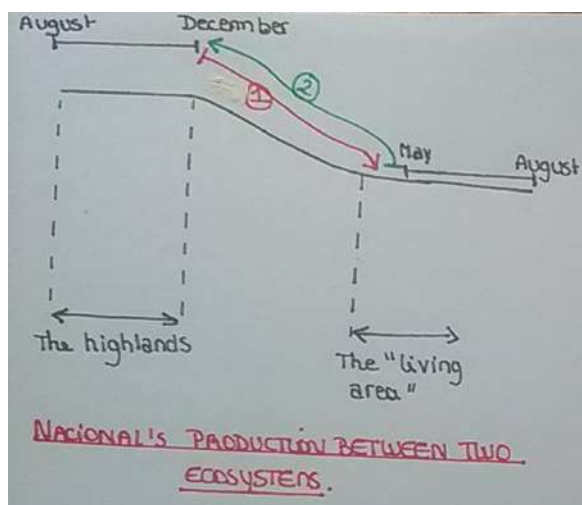


Figure 37 : Nacional sprouts reproduction mechanism (according to current agricultural practices).

◇ *How are potato growers trying to remove these constraints?*

Facing this situation, farmers who are most likely to take risks (the "innovative" ones) are experimenting to lift these production constraints. They try in particular to :

- Improve the techniques and conditions of conservation of the sprouts so that some farmers are now able to plant their highland tubers in the living area ("**way 1**").

- Anticipate the off-season cycle (in February/March instead of May) in order to give more time to the harvested tubers to germinate before August ("**way 2**"). On this step, the tests¹⁶ are still inconclusive so far. However, if farmers cannot reuse their tubers for planting, they find another advantage in anticipating the off-season production : selling between the end of June and the beginning of July, when prices are as high as in December.

◇ *What to remember ?*

The potato production in the highlands is about to evolve. Technical solutions are very likely to be found in a near future to improve the conservation and accelerate the germination of the Nacional's sprouts. These innovations may not require more surfaces or work¹⁷. Thus, all farmers, even the most vulnerable, would be able to integrate them in their production system. The main

¹⁵ Period during which tubers are unable to germinate independently of environmental conditions (physiological factors). Not to be confused with the "dormancy", that designates an inability to germinate induced by unfavorable environmental conditions.

¹⁶ These tests are carried out in the living area or in the highlands, depending on the land available to the farmers and their labor resources.

¹⁷ A similar crop system for Angonha's sprouts production already exists in the living area. Farmers can combine both cultures on the plot, at the same time.

current obstacle to the development of potato cropping in the highlands would so be lifted and a very strong intensification of the production would occur. Accordingly, household incomes would increase, but deforestation would also intensify.

Not surprisingly, potato cropping in the highlands is identified as the main “driver” of local deforestation. However, to tackle the deforestation issue, we cannot focus only on this crop as other activities could, directly or indirectly, feed the deforestation local dynamic.

3.2. What link can be made between other economic activities and the local deforestation dynamics ?

As previously seen, the investment capacity of farmers to buy sprouts of Nacional, is the main factor which currently limits potato production in the highlands. When the level of production is already high, a second joint limiting factor appears : the access to hired labour. Thus, any activity which contributes to the household income could be seen, at first glance, as an indirect contributor to deforestation.

Yet, it is necessary to analyze the situation according to the activity and the type of farmer which is considered. The following paragraphs present the hypotheses arising from this study. They heavily rely on the study of cash flow schedules (see above) and cash reinvesting dynamics. Each paragraph corresponds to a type of potato producer. For each, the links between the producer's crops/activities and the dynamics of deforestation are explained in tabular form. Each table gives a static and a dynamic vision of the situation :

1) A static vision (first two columns)

How does each activity contribute to current deforestation dynamics. Each crop/activity of the household is classified according to its current impact on highland forest. This lead to identify “drivers” (a crop/activity that, in itself, justifies cutting trees), “accelerators” (a crop/activity that is not the first cause of deforestation but contributes positively to it) or “brakes” (a crop/activity that has a downward impact) on/of deforestation and finally “neutral” crops/activities (which have no impact on deforestation dynamic).

2) A dynamic vision (three following columns)

How will the deforestation dynamic evolve if these activities/crops are supported as part of an agricultural support project ? This time available tools are used to project ourselves into evolution scenarios by considering three possibilities :






- The forest remains “open” (as today) : no limitation of uses.
- The forest becomes “half-open” : it is still allowed to cultivate in the already existing fields and fallow, but any new tree cutting is forbidden.
- The forest is “closed” : any agricultural use is forbidden even in fallow or existing fields.

Each time, HL means “HighLands” and LA “Living Area”.






3.2.1. The small farmer with a diversified self-subsistence strategy

| Current crop systems/activities | Current place in deforestation dynamics | A support of this crop system ? What consequences on deforestation ? | | | Comments |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | "Open" forest | "Half-closed" forest | "Closed" forest | |
| Potatoes ^{HL} | Drivers of deforestation See above | The higher the production, the more valued the land in the forest. If this land is accessible, producers are encouraged to deforest more. | Better valorization of cultivated lands and renewal of the fertility of the soils. | No interest in working on potato cropping in the highlands. | Possibility to work also on potato cropping, during the same period, but in the living area. This directly competes with forest production while potentially increasing labor productivity. |
| Potato Angonha ^{LA} | Accelerator of deforestation As the goal is to produce sprouts for planting in the highlands. | The higher the potato production, the more sprouts the producer has, the larger the area cultivated with Angonha in highlands. | Possibility of selling the potato produced in the living area (very high prices end of June / beginning of July) -> increase of income and diversification of the production system -> decrease of the dependence on highlands potato. | | |
| Green cabbage ^{LA} and waged work | Accelerators of deforestation These are the two activities that earn money when the producer needs to buy his sprouts of Nacional for the highlands. | The higher the income, the more the producer can buy sprouts of Nacional, the larger the areas cultivated with Nacional in the highlands. | Increase of income and diversification of the production system -> decrease of the dependence on the potato cultivated in the highlands. | | |
| Tomato ^{LA} and Common bean ^{LA} | Brakes on deforestation These are the two crops that make money at the same time as the highlands potatoes during the lean season. The tomato reduces the dependency on the Nacional (cash in December), and so do the common bean with the Angonha and CCM (cash in March). | The higher the income during the lean season, the less dependent on highlands potatoes the producer. To compensate for the income of the three potatoes (Nacional, Angonha and CCM) it would be necessary to : <ul style="list-style-type: none"> - Triple the current income of tomato and extend it over several months. - Some other profiles of farmers proved that tomato can earn a big amount of money (during, moreover, three months) if the volatilities of yields and market are controlled. - Multiply by five the current income of the common bean. The market is stable and profitable, the main obstacles are related to the production. | | | |

3.2.2. The large potato producer in the highlands













| Current crop systems/activities | Current place in deforestation dynamics | A support of this crop system ? What consequences on deforestation ? | | | Comments |
|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | "Open" forest | "Half-closed" forest | "Closed" forest | |
|  Potatoes_{HL} | Drivers of deforestation See above | The higher the production, the more valued the land in the forest. If this land is accessible, producers are encouraged to deforest more. | Better valorization of cultivated lands and renewal of the fertility of the soils. | No interest in working on potato cropping on forest. | Possibility to work also in the living area. This directly competes with forest production while potentially increasing labor productivity. |
|  Potato Angonhala | Accelerator of deforestation As the goal is to produce sprouts for planting in the highlands. | The higher the potato production, the more sprouts the producer has, the larger the area cultivated Angonhala in the highlands. | Possibility of selling the potato produced in the living area (very high prices end of June / beginning of July) -> increase of income and diversification of the production system -> decrease of the dependence on the potato cultivated in the highlands. | | |
|  Trade of common bean | Accelerator of deforestation Highly lucrative business, the primary source of income on which the farmer relies to buy his sprouts of Nacional. | The higher the income, the more the producer can buy sprouts of Nacional, the larger the areas cultivated with Nacional in the highlands. | Increase of income and diversification of the production system -> decrease of the dependence on the highlands potatoes. + Possibility to reinvest elsewhere (production of potatoes in the living area for example ?). | | |
|  Green cabbage_{LA} and Common bean_{LA} | Neutral effect Green cabbage : unlike the previous profile, the producer does not rely on its sale to buy his sprouts of Nacional -> negligible impact compared to the trade of beans. Common bean : no impact since the farmer prefers to negotiate the beans of others than to produce his own. | Even if the productions of common bean and green cabbage would raise, the farmer will probably continue to rely on its trading activities to buy potato sprouts. | Diversification of the production system -> decrease of the dependence on the potato cultivated in the highlands (during the lean season for common bean). | | If we manage to better control the volatility of bean yields without increasing the workload, the farmer will also be able to negotiate his own production -> increase in his margin + potential increase of labor productivity |
|  Tomato_{LA} | Brake on deforestation It is THE crop that makes money at the same time as the highlands potatoes during the lean season. The tomato reduces the dependency on the Nacional (cash in December). | The higher the income during the lean season, the less dependent on highlands potatoes the producer. To compensate for the income of the three potatoes it would be necessary to multiply by four the current income of tomato, and extend it over several months. Some other profiles of farmers proved that tomatoes can earn a good amount of money during three months if the volatilities of yields and market are controlled. | | | |

3.2.3. The innovated farmer living from tomato

| Current crop systems/activities | Current place in deforestation dynamics | A support of this crop system ? What consequences on deforestation ? | | | Comments |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | "Open" forest | "Half-closed" forest | "Closed" forest | |
| Potatoes^{SH}  | Drivers of deforestation See above | The higher the production, the more valued the land in the forest. If this land is accessible, producers are encouraged to deforest more. | Better valorization of cultivated lands and renewal of the fertility of the soils. | No interest in working on potato cropping on forest | Trying to produce potato in the living area at the same season will not work if the forest remains open : the farmer employees salaried workers. |
| Potatoes^{LA} (Angonha and tomorrow Nacional ?)  | Accelerators of deforestation As the goal is to produce sprouts for planting in the highlands. The farmer also uses this crop system to test the production of Nacional potato sprouts in order to gain autonomy. | The higher the potato production, the more sprouts the producer has, the larger the area cultivated in the forest (especially since there is manpower available) | Possibility of selling the potato produced in the living area (very high prices end of June /beginning of July) -> increase of income and diversification of the production system -> decrease of the dependence on the highlands potatoes. | | The farmer already innovates trying to increase the profitability of this crop system by an anticipated production of germs of potato (including Nacional). |
| Green cabbage^{LA}  | Accelerator of deforestation A crop that earn a satisfactory amount of money when the producer needs to buy his sprouts of Nacional for the highlands. | Probable reinvestment in Nacional sprouts/wage labour for the highlands. However, effects on deforestation probably very limited as the production is already performant and the margin of progress relatively small. | Increase of income and diversification of the production system -> decrease of the dependence on the highlands potatoes. | | Already performing production : relatively small margin of progress -> the probable effects on the dynamics of deforestation must be relativized. |
| Common bean^{LA}  | Neutral effect A small contribution (given the farmer's income elsewhere) to the purchase of sprouts of Nacional potato. | Probable reinvestment in Nacional sprouts, but in such little proportions that the impact in terms of cultivated areas in the forest will probably be minimum. | Diversification of the production system -> decrease of the dependence on the highlands potatoes. | | The problems are mostly related to production. The market is stable and profitable. |
| Tomato  | Brake on deforestation Although it is certainly thanks to the cash of tomato that the farmer can grow potato, it is above all the both successful tomato growing and selling that make him the least dependent on forest. | Probable reinvestment in Nacional sprouts or in wage labour to cultivate on the plateau. However, effects on deforestation probably very limited as the production is already performant and the margin of progress relatively small. | Reinvestments today partly turned to the highland potatoes in the absence of constraints (labor and land both available). If tomorrow constraints appear (availability of land for example) possibility to reinvest elsewhere (production of potatoes in the living area for example). | | Both growing and selling are already performant : relatively small margin of progress -> the potential effects on the dynamics of deforestation must be relativized. |

3.2.4. The innovative farmer living from forest

| Current crop systems/activities | Current place in deforestation dynamics | A support of this crop system ? What consequences on deforestation ? | | | Comments |
|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | "Open" forest | "Half-closed" forest | "Closed" forest | |
| Potatoes_{HL} | Drivers of deforestation See above | The higher the production, the more valued the land in the forest. If this land is accessible, producers are encouraged to deforest more. | Better valorization of cultivated lands and renewal of the fertility of the soils. | No interest in working on potato cropping on forest. | Trying to produce potato in the living area at the same season will not work if the forest remains open : the farmer does not care about the hardness of labor in the highlands as he employees salaried workers. |
| Potatoes_{LA} (Angonha and tomorrow Nacional ?) | Accelerator of deforestation As the goal is to produce sprouts for planting in the highlands. The farmer also uses this crop system to test the production of Nacional potato sprouts in order to gain autonomy. | The higher the potato production, the more sprouts the producer has, the larger the area cultivated in the forest (especially since there is manpower available) | Possibility of selling the potato produced in the living area (very high prices end of June/beginning of July) -> increase of income and diversification of the production system -> decrease of the dependence on the highlands potatoes. | | The farmer already innovates trying to increase the profitability of this crop system by an anticipated production of sprouts of potato (including Nacional). |
| Trade of common bean | Accelerator of deforestation Highly lucrative business, the primary source of income on which the producer relies to buy his sprouts of Nacional. | The higher the income, the more the producer can buy sprouts of Nacional, the larger the areas cultivated in the forest. | Increase of income and diversification of the production system -> decrease of the dependence on the highlands potatoes + Possibility to reinvest elsewhere (production of potatoes in the living area for example). | | |
| Headed cabbage_{HL} | Accelerator of deforestation Crop that occupies alone forest plots (succeeding the Nacional potato in crops rotation) and that provides an income when it is time to buy potato sprouts. | The larger the production the larger the land used in forest. The higher the income the more sprouts of Nacional the farmer can buy. | Better valorization of cultivated lands and renewal of the fertility of the soils. | No interest in working on potato cropping on forest. | It might be interesting to try to grow these crops at the same season (market interest) but in the living area, with this type of farmer (may not work if the forest remains open) or the others. |

| Current crop systems/activities | Current place in deforestation dynamics | A support of this crop system ? What consequences on deforestation ? | | | Comments |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | "Open" forest | "Half-closed" forest | "Closed" forest | |
|  Common bean and Green cabbage | Accelerators of deforestation No direct drivers of deforestation (plots in the forest are not opened to grow cabbage or beans). Are cultivated to increase the value of labor and land in plots that were opened for potato. Therefore, these crops contribute to reinforce the dependence of families on forest especially during the lean season. |  The higher the production, the more valued the land in the forest. If this land is accessible, producers are encouraged to deforest more. |  Better valorization of cultivated lands and renewal of the fertility of the soils. |  No interest in working on potato cropping on forest. | It might be interesting to try to grow these crops at the same season but in the living area, with this type of farmer (may not work if the forest remains open) or the others. |
|  Green cabbage | Neutral effect Relative marginal source of income -> marginal contribution to highlands crop systems. |  No major impact. |  Diversification of the production system -> decrease of the dependence on the potato cultivated in the highlands. |  | A particular land availability problem in the living area for this profile of farmer. |
|  Tomato | Brake on deforestation Although tomato helps to buy potato sprouts, it is almost the only crop grown in the living area that earns a satisfactory amount of money and thus which reduces the dependence of the farmer on forest. |  Probable reinvestment in Nacional sprouts or in wage labour to cultivate in the highlands. However, effects on deforestation probably very limited as the production is already performant and the margin of progress relatively small. |  Reinvestments today partly turned to the highlands crops in the absence of constraints (labor and land both available). If tomorrow constraints would appear (availability of land for example) possibility to reinvest elsewhere (production of potatoes in the living area for example ?). |  | Both growing and selling are already performant : relatively small margin of progress -> the potential effects on the dynamics of deforestation must be relativized. |

4_ Accompany the producers

The following study has led to the proposal of “accompaniment measures” (AM). Their goal is to support local rural development and contribute to increase the incomes of the local agricultural households. Table 5, Table 6 and Table 7 present these AM organized according to the crop which is considered and their objective(s). Each AM is named by a letter (A to O). For each AM, the profiles of farmers it would be interesting to work with are specified. Last but not least retained hypothesis regarding the impact of each AM on the highland forest are presented and symbolized by a color :

These accompanying measures would ... the deforestation dynamics :

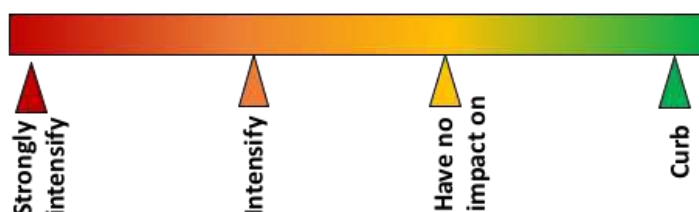


Figure 38 : AMs impact on forest.

Finally, each “accompaniment measure” (AM) is declined in proposals of concrete activities (attached document). To concretely work on these AM, their possibility and methods of implementation must respectively be validated and reflected with the farmers. Concretely it is necessary to go back on the field and organise interviews with little groups of farmers, depending on their profiles, in their fields, to identify and/or (in)validate levers that would help us to put these AM into practice. The reflection must concern the modification of the technical itineraries and the modalities of access to the resources by integrating the different scales of the production systems. It is necessary to work when the crops of interest are in the fields. An example of a provisional timetable for deepening each MA is presented by Table 4:

| Phase 1 ¹⁸ preparation | Phase 1 | | | Phase 2 | | | | Phase 3 | | |
|--------------------------------------|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| July | A | S | O | N | D | J | F | M | A | M |
| 2019 | | | | | | 2020 | | | | |

Table 4 :Proposed provisional chronogram to work on the feasibility and implementation of AM.

| Phase 1 | Phase 2 | Phase 3 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> - Definition of first generical AM regarding most of all fertility management in the living area - Potato cropping feasibility in the living area (AM D) - Tomato production (AM D) - Cassava (AM K) - Diversification of crops associations (AM H + J) | <ul style="list-style-type: none"> - Common bean (including a work session with producers of Mucunha) (AM F) - Caxaço manufacturing (AM L and M) - Pineapple production (AM N) - Tomato market (AM E) | <ul style="list-style-type: none"> - All the off-season systems (AM B, G and I) |

¹⁸ The chosen representation does not mean that “phase 1 preparation” would take a whole month, but that “phase 1 preparation” can take place in July.

| Crops | Code | Accompaniment Measures (AM) | Objective(s) | Whom to work with ? Who would be interested | Impact on forest |
|----------|------|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Potatoes | A | "Sprouts reproduction from one year to another" | Remove the obstacles currently faced by the farmers to reproduce their sprouts of potato (conservation and pre-germination) | <ul style="list-style-type: none"> Potentially all the farmers, including those who are not growing potato because they do not achieve to produce and buy sprouts. | By increasing the surface cultivated with Nacional potato in the highlands. |
| | B | "Production during the dry season" | Improve the production of potato (including Nacional) during the dry season, in the living area | <ul style="list-style-type: none"> Potentially all the farmers, Excepted the "innovative farmers living from forest" who pay hired labour to do this crop system in the highlands (ineffective AM as long as forest remains open). | By increasing the surface planted with potatoes in the highlands (facilitating self-supply in Angonha sprouts and cash re-investments in Nacional sprouts) |
| | C | "Production during the rainy season" | Adapt the production of potato during the rainy season to the constraints of the living area | <ul style="list-style-type: none"> Potentially all the farmers (including those who have no access to the highlands), Except the two "innovative" potato producers, as they pay hired labour to work in the highlands (ineffective AM as long as forest remains open). | By competing directly with potato production in the highlands reducing the arduousness of agricultural work (and increasing its productivity). |
| Tomato | D | "Yields stabilization" | Limit the volatility of tomato yields to make it a safe crop for farmers, and therefore an alternative to highland potato production. | <ul style="list-style-type: none"> Potentially all the farmers, Except the two "innovative" potato producers (relative low improvement potential). | By increasing work productivity and the household incomes during the lean period (and thus reducing dependency on highland potato). |
| | E | "Securing the market" | Limit the volatility of the market (a source of insecurity) | <ul style="list-style-type: none"> Farmers with a stable and secure production of tomato (the two "innovative" potato producers). | By increasing the income during the lean period (and thus reducing dependency on highland potato) without increasing the workload. |

Table 5 : Accompanying measures description 1.

| Crops | Code | Accompaniment Measures (AM) | Objective(s) | Whom to work with ? Who would be interested | Impact on forest |
|----------------|------|--------------------------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Common Bean | F | "Securing production" | Decrease current volatility of yields without increasing workload for farmers | <ul style="list-style-type: none"> • Potentially all the farmers, • Especially the small potato producers (diversification of the productions and sources of incomes), • Also the common bean traders (increased margins), • Except the "innovative farmer living from forest" who pays hired labour to grow bean in the highlands (ineffective AM as long as the forest remains open) | By increasing the income during the lean period and work productivity |
| | G | "Production during the dry season" | Improve the current production of green cabbage as an essential cash-crop during the dry season | <ul style="list-style-type: none"> • Potentially all the farmers, • Except the "innovative farmers living from forest" who pays hired labour to produce green cabbage in the highlands (ineffective AM as long as forest remains open) | By increasing the surfaces cultivated in potato (potential cash-reinvestment in Nacional sprouts and hired labour) |
| Green Cabbage | H | "Production during the rainy season" | Diversify the current crop systems of the rainy season with a mixed cash/food crop | <ul style="list-style-type: none"> • Same as above | By increasing the income during the lean period, and reducing the ardueness of agricultural work (work productivity) |
| | I | "Production during the dry season" | Make this other source of income more accessible to all, during the dry period | <ul style="list-style-type: none"> • Same as above | By increasing the surfaces cultivated in potato (potential cash-reinvestment in Nacional sprouts and hired labour) |
| Headed Cabbage | J | "Production during the rainy season" | Transpose highland cabbage production of the rainy season, to the living area | <ul style="list-style-type: none"> • Les trois premiers | By increasing the income during the lean period, and reducing the ardueness of agricultural work (work productivity) |

Table 6 : Accompanying measures 2.

| Crops | Code | Accompaniment Measures (AM) | Objective(s) | Whom to work with ? Who would be interested | Impact on forest |
|-----------|------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cassava | K | "Cassava yields and food security" | Increase the share of self-produced cassava in the household diet | <ul style="list-style-type: none"> All the farmers | By reducing the households food expenditures (most of all during the lean period) and thus the dependency on highland potatoes. |
| Caxago | M | "Energetic efficiency" | Decrease the amount of wood needed for the distillation of caxago, and thus, also women work. | <ul style="list-style-type: none"> All caxago producers Potato producers of Murabué Sede who also distil a little (or want to). | By facilitating a production that directly compete with highlands potatoes reducing the ardueness of agricultural work and increasing incomes during the lean period. |
| | N | "Quality and storing" | Combine efficiency during the manufacturing process, quality of the final product and advantages on the market by deferring production and sales. | <ul style="list-style-type: none"> Big caxagoproducers | By increasing incomes during the lean period for less work. |
| Pineapple | N | "Improve the pineapple income" | Improve the size of the fruits (and, as a consequence, their selling prices) and give the producers more weight on the market | <ul style="list-style-type: none"> All pineapple producers Potato producers of Muresse and Murabué Sede who also produce a little pineapple. | By securing a production that directly compete with highlands potatoes reducing the ardueness of agricultural work and increasing incomes during the lean period. |
| Avocado | O | "Access to markets" | Facilitate access to markets for producers who live above Muresse | <ul style="list-style-type: none"> All producers that have avocado trees above Muresse | |

Table 7 : Accompanying measures 3.

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ANNEXES : Accompaniment measures

| | | Potato_ AM A “sprouts reproduction” | | State of progress | | |
|---------------------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
| | | | | Done ! | Being processed | To do |
| Identification of the problems | | Between the highlands and the living-area : sprouts conservation | | Between the living-area and the highlands : sprouts pre-germination (most of all for Nacional potato) | | |
| Specific goals | | Support the producers to better conserve their sprouts | | Accelerate the pre-germination of Nacional sprouts so they can be planted in time, in August | | |
| Identification of the causes of the problem | Field ¹⁹ | <ul style="list-style-type: none">• <u>Storage condition</u> : brightness, temperature, airflow, regular monitoring and sorting of the sprouts...• <u>Innovative practices that work</u> : pre-storing drying (2-3 days), conservation of the sprouts in a dark and cool room, spreading them on a raised bed (“copa”) made of wood and herbs. | | <ul style="list-style-type: none">• The Nacional does not have time to sprout. Farmers supply in sprouts at Nicaú, where the cycles are in advance. | | |
| | Bibli ²⁰ | <ul style="list-style-type: none">• <u>Influence of agricultural practices</u> : top-killing, plantation date, weather conditions at harvest, pre-storing, pre-selection of the sprouts for storing...• <u>Other methods of conservation</u> : earthen for example | | <ul style="list-style-type: none">• The duration of the vegetative rest period <u>depends mostly on the variety of potato</u>.• <u>Possible interventions on sprouts</u> : desprouting, cutting/scratching, chemical treatments... | | |
| Support for changing practices | | Certainly by helping to disseminate innovative already existing practices (picture boxes...). | | A first step co-research , on a small scale, with some motivated farmers, to test solutions encountered in the bibliography. | | |
| Research of partners | | Technical knowledge in the IIAM (agronomic public research institute) | | | | |
| Call to other AMs? | | Would help to put AM B into practice, and reduce the risks linked to AM C . | | | | |

¹⁹ Information from the field study

²⁰ Information from bibliography

| POTATO _ AM B “Production during the dry season” | | | State of progress | | |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
| | | | Done ! | Being processed | To do |
| Identification of the problems | Angonha Size of tubers | Nacional No yield problems • Outlets for potato (as sprouts cannot be used to be planted in the mountain) | | | |
| Specific goals | <ul style="list-style-type: none"> Improve the cropping conditions to grow bigger tubers of potato Angonha in the living area during the dry season. | <ul style="list-style-type: none"> Make the production of Nacional potato during the dry season interested for farmers. Two possibilities: production of sprouts for the rainy season planting (see AM A and C), or market (cf innovative producers). | | | |
| Identification of the causes of the problem | Field | <ul style="list-style-type: none"> The two possibilities identified require an <u>intervention on traditional cropping calendar</u> : <ul style="list-style-type: none"> By anticipating the plantation to produce sprouts or take advantage of June/July high prices, By delaying the plantation to sell in October (when there is no potato Nacional on the market anymore) | <ul style="list-style-type: none"> The identification of the factors wich are currently limiting the yields of Angonha potato needs to be carried on by going back and forth between : <ul style="list-style-type: none"> - Focus groups with a few producers (producers with different levels of yields) on their tomato plots - Bibliographic research | | |
| | Biblio | <p>These hypotethetic limiting factors affect especially the Angonha potato. In fact, farmers who tried, achieved good yields (tuber size and number) with the Nacional one.</p> <ul style="list-style-type: none"> <u>Water needs</u> : especially during the initiation and magnification phases of tubers (Nacional potato is very more resistant than Angonha) <u>Nutrient needs</u> : especially nitrogen between the plant emergence and the initiation of the tubers -> fertility <u>Soil structure</u> : amount of organic matter, level of compaction... | | | |
| Support for changing practices | <ul style="list-style-type: none"> Reflection on cropping practices : how to remove the obstacles encountered (including the research of innovative farming practices)? Reflection on access to productive resources (water, nitrogenous matter ...) Co-experimentation with farmers to test solutions. | | | | |
| Research for partners | Technical knowledge in the IIAM (agronomic public research institute) | | | | |
| Call to other AMs? | The question of the dry-season production cannot be tackled without considering the production of the rainy season (AM C) and the production of material for planting (AM A). | | | | |

| | | POTATO _AM C "Production during the rainy season" | | | State of progress | | |
|---------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Identification of the problems | | Farmers only grow potato in the highlands during the rainy season. | | | Done !Being processedTo do | | |
| Specific goals | | Make it possible to produce potato in the living area during the rainy season. Admittedly, the yields that could be achieved would probably be below the current highland potato productions. But this small progress, added to other efforts (see others AM) could contribute to replace current highland potato income during the lean period (at least for small farmers). | | | | | |
| Identification of the causes of the problem | Field | • Potato (Angonha and Nacional) is planted in the living area only between February and July. | | | • Why are farmers not growing potato in the living area at this season when it request less work ? Is it because it is completely impossible (environmental conditions) ? Or because they just did not need to arrive solutions yet, as forest (which offers the best growing conditions for potato) remains open ? • Identification of the limiting factors with farmers and bibliography. → August 2019 ? | | |
| | Biblio | Why could it be complicated to grow potato at this period in the living areas ? • <u>Hight (soil) temperature</u> : the main limiting factor for potato production (FAO). • <u>Excess of water</u> in poorly drained soils (most of all for Nacional) -> <u>crop diseases</u> (bacterial and/or fungal infections) • <u>Availability of lands</u> : if potato growing is possible, it will be necessary to associate it with already existent crop systems (! Potato is a Solanaceae, as tomato. It would therefore be risky to associate the two crops !) | | | | | |
| Support for changing practices | | • If the limiting factors identified are not prohibitive -> co-experiments with farmers. | | | | | |
| Research for partners | | Technical knowledge in the IIAM (agronomic public research institute) | | | | | |
| Call to other AMs? | | Production of sprouts (AM A) and thus dry-season production (AM B) to minimize the risks carried by the producer. | | | | | |

| TOMATO_AM D | | State of progress | | |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
| “Production : yields, quality and calendar” | | Done ! | Being processed | To do |
| Identification of the problems | Volatility of yields that makes tomato not considered as a secure of income by producers | | | |
| Specific goals | Limit the volatility of tomato yields to make it a safe crop for farmers, and therefore an alternative to highland potato production | | | |
| Identification of the causes of the problem | Field | Continue to identify the factors explaining the volatility of yields by going back and forth between : - Focus groups with a few producers (producers with different levels of yields) on their tomato plots - Bibliographic research ⇒ Ideally in August 2019 (tomato transplanting period). | | |
| | Biblio | | | |
| Support for changing practices | Reflection on the technical itineraries going back and forth between the plot and production system (type of producer) levels. | Could begin with the purchase of the survey (August 2019 ?) | | |
| Research for partners | Technical partner for horticultural, market gardening crops. | | | |
| Call to other AMs? | <ul style="list-style-type: none"> Work on potato Nacional workload (AM D) -> small producers would have more time to focus on tomato cropping. After stabilizing production and improving the image of the tomato among producers : facilitate access to markets (AM E) | | | |

| | | Tomato_ AM E “Securing the market” | | State of progress | | |
|---------------------------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------|-----------------|-------|
| Identification of the problems | | Daily price volatility (typical of perishable productions) on the local “Eucalyptus market” | | Done ! | Being processed | To do |
| Specific goals | | Limit the volatility of the market which is a source of insecurity for the farmers | | | | |
| Identification of the causes of the problem | | <ul style="list-style-type: none">• <u>On one hand</u> : small producers (the majority) who spread their sales (every two or three days) and sell to buyers always different, at a price that changes from one day to another<ul style="list-style-type: none">• Tomato is the daily wallet.• <u>On the other hand</u> : big innovative producers (a minority) who :<ul style="list-style-type: none">- Go by themselves by car to Nampula or Quelimane by car and multiply by four or five the selling price of their potato baskets.- Sell on the “Eucalyptus” market, with on a weekly basis, always to the same buyer, negotiating a higher margin on prices applied with final consumers. Payment postponed of one week after the delivery of the products.• Tomato is an effective cash crop | | | | |
| Support for changing practices | | Preliminary work on the production is necessary. Once production is stabilized, initiatives may emerge spontaneously without producers needing us. <ul style="list-style-type: none">• Reflect later to meet producers new needs (by organizing trainings on the interest of grouping for selling for example). | | | | |
| Research of partners | | | | | | |
| Call to other AMs? | | Previous work on production (AM D) necessary. | | | | |

| | | Common bean_AM F “Securing production” | | |
|---------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Identification of the problems | | Volatility of yields that makes common bean not considered as a secure of income by producers | | |
| Specific goals | | Limit the volatility of tomato yields to make it a safe crop for farmers, and therefore an alternative to highland potato production | | |
| Identification of the causes of the problem | Field | <ul style="list-style-type: none"> • Seeds conservation (pests) and accessibility (price) • Soil fertility (fallow duration) and erosion (sloping plots due to drainage issues) • Wind at flowering (especially in Curuca) • Availability of labour for sowing (competition with planting of Angonha potato in the highlands) • Pest pressure (mosaic virus, leaves wilt, roots rot, pests in the root system...) | | |
| | Biblio | <ul style="list-style-type: none"> • Transmission of the Mosaic virus by a fly • Particular drainage constraints according to this crop | | |
| Support for changing practices | | Reflection on the technical itineraries going back and forth between the plot and production system (type of producer) levels. | | |
| Research of partners | | Public research institute (IIAM) -> research on enhanced seeds and technical knowledge about the crops and its pests (although in very different conditions as work is done in plains) | | |
| Call to other AMs? | | Work on potato Angonha workload (AM D) -> small producers would have more time to focus on common bean cropping. | | |

| State of progress | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
| Done ! | Being processed | To do |
| <ul style="list-style-type: none"> • Continue to identify the factors explaining the volatility of yields by going back and forth between : <ul style="list-style-type: none"> - Focus groups with a few producers (producers with different levels of yields) on their tomato plots - Bibliographic research ⇒ Ideally in October-November 2019 (bean sowing period). • To reach this goal, a field work with farmers in Mucunha Sede could be done, as it is the larger area for common bean production in the mountain -> Why do farmers achieve to grow bean there ? Is it thanks to a real different environment or just because they do have more time as they do not grow potato ? | | |

Could begin with the purchase of the survey (October-November 2019 ?)

| Cabbages _AM G, H, I and J | | | State of progress | | |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
| | “Production during the dry season” (AM G and I) | “Production during the rainy season” (AM H and J) | Done ! | Being processed | To do |
| Identification of the problems | It could be useful to increase cabbage incomes during the dry period, especially for small producers. What is currently preventing farmers from increasing their production ? <ul style="list-style-type: none">Specific issues linked to this crop have to be identified | Willingness to increase household income during the lean season to limit <ul style="list-style-type: none">Their vulnerabilityTheir dependence on highlands potatoes | Dry period : specific issues need to be identified yet. | | |
| | | | | | |
| Specific goals | Increase both headed and green cabbages production during the dry season. | Produce cabbage during the rainy period as part of a global cash alternative to highland potato. | Dry period : specific issues need to be identified yet. | | |
| Identification of the causes of the problem | Field <ul style="list-style-type: none">Access to seeds : insufficient self-production or/and stock shortage in the shops.Water supply (most of all for headed cabbage)Pets pressure (especially Rilé the larvae of which are looking for water during the dry season and cut the stems to suck the sap) | <ul style="list-style-type: none">Availability of land -> may be necessary to think about an association with an existing cropping system.Availability of seeds | <ul style="list-style-type: none">Dry period : identification of factors which are currently limiting the production have to be completed by going back and forth between :<ul style="list-style-type: none">Focus groups with a few producers (producers with different levels of yields) on the plots, including highland plots to make the comparison.Bibliographic researchFrom March to April 2020 ?Rainy period : go back and forth between interviewsOf producers and bibliographic researchs to identification the factors that are currently preventing the farmers from growing cabbage during the rainy season. | | |
| | Biblio | <ul style="list-style-type: none">Green cabbage : when the leaves are regularly cut for selling, the plant goes to seed with difficulty.Headed cabbage : the difficulty to go to seed may be due to the variety. | | | |
| Support for changing practices | <ul style="list-style-type: none">Reflection on the technical itineraries going back and forth between the plot and production system (type of producer) levels. | <ul style="list-style-type: none">Design of solutions if the limiting factors identified are not prohibitive. | | | |
| Research of partners | Technical partner for horticultural, market gardening crops. | | | | |
| Call to other AMs? | All the AM related to potato, tomato or common bean cropping to think about crop associations. | | | | |

| | | Cassava _AM K “Cassava yields and food security” | | State of progress | | |
|---------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------|
| | | | | Done ! | Being processed | To do |
| Identification of the problems | | <ul style="list-style-type: none">• <u>Yields</u> : size of the tubers. | <ul style="list-style-type: none">• Cassava is unfit for consumption (texture) between November and December (lean period). | | | |
| Specific goals | | <ul style="list-style-type: none">• Improve the size of the tubers | <ul style="list-style-type: none">• Make cassava fit for consumption between during the lean period. | | | |
| Identification of the causes of the problem | Field | <ul style="list-style-type: none">• Soil texture and compaction• A disease transmitted by a pest that atrophies the leaves and is responsible for puny tubers | <ul style="list-style-type: none">• Explication of farmers : soils are waterlogged at that period. | <ul style="list-style-type: none">• Continue to identify (interviews with farmers and bibliography) factors that are limiting cassava yields (fertility ...). Are they differences between plots ? Varieties ? | | |
| | Biblio | <ul style="list-style-type: none">• Soil texture and compaction• Cassava Mosaic virus (propagation facilitated by the transport of infected cuttings and the absence of crop rotation) | | <ul style="list-style-type: none">• Investigate the practices of cutting (origin of the cuttings, criteria of choice, constraints related to the renewal of the plants and the establishment of crop rotations ...).• From August 2019• Deeper investigation of the issue of cassava in the middle of the rainy season : what is really happening ? Is it happening in all the plots ? What are the risk factors ?• From November-December 2018 | | |
| Support for changing practices | | <ul style="list-style-type: none">• Introduction and reproduction of healthy planting material. | <ul style="list-style-type: none">• Design of solutions if the limiting factors identified are not prohibitive. | <ul style="list-style-type: none">• How could we introduce healthy planting material in the area ? Where healthy cuttings can be found ?• How the persistence of a local pool of healthy cuttings could be ensured (training of nursery farmers, domestic management of private reserves...) | | |
| Research of partners | | Probably for healthy cuttings research. | | | | |
| Call to other AMs? | | | | | | |

| | | Caxaco | | State of progress | | |
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| | | AM L “Energetic efficiency” | AM M “Quality and storing” | Done ! | Being processed | To do |
| Identification of the problems | | <ul style="list-style-type: none">Wool consumption : the distillation process requires the burning of wood, a resource increasingly rare locally. In addition, the search for wood is a hard task, often done by women. | <ul style="list-style-type: none">Following a commercial strategy, big “caxaco” producers distil the most when prices are higher, and thus, while yields are also not optimum. | <ul style="list-style-type: none">Quality and storing : it is a theoretical problem. It was identified by analyzing farming practices but has never been directly expressed by producers.Does the issue as expressed here, make sense for local caxaco producers (probably the biggest) ? Does it reflect a need ? Could it help ? | | |
| | Specific goals | <ul style="list-style-type: none">Improve the energetic efficiency of distillation process to decrease the wood consumption. | <ul style="list-style-type: none">Allow producers of “caxaco” to combine efficiency during the manufacturing process, quality of the final product and advantages on the market (high prices) by deferring production and sales. | <ul style="list-style-type: none">Same thing as above : would caxaco producers (probably the biggest) be interested ? | | |
| Identification of the causes of the problem | Field | <ul style="list-style-type: none">Open, “three stones”, wood fire fireplaces. | <ul style="list-style-type: none">No storage of “caxaco” by the producers | <ul style="list-style-type: none">Quality and storing : Why do producers not distil when yields are at their highest, store the product, and sell later, when prices rise ? Is it because of a lack of cash flow ? Lack of place ? Of material ? Problems of conservation ? | | |
| | Biblio | <ul style="list-style-type: none">Possibility of improvement, technically easy and inexpensive. | | | | |
| Support for changing practices | | <ul style="list-style-type: none">Technical proposals,Tests of construction and the utilization with producers in real manufacturing conditions.Monitoring and collect users feedbacks,Continuous improvement of the prototypes to better feed producer’s needs. | <ul style="list-style-type: none">Will depend on previous reflections. | | | |
| Research of partners | Take advantage of Nitidae expertise in terms of energy. | | | | | |
| Call to other AMs? | Work on potato workload (AM D) -> small producers would have more time to focus on caxaco distillation. | | | | | |

| | | Pineapple_ AM N "Improve pineapple income" | | | State of progress | | |
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| | | | | | Done ! | Being processed | To do |
| Identification of the problems | | <ul style="list-style-type: none"> Pineapple is sold individually. The selling price depends on the size of the fruit. However, according to traders in the region, the fruits produced on Mount Namuli are relatively small. | <ul style="list-style-type: none"> Many producers sell their products on a daily basis, in Gurnué town. There, as they need to go back home quickly before the night falls, they sell off their fruits. As a consequence, they do not earn more than a farmer who sells to a trader directly in his field. | | <ul style="list-style-type: none"> <u>Market</u> : why do producers continue to sell in the city of Gurnué if there is no commercial advantage ? What is the link between the profile of the producer and his marketing strategy ? | | |
| Specific goals | | <ul style="list-style-type: none"> Improve the size of the fruits and, as a consequence, the selling prices. | | | <ul style="list-style-type: none"> <u>Market</u> : needs to be specified | | |
| Identification of the causes of the problem | Field | <ul style="list-style-type: none"> Cropping practices : cutting the offsets, regularity of weeding Age of the plantation Pineapple variety ("Lisboa" in the area) | | | <ul style="list-style-type: none"> <u>Production</u> : identify (interviews with farmers and bibliography) factors that are limiting pineapple yields (fertility,...) and possible innovative farming practices. <ul style="list-style-type: none"> From November 2019 to January 2020 ? <u>Market</u> : compare the costs/opportunities balances for farmers between the following situations : selling pineapple in the city (Gurnué), selling directly on the field, selling in another urban center (-> where do traders go ?) | | |
| | Biblio | <ul style="list-style-type: none"> Soil fertility (leached soils in slopping plots and no crop rotations) Cropping practices : cutting the offsets Age of the plantation | | | | | |
| Support for changing practices | | | | | | | |
| Research of partners | | Knowledge in pineapple production and technical itinerates. | | | | | |
| Call to other AMS? | | | | | | | |

| | | Avocado_ AM O | | |
|---------------------------------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | “Facilitate access to markets for producers who live above Muresse” | | |
| Identification of the problems | | | • (Even if there are many avocado trees on Mount Namuli’s slopes, and even if Gurrué is a commercial center for avocado trade...) many producers of the mountain (mainly above Muresse) do not achieve to transport and sell their avocados. The fruits, (there are too many and families cannot eat everything) often ripen on the floor. | • Do farmers have an interest in selling their avocado ? Is it worth it ? Or, with the current market organization, is it too much work for just little money ? -> A costs/opportunities study is needed. |
| | Specific goals | | Facilitate access to markets for producers who live above Muresse | • Need to be specified : depending on costs/opportunities balance. |
| Identification of the causes of the problem | | • Path between Namuli’s villages and Gurrué is impassable for a car. • Avocado is a heavy product. • The avocado mature in three days after being harvested. • The transports between Gurrué and other urban centers (Nampula, Quelimane : where Gurrué’s avocado is consumed) are irregular and unreliable . • Some producers tented to travel with their production in order to sell it in Nampula or Mucuba, but are discouraged by the obstacles encountered. | | |
| | Field | | | |
| | Biblio | | | |
| Support for changing practices | | | • Help producers to better integrate into the local market, as it is currently organized (by selling to Gurrué traders or directly where the final consumers are found). • Find other more suitable outlets... | • Will depend on the costs/opportunities study. |
| Research of partners | Depend of specific goals that would be chosen. | | | |
| Call to other AMS? | | | | |