Assessing the potential of bio-energy production in smallholder farming systems

The case of Nhambita community
Gorongosa District, Sofala Province

March 2010

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Introduction

This report provides insight in the potential of bio-energy production and application within smallholder farming system in Mozambique. Analysts see Mozambique as a promising country for biomass production for bio-energy purposes (Batidzirai, 2006). The recently approved National Biofuel Policy and Strategy (Government of Mozambique, 2009) indicates that the Mozambican government promotes bio-energy production to diversify the country's energy matrix, as well as to stimulate social and economic development, specifically in the rural areas. The National Biofuel Policy and Strategy supports both commercial large-scale, and small-scale bio-energy production. However, few initiatives focusing on bio-energy production within smallholder farming system exist in Mozambique apart from some commercially driven pilot projects. Due to the absence of markets and a lack of 'lessons learned', the off take of smallholder bio-energy production seems to be slow down even further. With this report, the authors hope to provide some lessons learned in this area.

Worldwide, 1.6 billion people lack access to electricity and over two billion still rely on traditional biomass for their everyday cooking and heating needs (Practical Action Consulting, 2009 1). Mozambique is well confronted with this reality, as its electricity system serves about five percent of the country's population (Econergy, 2008 3). The growing bio-energy industry is believed to provide opportunities for improving energy access in rural areas. Given that 85% (FAO, 2007) of the Mozambican rural population are subsistence farmers, the involvement of smallholders in the promising bio-energy sector can contribute on the one hand to rural development and on the other hand to energy access for rural populations.

To gain more insight in how bio-energy production could play a role within smallholders farming systems, the Ministry of Energy, in collaboration with the Programme for Basic Energy and Conservation implemented by the German Technical Development Cooperation (GTZ-PROBEC), has initiated and financed this study. The overall objective of this study is to explore opportunities for, bio-energy production within smallholder farming systems. This will hopefully contribute to a broader understanding of the complexities of smallholder farming systems and the potential of bio-energy use and production in Mozambique.

In order to achieve this objective, an assessment of market opportunities for Jatropha production in existing smallholder farming systems has been conducted by a team of researchers and specialists. The case study was selected in collaboration with the Ministry of Energy, taking into account the established link between the Ministry of Energy and the community, as well as the communities' willingness to participate in the study. Nhambita community in Gorongosa district, Sofala Province is one of the few examples where smallholder farmers are involved in Jatropha production. The community started growing Jatropha in 2004 with support from Envirotrade. Envirotrade is an UK based company that initiated a reforestation project in Nhambita community through the sale of CO^2 offsets. As the production of Jatropha seeds initially seemed very promising, the National Directorate for Renewable Energy (DNER) granted a loan to Envirotrade consisting of an oil seed press running on diesel, to be used by the community. For this reason, the Ministry of Energy suggested the Nhambita community as an interesting location to carry out the assessment.

Partners and cooperation

The initiator of this study is the Ministry of Energy in Mozambique in collaboration with its partner Programme for Basic Energy and Conservation (ProBEC). ProBEC is implemented by the German Technical Development Cooperation (GTZ). Additional contributing institutions are the GTZ programme for Access to Modern Energy Services Mozambique (Germany), Wageningen University and Research Centre (Netherlands), SBI Consultancy (Mozambique), FACT foundation (Netherlands) and Envirotrade (UK).

Research approach

In order to achieve the objective of this project: 'Explore opportunities for bio-energy production within smallholder farming systems', we subdivided the research in the following activities:

Research activities:

1. Assessment of farming systems in Nhambita community;
2. Assessment of opportunities for a bio-energy market in Nhambita community;
3. Identifying opportunities for bio-energy production within existing smallholder farming systems.

Methodology:

A four-day mission to Nhambita community was organized to carry out a farming system assessment by interviewing various types of farmers, and to carry out an assessment on current energy use by interviewing households, local businessmen, and the Envirotrade project team. The fieldwork for this study was conducted between August 31, 2009 and September 4, 2009. During this mission, the research team worked with a local extensionist who assisted in identifying respondents and did translations.

Furthermore, a literature study was conducted to get a better idea on agricultural practices in the Nhambita community and the introduction of Jatropha in the community. The used literature mainly consisted of Annual Reports by Envirotrade and research documents of the University of Edinburgh, one of the partners of the Envirotrade project.

The research methodology for each of the two assessments is described in detail in the introduction of chapter 2 and 3. The interview lists for the assessments can be found in the appendix (appendix 1 and 2). Note that not all topics from both interviews lists were addressed. The lists were merely used as guidance for the interviews.

1. Background

1.1 Nhambita community

The Nhambita community is located in Gorongosa district in the province of Sofala. According to Envirotrade, Gorongosa district has about 6,000 households with a total population of 283,400. The district consists of two areas, Chicare and Matenga. Communities in both areas are involved in the Envirotrade project. Nhambita community, together with nine other communities falls under the traditional authority of Regulo Chicara. The district is a previous war front and this had a great impact on the social structures within the communities due to the displaced of many people during this period. With the signing of the peace accord in 1992, these people started returning to their homes and the process continued through most of 1990s, thus leading to major increase in local population (University of Edinburgh, 2008 53).

Nhambita community is located in the buffer zone of Gorongosa National Park. During the war, the park was severely damaged as refugees invaded the park and animals were shot to supply the bush-meat markets in the city of Beira (Carbon Livelihoods Trust, 2007). After the war, the situation for the communities in the area remained difficult. Agricultural production had collapsed and there was little or no access to medical services, education, employment, capital or markets. This had a negative impact on the park and it surroundings, as the communities relied heavily on the area for slash and burn agriculture and charcoal production (Envirotrade B, 2009).

Almost all households in the community depend on forest resources and subsistence agriculture for their livelihoods, mainly done manually without agricultural inputs. Only 8.6% of the households grow commercial crops (University of Edinburgh, 2008 59). Literacy levels are low (34.4%), particularly among women (University of Edinburgh, 2008 54). Most households own very few durable items which indicate a low economic status. Agricultural operations follow a seasonal cycle, with women being responsible for both the household and the agricultural activities (University of Edinburgh, 2008 80).

Main sources of income in Nhambita community can be categorized as; selling of agricultural products, animal products, non-timber forest products, locally made products such as clay pots, bricks and alcohol, involvement as casual labour in nearby agricultural fields, and regular income from permanent jobs (University of Edinburgh 2008 63). The sale of agricultural products is the most common source of income. The major source of permanent jobs in Nhambita is provided by the Envirotrade project.

1.2 Envirotrade

Envirotrade is a UK-based company that has developed a business model using the sale of carbon offsets to support the conservation and management of existing forests and to invest in reforestation activities. One of the conservation areas they work in is Nhambita community in the district of Gorongosa. The project in Nhambita started in 2004 with EU-funding. Since 2008, the project runs independently on the sale of carbon trade. The carbon earning is generated by involving local farmers from Nhambita and the neighbouring communities in conservation management and reforestation activities. The involved farmers are paid for their activities through the sale of CO^2 offset, which is measured by the Plano Vivo methodology developed by the University of Edinburgh. Reforestation activities and conservation management offer the involved communities alternative sources of income which enables them to make the switch from 'slash and burn' agriculture to sustainable agriculture (Envirotrade, 2009). The objective of the Envirotrade project is two-folded; improving

the livelihood of people in a previous conflict zone, and decreasing the pressure on Gorongosa National Park in relation to deforestation and hunting. Envirotrade initially started with a group of 62 farmers engaged in tree-planting activities. Today, the project has contracted 1,514 farmers in the district of Gorongosa.

The project has three ways of supporting the involved communities through the sell of CO^2 offset: Agro forestry, Community Trust Funds, Support of Micro Businesses.

Agro forestry

The Envirotrade project offers different agro-forestry packages to the involved communities. Farmers can participate in one of these packages. Each package has a contract of seven years; Envirotrade provides the trees to be planted to the contracted farmers and monitors the progress of the planted trees twice a year. The farmers get compensated for their work, depending on the number of hectares and trees they have planted. They receive an annual remuneration; the first year 30% of the contractual value is paid, second till the sixth year 11% of the value is paid, and in the seventh year the resting ten percent is paid. Managing the agro-forestry packages is most intensive in the first year, due to planting and watering the seedlings. Therefore farmers receive a bigger amount in the first year. After seven years the trees are expected to have a sufficient size to manage on their own.

The Agro-forestry packages:

- Fertilization and soil improvement with tree specie *Gliricidia*
- Fertilization and soil improvement with tree specie *Faidherbia*
- Fruit tree plantation around homestead
- Fruit tree plantation of improved variety Mango
- Fruit trees plantation of improved variety Cashew
- Boundary system for demarcation of fields
- Conservation of woodlots
- Non-burning management of fields

Remuneration for farmers depends on the type of system they have chosen, the combination of packages, and the size of the field. The boundary system used to be most popular since it was the easiest package to maintain. Now the soil improvement system is most popular due to the high payment. The following list gives an indication on the remunerations given out in a contractual period of seven years:

- 1 Ha of *Gliricidia* US$ 139 per ha
- 1 Ha of *Faidherbia* US$ 807 per ha
- 1 Ha of Cashew US$ 500 per ha
- 1 Ha of Mango US$ 444 per ha
- Fruit trees around homestead US$ 584 per ha
- 1 Ha of woodlot (183 trees) US$ 695 per ha
- Boundary system US$ 180 per ha
- Non-burning US$ 97.30 per ha

Community trust fund

The community trust fund is established to reward the community for their contribution to forest management. All households in the community are involved in forest management. Every family within the involved communities receives a yearly payment of 260 Meticais (MZN) per year for their contribution to forest management. The forest management is controlled by a rural community committee (*gestão rural*), which is formed in every community. This committee has to monitor the forest management activities, patrolling

firebreaks and making fire gates together with the community. Furthermore, the community trust fund is used for communal projects, for example building a new school. Ten percent of the profit of the sale of CO^2 offset is paid to the community trust fund. In 2008 this resulted in US$59,000.

Support of micro business groups

The Envirotrade project also supports the establishment of micro business groups in the communities. There are six different micro business groups presently formed; carpentry, honey, tourism, saw mill, nurseries, and vegetable garden. The nursery association is growing the seedlings for the agro-forestry packages. At the beginning of the project, Envirotrade had its own tree nursery. At the moment, the tree nursery is run by the nursery association, a micro business group that produces 200,000 trees per year which are sold to the Envirotrade project. The other associations are aiming at the presently small but growing tourist market of the Gorongosa National Park. As the community is very close to the park entrance, they can benefit from the existing flow of tourists. One successful example of this strategic market focus is the carpentry association that sells their products to Gorongosa Park and private costumers. The carpentry gets its timber from the sawmill association. The sawmill has a sustainable cutting licence from the government, which allow them to collect natural dead wood and logs from previous cutters in Gorongosa National Park. They pay an annual tax for this licence. Furthermore, the community tourist lodge is offering an alternative for tourists going to the park.

1.3 Impact of Envirotrade project on Nhambita Community

The Envirotrade project plays an important role in the Nhambita community and its impact has gradually grown during the five years it has operated in the community. According to the Envirotrade staff, before the project started the community was isolated with little access to markets. No roads, clinics or proper school buildings existed within the community. As the Envirotrade projects brought new sources of income, some changes can be observed. Two schools have been built with the community trust fund, some shops have opened in the community and a local health centre has been established which is occupied two times a week by a healthcare official from the park. Through the years the situation in the community has been improving. Some of the positive changes identified by the Envirotrade staff are the increased number of constructed houses build, decreased number of farmers involved in slash and burn agriculture, more inflow of external goods to the community shops, and a more independent operation of the micro business associations.

At the moment, more than 1,500 of the 6,000 households in the Gorongosa district (Matenga and Chicara) have 4,000 agro-forestry contracts with the Envirotrade project. This means that on average, the involved households have between two and three contracts. In 2008, the Envirotrade project financed agro-forestry packages for a total amount of US$ 62,000. In Chicara a total of 1,018 households are involved in agro-forestry covering a total area of 1,000 ha. In Nhambita community, 103 households are involved covering an area of 132 ha. In Matenga, 496 households are involved, covering an area of 500 ha (see table 1).

Regulado Chicara	*Nº of contracted households*	*Nº of hectares*	*Regulado Matenga*	*Nº of contracted households*	*Nº of hectares*[1]
Pungue	125	143	Bairo 8	87	
Bua-Maria	65	75	Baptista	64	
Mbulaua	56	110	Chiro	87	
Mucinhawa Velho	188	185	Ernesto	39	
Mucinhawa Nova	43	20	Muchurue	55	
Munhanganha	141	150	Mucombezi Ponte	51	
Mutiambamba	190	217	Ziro	113	
Nhambita	103	132			
Povua	77	72			
Vanduzi	25	15			
Total:	1,013	1,000	Total:	496	500

Table 1: Overview number of households involved in agro-forestry in Gorongosa district (Personal communication Envirotrade, September 2009)

[1] Note that exact number of hectares allocated to agro forestry per community in Matenga district was not known at the time of the visit due to ongoing monitoring measurements.

2. Possibilities for Jatropha production in smallholder farming systems

Authors: Marc Schut and Wilson Leonardo

2.1 Introduction

Jatropha curcas L. (Jatropha) is a small tree that produces seeds with considerable high oil content (around 35%). The crop originates from Central America where it was used by native Indians as herbal medicine (FACT, 2009A). Nowadays it is found growing in many countries across the tropics including Mozambique. In Mozambique, Jatropha was and is cultivated as hedge to protect crops against cattle, as herbal medicine and seeds are used in local candles. Due to its potential for oil production and in light with rising fossil fuel prices, Jatropha has been promoted as an attractive source for Pure Plant Oil (PPO) and biodiesel production. During his last campaign in 2004 the President of Mozambique launched Jatropha production throughout the country where small-scale farmers were provided with seed to grow on their fields. The initial idea was that Jatropha can grow on so called 'marginal land' without any extra inputs. However, nowadays available literature on Jatropha shows that for good performance and competitive production sufficient rainfall, nutrients and good crop management practices are crucial. One of the communities where Jatropha production was initiated was the Nhambita community.

Since the president's campaign in 2004, much has changed in Mozambique. From promoting biofuel production by smallholders for domestic purposes, the focus has shifted to foreign commercial investors whose main focus is supplying the external market (Schut et al., *forthcomin*g). The commercial boom of biofuel developments in Mozambique distracted the attention from the initial objective to promote Jatropha production for local use. As many of the Mozambican government's biofuel-related objectives are still related to the inclusion of smallholder producers in the biofuel value-chain, there exists a need for data on the potential of Jatropha production within smallholder farming systems.

Objective

The aim of this chapter is twofold. Firstly, the question 'if' and 'how' Jatropha production merged within the existing smallholder farming systems in the Nhambita community will be explored. Secondly, the opportunities and challenges for Jatropha production in smallholder communities will be highlighted on which the main conclusions and recommendations are based. In order to achieve these objectives the following questions are addressed:

a. What are the main characteristics of farming systems in Nhambita community?
b. What is the role of Jatropha production within the different farming systems?
c. What biophysical and socio-economic opportunities and challenges can be identified in relation to Jatropha production in smallholder farming systems?

Methodology

A first step towards achieving the study's objectives was to explore the diversity of farming systems in Nhambita community. We specifically looked at the heterogeneity in access to resources such as labour, land, water and financial means. Initially we conducted a semi-structured interview with Envirotrade's operations manager to get some background information on the project, the introduction of Jatropha in the community and the current state of affairs. Subsequently we interviewed a senior extensionist of the Envirotrade project, who helped us with identifying different farming systems in Nhambita community. Based on the interviews we initially categorised farmers from Nhambita community in groups ranking from 'access to many resources' to

'access to few resources'. This approach has been used in many studies on household resource dynamics and decision making process (Tittonell, 2005; Zingore, 2006). Based on this initial ranking exercise, the extensionist identified five names of representative farmers from each of the two groups. Subsequently we asked for five names of farmers which were somewhere in the middle; with 'average access to resources'. Table 2 shows the summary of Nhambita's farming systems.

Farming system	*Resources*
1	Access to many resources
2	Average access to resources
3	Access to few resources

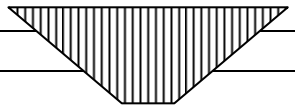

Table 2: Initial division of farming systems

Time-constraints allowed us to have in-depth interviews with one or two farmers or households from each group. Semi-structured interviews were conducted by the two consultants at the homestead of the farmer, followed by a visit to the farmer's field(s). An average interview took around two hours. The extensionist joined to translate questions and answers. The topic-list can be found in appendix 1.

Our analysis takes into consideration different livelihood characteristics and strategies within Nhambita community. Ellis (1998) defines livelihood strategy as a complex and dynamic matrix that enables people to meet not only the need for food and generate income but also concerns cultural and social choices. Although we could not fully grasp the complexity of farming systems in Nhambita community, we interviewed farmers who represent the different farming systems as identified in Nhambita community. In our analysis we schematised the farming systems, compared them and looked for interrelations between them. Special attention was given to the role of Jatropha production, whether within the individual farming systems or in the community as a whole.

GPS-coordinates of the farmers' homesteads were taken and farmers' plots were measured where possible. A transect-walk allowed us to show the geographical spread of the fields and the vertical profile of the landscape.

2.2 Research area

In order to give an idea of the research area, some geological and GPS-data is provided below:

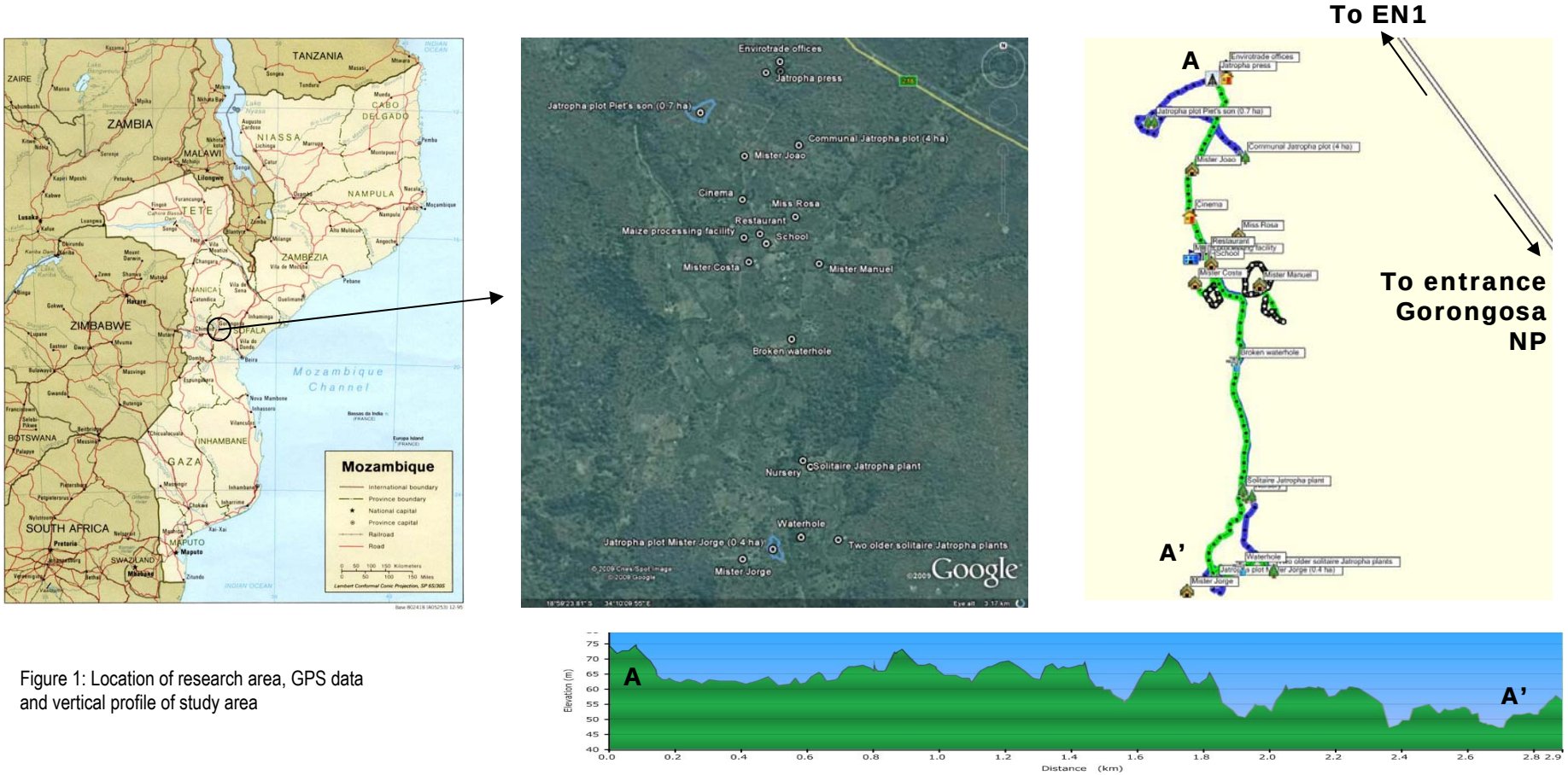

Figure 1: Location of research area, GPS data and vertical profile of study area

2.3 Agricultural practices in Nhambita community and the introduction of Jatropha

As described by the University of Edinburgh (2008 69-70): "Traditionally, farmers used to follow shifting cultivation wherein agricultural productivity was maintained by rotating crops. An area was cleared by cutting down standing vegetation and burning the site (slash and burn) before it was put under cultivation. Typically, farmers would grow crops on a piece of land for a few years, before it was left fallow for ten till twenty years to regain productivity. However, with the large-scale exodus of the local population during the civil war, most of the local area was left fallow for a long time with a result that when the people started returning in 1990s, they effectively returned to what was considered fertile soil, which had not been farmed for a long time. In addition, as Howell and Convery (1997) point out, this new generation of farmers had spent most of its time away from their land, had little knowledge of the traditional agricultural practices, especially the duration of each rotation cycle."

"Most households grow several kinds of crops such as maize, sorghum, pigeon pea, cassava, sugarcane, and various fruits and vegetables. However, the most common crops grown on a plot (referred to as *machamba)* are maize intercropped with sorghum in rows across the *machamba*, and surrounded by cassava intercropped with pigeon pea. In case of plots in the *dimbas* (which are flood plains of the various seasonal and perennial streams in the area), the most common crops are maize, with fruit trees such as banana and papaya on one side (away from the stream) and vegetables such as tomatoes and onions on the other (closer to the stream). Therefore, most households practice both intercropping and multi-cropping on their farms" (University of Edinburgh, 2008 70).

"Another important aspect of agricultural production is that it is predominantly rainfed with September – March as the main production season. Agricultural operations follow a seasonal cycle wherein crops such as maize, sorghum, pigeon pea and cassava are sown in *machambas* from October to November after the arrival of rains (refer table 13 below). While cassava and maize are harvested in January and March respectively, sorghum and pigeon pea are harvested as late as in June and August respectively. In case of *dimbas*, maize is sown in April after the end of rains and once the water in the streams has receded. It is harvested in August. Most households burn their *machambas* during August – September, to clear away any standing vegetation before sowing new crop" (University of Edinburgh, 2008 73).

2.3.1 The search for new cash-crops: The introduction of Pigeon Pea and Jatropha in the community

As described in Envirotrade's Annual Report: "The Nhambita Community Project aims to develop the community and its environment by far-reaching change in land-use practices. This is done primarily through the training of small subsistence farmers and forest dwellers to become custodians of their habitat, as well as developing sustainable land use practices and in so doing becoming committed to their environment. In this way they secure the regular income and sustainable food supply they need to survive. The money they earn from carbon dioxide offset sales allows them to make the switch from 'slash and burn' agriculture to sustainable food production, repeatedly on the same field" (Envirotrade, 2006 5).

In order to addressing unsustainable resource utilisation and provide alternatives to 'slash and burn' agriculture, the project has stimulated the production of vegetables and other cash crops for sale on local markets. For the purpose of this study we will highlight two different cash-crops; Pigeon Pea and Jatropha.

Pigeon Pea

Between November 2004 and January 2005 a program of inter-cropping with Pigeon Pea started (Envirotrade, 2006 10). "Envirotrade has taken this responsibility with farmer training and the supply of nitrogen fixing trees to farmers who will inter-crop with these trees and will in addition benefit from carbon sales. A rolling program

involving the supply of pigeon pea seed was initiated for winter fallow planting. Each farmer was given a five kg of seed which had to be replaced after the crop was harvested. Pigeon pea produces a high biomass yield that can be cut down and the leaf biomass retained to benefit the soil while the growing plant is nitrogen fixing and restores soil fertility quickly. The additional benefit is that the seed is edible and very nutritious" (Envirotrade, 2006 22).

During our study we observed that pigeon pea is widely adopted by different farmers in Nhambita community. The peas are both used for self consumption as sold as cash crop. On plots where Pigeon Pea was grown we observed thick layers of leaf biomass on the soil.

Jatropha

Between November 2005 and January 2006 a communal Jatropha trial plot was planted within the community at the request of the Sofala Agricultural Department. Between February and April 2006 the Jatropha trial plot increased to six and later to seven hectares. This trial has attracted a considerable amount of attention, both locally and from afar as the first organized plantation in Mozambique. Radio Moçambique and National newspaper followed with favourable reviews of Jatropha program. Between May and July 2006, 250 other farmers in and around Nhambita community showed interest in planting Jatropha for the possible bio-fuel market that is constantly being raised by Government. During that same time also the first seeds were collected from the trial plots (Envirotrade, 2006). Several sources told us that the plants grew beautifully during the first years. In 2008, the Ministry of Energy, (DNER) granted a loan to Envirotrade consisting of an oil seed press running on diesel. Envirotrade has the right to use this press during its operational time in the community.

At the time the first pruning was needed, little knowledge was present on how and when to prune effectively. From our interviews we learned that at the time of the pruning it had been dry for some time, whereas after the Jatropha plants were pruned a time of humidity followed. It was since the pruning that the plants started to have problems. The plants did not continue to grow, but started rotting inwards. Samples were analysed in South Africa for bacterial infections, but they came out negative. It could however also been viral plant infections that affected the Jatropha. During our fieldwork we observed that only few plants were still alive on the plot (see photo).

Limited availability of Jatropha seeds is preventing optimal use of the press, which is therefore not well maintained and in bad condition.

There is another Jatropha-plot of 0.7ha in the community. The plot is not owned by one of the farmers from Nhambita, but by the son of Envirotrade's manager. At the time of the mission the plot seemed in reasonable condition. There were no leaves on the plants, but that was perceived as normal during winter/ dry-season.

Moreover we found two older Jatropha trees close to the river, which apparently had been there long before the Jatropha initiative in the Nhambita community started.

2.3.2 Characterisation of farming systems

In this section we provide an overview of the interviews held. As said, one or two farmers per pre-identified farming system have been interviewed. We described the livelihood strategies of each of the farmers with regard to allocation labour, cropping and livestock systems, off-farm activities and expenditure patterns. Where possible we tried to quantify the information. Each of the descriptions is followed by a schematic overview of the farming systems. All names of the interviewed farmers have been changed to preserve anonymity.

Mister João; access to many resources

Mister João is a well-known farmer in the community and involved in many activities. His household consists of twelve members of which eight provide labour for on- and off-farm activities. Mr. João himself works as a driver for the Envirotrade project. His three wives and labourers run his farming activities. The farm-size is approximately 16 ha, divided over ten fields. Location of the fields are around the homestead (1.4 ha), they have a big field in Themba (2.4 ha) and eight fields in the *baixa* near the river (around 12 ha). The field in Themba is considered to be the most important field as it gives 'guaranteed production', followed by the fields near the homestead and the fields near the river. The field in Themba – approximately 5 km from the homestead – is being cultivated only recently. The main crops are maize and cassava. Near the homestead they grow pigeon pea, sorghum, maize, cassava, sesame and some vegetables like sweet potatoes. Besides sesame and cassava they intercrop all crops. As oil-crop Mr. João grows Jatropha intercropped with pigeon pea (in total 0.4ha). The fields near the river are about 1 km from the homestead. Mr. João has a lot of banana- and papaya-trees there and they grow vegetables such as cabbage, tomatoes, beans, pumpkin and onion.

Mr. João applied three kg of fertilizer (type not specified) during the last growing season, entirely for growing vegetables. He bought the fertilizer in Chimoio. When soil fertility decreases they replace maize by cassava. They also incorporate residues during land preparation to increase the soil organic matter and improve soil structure. Manure from livestock (mainly goat-manure) is gathered and applied to the vegetable garden. They mainly use local seed varieties, but bought a PANNAR improved maize variety in Chimoio last year. This short duration variety (two to three months) gave good yields compared to local varieties with relatively long cycle. They did have problems with pests last year (mostly soil-pests), but do not apply any kind of agro-chemicals to fight them.

Main food crops for consumption are maize, cassava, sorghum and pigeon pea. Sorghum is never used as cash-crop, whereas surpluses of the other crops are sold. Other cash-crops are beans, sesame and bananas. Maize and cassava are sold on-farm, but occasionally they also sell maize, cassava and bananas in Beira. For the sesame there is no local market, so it is sold on a

neighbouring market. Mr. João owns quite some livestock. He has chicken, goats, turkeys and ducks. Last year he sold two goats for 200 MZN each. They fish for self-consumption. The household does not own any cattle. Other income-generating activities are related to the Envirotrade-project. They grow native trees, N-fixation trees and have a fruit-tree yard. Moreover Mr. João is involved in one of the nursery-projects and he is shareholder in the maize-mill together with three other community-members. It was unclear how much income he received from this activity. Occasionally the household receives 'remittances in kind'. Last year this was two bags of rice which came from family living in Beira.

The household's main expenditures are hiring labour for land preparation, soap, cooking-oil, salt, sugar, fish and school-equipment for the four children (books and pens). Moreover money is being spent on milling and buying airtime for cell phone-use. One of his wives explains she uses around 200 MZN per month on cell phone-use. As said they also spend money on buying improved maize-seeds and fertilizer. Ploughing and other soil preparation activities are done by hand. They hire labour from the community, which they pay cash depending on the amount of land they ploughed. According to one of Mr. João's wives they pay 500 MZN for ploughing 50 x 50 meters, 200 MZN for 20 x 20 meters, and for clearing and ploughing newly established plots 200 MZN for 15 x 15 metres). We doubted the realness of these salaries as they are quite high in relation to what we heard from other farmers in the communities who hired labour.

Agricultural extension support is minimal in the community. During the interview we were told that an extensionist only visited once. Envirotrade provides basic assistance and recently distributed five kg pigeon pea seeds to each of the households in the community.

The Jatropha (we estimated it at 0.2 ha)[2] was planted in 2005 using seed provided by Envirotrade. These seeds had been collected in neighbouring areas. First fruits were picked recently, only limited in quantity. Currently, there is no market for the Jatropha-fruits, so the seeds are not sold. As Jatropha plantation was promoted by Envirotrade, Mr. João is still waiting for advice on what to do with the harvested seed. Based on the small amount of harvest (half a bucket) we do not expect any other use than using this seed for future sowing. Mr João planted the Jatropha as an experiment for a maximum of five years. If there is no off-take of the seeds, he will stop investing land, labour and energy in Jatropha-production. He expects to have yields up to 100 kg from the area they planted. The Jatropha on Mr. João's field looked quite good. It had leaves and fruits, in contrast to the other Jatropha-plants in the community.

[2] The plot was 0.4 ha, but Jatropha was intercropped with 50% of Pigeon Pea

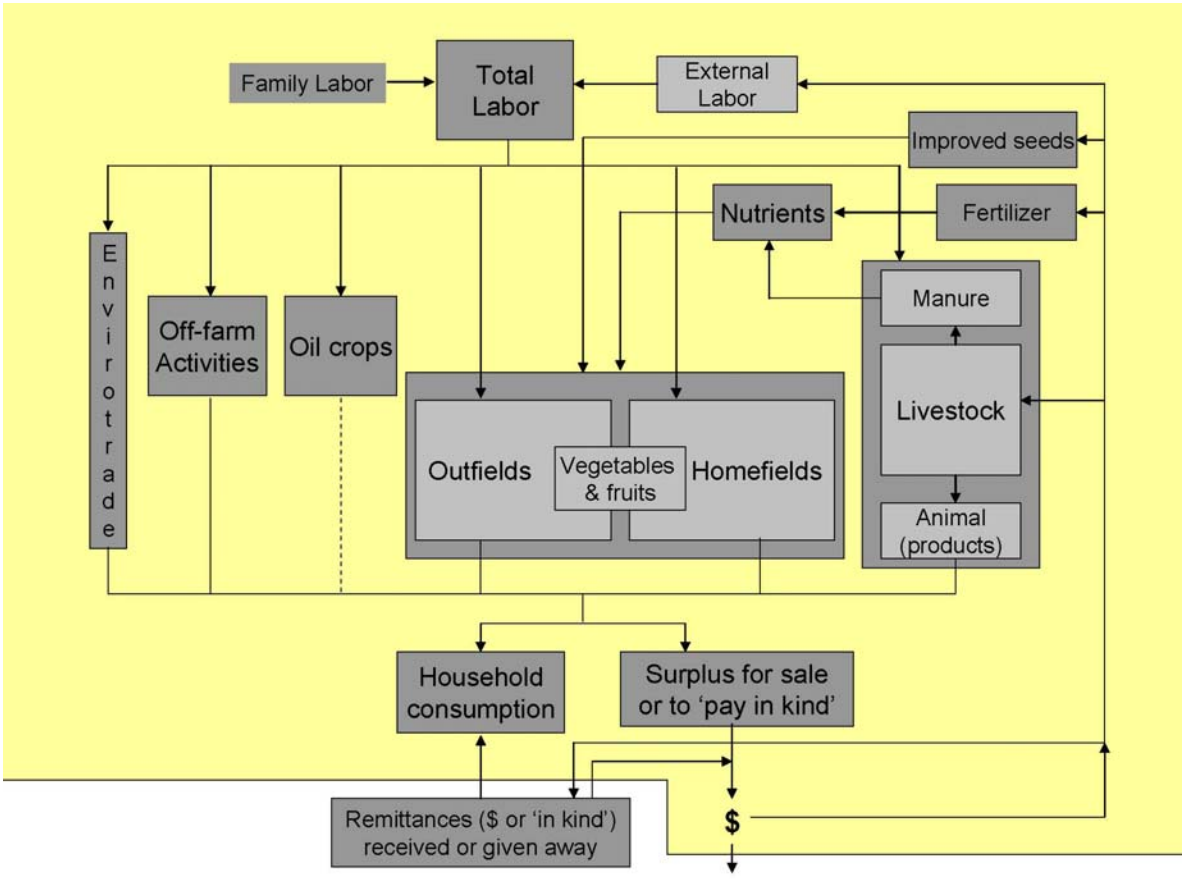

Figure 2: Schematic representation of farming system Mister João

The yellow block represents the farming system. Remittances (either given away or received) are outside the farming system. Dotted lines mean no flows of resources (labour, money or inputs).

Mister José; access to average resources

Mister José is a civil war-veteran who settled in Nhambita community. He receives government-allowance which he collects in Gorongosa once a month. Mr. José's household consists of four people, who all participate in the farming activities. During the beginning of the interview Mr. José excused himself to raise the Frelimo-flag, as a Frelimo-delegation from Gorongosa was expected. The homestead of Mr. José consists of two huts, a separate toilet-building and a concrete house which is being constructed (not used yet). The construction of a concrete house is seen as an investment for the future, financed with money he earned through his participation in Envirotrade activities. Mr. José employed a construction worker who does the work together with him.

Mr. José has three contracts with Envirotrade; boundary-contract (for all of his four ha), fruit-trees and '*Machambas sem quemadas*' (not burning their fields). In total he received 5,000 MZN in the first year. He explained that it requires quite some time. In the dry-season watering the trees has to be done once every four days, five litres per tree. The water is collect by his wife from the river banks and lowland areas. Besides his contracts Mr. José also works as an employee for the Envirotrade project.

On the fields closest to his homestead Mr. José grows maize and pigeon pea (one ha). On his other home-fields (four ha) he grows sorghum, pigeon pea and maize. Moreover we saw mangos, sesame, pineapple, cashew, tomatoes, bananas and sweet potato. He does not cultivate all four ha because of labour constraints (especially weeding). He does not apply fertilizer, but keeps residues on the fields as this keeps moisture in the soil. He is

not part of an association and does not receive assistance from extension service. As seeds he mainly uses local varieties, although he did receive an improved pigeon pea seed variety through Envirotrade. Seeds were distributed to improve soil fertility using legume crops. He has a third field near the river which he ploughs first. When the production is good, he sells his surpluses. Last year he sold some sorghum and maize.
Mr. José does not own cattle, but he does have around thirty chicken, two ducks and two goats. He did not sell any last year. He does not apply manure to his fields, as – according to Mr. José: "The goat manure is too dry, which can kill the plants. The chicken manure he cannot collect as it is too little to put on his fields. He also explains that he has to keep the manure for one year before he can apply it."

The homestead is surrounded by mango-trees (see photo). Mr. José uses mangos to pay day-labourers to plough and weed on his fields. He marks areas of 25m^2 which is equivalent to a bucket of mangos.
The major expenses of the household are cooking oil, soap, salt, and milling maize and sorghum. The household has two lanterns of which one was offered by the project. The lanterns work on diesel, which Mr. José buys when he travels to Gorongosa. They use batteries for the radio. Mr. José does not have Jatropha or other oil-crops. He believes Jatropha does not grow good. He first wants to see if it grows good before he would start growing himself.

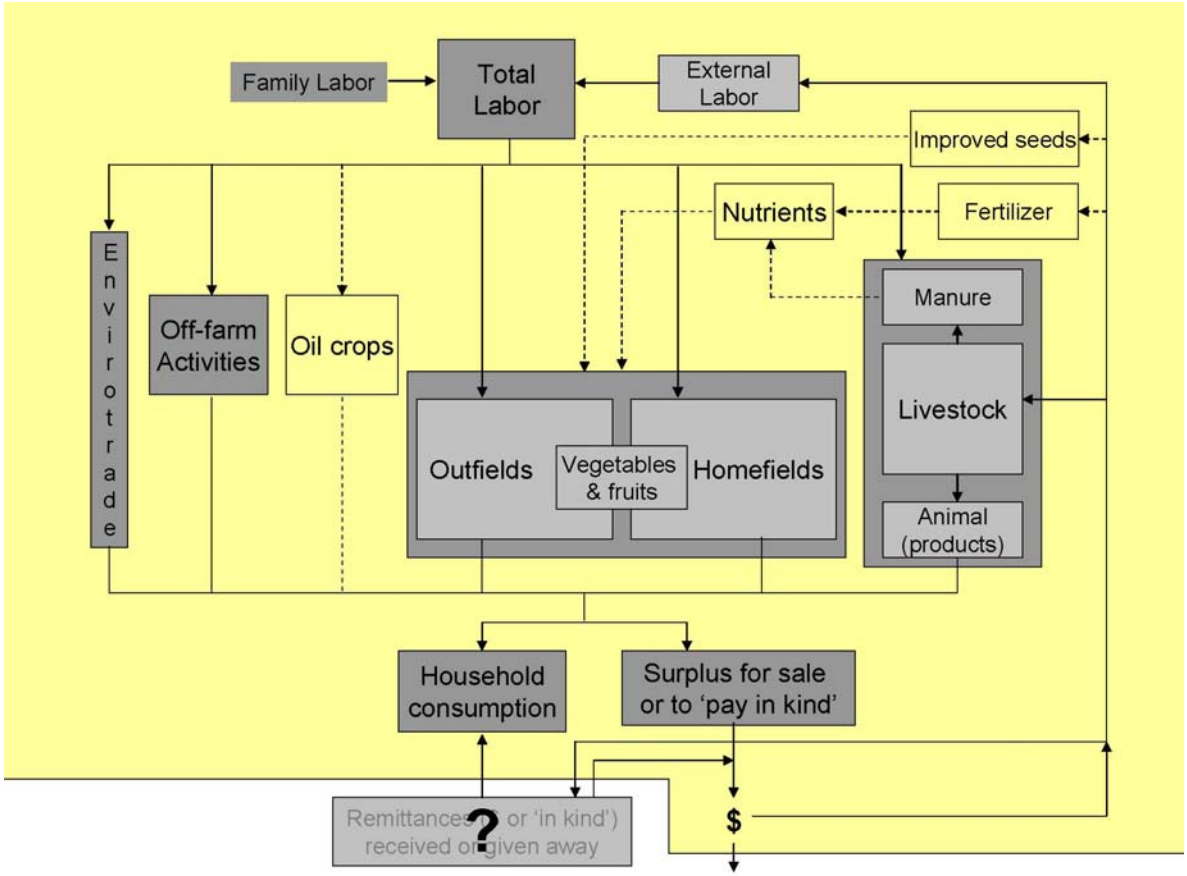

Figure 3: Schematic representation of farming system Mister José

The yellow block represents the farming system. Remittances (either given away or received are outside the farming system. Dotted lines mean no flows of resources (labour, money or inputs). If boxes are transparent it means the activity is not part of the specific farming system.

Mister Pedro; access to few resources

Mister Pedro's household consists of five persons; himself, his wife and their three children. Four of the household-members contribute labour. At the time of the interview Mr. Pedro himself could not work on his fields as he had an infection on his arm. They have two fields, one near the homestead (0.5ha) and one in the lowland/ *baixa* (estimated around 1ha). Mr. Pedro's wife is responsible for the homestead fields, Mr. Pedro works on the fields near the river as the soil there are harder to work. On the field near the homestead they intercrop maize and sorghum. On the other field in the *baixa* they grow maize, sorghum, tomatoes, onions and cabbage. They do two growing seasons on the *baixa* field. The first is maize intercropped with sorghum, the second growing season they only plant maize. The second harvest often is higher than the first, Mr. Pedro explained. The *baixa*-field is the most important field for the household. Pigeon pea is planted around the fields and randomly in the fields. They also have some mango and papaya. Mr. Pedro explained that they normally have enough food to eat. They brew some beverages for home-consumption.

Everything they grow is for household consumption. Income is received by working as a labourer for other farmers (including Mr. João) and Mr. Pedro worked for Envirotrade last year as a construction worker. They work two to three days per week as labourer, the rest of their labour they invest in their own fields. They have a 'boundary-contract' with Envirotrade for planting indigenous trees. The trees are planted during the rainy season.

Seeds come from previous harvests, they do not use improved seed varieties or fertilizers of any kind. Mr. Pedro is not part of any kind of social organization and does not receive any kind of extension support. They have no livestock at the moment. They used to have some chicken but they all died due to a disease.

Their main expenditures are on milling, buying salt and soap. Schooling for the children brings additional indirect costs, as clothes get dirtier and therefore need more washing (soap). They spend five MZN per week on salt, 30 MZN per month on soap.

Mr. Pedro has heard about Jatropha as that it has been planted in the community. Before that he never heard of it. He knows that it can be used as petrol, but that it is difficult to grow, even more difficult than other crops. If others would start to plant, he would also become interested. He explained that they have no source of remittances.

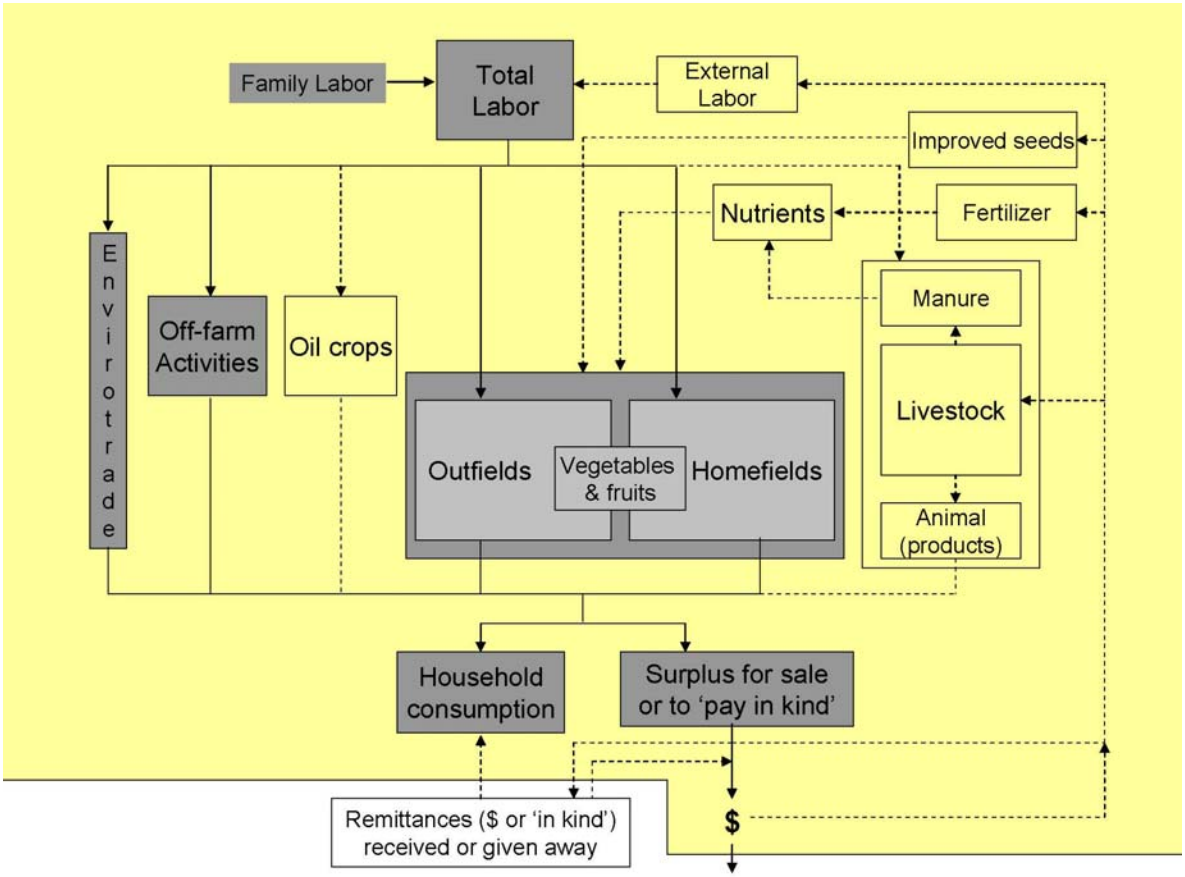

Figure 4: Schematic representation of farming system Mister Pedro

The yellow block represents the farming system. Remittances (either given away or received are outside the farming system. Dotted lines mean no flows of resources (labour, money or inputs). If boxes are transparent it means the activity is not part of the specific farming system.

Miss Maria; access to few resources

Miss Maria lives alone, without husband or children. She has three fields; one close to the homestead, one outfield and one in the *baixa*. On the field close to the homestead she grows pigeon pea, cassava, sorghum, maize, and sweet potato. On the outfields they crows maize and cassava, of which the cassava was eaten by the monkeys last year. She also tried to grow onion and tomato there, but it did not work. She produces enough for herself, although she had to buy food last year. She eats sorghum everyday, sometimes with dried fish or prawns. She occasionally sells surpluses to neighbours for which she receives cash. She has ten chickens, which she keeps in a small hut, but does not apply the manure to her fields. She explained that she does not have the knowledge on how to do that. Occasionally she sells a chicken to buy basic products like soap. She works as a labourer for farmers like Mr. José and Mr. João. They pay her in maize-flour (farina).

Ms. Maria has three contracts with Envirotrade; indigenous trees (boundary), the planted *Faidherbia albida* (N-fixating tree) and has a fruit-tree yard. Most of the work is maintaining the *Faidherbias* and the boundary-system; she cleans it from weeds to prevent fire. After the first year she received 1,300 MZN for planting and maintaining the trees. She will invest it in constructing a house. Also, she was offered an improved cooking stove by the project, but she could not afford it.

She does not buy improved seeds or agricultural inputs. She uses seeds from previous harvests. Ms. Maria is not part of any association and does not receive support through agricultural extension. She receives remittances in kind from her brother who lives in Beira. He sometimes provides salt, soap, and cloths. In return she gives him some sorghum and maize.

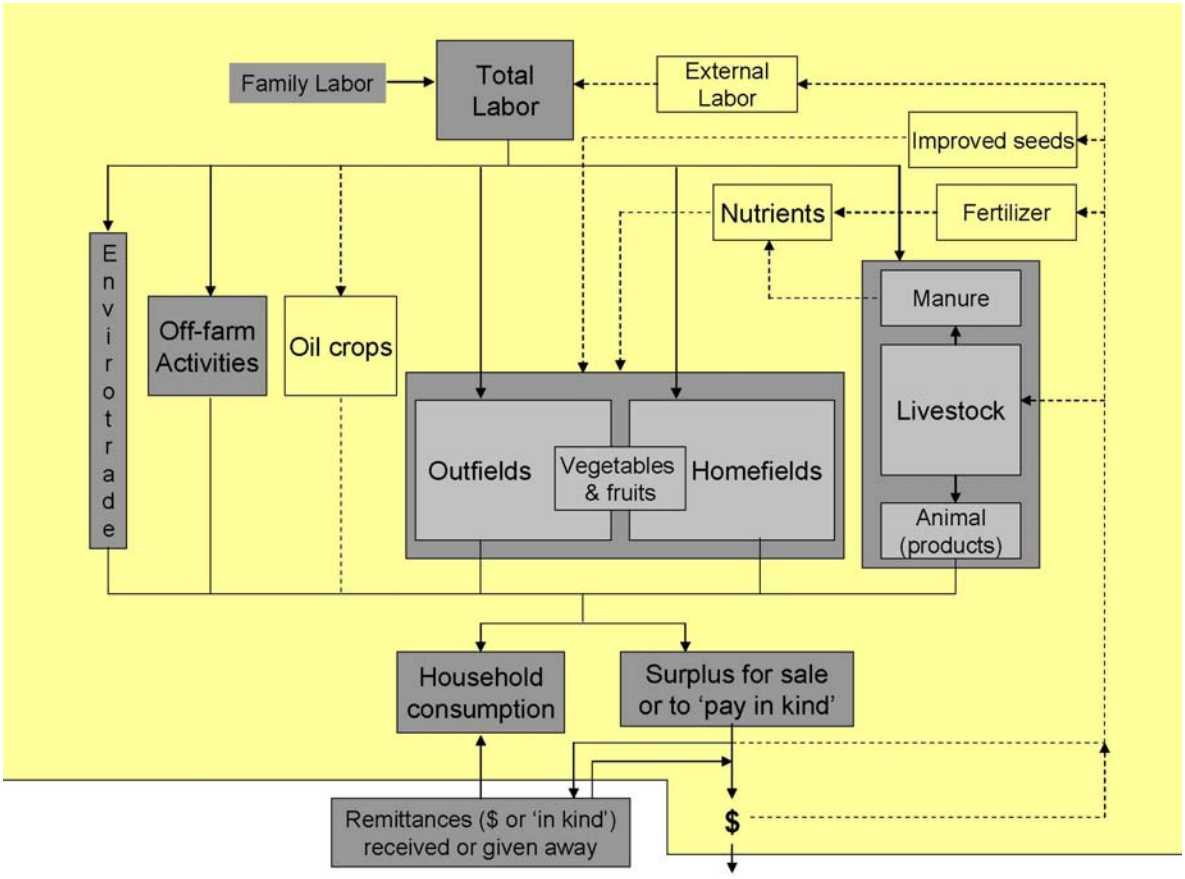

Figure 5: Schematic representation of farming system Miss Maria

The yellow block represents the farming system. Remittances (either given away or received are outside the farming system. Dotted lines mean no flows of resources (labour, money or inputs). If boxes are transparent it means the activity is not part of the specific farming system.

2.4 Analysing possibilities for Jatropha production

We have summarized the findings from our interviews in table 3. It shows the diversity within the Nhambita community with regard to the different farming systems present.

Household	*Mr. João*	*Mr. José*	*Mr. Pedro*	*Ms. Maria*
Access to resources	Many	Average	Few	Few
Household size (persons)	12	4	5	1
Labour in household (persons)	8	4	4	1
Fields (#)	10	3	2	3
Location of the fields (homestead, outfield, *baixa*)	Homestead, outfield, *baixa*	Homestead, outfield, *baixa*	Homestead, *baixa*	Homestead, outfield, *baixa*
Hectares[3]	16	4	1.5	2
Food/ cash-crops	Maize, cassava, pigeon pea, sorghum and sesame	Maize, sorghum, and pigeon pea	Maize, sorghum and pigeon pea	Maize, pigeon pea, cassava, and sorghum
Fruits, vegetables and other crops	Bananas, papaya, cashew, sesame, sweet potato, tomato, beans, onion, and cabbage	Mangos and pineapple, cashew, sesame, sweet potato, and tomato	Mango and papaya, tomatoes, onion, and cabbage	Sweet potato
Non-edible oil-crops	Jatropha	-	-	-
Livestock				
▪ Cattle	-	-	-	-
▪ Goats	5	2	-	-
▪ Ducks	10	2	-	-
▪ Chicken	>30	30	-	10
▪ Turkeys	10	-	-	-
Use fertilizer	Yes (for vegetables)	No	No	No
Use manure	Yes (for vegetables)	No	No	No
Use improved seed	Yes, PANNAR maize-variety	Rarely	No	No
Contracts with Envirotrade				
▪ Indigenous trees (boundaries)	X	X	X	X
▪ Indigenous trees (full field)				
▪ Fruit yard	X	X		X
▪ N-fixating trees	X			X
▪ *Machambas sem quemadas*	X	X		
Remittances (money/ in kind)	In kind (rice)	*Unknown*	-	In kind (salt, soap, and cloths)
Off-farm income				
▪ Labourer			X	X
▪ Government pension		X		
▪ Work for Envirotrade	X	X		
Main expenditure of income	Cooking oil, soap, salt, sugar, milling, cellphone credit, labourers, fertilizer, improved seeds	Cooking oil, soap, salt, milling, diesel for lighting	Milling, salt and soap	Milling, cooking oil, soap and salt

Table 3: Overview of different farming systems in Nhambita community

[3] Amount of hectares are a combination of fields measured with GPS and estimations made together with the farmers

From the analysis of farming systems characteristics and livelihood strategies among different farmers groups in community, we concluded that agriculture, off-farm activities and contracts with the Envirotrade are the main components within each of the farming systems. Subsistence agriculture is practiced by the majority of farmers in the community and is dominated by maize, sorghum, cassava, sweet potatoes and pigeon pea production. All of the farmers generate additional income through Envirotrade activities such as: reforestation of native forest, growing fruit trees and participation in micro business groups like nurseries and carpentry (see chapter 1.2 *Support of micro business groups).* Moreover some farmers had jobs at the project. Off-farm activities were mainly related to wage-labour activities, where farmers with access to few resources tend to allocate part of their labour for working for farmers with access to average or many resources.

Our analysis seems to indicate a relationship between access to resources, household size, and the amount of land cultivated. Farmers which were categorized as having access to average or many resources cultivated more land and have more livestock than farmers with access to few resources. Subsequently farmers with access to many or average resources have the ability to hire labour which allows them to cultivate more land. The farmer with access many resources moreover used improved seeds, fertilizer and applied manure which could improve productivity.

Two types of fields were identified: close to homestead and outfield. All of the interviewed farmers had outfields on river banks (*dimbas* or land in *baixa*). Traditionally, ownership of land is through heritage although a richer farmer reported to have bought some piece of land especially on river banks. Land seems not a limiting factor for crop production, although some restrictions/ scarcity were mentioned for land in river banks or areas often flooded (*baixa* or *dimbas*). Labour is the most limiting factor among poor farmers and in years of poor harvest they exchange labour for food. This relationship is based on so called social capital (Scoones, 2001; Baumann, 2002), and is a recognizable feature in Mozambican subsistence agriculture (Brouwer and Nhassengo, 2006; Leonardo, 2007).

The main food crops are maize, sorghum, cassava and pigeon pea. Main cash crops are beans, sesame and bananas. Maize is also a cash crop in case of surplus. Livestock is limited to small numbers of chickens, goats, ducks, turkeys and occasionally guinea fowls. Manure of these animals is generally not applied to increase soil fertility (only by Mr João), mainly because farmers have limited quantity or lack of knowledge on how to apply it to their fields. We did not found a single household with cattle. Even the farmers with access to many resources do not own cattle. This is in line with research finding by Edinburgh University who conclude that: There was no household in the area which owned any cattle or other large ruminants (University of Edinburgh, 2008 61). Main reason is the absence of a system to protect the animals from Tsetse-fly and other diseases, which makes having livestock a risky business.

With exception of Mister João, farmers do not apply fertilizers and other inputs to increase productivity. In general, farmers perceive their land as fertile, and moreover do not have the resources to buy agro-chemicals. The use of improved seed is limited to maize crop, and only applies for farmers with access to many resources. For all farmers their main expenditures were on milling (maize and sorghum), cooking oil, salt and soap. The 'richer' farmers also bought cell-phone credit, diesel for lighting, fertilizer (only for vegetable production) and – as said – improved maize seeds.

As sensitized, the relationship between the interviewed farmers is mainly labour-based (figure 6). We see that Mr. Pedro and Ms. Maria contribute to the external labour-inputs for Mr. João and Mr. José (solid lines). In return they receive either payment in kind or a wage based on the amount of land they plough or weed (dotted lines). Labour is seen as the constraining factor for expansion of agricultural activities. The majority of the farmers owned more land than they actually could cultivate.

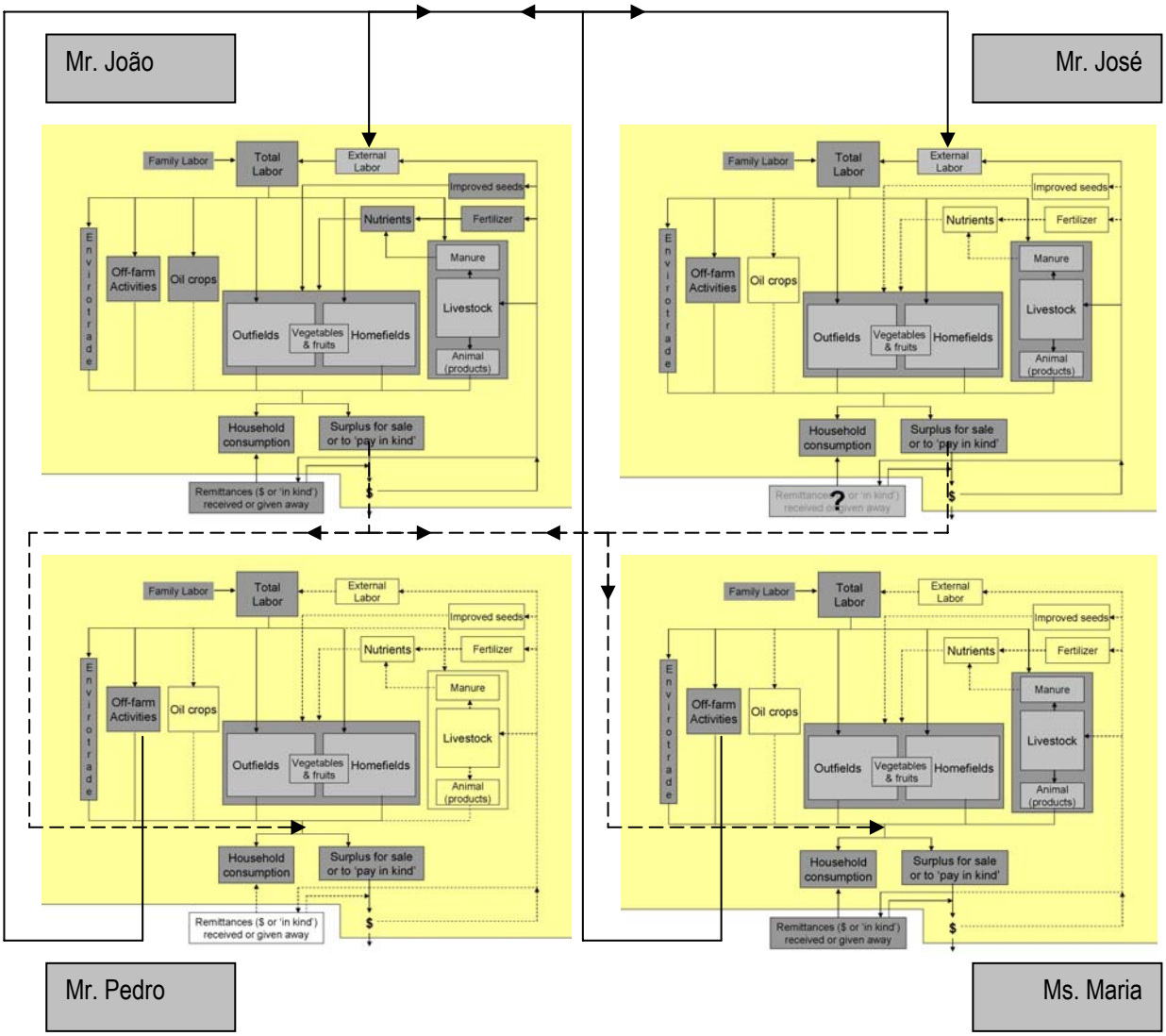

Figure 6: Interrelations between the different farming systems

2.4.1 Jatropha production in Nhambita community

Besides some solitaire Jatropha plants, we found three areas where Jatropha was planted: The communal plot (once near 7ha, now left with only some plants in poor condition), the plot of the son of Envirotrade's manager and on the home field of Mister João (both in good condition).

Mr. João (access to many resources) dedicated 0.2ha of his land to Jatropha production, which he sees as an experiment. His Jatropha intercropped with pigeon pea appeared to be in good condition and – although low in quantity – first yields had been harvested. Unfortunately he did not know what to do with his yields as the quantity was too little for pressing, and no local market for the seeds is present. From socio-economic point of view the lack of market to absorb the very low production of Jatropha was the main constraints, and Mr. João expressed that he would stop Jatropha production if this would not change.

In the three areas where Jatropha was grown, biophysical conditions (soil type, water availability, and fertility status) did not seem to be limiting factors for Jatropha production. Some of the fields used were left fallow for long time, however, the lack of crop management skills such as time and height for pruning appear to have hampered the fulfilment of Jatropha potential in the area. It's important to point out that the Jatropha on the communal plot initially was very successful, but after the pruning the plants were hit by bacterial or viral plant infections which devastated the majority of the crop (FACT, 2009A).

During the successful days of Jatropha production in Nhambita (May-July 2006), almost 250 farmers from the area showed interest in planting Jatropha on their land. At the time of our study (September 2009) only one individual farmer was growing Jatropha, while the majority of other farmers did not allocate land or labour to growing the crop. They described Jatropha as difficult to grow, and a crop they had little knowledge about. On the other side, they remained interested if others would also start to grow it.

2.5 Conclusions

In absence of draught power, labour seems to be the most restricting factor for the expansion of agricultural activities in communities like Nhambita. However, based on this study we cannot relate labour restrictions to the unsuccessfulness of Jatropha production in the community. Although we could not take soil-samples and other data related to the growing conditions for Jatropha, it seemed that also the biophysical conditions were not the main reason for failure of Jatropha production in the community. The main reasons seem to be related to lack of knowledge on agronomic crop management in terms of pruning, and virus and pest management. The failure of the first Jatropha trials has consequently led to a lack of trust to grow the crop. This lack of trust is amplified by the absence of markets where potential yields can be sold, and the fact that Jatropha cannot be used for household consumption as it is toxic.

The Nhambita case study shows that farmers are not reluctant to adopt new (cash) crops as part of their farming strategy. Both Pigeon Pea and Jatropha were introduced at the same time, but where Pigeon Pea is grown by almost every farmer in the community, Jatropha production could not live up to its expectations. Pigeon Pea is easily to grow, does not require strict and complicated crop management skills, and moreover has the advantage that it can be used both as food and cash crop. As most subsistence farmers are already struggling to make a living, it is unlikely that they will allocate resources to non-edible crops of which they have little agronomic knowledge and both yields as well as markets are uncertain.

The case of Jatropha production in Nhambita shows us that subsistence farmers apply a low-risk strategy, characterized by only investing their resources in activities of which they feel will have a return. Only farmers which have access to many resources can allow themselves to experiment. It is these farmers which could re-establish trust in Jatropha production. However, due to the absence of a market for their seeds, this seems unlikely to happen.

3. Energy Use in Nhambita community

Authors: Anna Lerner and Sandra Bos

3.1 Introduction

In Mozambique, around five percent of the country's population have access to the electricity. The primary energy supply is dominated by biomass and waste (Econoergy, 2008 3), accounting for some 81% of total energy use. The overwhelming importance of biomass reflects the poverty and largely rural character of Mozambique. Charcoal and firewood are the basic energy sources of most rural and peri-urban households.

In Nhambita community, most households use firewood when cooking, using the traditional three stone cooking stove. The women spend several hours a week collecting firewood to power a stove which is quite energy inefficient. Indoor lighting through battery lamps or solar systems is very rare within Nhambita with exception of the small shops (bancas) and some households. Most households use petroleum lamps for indoor lighting. Improved clay cooking stoves have been demonstrated by ADEL in collaboration with GTZ-ProBEC in early 2009, however, little presence of the improved stoves could be found in the community. A recent initiative from the University of Johannesburg, South Africa, in collaboration with GTZ-ProBEC South Africa, has provided 20 families with a modern improved cook stove, the Aprovecho stove, fabricated in China. This initiative forms part of a pilot project for testing market interest for the Aprovecho stove. Nhambita community is not connected to the electricity grid, although a power line runs alongside the community to supply the Gorongosa National Park. At the moment there are no plans to connect the community to the electricity grid. Given the low level of development in the community few households see electricity connection to the houses as necessary or even affordable at the moment.

Objective

The aim of this chapter is to explore the potential for bio-energy use within the Nhambita community. In order to achieve this objective the following questions are addressed:

a. What is the current energy use in Nhambita community?
b. What potential bio-energy applications can be identified in Nhambita community?
c. What market opportunities can be identified for bio-energy production in Nhambita community?

Methodology

The current energy use within Nhambita community and within the Envirotrade project has been assessed. Qualitative data on energy use have been collected through semi-structured interviewing. On community level we randomly selected households, local businesses, and public buildings to get a diversified insight into the general energy usage in the community. Moreover, at the Envirotrade project we especially looked at the energy consumption (quantity and costs) of the generator. Interviewees were questioned on their energy consumption and expenditures of energy. The findings are described below and will be used to analyse whether the current energy use in Nhambita community could provide market opportunities for bio-energy production.

3.2 Current energy use in Nhambita community

In this section an overview of the information from the interviews held is provided. All names of the interviewees have been changed to preserve anonymity.

3.2.1 Household level

Family 1: Miss Carolina

Miss Carolina is a young mother of seventeen with a three months old baby. Her family is one of the 20 households within the district that recently received the Aprovecho cooking stove. The distribution of the 20 cooking stoves was a project component of a South African PhD-researcher who worked in the community in collaboration with GTZ-ProBEC South Africa. At the moment Ms. Carolina is not using the cooking stove as it is new and very shiny and she is thus afraid of damaging it. “We will only use it for special occasions”, as she explains. Instead, Ms. Carolina cooks on the three stone cooking stove using firewood which she collects herself. The gathering of firewood takes here several hours per week.

For indoor lighting Ms. Carolina uses a petroleum lamp. The lamp can be refilled at one of the bancas in the community. A lamp fuel refill costs 10 MZN. Ms. Carolina buys a refill very two weeks. Her husband works for Envirotrade. At the time of our visit she was preparing a dish with pigeon pie. The household does not use any other energy sources besides the petroleum lamp and the three stone cooking stove.

Family 2: Mister Domingo, Technician Envirotrade

Mister Domingo works as contractor in the construction sector as well as a technician for Envirotrade. He lives with his family in the neighbouring community of Nhambita. At the moment he is contracted to construct a new church in his community. From this construction project he will earn 6,000 MZN during the upcoming 1.5 months. Within the Envirotrade project, Mr. Domingo is responsible for managing the Jatropha-press. He was selected to participate in a technical training on how to operate the press, organized by the Ministry of Energy. Until now however, the press has not been used often because of the lack of Jatropha seed production.

Mr. Domingo and his wife have six children. His wife is enrolled in an analphabetic program for adults. In terms of agricultural land, Mr. Domingo owns 1.3 ha of land where he grows maize, sesame, cassava and sweet potato. The sesame is grown as a cash crop that is sold for 20 MZN per kg. Maize, on the other hand, is sold locally. One of the biggest expenses of the Domingo household is cooking oil, which is bought for 220 MZN per five litre. Due to this high expense, Mr. Domingo is planning to plant sunflower on 0.4 ha of his *machamba* next growing season.

For indoor lighting, the family uses a battery lamp and a petroleum lamp. The battery lamp was bought in Chimoio for 80 MZN. The small batteries for the lamp are bought locally for 7.5 MZN each. The petroleum lamp is used when they lack money for batteries. The cost of refilling the petroleum lamp is ten MZN. Albeit presently using a three stones cooking fire, the family have heard about improved cooking stove technologies and are interested in buying one in the future.

Family 3: Mister Antonio, Member of Gestão Rural

Mister Antonio is member of the committee *gestão rural* (see chapter 1.2 *Community trust fund)*. Mr. Antonio lives in Nhambita with his wife and eight children. He owns two houses and one storage hut. The oldest child of the family is 18 years and has two children of its own; the youngest is three years old. The four oldest children support the farming activities at the family field, where they grow cassava, maize, sweet potato and chicken pea. Mr. Antonio has been growing sesame for the last three years, which he sells for 20 MZN per kg. Additionally, Mr. Antonio has a few chickens and goats. Household cooking is done with the three stone cooking stove. For indoor lighting, a petroleum lamp is used, which was bought and is usually refilled at the local shop.

3.2.2 Local business level

Banca 1: Mister Francis

Mister Francis owns one of the bancas in the centre of the community. In his banca he sells, amongst other things, energy products like petroleum lamps and petroleum refills, alcohol and soda drinks, and cigarettes. Mr. Francis further owns a small bar area for consumption and socializing next to the banca. Mr. Francis operates a 12V solar system to light his shop in the evenings and to recharge a battery. He does not use a charge controller, only an inverter to power a lamp and a radio. The panel for 2,750 MZN and the battery for 1,500 MZN were both bought at the market in Muxungue. The inverter was bought in Chimoio at a cost of 1,100 MZN. Mr. Francis uses his solar system to run a small business recharging cell phones for five MZN per recharge. He recharges between three to five cell phones per day. Besides his commercial activities related to the shop, Mr. Francis also grows maize and cassava as food crop, and sesame as cash crop.

Banca fixa 2: Mister Artur

Mister Artur is the son of the owner of another banca located in the centre of Nhambita community. Mr. Artur's shop has a broader supply of domestic articles and energy products (such as; washing powder, cooking oil, soap, salt, candles, petroleum lamps, matches, small batteries, etc.). The shop uses a 12V solar system for own use like indoor lighting and listening to the radio. The system was bought in Chimoio from Sena Centre for 1,500 MZN for the panel, 1,100 MZN for the battery, and 1,100 MZN for the inverter. Tin petroleum lamps are sold in the banca for ten MZN each. Costumers can also refill their lamp for ten MZN or buy a small bottle of 250ml petroleum for 15 MZN. According to Mr. Artur, 250ml petroleum can last seven nights with economic usage. Petroleum lamps of glass are also sold in the shop but these are more expensive. Normal candles are sold for five MZN each.

Mr. Artur supplies his shops with goods from Gorongosa village. A one-way trip to Gorongosa village with local transport (chappa) costs 30 MZN, resulting in high transport costs. Sometimes, however, the local shop keepers can benefit from the regular trips of the Envirotrade car to e.g. Gorongosa village to purchase their his goods. The soap sold in the shop is bought in long bars in Gorongosa village. A box of 20 bars of soap cost 230 MZN. The bars are sold for 15 MZN each. If the shop owners include transport costs in the item price, the current selling price of 15 MZN barely covers the costs.

Mister Luis

Mister Luis runs a small informal business from his house. Items he sells are wine, beer, cigarettes and brandy. Mr. Luis previously worked for the Gorongosa National Park. Originally he is not from this area, but moved to Nhambita for the job in the Park. Mr. Luis used to combine the job with his local business in Nhambita., Recently however, his job ended. Through his job in the park Mr. Luis got a second-hand solar panel of 12V, which he complemented with an inverter that cost him 1,500 MZN and a battery for 550 MZN, bought in Gorongosa village. He uses his solar system to power a radio, a music installation and for running a cell phone recharging business, earning five MZN per recharge. Mr. Luis owns a 24V lamp for lighting, but since it does not comply with his solar system, it does not work. Instead, he uses a lamp which runs on three batteries per week, generating a total cost of 21 MZN per week. Furthermore, Mr. Luis has a *machamba* of 2.5 ha used for food production. He is not contracted in any of the agro-forestry packages of the Envirotrade project. He explains that he is not interested in growing trees as it will take too much work, especially because his *machamba* is not so big.

3.2.3 Community services

The most prominent public buildings in Nhambita are the primary school (grade one to six) and the office of the community committee for managing the rural area. Both buildings are new and built with finance from the community trust fund. The buildings are not connected to the electricity grid and none of the buildings use any

kind of electricity system (such as solar systems or generators). The neighbouring communities also lack access to electricity.

3.2.4 Envirotrade

The Envirotrade project has a diesel generator to supply their office with electricity. Besides the office, the generator is also used to provide the office, the nursery and the technician camp with water. The consumption of the generator varies from 20 litre to 60 litre per day, depending on the amount of work they have (number of hours operating). Diesel is bought in Chimoio for an average price[4] of about 25 MZN per litre. The generator is also used by the carpentry for sharpening the saws. At the moment, Envirotrade is not charging any money for this service. In general, the carpentry consumes between 20 and 30 litre per month.

Besides the Envirotrade project, one of the local businesses, the maize mill association, also runs on a diesel engine. The maize mill consumes about 10 litres per week (see table 4).

3.3 Analysing market opportunities related to energy usage

Table 4 provides an overview of the current use of energy related sources. On household level, the most commonly used energy sources are firewood and fossil fuel (petroleum). On business level (*bancas*), other energy sources can be found, such as solar systems, which are used as an energy source for lighting, radio and as recharging business. As the petroleum lamps are commonly used on household level, the lamps and additional refills are important commodities for the local shops. However, the locally sold fuel is very expensive, 15 MZN per 250 ml, amounting to 60 MZN per litre compared to 25 MZN per litre in Chimoio or Gorongosa village. Table 4 also indicates the consumption of diesel on business level (generators used by Envirotrade and the two micro businesses). Based on the outcome of the assessment on energy use in Nhambita community, the consumption of diesel on household level (petroleum lamps) and business level (generators) is likely to provide market opportunities for local production of Jatropha.

[4] Average price of diesel in the third and fourth quarter of 2009 was 25 MZN per litre.

Household level	*Energy sources & applications*	*Energy consumption*	*Purchase*
Miss Carolina	Three stone cooking stove	Daily firewood collection	Locally collected at no cost
	Petroleum lamp	Refill (15ml) per two weeks	Banca (10 MZN per refill)
	Cooking stove	Infrequent usage	GTZ
Mister Domingo	Three stone cooking stove	Daily firewood collection	Locally collected at no cost
	Petroleum lamp	1 refill (15 ml)	Banca (10 MZN per refill)
	Battery lamp	3 small batteries	Lamp Chimoio (80 MZN)
			Batteries Banca (7.5 MZN each)
Mister Antonio	Three stone cooking stove	Daily firewood collection	Locally collected at no cost
	Petroleum lamp	1 refill (15 ml)	Banca (10 MZN per refill)
Local businesses	*Available energy sources & applications*	*Function of Energy products*	*Purchase*
Mister Francis	Solar system	Lighting in the shop	Inverter Chimoio, components Muxungue
		Recharge 5 MZN per cell phone	
	Petroleum lamp	Shop sale 10 MZN	
	Fuel for lamp	Shop sale 1 refill for 10 MZN	
Mister Artur	Solar system	Lighting & radio in the shop	Chimoio
	Candles	Shop sale 5 MZN each	Gorongosa village
	Petroleum lamps	Shop sale 10 MZN	Gorongosa
	Fuel for lamp	Shop sale 250 ml for 15 MZN	
	Glass lamps	Shop sale	
	Batteries	Shop sale	
Mister Luis	Solar system	Radio & electric appliances at home	Panel Gorongosa park, components Gorongosa village
	Battery lamp	Recharge 5 MZN per cell phone	Banca (7 MZN each)
		3 batteries per week own use	
Community Services	*Energy application*	*Energy consumption*	*Purchase*
School	-	-	-
Gestão rural	-	-	-
Envirotrade and micro businesses	*Energy application*	*Average energy consumption*	*Purchase*
Envirotrade project	Generator	40 litre of diesel per day	Chimoio
Association carpentry	Generator	25 litre of diesel per week	Chimoio
Association maize mill	Maize mill	10 litre of diesel per week	Chimoio

Table 4: Overview of energy usage in Nhambita community

4. Possibilities for bio-energy production in Nhambita community

In chapters two and three, different possibilities for bio-energy production and use were identified. Chapter three showed the potential of replacing fossil fuels by Jatropha-based PPO, which could lead to considerable savings on both the household and business level. Moreover, PPO could be used to produce soap, which is one of the main expenditures for households in the community. If sufficient quantities of Jatropha seeds are produced, the press cake could be used as organic fertilizer. As fertilizers are not commonly used within the existing farming systems in Nhambita, this could boost agricultural production in the community.

4.1 Potential applications of Jatropha products

In the following sections, four different applications of Jatropha products are discussed that can be indicated as market opportunity, namely:

- The use of PPO on household level for the petroleum lamps
- The use of PPO for the production of soap
- The use of PPO on business level for the generator
- The use of residues after pressing PPO as fertilizers

4.1.1 Potential for using PPO on household level

Most people in Nhambita community buy fuel locally for a fixed price of 15 MZN per 250 ml. As already mentioned, this is much higher than the current fuel price at the fuel station (25 MZN for one litre of diesel). According to the local shop owners, an average household uses 250 ml of fuel per week to fuel petroleum-based lamps. As the majority of households use these lamps, there is huge potential for replacing this fuel by Jatropha-based PPO. There are however some issues to bear in mind. According to Jongschaap et al. (Jongschaap et al., 2007 15), the seeds of Jatropha contain viscous oil with very few other components than oil, fats and carbohydrates, which makes it well suited for burning. It does however require filtering after pressing, as small impurities or sediments may still be present in the oil (Jongschaap et al., 2007 14). According to Nielsen (2009 – personal communication), Jatropha PPO will not easily burn in oil lamps from glass because of the high viscosity. A simple lamp, made out of tin, could however serve this purpose better. The tin lamps are most commonly used in Nhambita community. Therefore, the existing lamps could be tested to see if they work on high viscous oil.

To calculate the potential of Jatropha-based PPO in Nhambita to be used for the petroleum lamps on household level, the following estimations can be made:

If 80% of the households in Nhambita community (68 households) use a petroleum lamp, and each household needs 250ml of petroleum per week, 4,420 kg of Jatropha seeds are needed to provide these 68 households with 250 ml PPO per week on a yearly basis. We assumed that five kg of Jatropha seeds is needed to produce one litre of Jatropha-based PPO (Nielsen, 2009 – Personal communication).

4.1.2 Producing soap from PPO

For most households in Nhambita community, soap is one of the main expenditures (see table 3). From interviews, it became clear that an average household of five persons uses approximately two bars of soap per month, corresponding to 30 MZN. As Jatropha-based PPO is suitable for manufacturing soap, there is potential for local soap production in Nhambita community. Furthermore, soap production could be seen as an opportunity for a new micro business association.

The process of making soap is relatively easy, as it only requires some caustic soda and water as ingredients (FACT 2009C 22). The production process of Jatropha soap involves: 0.35 litre of water, 150 g caustic soda, one litre PPO. This will produce approximately 1.27kg[5] of soap. A bar of soap weights about 0.45kg[6]. This means that at least two bars of soap can be manufactured with one litre of PPO, which means five kg of seeds per household per month. Calculations in table five show that to provide 80% of the households in Nhambita community monthly with two bars of soap 8,160 kg of Jatropha seeds are needed on a yearly basis.

4.1.3 Using PPO for engines:

Literature shows several examples of how PPO could be used for running engines (FACT 2009C, Jongschaap 2007). This however, requires conversion of a diesel engine. Recently, a modified diesel engine is being tested in Mozambique at ADPP in Bilibiza, Gabo Delgado, by FACT Foundation (FACT, 2009D). The scenario of modifying engines to be run on PPO will be of interest when a regular and sufficient oil production can be guaranteed. The below shows the amount of diesel used by Envirotrade, the carpentry- and the maize mill association on a yearly basis. We made our calculations based on five working days per week, and 50 working-weeks per year.

- Generator Envirotrade: Average 40 litres of diesel per day = 200 litres per week = 10,000 litres per year
- Generator carpentry: Average 25 litres of diesel per week = 1,250 litres per year
- Maize mill: Average 10 litres of diesel per week = 500 litres per year

To generate power for Envirotrade, the carpentry and the maize mill, 11,750 litres of diesel per year is needed. Table 5 provides an overview of the amount of Jatropha seeds and hectares of Jatropha needed to replace 50% of the diesel consumed (5,875 litres) by Jatropha based PPO. For additional technical information on the conversion and modification of engines, see the Jatropha Handbook by Fact Foundation (2009C 8).

4.1.4 Using Jatropha press cakes for fertilizers

If production of Jatropha will increase, the residues (press cake) after oil pressing can be used as organic fertilizer. The remaining press cake contains a considerable amount of energy and is rich of minerals. One ton of press cake contains approximately 51 kg of nitrogen (N), 18 kg of phosphorus (P) and 13 kg of potassium (K). It is equivalent to 153 kg of NPK industrial fertilizer[7] having the composition ratio of 15:15:15, based on the nitrogen content in press cake (Jongschaap et al., 2007 11, FACT, 2009C 30). Research has shown that fertilization with Jatropha seedcake significantly increases Jatropha seed yields (Ghosh et al., 2007). As fertilizers are not commonly used in Nhambita community, Jatropha press cakes could be used for fertilization of the Jatropha plots or for other crops. Note that press cake has to be composted before it can be used as fertilizer by leaving the cake for some time (a few days) outside (FACT, 2009C 30). No information is available on what amount (in kg) of press cake will be left after composting.

[5] 1 litre PPO + 0.35 litre water = 0.92 kg PPO + 0.35 kg water = 1.27kg soap (assuming that the caustic soda will dissolve in the water)
[6] Soap bars weighed by FACT in Bilibiza, Cabo Delgado
[7] Inorganic NPK fertilizers that consist of the three major plant nutrients: Nitrogen (N), Phosphorus (P), and Potassium (K).

4.2 Scenarios for PPO applications

Table 5 gives an overview of the recommendations described in paragraph 4.1, presented as different scenarios of PPO application for Nhambita community using Jatropha as oil-crop. Per scenario we show the amount of PPO, oil-seed and hectares needed per year. Although one could question the accuracy of our assumptions and calculations, table 5 does give an impression about the potential of PPO-applications in communities like Nhambita.

For the calculations in table 5, we estimated a normal water supply and medium soil fertility resulting in 1,500 kg of dry Jatropha seeds per hectare per year (FACT, 2009B 17). Roughly, five kilograms of Jatropha seeds are needed to produce one litre of Jatropha-based PPO.

	Lighting	*Soap*	*Generator*	*Total:*
Scenarios:	*Provide 80% of the households weekly with 250 ml PPO for one year*	*Provide 80% of the households with two soap bars per month for one year*	*Replace 50% of the diesel consumed by Envirotrade, carpentry and maize mill by PPO for one year*	*If all three scenarios are implemented*
PPO needed per year	816 litre	816 litre	5,875 litre ▪ Envirotrade 5,000 litre ▪ Carpentry 625 litre ▪ Maize mill 250 litre	7,507 litre
Seeds needed per year (5 kg seeds needed to produce one litre of PPO)	4,080 kg	4,080 kg	29,375 kg ▪ Envirotrade 25,000 kg ▪ Carpentry 3,125 kg ▪ Maize mill 1,250 kg	37,535 kg
Hectares needed per year (estimated seed production of 1,500 kg per hectare)	2.72 ha	2.72 ha	19.6 ha ▪ Envirotrade 16.7 ha ▪ Carpentry 2.1 ha ▪ Maize mill 0.8 ha	25.0 ha

Table 5: Different scenarios of Jatropha PPO application in Nhambita community

The described Jatropha PPO scenarios all depends on the expected Jatropha production. If all three scenarios are adopted, about nine ha of Jatropha will be needed. An average applied planting density is 1,133 plants per hectare (with a plant spacing of 3 by 2.5 meters) (FACT, 2009B 4). Crop management of Jatropha, harvesting, pressing, as well as the manufacturing of soap will require extra labour and new skills. However, at the moment the production of Jatropha in Nhambita has not yet provided sufficient quantities of seeds for any of the described scenarios. Therefore, if seed production would increase, the most feasible and practical application should be selected. Of the four described scenarios (table 5), the production of PPO for lighting or soap production could be the most realistic option, as it does require the smallest area of Jatropha production. It further seems logic to use the Jatropha press cake for fertilizing the Jatropha plots when seed pressing has been started again. The use of the press cake as organic fertilization will improve the seed production and thus future yields. Consequently, when seed production improves, the other bio-energy options can be explored. Using Jatropha PPO for engines seems more feasible on the long term as this will require further research and investment in the conversion of engines. The attractive impact of supplying PPO for the Envirotrade generator and engines would be the establishment of a guaranteed off-take of Jatropha PPO, thus reducing the uncertainty of access to markets.

5. Conclusions

The assessment of current energy use and the potential for PPO-applications in Nhambita, demonstrates that there is a potential market for bio-energy products in smallholder communities. Many households buy petroleum in the local shops for indoor lighting, and one of the main expenditures of many households is buying soap. Moreover, the Envirotrade project uses large quantities of diesel, which could be partly replaced by PPO from locally produced Jatropha. Within all scenarios presented in table 5, organic fertilizer can be produced from the Jatropha seed shells that could boost agricultural productivity, as currently no organic or chemical fertilizers are used.

Based on the assessment of farming systems within Nhambita, we can conclude that farmers are not reluctant to adopt new crops. The success of Pigeon Pea cultivation in the community shows that the introduction of new (cash) crops can be sustainable if some critical conditions are met. Subsistence farmers with access to average or few resources generally adopt a low risk strategy. Farmers carefully allocate their labour to crops and *machambas* of which they think will give the highest yields. As labour seems to be a crucial resource within the farming system, it is unlikely they will invest in a non-food crop of which they have little knowledge, and which will only give profitable yields after some years. Subsequently, the disappointing results of growing Jatropha in the community have resulted in widespread scepticism about Jatropha-production among smallholder farmers.

Our study shows that there is a mismatch between the potential for bio-energy applications such as PPO, and the actual production of bio-energy crops. Under the current conditions, even the modest scenarios for PPO-applications seem very difficult to achieve. Even in communities like Nhambita where there is access to an oil-press and promising biophysical conditions such as soil-fertility and water availability, success is not guaranteed. After the initial successful production of Jatropha, the lack of knowledge and crop management skills led to crop failure. This negative development made the majority of farmers decide to allocate their scarce resources to other (cash) crops and activities which they regard as more profitable. Consequently, insufficient production of seeds kept the potential market from being realized.

We found that when introducing new cash crops like Jatropha, an enabling environment, as provided by the Envirotrade project, is of great importance. Such an enabling environment can provide access to knowledge, training and technology, establish a guaranteed off-take, and by doing so reduce risks for smallholder producers. Envirotrade has several mechanisms in place that reduces risks and could be adopted for local, smallholder biofuel production. For example, farmers receive an annual remuneration for planting trees, which could stimulate Jatropha production and result in more short-term benefits.

6. Recommendations

Our study in Nhambita community provides valuable lessons learned on the potential of bio-energy production and use in smallholder communities. In this final chapter, we provide general recommendations on bio-energy production within smallholder farming systems (paragraph 6.1), and more specific recommendations for the Nhambita case study (paragraph 6.2).

6.1 General recommendations

1. Assessment of farming system dynamics

Labour availability and allocation is crucial in smallholder farming systems. The introduction of biofuel crops – like any other food or cash crop – will thus always impact labour allocation, and by doing so, impact the farming system as a whole. Before promoting smallholder bio-energy production, it is therefore necessary to first analyze and assess how bio-energy feedstock production can fit the existing farming systems. Results from the initial analysis can be assessed in relation to opportunities and challenges of adopting a new feedstock, such as Jatropha, and appropriate mechanisms to deal with the challenges can be developed.

Furthermore, a baseline study on biophysical potential – soil, water and fertility status – for bio-energy crop production should be carried out. If results are promising, a participatory process of experimenting can be initiated in which farmers receive training and support on how to grow and maintain the crop. A general emphasis on agricultural training and skills development for farmers is essential for a responsible introduction of bio-energy crops in smallholder farming systems.

2. Assessment of the market possibilities for bio-energy products

Parallel to this process, market opportunities related to bio-energy applications should be assessed. As can be learned from the Nhambita case study, the production of PPO for local consumption offers several market opportunities. Identifying potential markets and demonstrating the potential benefits for smallholders could provide a more secure framework for smallholder farmers to engage in bio-energy production.

3. Focus on local markets

On the short term, a focus on establishing local markets is recommended, as it will directly benefit rural communities. Access to market will benefit smallholders either by the opportunity to directly sell feedstock and seeds, or indirectly by reducing expenditures on fuel, batteries or soap. Moreover, access to organic fertilizer, produced from press-cake or crop residues, might boost agricultural production at household or community level. In line with the PISCES study (Practical Action Consulting 2009 39), we agree that a primary focus on local bio-energy production and application, appears to be more stable and consequently less sensitive for distortion by foreign governments and firms. With an appropriate enabling environment, this strategy contributes to sustainable development by local production, processing and use; distributing more benefits to rural communities than an export-first orientation.

4. Make a distinction between the various approaches for bio-energy production

Bio-energy production within smallholder farming systems requires its own unique approach that differs per locality and per farming system. Therefore, Bio-energy production within smallholder farming systems cannot easily be compared with the commercial biofuel market, as end-products and markets greatly differ from each other. Policies on bio-energy production should consequently make a clear distinction between these two different models of bio-energy production in Mozambique. Both systems, commercial bio-energy production and bio-energy production within smallholder farming systems, can however make their own valuable contribution to

socio-economic rural development in Mozambique, and diversifying the country's energy matrix by serving different markets with different end-products.

6.2 Specific recommendations for Nhambita

To promote Jatropha production in Nhambita community, an enabling environment, as provided by the Envirotrade project, is of great importance. Such an enabling environment could revitalize the Jatropha-trials, provide access to knowledge and training, a guaranteed off-take, but also incentives and support that reduce the risks for farmers to engage in Jatropha production and re-establish trust. Recently, some technicians and community members from Nhambita community have received training on Jatropha crop management and PPO-applications. This newly introduced know-how and experience could provide a starting point for a more secure framework for Jatropha production in the community. Additionally, as already mentioned, Envirotrade has several mechanisms in place that could stimulate Jatropha production and reduce risks for smallholder bio-energy producers. Furthermore, the fact that Nhambita community has access to an oil press indicates that other opportunities for bio-energy production could be explored. A recent study on straight vegetable oil, conducted by Technoserve and GTZ (2009), demonstrates the characteristics and market opportunities for various oil crops produced in Mozambique.

As for the PPO-applications; experimenting and testing is required. As described, finding appropriate lamps for Jatropha-based PPO and techniques for local soap and fertilizer production are essential. The suggested PPO-applications could provide new opportunities for micro business associations, for example in Jatropha nurseries, Jatropha oil production, Jatropha soap production, and organic fertilizer production.

Taking in to account that Jatropha can be seen as an invasive species and the fact that Nhambita is located in the buffer zone of the Gorongosa National Park, considerations should be made regarding the feasibility of growing Jatropha in this specific area.

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Appendix 1: Farming systems questionnaire

Farming systems questionnaire Nhambita community, Gorongosa
20090831 – Marc Schut and Wilson Leonardo

1.	General data		
1.1.	Name:		
1.2.	Age:		
1.3.	Location (GPS)	Waymark:	
1.4.	Education	None Primary Secondary Technician University	
1.5.	Position in the community	Chief	
		Big farmer	
		Son of …	
1.6.	Household size	1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 - ……..	
1.7.	Number of household members providing labour (on- and off-farm activities)	1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10 - ……..	
1.8.	Number of houses homestead		
1.9.	Other remarks	-	

2.	Income generating activities					
2.1.	Main activities	Agriculture			Handicraft	
		Labourer				
		Off farm activities				
2.2.	# of fields		Fields			
2.3.	Total size		Ha/ acres			
2.4.	Main crops	Maiz			Banana	
		Sweet Sorghum			Papaya	
		Cassava				
2.5.	Vegetable garden					
2.6.	Main vegetables					
2.7.	# of livestock					
2.8.	Type of livestock	Cows			Chicken	
		Goats			Pigs	
2.9.	Off-farm activities (paid activities inside the community)					
2.9.1.	From which activities?	Charcoal		Brewing		
		Wood production				
		Honey				
2.9.2.	How much?					
2.10.	Remittances (household members with paid job outside the community)					
2.10.1.	From where?	Mozambique				
		Outside Mozambique				
2.10.2.	How much?	… MZN/ Rand				

2.11. You describe that these are your main income-generating activities… could you divide these 10 paper balls over the activities?	1 … 2 … 3 … 4 …	% % % %

We would like to visit your fields and garden later…

3. Expenditure pattern			
	MZN per month	MZN per year	% of total
3.1. School			%
3.2. Food			%
3.3. Groceries, such as: ……			%
3.4. Clothes			%
3.5. Communication (telephone, etc.)			%
3.6. Transport			%
3.7. Energy			%
3.7.1. Fuel			
3.7.2. Electricity			
3.8. Health			%
3.9. Agricultural inputs			%
3.9.1. Seeds			%
3.9.2. Fertilizer			%
3.9.3. Pesticides			%
3.9.4. VET			%
3.10. Remittances			%
3.10.1. To whom, to where			
3.10.2. How much?	MZN	Per month/ year	
3.11. Savings			%
3.12. House (maintenance, renovation)			%
3.13. You describe that these are your main expenditure activities… could you divide these 10 paper balls over the activities?			

4. Social organization and extension services		
4.1. Social organization (farmers organization, cooperation)		
4.2. Size of the farmers' group	Farmers	
4.3. What activities do they do together?	Planting	
	Weeding	
	Ploughing	
4.3.1. Do you buy inputs together?		
4.3.1.1. What?		
4.3.1.2. From where?		
4.3.2. Do they sell together?		
4.3.2.1. What?		
4.3.2.2. To where?		
4.3.3. Is their support of an extensionist in the community?	YES/ NO	
4.3.3.1. How often?	…….. times per week/ month/ year	
4.3.3.2. What do they do offer (technology transfer)?		
4.4. Access to loans/ credit?		

4.4.1. How much per year?	
4.4.2. Where do they use this for?	
4.4.3. What is the amount of interest they are paying?	

5. Livestock					
5.1. Type					
5.2. # per type		#			#
	Cattle		Chicken		
	Pigs				
	Goats				
5.3. Grazing area/ feed/ residues?					
5.4. Amount of grazing area (ha) 5.5. Where					
5.6. Herding					
5.6.1. By whom?					
5.7. Inputs:					
5.7.1. Medicine			… times per year	MZN	
5.7.2. VET-services				MZN	
5.7.3. Other				MZN	
5.8. Outputs:					
5.8.1. Manure (collect/ curral/ leave it)					
5.8.2. Renting out animal draught power					
5.8.2.1. To whom					
5.8.2.2. How many days per year					
5.8.2.3. Per diem (……MZN) or labour in exchange (…… hours/ days)				MZN	
5.8.3. Animal products					
5.8.3.1. Consumo					
5.8.3.1.1. Type of product(s)					
5.8.3.2. Selling for cash					
5.8.3.2.1. Type of product(s)					
5.8.3.2.2. Income				MZN	

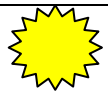
6. Farming system

6.1. You mentioned that you have … (#) fields. What is the most/ least productive field?
6.2. On which field do you spend most of your time?

Field:	*Field 1:*	*Field 2:*	*Field 3:*	*Field 4:*
Type of field (gardening/ cropping/ fallow):				
Location (homestead/ outfield)				
Distance from homestead:				
Geographic location (lowland, upland, close to river?)				
Size (ha)				
Hedge? Fence	Yes/ No	Yes/ No	Yes/ No	Yes/ No
Type of hedge/ fence?				
# of cropping seasons				
Crop(s):	Milho Cassava - - -	Milho Cassava - - -	Milho Cassava - - -	Milho Cassava - - -

Harvesting/ yield		*Kg*		*Kg*		*Kg*		*Kg*
	Milho		Milho		Milho		Milho	
	Cassava		Cassava		Cassava		Cassava	
			-					
	-		-		-		-	
	-		-		-		-	
	-		-		-		-	
Consumo/ cash crops (different crops/ amount sold/ prices per crop?)			Consumo		Cash crop			
	Milho							
	Cassava							
	-							
	-							
	-							
	-							
Market?								
Intercropping/ Monocultures What? Why?								
Ploughing (source of plough, animal draft)								
From where								
How much time								
Land history (previous crops, intercropping, crop rotation, fallow):								
Activities and labour input (ranking):								
Burning	YES/ NO		YES/ NO		YES/ NO		YES/ NO	
Land preparation								
Sewing								
Weeding and pest-management								
Pesticides	YES/ NO		YES/ NO		YES/ NO		YES/ NO	
Where do you buy them								
Residues? What do you do with them? Composting Animal fodder								
Inputs:								
Manure	YES/ NO		YES/ NO		YES/ NO		YES/ NO	
Fertilizer	YES/ NO		YES/ NO		YES/ NO		YES/ NO	
Type 1: Type 2:								
Pesticides	YES/ NO		YES/ NO		YES/ NO		YES/ NO	
Type 1: Type 2:								
Main risks? How often?								
What do you do is yields are low? How do you manage								
Of total	Consumption				Cash crop			
	Kg		%		Kg		%	
Milho Cassava								

7. Cropping Calendar

												
Jan	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	
												+ / -
												% of 100
												W / H

+ / - is lot of work/ little work
% of 100 = 100 paper dots divided over 12 months
W = Weeding
H = Harvesting

8. Final Conclusions	
8.1. In what area do you consider yourself to be an expert?	
8.2. In what area would you like to develop yourself/ learn more?	
We learned a lot about your farm and the region. You told a lot about things that could be improved. You told this and that…	
8.3. How could we improve these things?	
8.4. From where we can start?	

9. We have asked you so many questions? Is there anything you want to ask us?

Appendix 2: GTZ Low cost Energy Technologies Field Survey

GTZ Low-cost Energy Technologies (LET) Initiative Pico PV:
Solar Lantern Field Survey
Baseline Questionnaire - Households

FILL IN

No of Questionnaire	
Date	
Name of Interviewer	

Country	
District	
Village	
Address/Street	
GPS	
Name of Interviewee	

a) HOUSING

	Sex	1. Under 16	2. Over 16	3. TOTAL
How many people live in your household in total on a permanent basis?	1. Male			
	2. Female			
Which is the highest level of education one of the household members received? 1.None, 2.Primary, 3.Secondary, 4.Technician, 5.University	3. Male			
	4. Female			

b) PERSONAL INFORMATION

What is the regular occupation of each household member? (multiple answers possible) CODE MAIN OCCUPATION=1 FURTHER OCCUPATION =2								
	1. School	2. Agri-culture	3. Commerce	4. Artisan	5. Construction worker	6. Techniacin	7. Domestic work	8. Other What?
5. Head of household								
6. Spouse								
7. Children < 16								

c) ELECTRIC GRID

8. What is your nearest town/village connected to the electric grid?	(NAME OF TOWN/VILLAGE)

9. How close is this town/village or your nearest mains power line?	(IN KM)

10. Do you know of any extension plans to include your village to the grid? Or do you know of other electrification project (generator, photovoltaic...) of your government or international donors?				
Yes 1		No 0		IF YES
1. What kind of project? Project name?			2. When should the project start?	

d) ENERGY SOURCES USED IN THE HOUSEHOLD

11. Are you connected to the electric grid?							
Yes 1 (minigrid)		No 0		IF YES			
Yes 2 (national grid)							
1. Do you have your own meter?				2. Are you connected to a shared meter?			3. How much did you pay last month for your electricity?
Yes1		No 0		Yes1		No 0	

12. Do you use a generator?				
Yes 1		No 0		IF YES
1. How many days a week?	2. How many hours per day?	3. How much do you pay per month in total for using the generator?		

13. Which of the following Energy sources do you use in your household? READ OUT CIRCLE ALL THAT APPLY	14. Code the most important ones 1= most important	15. Quantity per typical week	16. Unity price	17. Expenditures per typical week	18. Place of purchase	19. Distance to the place of purchase	20. Ho many hours do you spend per week to get the energy sources
1.- Candles		___Pieces	One candle			_____Km.	_____h
2a.- Kerosene for illumination		____Liters	One liter			_____Km.	_____h
2b. Kerosene for other		____Liters				_____Km.	_____h
3a.- Dry cell batteries for lighting		____Pairs	One pair			_____Km.	_____h
3b.Dry cell batteries for radio		____Pairs				_____Km.	_____h
4.- Car battery		____Piece	Unity			_____Km.	_____h
5.- Gás		____Liters	One bottle			_____Km.	_____h
6. Wood			One			_____Km.	_____h

		__Package	package				
7. Coal		_____Kg	One sac/kg			_____Km.	_____h
8. Diesel/ fuel (generator)		____Liters	One liter			_____Km.	_____h
8. Electricity (Grid)		_____Kwh	One Kwh			_____Km.	_____h
9.- Other		____( )	Unity			_____Km.	_____h.

e) HOUSEHOLD LIGHTING

21. Which of the following lighting devices do you use? USE PHOTOS TO IDENTIFY LAMPS AND CIRCLE ALL THAT APPLY	22. How many of each device do you use on a typical evening? WRITE IN EXACT NUMBER	23. Where is the lighting device located while using it? 1.Floor 2.Table 3.Wall 4.Celing 5.Outside 6.Carried	24. How many days a week do you use each type of lighting?	25. How many hours do you light each source the days you use them?	26. How much does the lighting devise costs itself?	27. How much do you spend per week to light each lighting device (running costs per week for paraffin...)?	28. What do you mainly use the lighting for?
1. Firelight							
2. Candles							
3. Paraffin glass cover							
4. Paraffin simple wick							
5. Pressure lamp (gas)							
6. Lamp to gas bottle							
7. Light bulb in socket							
8. Lantern (battery)							
9. Torch (battery)							
10. Electric Incandescent Watt?_____							
11.Electric Fluorescent. Watt?_____							
12. Solar lamp WHICH ONE_____							

29. What, if anything, do you use to light the main room (what is your main lighting source indoors)?_____

30. What, if anything, do you use to light outside the house (what is your main lighting source outdoors)?_____

What would you say are the strengths and weaknesses of your main lighting sources Indoors/outdoors? RECORD EXACT VERBATIM RESPONSE		
Use of lighting devices	1. Strength	2. Weakness
31. Indoors		
32. Outdoors		

33. On average, at what time in the evening do you begin to use lighting devices?	34. On average, at what time in the evening do you turn of the last lighting device?
35. On average, at what time in the morning do you begin to use lighting devices?	36. On average, at what time in the morning do you turn off the last lighting device?

Which activities do household members pursue mainly at night and in the morning when it is dark outside? DO NOT READ OUT ONE CODE ONLY						
Activity	37. Men		38. Women		39. Children<16	
	Morning	Night	Morning	Night	Morning	Night
1. Listening to the radio						
2. Watching TV						
3. Reading						
4. Studying/Homework for school						
5. Some activity that will be compensated in some way What kind of?_____						
6. Domestic work						
7. Socializing/reunions						
8. Other? What?						

40. How many rooms in this dwelling were used after dark yesterday evening? WRITE IN EXACT NUMBER INCLUDING SEPARATE HOUSES, COOK-HOUSES, LAVATORIES_____

41. How many rooms in this dwelling were lit at all yesterday evening? WRITE IN EXACT NUMBER INCLUDING SEPARATE HOUSES, COOK-HOUSES, LAVATORIES, ETC._____

42. Did the use of one of the lighting devices have caused any accidents in your household?

Yes 1		No 0	
IF YES			

1. What kind of lighting device?	2. What kind of accident?

43. Could the light in this household be improved	Yes 1		No 0		IF YES 1. How might it be improved? ONE CODE ONLY READ OUT
1. Introduce lights					
2. Add more lights					
3. Increase the amount of light from each devise					
4. Use a light which is less glaring (so I do not have to shield my eyes)					
5. Operate the light for more hours					
6. Use a light that can be placed in a different position					
7.Other					

44. Do you think there is a current lack of lighting in your household?

Yes 1		No 0	
IF YES			

1. What kind of problems/inconveniences does the current lack of lighting cause? RECORD EXACT VERBATIM RESPONSE

45. Which activities could not be done well or comfortably due to lack of lighting? (multiple mentions possible) DO NOT READ OUT.		What would you or other members of your household do at night if you had better light? (multiple mentions possible) DO NOT READ OUT.		
		46. Head of household	47. Spouse	48. Children under 16
1. Listening to the radio				
2. Watching TV				
3. Reading				
4. Studying/Homework for school				
5. Some activity that will be compensated in some way, What kind of?_____				
6. Domestic work (cooking, cleaning etc.				
7. Socializing				
8. Resting				
9. Other, what?				
10. Other, what?				

For each of the following lighting devises you use how would you rate them?
READ OUT DEVISES ONE BY ONE AND APPLY ONLY THOSE THAT ARE USED BY HOUSEHOLD INSERT RELEVANT CODE INTO BELOW GRID

Excellent	4	4	Very easy	4
Good	3	3	Easy	3
Poor	2	2	Difficult	2
Very poor	1	1	Very Difficult	1

	49. Light Quality	50. Adopted to the main use	51. Ease of operation
1. Paraffin lamp with glass cover			
2. Paraffin lamp with simple wick – no cover			
3. Light bulb in socket or connected to car battery			
4. Candles			
5. Pressure lamp			
6. Lamp connected to a LPG or gas bottle			
7. Battery powered stand up lantern			
8. Flashlight or torch			
9. Incandescent electric light			
10. Fluorescent electric light			
11. Solar lamp FILL IN WHICH ONE_____			

52. What is your preferred type of light, excluding mains powered light bulbs? ONE CODE ONLY
READ OUT ALL BEFORE THE ANSWER

Type of lighting		1. Why?
1. Nothing / moonlight / starlight / natural light		
2. Firelight		

3. Paraffin lamp with glass cover		
4. Simple paraffin lamp with wick and no cover		
5. Pressure lamp		
6. Lamp connected to a LPG bottle of gas		
7. Light bulb in socket or a lamp connected to a car battery or inverter		
8. Candles		
9. Battery powered stand up lantern		
10. Flash-light / torch (usually hand held)		
11. Other		
12. SOLAR LAMP FILL IN WHICH ONE_____		

f) HEALTH EFFECTS

53. Do you ever worry about the health effects using paraffin/kerosene in your home may have on you and your family?

Yes 1		No 0	
IF YES			
1. What kind of?			

g) RADIO

54. Do you or some of the household members use a radio?

Yes 1		No 0		
IF YES				

55. How many radios do you use in your household?	56. What is the energy source of the radios? 1. Dry cell batteries, 1. how many? 2. Grid 3. Generator 4. Solar panel 5. Other_____	57. On average, for how long do you use each radio per day?

	58. Head of household	59. Spouse	60. Children <16
1. How long do household members listen to the radio on average per day? (NOT LISTENING CODE=0)			
2. What do they mainly listen to? ONE CODE ONLY 1. music 2. information 3. entertainment 4. church 5. community radio 6. price information 7. other, what?			

h) CELL PHONE

61. Do you or some of the household members use a cell phone?

Yes 1		No 0		
IF YES				

62. How many cell phones do you use in your household?	63. Where do you charge the cell phones? 1. Grid at home 2. Grid at neighbour 3. Generator 4. Solar panel 5. Other_____		64. On average, how much do you pay to charge your phone?
	Cell 1		
	Cell 2		
	Cell 3		

	65. Head of household	66. Spouse
1. On average, how much do you spend for cell phone credits per week? (NO USE CODE=0)		
2. What do you use the cell phone mainly for? ONE CODE ONLY 1. call friends/family 2. work 3. entertainment 4. other, what?		