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Potential changes in Mozambican farming systems due to Jatropha introduction for biodiesel

Maria Margarida de Oliveira Mota
July 2009

competing claims

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Msc Thesis Plant Production Systems
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List of Abbreviations

AES	Agricultural Extension Services
IIAM	Instituto de Investigação Agrária the Moçambique
HH	Household
-L-JW	Category no work at the Jatropha plantation neither land lost
+L+JW	Category work at Jatropha plantation and lost land
-L+JW	Category no lost land and work at Jatropha plantation
+L-JW	Category Lost land and not work at Jatropha plantation
FWJ	Formal Wage Job
Rem	Immigrants sending remittances
BC	Biofuels company
CS I	Cropping system I
CS II	Cropping system II
CS III	Cropping system III
CS IV	Cropping system IV
Ba	Bambara groundnuts
Cs	Cassava
Gr	Groundnuts
Pa	Pineapples
Cp	Cowpea
Sc	Sugar cane
Sp	Sweet potato
Ba	Banana
Mz	Maize
Pk	Pumpkins
Wm	Watermelon

Abstract

Biofuel answers the global concerns about environment, dependency for global energy supply on few countries only and rural development. Within the range of biofuels crops *Jatropha curcas* L. has gained the confidence of several biofuel companies which are operating in developing countries in Africa and Asia. Since 2007, a large Jatropha plantation aimed at biodiesel production is present in Bilene Macia district, south of Mozambique. The main objective of this study was to characterize and identify the changes in smallholder farming systems due to the establishment of the Jatropha plantation. Surveys, informal interviews, field visits and observations were conducted during the period January to April 2009 in two villages adjacent to the Jatropha plantation. The cropping system of the villages was mainly based on cassava, groundnuts, bambara and cowpea in the Upland area. In the Bottomland, farmers grew banana, sugar cane, cassava and sweet potato. The average farm size was about 0.48ha and field size was higher from Upland (0.12ha) to Bottomland (0.02ha). Farm labour is mainly female and provided by the family. Usually the man had formal wage job in tourism or construction at Bilene Beach while the woman was the responsible for both the farm and domestic activities. Establishment of the Jatropha plantation obliged farmers to move to land further away from their homestead and they lost some of their fields to the Jatropha plantation. Still, nobody finished farming activities and no crop disappeared from the cropping system. In general, families practiced multiple cropping systems and the majority had a member employed in a formal wage job. These characteristics together constitute a survival strategy for south Mozambican families The biofuels company employs men and women equally. The women that work at the Jatropha plantation reduced their time spent on farm activities and the average field size decreased. However, it was not possible to conclude about a possible compensation between the salary earning at the private company and the reduction on field size and subsequent family food production. The cropping system in Upland may suffer changes in the future (such as changes in crops and soil management or end of Bambara groundnuts production) due to land availability constraints.

Resumo

Os biocombustíveis respondem a várias preocupações globais entre elas o ambiente, o desenvolvimento rural ou o facto do fornecimento global de energia estar dependente de alguns países,. Dentro da diversidade de culturas agrícolas que visam a produção de biocombustível, *Jatropha curcas* L. (Jatrofa) tem ganho a confiança de muitas empresas de biocombustíveis. Estas empresas operam principalmente em países em vias de desenvolvimento na África ou Ásia.

Desde 2007, uma extensa plantação de Jatrofa orientada para a produção de biodiesel está presente no distrito de Bilene Macia, sul de Moçambique. O principal objectivo do presente estudo é caracterizar e identificar as mudanças ocorridas nos sistemas agrários dos pequenos agricultores, devido à plantação de Jatrofa. Setenta questionários, várias visitas de campo e entrevistas semi-estruturadas a vários informantes-chave, foram conduzidas no período de Janeiro a Abril de 2009, em duas comunidades (Chilengue e Ngolene) próximas de duas grandes unidades de exploração de Jatrofa *(galamaluco*, como é designada em Moçambique).

O sistema de culturas praticado nas terras altas pelos pequenos agricultores, é baseado na produção de mandioca, batata doce, amendoim, feijão-jugo ("*gergeli*" para a população) e feijão-nhemba (feijão frade). Nas terras baixas e húmidas os pequenos agricultures cultivam bananas, cana de açúcar, mandioca e batata doce. O tamanho médio das explorações agrícolas é cerca de 0,48 hectares e a área dos campos diminui das terras altas para as terras baixas. Socialmente, o homem tem um trabalho assalariado enquanto a mulher é responsável pelas actividades domésticas e agrícolas. Devido à plantação de Jatrofa, os agricultores foram obrigados a deslocarem-se para uma zona mais longe, tendo todos eles perdido os campos que tinham ocupados com as suas culturas para a Jatrofa. Apesar disso, ninguém parou com a actividade agrícola ou com a produção das culturas tradicionais. Normalmente, as famílias possuiam múltiplos sistemas culturais (nas terras altas e baixas) e era comum terem pelo menos um familiar com emprego assalariado. O conjunto destas características socio-económicas constitui uma estratégia de sobrevivência das famílias moçambicanas do sul. Em média, metade das famílias com pelo menos um membro a trabalhar na plantação de Jatrofa tinham outras fontes de rendimento fora da actividade agrícola (trabalho assalariado noutra

actividade ou dinheiro enviado por emigrantes). Este valor é menor em comparação com famílias que não tinham ninguém a trabalhar para a empresa de biocombustíveis. Destas famílias, setenta por cento tinha algum membro familiar assalariado noutras empresas, maioritariamente empresas a operar na Praia do Bilene. As mulheres trabalhadoras na plantação de Jatrofa reduziram as horas de trabalho na exploração agrícola e por conseguinte a área média dos campos também diminuiu.

Apesar do reconhecimento da diminuição de horas de trabalho na exploração familiar pelas trabalhadoras da empresa de biocombustível, não é possível concluir nada acerca da possível compensação entre o salário auferido pela empresa e a diminuição da área cultivada pelos pequenos agricultores com subsequente redução da produção de alimentos na família. No entanto, o sistema de culturas das terras altas poderá sofrer alterações no futuro devido a limitações de terra, principalmente em Chilengue (comunidade que se encontra entre duas unidades de produção de Jatrofa). Tipicamente, este sistema depende do feijão-jugo que é semeado todos os anos em solo virgem ou que está em pousio há mais de quinze anos. Depois do feijão jugo segue-se a mandioca, amendoim, feijão nhemba e milho. Durante os próximos três a cinco anos (dependendo da fertilidade do solo e da capacidade de trabalho dos agricultores) o campo é cultivado e findo esse tempo, é abandonado. Porém, nunca se repete o feijão-jugo nesse campo, pois este todos os anos tem de ter “terra nova”. Devido a limitações de terra, muito possivelmente o período de pousio será reduzido o que poderá levar à diminuição da fertilidade do solo, já de si pouco fértil e arenoso. A redução do pousio poderá consequentemente levar à diminuição da produtividade das culturas. Uma visão mais negra, aponta para o fim da produção do feijão-jugo, pois muitos agricultores não o produzem em terra cultivada anteriormente, com a justificação maior de que a produção não é compensatória.

1. Introduction

This study is conducted under the research program "Competing Claims - Competing Models in Mozambique" co-funded by Department for International Cooperation under the WUR-DGIS partnership program. This program specifically focuses on the impact of the expansion of biofuel production systems on rural livelihoods and resource competition in Mozambique. The research of this study focuses on the impact of a recently introduced Jatropha plantation on the smallholder farming systems of Mozambique. The study area and fieldwork developed in Bilene Macia District, in the south of Mozambique.

2. Literature Review

2.1. The global context of biofuels: Jatropha as a biodiesel crop

The demand for renewable energy has increased during the last decades due to concerns about the environment, dependency for global energy supply on a few countries only and rural development. The Kyoto Protocol states that developed countries must reduce their greenhouse gas emissions by at least 5 per cent from 1990-levels during the commitment period 2008-2012 (Coelho, 2005). In the last decades biofuel is considered the renewable energy source that answers these global concerns. Biofuel is defined as solid, liquid or gaseous fuel obtained biomass. Bioethanol is produced from agricultural products containing starch and sugar, such as sugarcane, corn, beets, wheat, and sweet sorghum. Biodiesel is made from oil containing seeds, such as rapeseed, sunflower, soya, palm, coconut or jatropha.

Biofuels appear at first sight to be carbon-neutral (the carbon they emit to the atmosphere when burned is offset by the carbon that the plants absorb from the atmosphere when growing). Plants can be cultivated in many different environments (The Royal Society, 2008). Biofuel production is considered economically viable when its price is competitive with petroleum products (Tomomatsu and Swallow, 2007). If the price of fossil fuel increases to high levels, the production of biofuels can be expected to grow dramatically. According to Van Eijck et al. (2007) developing countries growing oil-producing crops aimed at biofuel production, may gain

major potential economic and environmental benefits. The same author also believes that biofuels will help to combat soil erosion, create additional income for the rural poor, and alleviate the countries' balance of payments by diminished dependency on oil imports or even by yielding export revenue.

However, the production of biofuels has initiated intensive debates, especially related to their environmental impacts, food security and land use implications. For instance, the extent of impacts such as GHG emissions, water consumption, biodiversity, eutrophication and air pollution varies according to feedstock [which refers to the starting products for biodiesel production] production methods, conversion and how efficiently it is distributed and used (The Royal Society, 2008). In addition, the developing countries face a different situation than developed countries and they must address the food security issue explicitly (Dong, 2007), as biomass production for energy purposes may imply the use of agricultural land, competing with food and /or feed production.

Jatropha curcas L., commonly known as Jatropha or Physic nut, is a small tree or large shrub that can reach a height of up to 5 m. Jatropha produces ovoid fruits and its seeds contain oil. The oil content of Jatropha seeds can vary between 38-40% (Pant et al, 2006). However much larger variation depending of location, soil conditions, crop management and varieties is reported in literature (Teixeira (1987); Ginwal et al (2004); Shah et al (2005). *Jatropha curcas* is native in tropical America, but nowadays it is distributed in many tropical and sub-tropical regions throughout Africa and Asia as well. Within the range of crops used for the production of biofuels *Jatropha curcas* L. has gained the confidence of several biofuel companies. This leans on the assumption that Jatropha requires little inputs such as labour, water and fertilizers. Jatropha is also claimed to have high resistance to pests and diseases and to grow well in poor soils and dry conditions. Van Eijck et al (2007) reviewed some studies in which the estimated Jatropha seed yields in different countries and regions range from 0.1 to 15 t/ha/yr. Pant et al (2006) referred to studies that revealed that in field condition Jatropha may produce seed yield as high as 12th/ha/year five years after plantation. According to Henning (2000) Jatropha has some properties that give it the potential to be exploited under semi-arid and arid conditions in the tropics. It has functions in soil and water conservation, soil reclamation, erosion control, living fences, firewood, green manure, fuel for light and local use in soap production, insecticide and medicinal application at modest scale. Tomomatsu and Swallow (2007) expect that Jatropha contributes to the improvement of rural livelihood because its main production location is in

semi-arid lands where poverty levels are high and land productivity low. However, in spite of large plantations all over the world there is little quantitative agronomic and economic information that supports the claimed benefits of Jatropha for biodiesel (Jongschaap et al., 2007).

2.2. Mozambican agriculture and biofuels production

Sitoe (2005) reviewed data from Censo Agro-pecuário 2000 (Agro and Livestock Census, 2000) and Trabalho de Inquérito Agrícola 2002 ("Agrarian Work Survey", 2002) to make a general description of Mozambican agriculture. According to the studies, Mozambique has 36 million hectares arable land but less than 10% is cultivated. The small farmers (with farm size smaller than 5ha) cultivate more than 95% of the cultivated land. In average the small farmers own about 1.4ha. In spite of large crop diversity, the major crops are maize and cassava. Maize is present on 80% of the farms and cassava on 76% (Appendix 9.1-a). The main livestock species kept by small farmers are chickens (present on 71% of smallholder farms), goats (27%), pigs (16%), but only 3.3% of smallholder farms have cattle. The Agrarian Extension Service is limited to 55 districts out of 128 Mozambican districts and there is one extension technician per 1067 farm households. The agricultural system of farmers in Mozambique is characterized by the use of the family labour force and a low mechanization grade. Agricultural inputs such as tractors, ploughs, fertilizers, pesticides and others are low, almost zero (Matsinhe, 2000). The Mozambican agriculture is constrained by environmental, historical, infra structural, social and economic factors. Besides the fact that Mozambique is systematically affected by calamities (droughts, floods or cyclones) the country has a poor infrastructure and the private or public economic institutes are weak (Sitoe, 2005). However, and in spite of all these constraints, the northern and central regions have a high agrarian potential with fertile soils and hydrographic basins with an outflow regime more permanent than in the south. In the north, cattle breeding is constraint by the tse-tse fly, but in the South the cattle are easily bred. However, the poor sandy soils and irregular rainfall in the South constrain production in rainfed agriculture. Cash crops such as tobacco, cotton and sunflower, are concentrated in the center and the north. Maize and cassava are important staple crops in all regions but sweet potato is more important in the center and south of the country. Sorghum is of high importance in the north, while in the center rice and in the south groundnut prevail (Sitoe, 2005).

Following the global tendency, Mozambican agriculture made the first steps in biofuel production in the past years and several international biofuel companies have invested in the country. Many plantations with sugar cane and jatropha aiming at biofuel production have been established or are under construction in several provinces of Mozambique such as in Maputo, Sofala and Gaza. In 2007 a company in renewable energies started the first Jatropha farming project in Gaza province. According to the website of the private company, *Jatropha curcas* L. was chosen because it is a hardy, inedible plant, whose seed produces a relatively high yield of oil when pressed. The company assumes that the land on which the project is farming does not compete with food production and this, combined with the inedible nature of Jatropha, ensures that cultivation for biodiesel does not lead to the displacement of land from food. production Although the biofuel investmentors claim poverty alleviation and rural development, observations indicated that companies choose areas close to infrastructures such as processing facilities, roads and harbours, labour markets, (tele-) communications and access to goods and services. Frequently, these areas do not coincide with the assigned potential zones for biodiesel production or with isolated poor rural zones (Schut, 2009).

The uncertainty about these biofuel production investments and their impact on food security, environment and their sustainability remain a national concern. However, only in March 2009, the Mozambican Government approved the “Política e Estratégia Nacional de Biocombustíveis” (National Biofuels Policy and Strategy). With this policy brief the government expects to regulate biofuel production by private and public sectors based on environmental and social principles. The definition of these policies, laws and strategies are not clear yet but meanwhile the biofuel investments continue as well as their unknown impact on the economic, environmental and social situation. In addition, the Mozambican government and several institutions worked together to identify, characterize and classify zones with potential for food production, productive natural forestry, conservation areas, livestock (pastures), reforestation for commercial uses and for biodiesel feedstock (IIAM,2007). Some of the expected results are shown on a map with potential agrarian zones (Appendix 9.1-b). The zoning indicates that the north of the country has a better potential for agriculture while the south-eastern region is classified as marginal land or without agrarian aptitude.

2.3. Main features of Bilene Macia District, Gaza Province

2.3.1. Agro-ecological characterization

Agro-ecological zones are areas with specific natural characteristics that make them particularly suitable for the development of agricultural activities (Amane, 2000). In Mozambique, there are ten agro- ecological regions (Appendix 9.1-c). Gaza Province includes three of them: "The Inland Maputo and South Gaza region", "The coastal region south of the Save River" and "The centre and North of Gaza and the West Inhambane Province" (Brito, et al., 2004).

Bilene Macia district (study district) belongs to the agro-ecological region called "The Inland Maputo and South Gaza region". The entire area is bellow 200 meters and the monthly average temperature varies between 22 to 26°C (Amane, 2000). The precipitation near the coast is about 1000mm/year and in the interior areas it varies from 600 to 800mm/year. The climatic data from the meteorological station of Bilene Beach show that the rainfall was about 700mm/year in 2006 and 2007 (Appendix 9.1-e). Temperature shows little variation over the year. The temperature was highest between September and March (average monthly temperature between 26º and 29ºC). From April to August, the months were dry and slightly cold (average mensal temperature between 21º to 26ºC). The relative humidity varies from 55 to 97% during a year (Appendix 9.1-f).

The irregularity of the rain leads to drought periods even during the rainy season but on the other hand, the rain can occur during the cool season, which brings benefits for crops like cassava and cashew (Amane, 2000). The zone has predominantly deep and sandy soils. This soil has a good to excessive drainage and the colour varies from brown to grey or orange. The organic matter of the topsoil it is low and varies between 0.5 and 2%. The soil is moderately acid, not salted, with a low sodium content, a low water retention capacity and a low fertility (Appendix 9.1-d). Some areas have hydromorphic soils, called "*machongos*" (Amane, 2000). In these soils, it is possible to grow rice, maize, bananas and legumes. It is a zone with high potential for livestock and for fruits trees such as lemons, mangoes, mafura, cashew and coconut trees. The last two crops are the main cash crops for the population in the districts where these cops are exploited.

The main food crops are cassava (*Manihot esculenta)*, groundnuts (*Arachis hypogaea)*, sorghum (*Sorghum* bicolor L.), pearl millet (*Pennisetum typhoideum* Rich) and cowpea (*Vigna unguiculata*). Amane (2000) considers the main constraints for the region's development the

high risk of drought, decreasing soil fertility and fallow periods due to urban pressure, pests and diseases in food and cash crops, lack of improved varieties that assure high productivity and lack of credits. The region has good roads that facilitate the trade of the products especially to Maputo city, the main consumer of the products from this region.

2.3.2. Socio-economic characterization

Bilene-Macia District is situated in the southeast of Gaza Province. The district has an area of 2.157 km^2 and is connected to the main cities in the south, centre and north by the national road number 1. Bilene-Macia district has 93 schools (73 are primary schools) and eleven health units including one Rural Hospital (Perfis Distritais, 2005). The population in 2005 was estimated at 165.104 habitants and 43% had ages below 15 years. Twenty percent of the population lives in urban areas of Bilene Beach and Bilene-Macia town. The native language is Xitsonga [synonym of: ChiTsonga, Gwamba, ShiTsonga, Shangaan, XiChangana] (Perfis Distritais, 2005). Forty two percent of the population speaks Portuguese and the majority of these are men. The local authorities (called Régulos, Chefes de Terra, Secretários and Presidentes de Localidades) are recognized by law and work together with the State's Administration to solve local problems (Perfis Distritais, 2005). People have several religions but the majority of the population practises Sião/Zione.

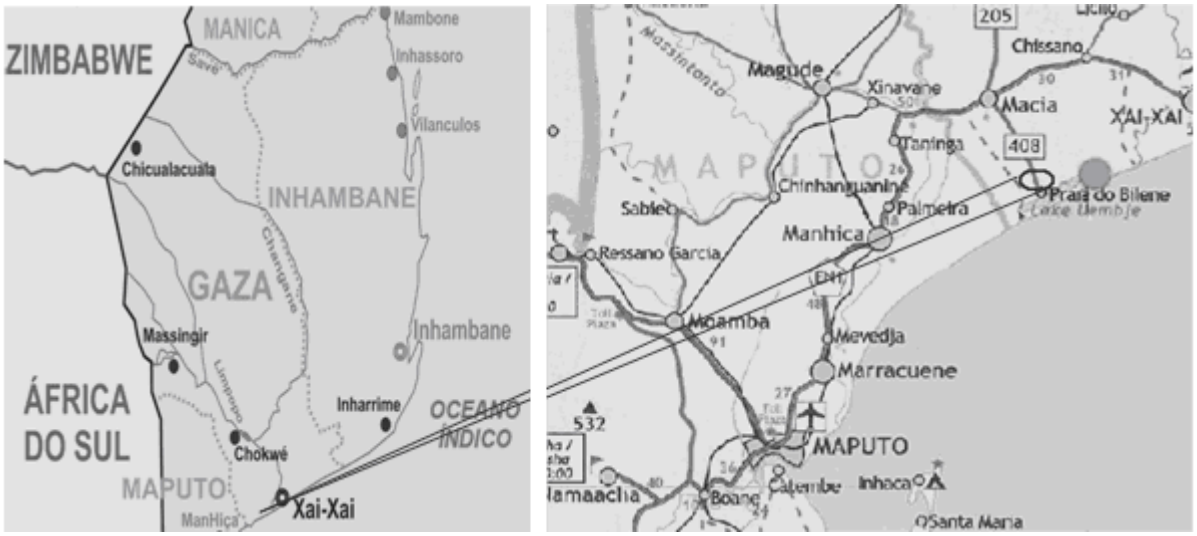

Figure 1 - Map of Gaza Province showing study region. *Source*: www.sleeping-out.co.za and commons.wikimedia.org

2.4. Farming systems from the south of Mozambique

According to Beets (1990), a farming system is a unit consisting of a human group (usually the households) and the resources it manages in its environment, involving the direct production of plant and/or animal products. A farming system is always part of a larger social, political, economic, cultural, and politic environment, which has impact on everything that happens within the farming system. For instance, opportunities for off-farm earnings through local and urban markets and remittances from household members working in the city strongly influence livelihoods of smallholder farmers and the use of agricultural inputs (Giller et al, 2006).

A cropping system is defined as the cropping patterns (the early sequence and spatial arrangement of crops or crops and fallow on a given area) used on a farm and their interactions with farm resources, other farm enterprises and available technology that determine their make up (Palaniappan et al, 1996). MAP (1996) identified four cropping systems present in the agro-ecological region studied named "Mixed cereal/cassava/pulse and cashew", "Peat soil systems", "Bilene system" and "Coconut-annual crops system". The last are practised along some coastal regions of Inhambane Province. The Bilene System is based on alluvial rich soils where crop production and cattle raising are intimately integrated and exists mainly in the Chókwè District. The main features of cropping systems present in the study district are (MAP,1996):

<u>Mixed cereal/cassava/pulse and cashew:</u> Maize, cassava, cowpea, pumpkins are intercropped in upland sandy soils along with some cashew trees. Pigeon pea may be sown on field edges. Groundnut is cultivated in monoculture or intercropped with cassava. Richer farmers raise cattle extensively and use cattle for land preparation. Poor farmers can access animal draft power in exchange for labour. Sugar cane grown in the low lands provides cash revenue to farmers. Farmers raise poultry and goats as far as allowed respectively by New Castle disease outbreaks and availability of pastures. Pigs are raised in a traditional way in pigsties or tied by ropes. Women cultivate the farmland and men seek employment in cities and private companies.

<u>Peat soils subsystem:</u> This is complementary to the first. Main crops are maize, rice, vegetables, banana, and sugar cane. Plots are much smaller than upland ones. Cultivation of these lands is dependent on their drainage status being normally limited during the rainy season. Intensive use of this land occurs during dry/cool season and during droughts. Rice is produced in lower and wetter areas. Cultivation is done by intensive manual work, as the use of animal draft power and tractors are not possible. Not all farmers have access to this land (*machongos*).

Compared to the Peat soils subsystem (bottomland), the crop productivity per hectare is low in Mixed cereal/cassava/pulse and cashew (upland), but the costs per unit are also low (Van Leeuwen, 1987). Owning fields in the upland area brings some advantage to small farmers: the soil is easier to work than the heavy soil of the bottomland, in case of flood the upland assure food to the family and the upland fields never have problems with water excess since the sandy soils have a good drainage. On other hand, during drought years the production from the bottomland assures food for the family as well as plant material to be used later in the upland (Van Leeuwen, 1987).

In a study about farming systems of Xai Xai, INIA (1994) reported that agriculture is done by women to whom a plot is allocated since their 12 years of age. From that moment, they are responsible for the farm activities until they die and for the domestic activities as well (get water, cook, and care for children). Boys and girls bellow twelve make small fields, take care of the animals and protect the crops from birds and monkeys. The men hunt, fish, breed animals, construct houses and granaries, and make tools and artesian pieces. Those gender tasks differences became generalized and common since the end of the 19th century and caused important transformations in the farming system such as the replacement of "mapira" (*Sorghum* bicolour) and bulrush millet (*Pennisetum typhoides*) by maize that requires less labour and does not need constant protection against birds (Van Leeuwen, 1987). On the other hand the maize cannot be stored for more than one year while bulrush millet can be stored during years to supply the family in bad times (Van Leeuwen, 1987).

The salary from a formal wage job is important to buy farm inputs, food in hungry years and to pay the "*lobolo*" (payment to a family for a future wife to assure them that the man is capable to support her) (Van Leeuwen, 1987; INIA, 1994).

Two types of labour exchange within smallholder farms exist in the farming systems from the south of mozambique (INIA, 1994): *kofunana* (regular exchange of labour between two or more households for a certain period) and *Tsima* (the neighbours work for a day on a specific task and receive a meal and drink). This exchange labour between neighbours, the holding of several plots with different crops in different areas (upland, bottomland or "*machongos*" or in "*bilene*") and the creation of a network based on friendships or weddings between families and neighbours or between people in different zones (from humid or arid zones) are different strategies used by

Changanas [people from south of Mozambique speaking Changane] to guarantee a minimal level of subsistence (INIA,1994).

3. Scope of study and Research questions

3.1. Research objectives and justification

The aim of the research is to describe and understand the influence of the establishment of large plantations of *Jatropha curcas* L. on smallholder farming systems. As a case study farming systems potentially affected by Jatropha plantations in Bilene Macia district are taken. The main objective of the study is to describe the current smallholder farming systems and understand the adaptation of these systems in time subject to introduction of a large Jatropha plantation for biodiesel production.

Due to the character of this master research and livelihood complexity, this study just mainly deals with the natural and human capital belonging to the livelihood framework (Ellis, 2003). The term livelihood attempts to capture not just what people do in order to make a living, but also the resources that provide them with the capability to build a satisfactory living, the risks factors that they must consider in managing their resources, and the institutional and policy context that either helps or hinders them in their pursuit of a viable or improved living (Ellis, 2003). A household is a social organization that elaborates mechanisms for the creation, defence, reproduction, and administration of resources to achieve a common goal. A household is also the locus of divergent interests and internal differentiation and stratification are revealed in the diversity of activities and tasks individual members perform, and in the ways in which goods and services are distributed (Jelin, 1990). In the livelihoods approach, different resources (assets or capitals) are owned or accessed by family members: human capital (skills, education, health), physical capital (produced investment goods), financial capital (money, savings, loan access), natural capital (land, water, trees, etc) and social capital (networks and associations) (Ellis, 2003). The livelihoods of farm households, where the decisions about resource allocation take place, depend on complex interactions between competing demands for investment of cash and labour, both within and beyond the farm boundaries (Giller et al, 2006). Land and labour are important resources used in farming systems. This study examines land availability for agricultural activities of smallholder farmers, how it is used in their cropping systems and which changes in land use for agricultural activities occurred due to establishment of a Jatropha plantation. The farm labour availability affects the area that can be managed and decisions relating to labour allocation can influence the crop choice, crop management and the

contribution of labour by different household members. During a year, farm activities and labour demand on smallholder farms fluctuate which is especially related with the dependency of seasonal rain that implies the concentration of labour over certain periods. Lack of labour at the start of the rainy season for land preparation, planting and weeding can restrict the land area planted, or lead to some fields being planted too late (Giller et al 2006). It is important to know who are the stakeholders involved in farming activities and understand the effect of labour allocation to the Jatropha plantation on the activities of the smallholder farms.

3.2. Research questions

In order to understand which changes in resource use, with special attention to land and labour, and in smallholder farming system were induced by establishment of large Jatropha plantation at Bilene Macia district in Mozambique, several other specific questions are address to it:

- How was the farming system characterized before the Jatropha plantation?
- How is the farming system characterized after the Jatropha plantation?
- How does Jatropha plantation affect the land used by smallholder farmers?
- How does Jatropha plantation affect the labour used by smallholder farmers?
- What is the social and economic impact of Jatropha plantation on the local communities?

4. Methodology: data collection and analysis

4.1. Time frame and approach to data collection

The field research was conducted from November 2008 to April 2009. The surveys and camping at the villages started in January and finished in April. Until then the time was spent in logistical preparation and gathering general information on the area. Three months were spent in the first village surveyed and one week in the second village. The reasons for the different time spent in the communities were related with logistic facilities, size of the community and cultural and meteorological conditions that constrained the surveys. A translator from Portuguese to Changane, the local language, was contracted to assist during the surveys amongst the village populations. All other stakeholder interviews and institutional documents search were conducted independently in Portuguese or English.

4.2. Survey strategy

After the choice of the study area, pre-defined objectives and logistic facilities helped to choose the study villages in particular.

For this study, I wanted to compare farming systems between a village where Jatropha plantation was present and a village where it was not. In Chilengue community as the Jatropha plantation is in the village since 2007. In the future, the biofuel company wants to start a Jatropha plantation in Ngolene so this village was selected to be the example of a village without Jatropha plantation. Later, it became clear that in spite of no presence of Jatropha plantation at Ngolene, the village was somehow affected already by the influence of the company in the region.

The strategy of sampling of households was different for the two surveyed villages mainly due to the size of the communities. The small size of Ngolene allowed interviews to almost all the households. Only when it was not possible to reach the people at home during the research time in the village the household was not interviewed. In total 20 out of the 27 households were interviewed in Ngolene. In Chilengue the households sampling tried to followed a snowball strategy. When it was not possible to apply it, a random selection was made taking into account the different neighbourhoods and the conditions of the moment. The sampling aimed also at equal representation of the four categories of households.

4.3. Methods

Through out the field research, a combination of quantitative and qualitative methods was used in order to contribute to the reliability and validity of the results by crosschecking and triangulation of the data collected.

4.3.1. Survey

A structured questionnaire was prepared to survey the households and frequently questions were added in accordance with the progress of the interview/conversation. A second visit to the households was made if the questions added later were not answered at the first visit. All interviews were conducted personally, using an interpreter where necessary. Respondents were coded to protect their privacy

Interviews were generally conducted in the yard of the homestead or infrequently in the house. Respondents were generally open to interviews but in some situations or with particular questions they were less comfortable to answer (for instance, to give estimation of crops yield, farm size or fallow years). The interviews took around 60-90 minutes depending on the progress of the conversation, which in its turn mainly depended on the education level, or background of the interviewed (Appendix 9.5-a).

From the structured questionnaire (Appendix 9.2), general information was derived about the household, labour and cropping systems present in the villages.

4.3.2. Field visits

The cropping systems were also studied by visits to the fields where the field area, crop yields and plant density were measured (Appendix 9.3-a). Due to logistic reasons not in all households was it possible to visit to all fields. In addition, data about crop yield and labour hours was limited due to farmers' inability to answer. Through GPS the area of each field was recorded. Plot's samples with 2 by 2 meters were randomly defined in the field to measured plants density. In each sample, the type of crop and number of plants was counted (Norman, 1995). To get a

general idea about crop yields some yield measurements were carried out on the field (Appendix 9.6).

Table 1- Number of households surveyed, number of field visits and number of fields with crops yield and labour hours/crop activity data.

No. HH surveyed	No. of HH with field visits	No. of fields visited	No. of HH with all fields visited	No. Fields with crop yield data	No. of fields with labour hours/ crop activity data
70	26	101	8	24	35

4.3.3. Semi-structured interviews to key informants

Information about the company and Jatropha plantation was achieved through semi-structured interviews to the farms managers' and visits to the plantation. The aim of these interviews was to understand how the company operates and how it interacts with the workers and population in general (Appendix 9.4).

The persons responsible for the Agricultural Extension Service and for Veterinary Services of the district were contacted to better understand the farmers' problems and limitations on their production systems.

4.3.4. Observations

The time spent walking between households was especially valuable in establishing individual perspectives, local knowledge and peculiar aspects of the village.

Visits to the fields were important to reach deeper understanding of the cropping systems. The participatory and not participatory observations were also relevant to know the households activities, the participants involved in these, and social and cultural aspects of the communities.

4.3.5. Literature research

Information about production systems and soil conditions of the study area was collected at Instituto de Investigação de Agrária de Moçambique-IIAM (Institute of Agricultural Research of Mozambique) and Agricultural Ministry libraries. The Meteorological Station of Xai-Xai was personally contacted to obtain information about climatic conditions of Bilene Beach.

4.4. Analytical methods

The data from both communities was analyzed together except when a comparison between villages was required. Some of the data (such as family size, farm size or field size) was analyzed using the Statistica 7 software. To determine significant differences between two groups T- student test was used at 0.05 level of confidence. ANOVA table was used to compare data between multiple groups, and Tukey-test run to test the differences between them.

5. Results

5.1. Introduction to the study villages

During the field research two villages were surveyed: Chilengue and Ngolene.

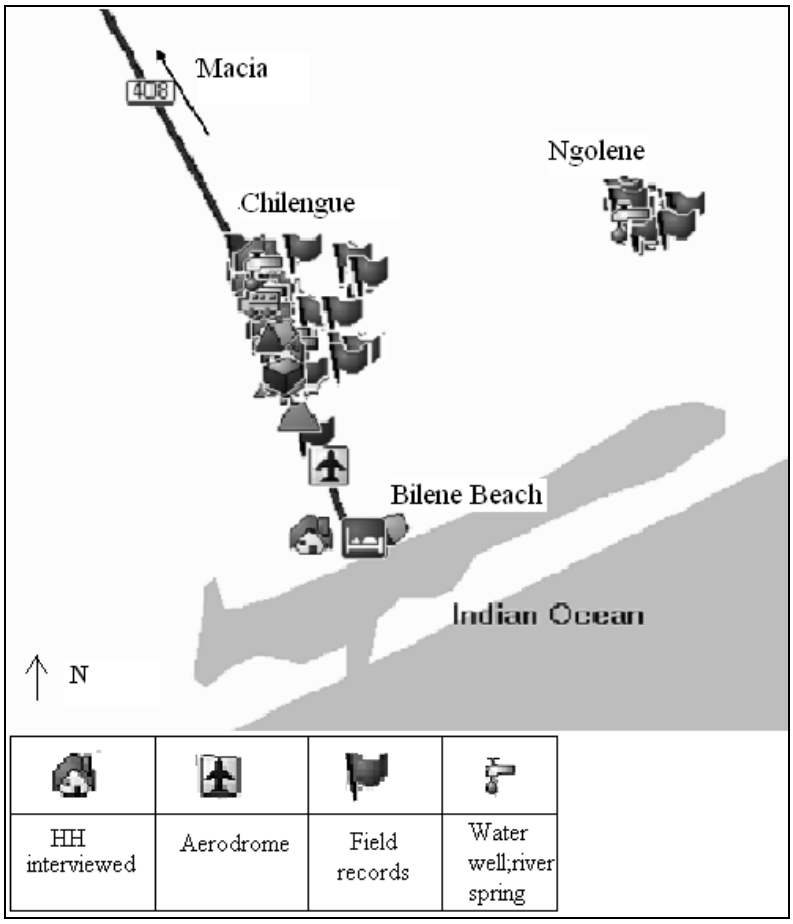

Figure 2- Map with location of the study villages.

Chilengue (Figure 2) is a large community with about 200 households. A national road that connects Macia to Bilene Beach crosses Chilengue, which is about 32km from Macia town and 6km from Bilene beach. In the south-east, the community finishes when starts an aerodrome of the neighbour village (Figure 2). The households are distributed mainly near the road along five kilometres. Due to its size, the village is divided in three neighbourhoods each with a Secretary responsible. These Secretaries worked together with the chief of the village.

The landscape of Chilengue is characterized by extensive sloping plains with dispersed spontaneous trees (for instance, *Strychnos spinosa* Lam., *Syzygium cumini* Lam.) and a diversity of fruit trees planted by the population, particularly cashew (*Anacardium occidentale*), amarula (*Sclerocarrya birrea*), mafura (*Trichilia emetica*) and mango (*Mangifera indica* L.) trees (Appendix 9.5-b)

The majority of the households were made in reed and few brick houses existed (Appendix 9.5-c). The community benefits from a water hole with manual pump and a primary school with one teacher. It has several water wells spread in the northwest part of the community. A river spring starts from the village and people are used to take water from there and take a bath in the spring (Appendix 9.5-d). An electricity project has been developed and it is expected to start working this year. There are four companies operating in Chilengue: a biofuels company, a toilet paper factory, carpentry and a brick company.

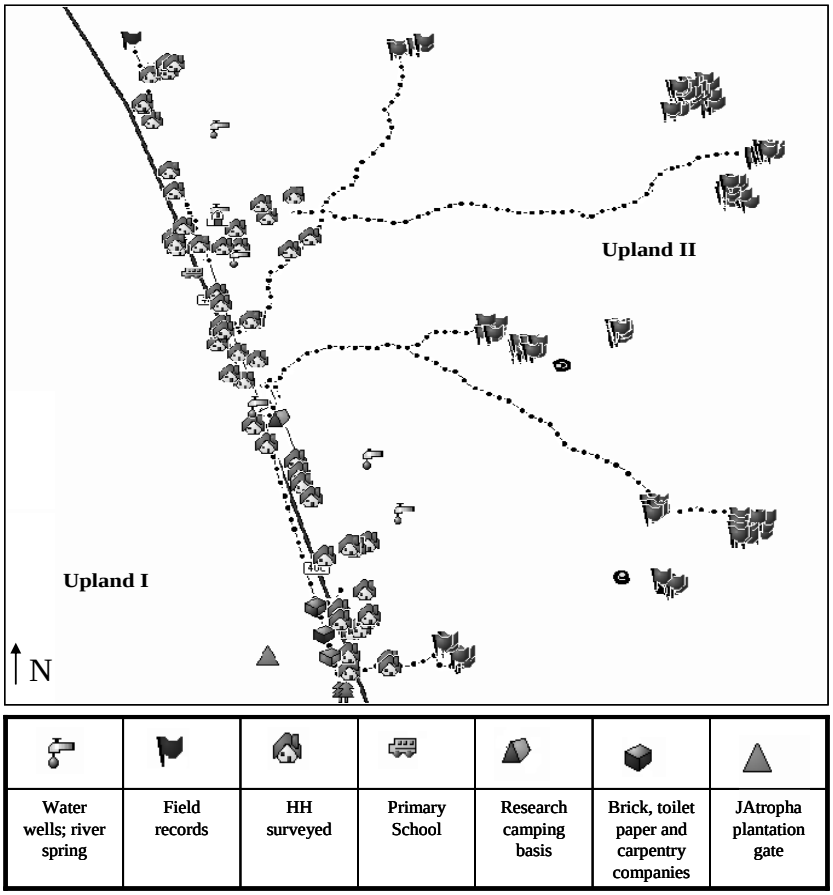

Figure 3- Map of Chilengue community.

The main activity of the community is arable cropping of cassava, groundnuts, Bambara groundnuts, cowpea and pineapples. Chilengue is influenced by the tourist activities on Bilene Beach and is also directly affected by the presence of the large area of Jatropha planted by the biofuels company. Since 2007 the Jatropha plantation occupies the south-eastern part of the community. The people that had fields on that side of the community (Upland I) had to move to a new area in the northern part of the community (Upland II).

Ngolene is a small isolated village which main access is a sandy road. The sandy road connects Ngolene to the nearest small village, Nzêve. The distance between the villages is about 4 km. The nearest small town is Bilene Beach and it takes about four hours walks through the bush to arrive there from Ngolene. A man and a woman are responsible for the management of the village as chiefs of the village. According to them this community has about 27 households and a total of 107 people.

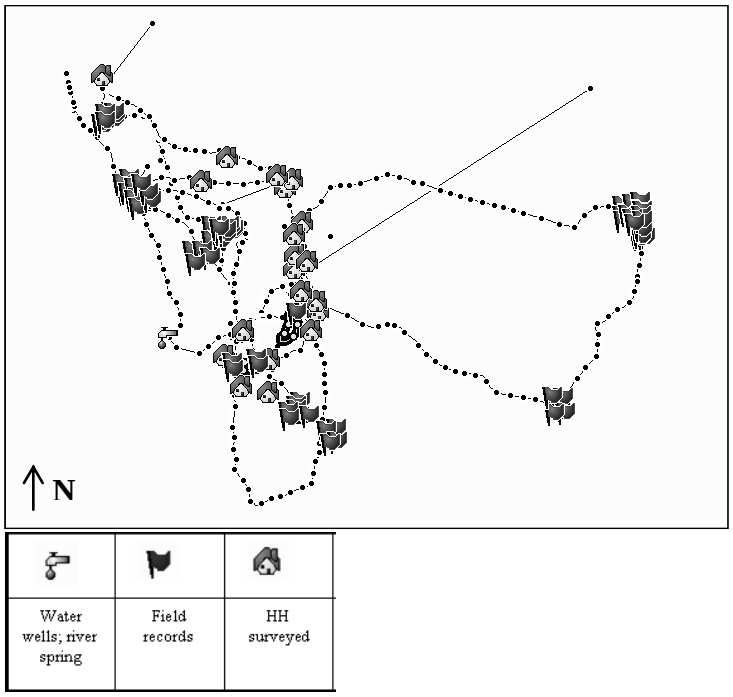

Figure 4- Map of Ngolene community.

Ngolene does not have a water well, nor electricity or a primary school. The water is taken from a river's spring. The children have to walk two hours to arrive to Nhabanga (other small village

near the lagoon) to have lessons in the primary school. If they want to continue their studies they need to sleep in Bilene Beach or Chiacho because the distance it is too long to make it every day.

As in Chilengue, the main activity of Ngolene village is agriculture. The landscape of Ngolene is similar to Chilengue, with extensive sloping plains and various trees.

Since 1992, an area of about 2500ha of Ngolene was transformed into one large farm. This farm, which mainly produces and process animal feed, is the property of the ex-President Joaquim Chissano and is commonly known as Chissano's farm. The farm employs several people from Ngolene village. Since 2008 the biofuel company is in negotiation with the community to acquire more land. From the moment the population knew about the interest of the company in their land they stopped using the destined area.

5.2. Survey

5.2.1. Cropping systems

Four cropping system were identified in the communities (Table 2). The distinction between them was based on the location of the fields and on the crops. They are denoted Cropping System I-IV (CS I – CS IV). Cropping System IV corresponds to a specific area found in Chilengue community (Zone A, Figure 5). The CS I is similar to the "Mixed cereal/cassava/pulse and cashew" described by MAP (1996) while CSII in similar to the "Peat soils subsystem".

Table 2- Fields' location and crops present in each cropping systems. Bg=Bambara; Cs=Cassava; Gr=Groundnuts; Cp=Cowpea; Mz=Maize; Pa=Pineapple; Sp=Sweet potato; Sc=Sugar cane; Ba=Banana; Vg= Vegetables; Pk=Pumpkin; Wm=Watermelon. "+"=crop present; "-" = Crop not present.

Cropping System	Fields location	Bg	Cs	Gr	Cp	Mz	Pa	Sp	Sc	Ba	Vg	Pk	Wm
I	Upland II	+	+	+	+	+	+	+	-	-	-	+	+
II	Bottomland	-	-	-	-	-	-	+	+	+	+	-	-
III	Midland	-	+	+	+	+	-	-	-	-	-	-	-
IV	Midland	-	-	+	+	+	-	-	-	-	-	-	-

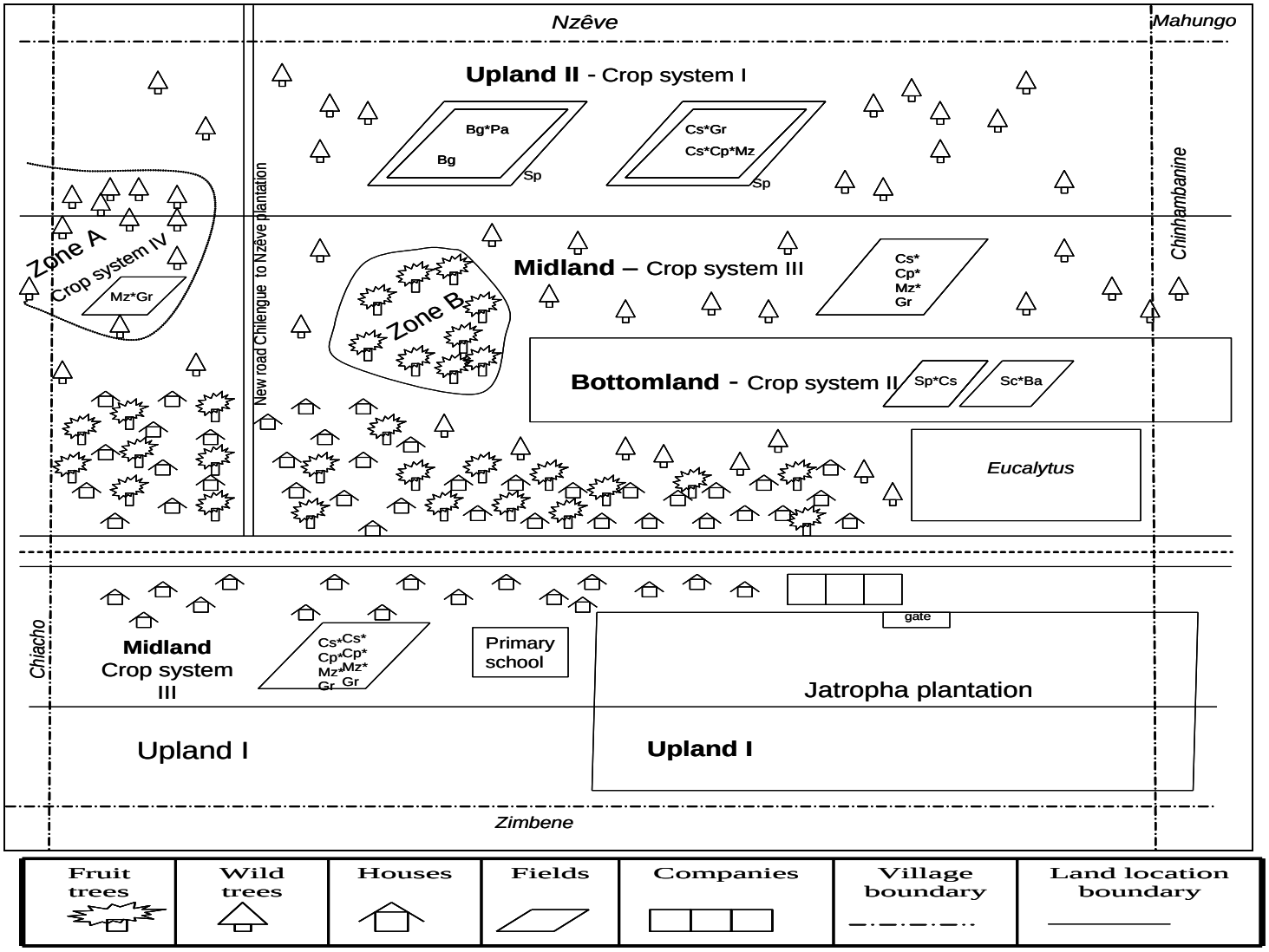

Figure 5- Schematic presentation of cropping systems in Chilengue village.

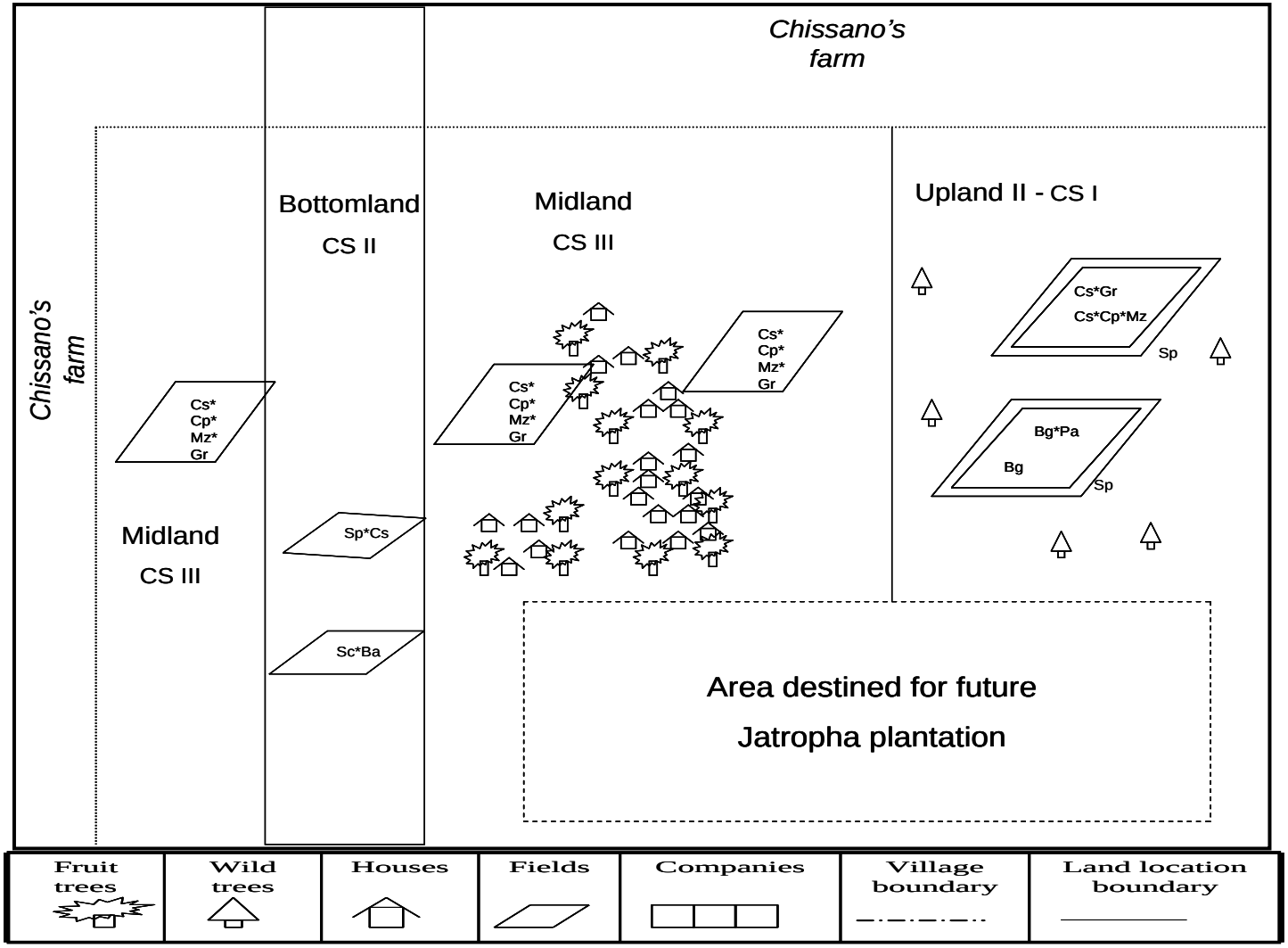

Figure 6- Schematic presentation of cropping systems in Ngolene village.

The survey was complemented with measurements. The majority of fields measured (62) were located in Upland II- CS I (Table 3). Only two fields were measured in CS IV and both belong to the category that lost land and did not work at the Jatropha plantation. Nevertheless, the field size from different cropping system showed significant difference. The fields from CSI and CSIII were always larger than fields from CSII. The fields' size of CSII had in average 0.02ha while the field size of CSIII was around 0.14ha (Table 3). The field size may be related with land availability and importance of the crop. In both CSI and CSII it was possible to grow cash crops and these seemed to be the most important cropping systems on the communities. However, the fields in the Bottomland (CSII) were the smallest. The reason of small fields in Bottomland may be related with space constraint or labour availability. Contrary to Upland, the total Bottomland area was smaller and had good soil and water conditions. These characteristics may increase the demand for this land with limited area which may lead to small field's size. Another plausible explanation of the small field size in Bottomland may be due the soil characteristics. The clay soil in Bottomland is harder to cultivate than the sandy soil of Upland and it implies more labour (Van Leeuwen, 1987). This may be a constraint for families with low labour capacity, for instance.

Table 3- Average field size and number of fields measured in different cropping systems.

Group	TOTAL			
	Fields measured (no.)	Average field size (ha)		
		$\bar{x}$	±	std
CS I	62	0.12a	±	0.11
CS II	13	0.02b	±	0.08
CS III	24	0.14a	±	0.10
CS IV	2	0.10a	±	0.02
p value		0.010		

One hundred and one fields were visited in 26 households (Table 4). Four fields were in fallow, forty one fields had crops in monoculture and 56 fields had mixed crops.

Table 4- Number of households in which field visits were made and number of mono and mix cropping fields measured.

HH with field visits (no.)	Fields Measured (no.)			
	Total	Fallow	Mono	Mix
26	101	4	41	56

The main mono cultivated crops were bambara and cassava. Cassava was mixed with groundnuts until December. By the time of field visits the groundnuts were already harvested (see Chapter 4.2.1.1) and cassava was the only crop on the field left. So, some fields had cassava in monoculture and other fields had cassava alone but not in monoculture (Table 5). When in monoculture, the cassava field size was smaller than the field size of cassava mixed with groundnuts. Also the groundnuts in monoculture did not have a large field size. Contrary, the field size of bambara in monoculture is large and it shows the importance of this crop. The sweet potato around the field of bambara was considered in monoculture (SP[1,] Figure 7). The most common mixed crops were cassava with cowpea, maize with cowpea and cassava with cowpea and maize (Figure 8). The common local variety of cassava called "*Munhaça*" and less commonly used "*Julamete*" or "*Gangasol*". The maize variety has white grains ("*Ximatana"* or "*Milimili*"), yellow grains ("Mugwalene") or yellow and white grains together.

Table 5- Number of fields measured and average field size for single or mixed crops.

Crop	No. Fields[1]	Field size (ha)		
		$\bar{x}$	±	std
Bambara	24	0.11	±	0.13
Bambara*pineapple	3	0.18	±	0.13
Cassava	9	0.07	±	0.06
Cassava*(*groundnuts*)[2]	19	0.10	±	0.08
Cassava*cowpea	11	0.12	±	0.12
Cassava*cowpea*maize	4	0.17	±	0.05
Groundnuts*maize*cowpea	4	0.12	±	0.07
Maize*cowpea	6	0.19	±	0.08
Maize*groundnuts	3	0.13	±	0.03
Groundnuts	4	0.07	±	0.01

1- Does not include fields measured for crops with less than three fields (Sp. Ba. Sc. Bg*Gr. Cs*Mz. Cs*Cp*Gr. Cp*Gr. Bn*Sc. Sc*sp).
2- Cassava*(*groundnuts*): cassava was alone on the field since groundnuts were already harvested.

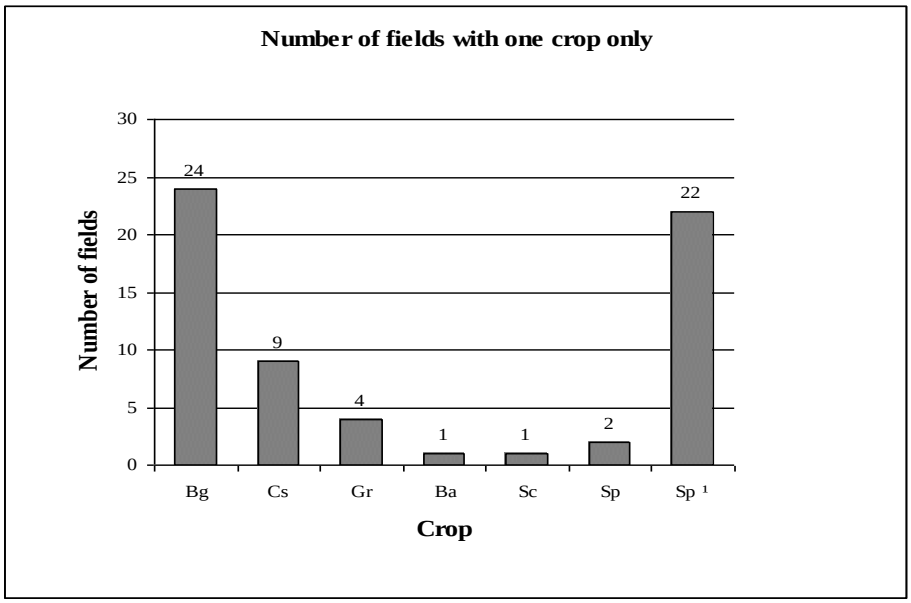

Figure 7- Number of fields in monoculture of Bambara (Bg), cassava (Cs), groundnuts (Gr), banana (Ba), sugar cane (Sc), sweet potato (Sp) and Sweet potato around bambara fields (Sp[1]).

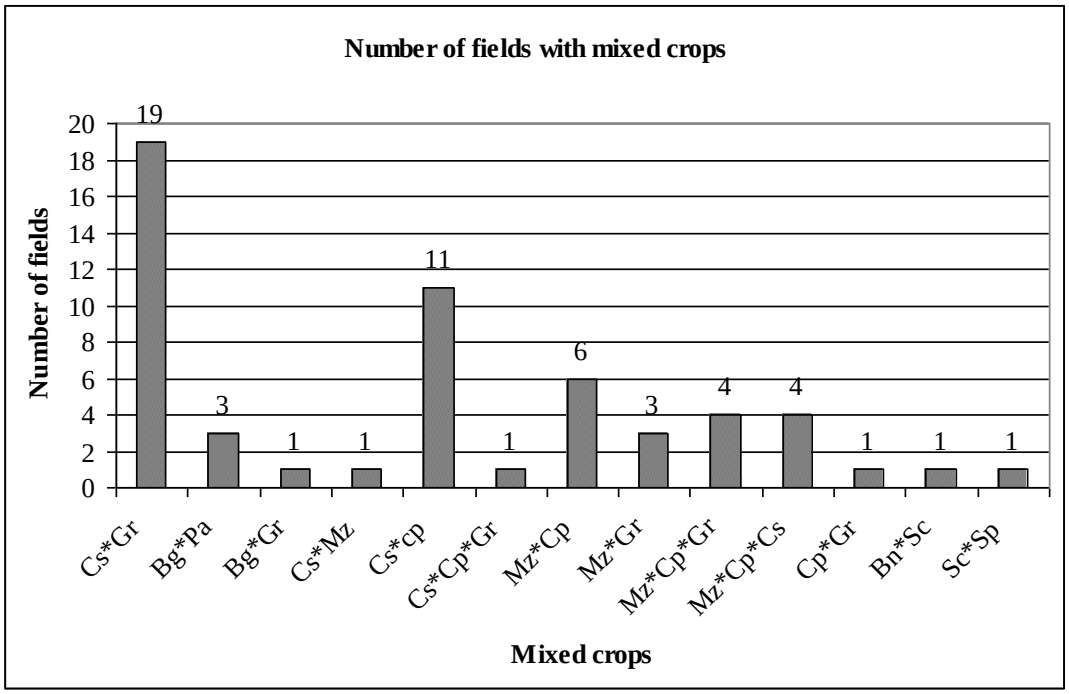

Figure 8- Number of fields with mixed crops (*). Bg=Bambara; Cs=Cassava; Gr= groundnuts; Ba=banana; Sc=Sugar cane; Sp=sweet potato (Sp); Mz=maize; Cp=cowpea. Cs*Gr - cassava was alone on the field since groundnuts were already harvested.

Table 6 shows the plant density measured for the main crops. The seeds or plants are irregularly sown or planted in the field. In a single hole farmers drop one seed of groundnuts or bambara and two to three seeds of cowpea or maize. When alone, bambara had about 68000 plants/ha and cassava 16000 plants/ha. The plants density is adapted when crop are mixed. Maize was less present in a field with only 8600 to 10 000 plants per hectare. Balsam pears (*Momordica balsamina*) grows naturally and in abundance in the fields and the people eat its leaves and fruits.

Table 6- Plants density (number of plants per square meter) for mono and mix crops (*).

Crop	No. fields	Plants density (plants/m^2)		
		$\bar{x}$	±	std
Bambara	8	6.76	±	1.79
Cassava	5	1.60	±	0.85
Cassava*(*groundnuts*)[1]	6	1.53	±	0.48
Bambara(*groundnuts)	1	4.38	±	-
Groundnuts(*bambara)		3.00	±	-
Cassava(*cowpea)	7	1.20	±	0.29
Cowpea(*cassava)		0.62	±	0.19
Cassava(*cowpea*maize)	3	0.85	±	0.31
Maize(*cassava*cowpea)		0.86	±	0.34
Cowpea(*cassava*maize)		0.38	±	0.13
Groundnuts(*maize*cowpea)	4	5.66	±	1.27
Maize(*groundnuts*cowpea)		1.01	±	0.42
Cowpea(*groundnuts*maize)		0.33	±	0.31
Maize(*cowpea)	3	1.31	±	0.43
Cowpea(*maize)		0.28	±	0.04

1- Cassava*(*groundnuts*): cassava was alone on the field since groundnuts were already harvested.

For bambara, groundnuts, maize and cowpea some farmers gave estimates for crops yield (Table 7). Usually they know how many bags or cans they harvested of each crop. The bags referred to 50kg rice bags, 20L cans or a "*banha*" (1L can of olive oil). The yields greatly varied and the standard deviation is high in all crops, except cowpea because only one farmer gave yield estimation for this crop. Many farmers could not tell how much they harvested in the last season mainly because the harvesting is spread over several days and depends of the presence of a buyer (in bambara case). Maize and cowpea yield was especially hard to estimate for farmers.

Table 7- Average yield of the main crops. The units used were based on the unit used by farmers: 50kg rice bags or 20L can. The average yield in units per hectare of bambara, groundnuts and maize refers to shelled /unthreshed fruits; the asterisk following the crop name means that the crop was mixed with other crops in a field.

Crop	No. of fields	Average Area (ha)			Average Yield (units)			Average yield (units/ha)	Unit
		$\bar{x}$	±	std	$\bar{x}$	±	std		
Bambara	13	0.14	±	0.11	4	±	5.07	28	50kg rice bags
Groundnuts*	8	0.14	±	0.09	2	±	1.35	11	50kg rice bags
Maize*	2	0.21	±	0.06	1	±	0.89	4	12kg rice bags
Cowpea*	1	0.25	±	-	2	±	-	8	20L can

From the yield measurements results, the groundnut's shell represented about 28% of the groundnuts fresh weight, and the cob represented about 53% of the maize ear fresh weight (Appendix-9.6a and 9.6-d, respectively). Based on the measurements, the average yield of groundnuts is about 139 kg per hectare (fresh weight of unshelled groundnuts) and about 444 kg of maize per hectare (fresh weight of threshed maize). The low plants density and the grain lost due to birds great affected the maize yield. No bambara pod measurements were done since it was the sowing date at the moment of the field visits. The farmers only estimate bambara pod yield by number of 50kg bags of rice. It is not possible estimate bambara cop yield since no bags with bambara groundnuts were measured in order to find out how many kilograms of bambara pods a 50kg rice bags can have in it. Mkandawire (2007) review studies which reported large variation of bambara pod yields (600-3000 kg/ha) depending on the ecological conditions, cultivars and symbiotic efficacy of native bradyrhizobia which nodulate this specie.

5.2.1.1. Cropping system I

Cropping system I in Upland II was mainly dependent on Bambara groundnut. According to the population, Bambara groundnut only grows well in "new land". For the majority of Chilengue farmers "new land" refers to land never cultivated before (as in fact some areas of Upland II were). They distinguish the "new land" from the other by the type of grass grown. However, fallow is also made in Upland II and it could go from 10 to 30 years.

Bambara groundnut is sown in February/March during the rainy period (Figure 9). Usually, the soil preparation consists of clearing the land few months before bambara sowing and few weeks before sow the fields are ploughed. If the clearing is not made few months before, farmers do it before sowing. Depending on labour availability farmers can clear the land in July, August or in October/November. Clearing land is done only once per field, in the beginning of bambara cycle. For each of the following crops on the same field no ploughing takes place. This means that the labour hours required for opening a field and ploughing should be divided over all the crops subsequently cultivated on that piece of land. Besides clearing the land for cultivation, clearing land has also the intention to delimit the area that the farmer wants to sow and to create a sort of "manure" with the rotten weeds. After clearing land farmers may sow watermelon and pumpkins that are harvested before bambara sowing. After the ploughing of January/February farmers burn the weeds, incorporate the ashes in the soil and sow bambara. From July to August Bambara groundnuts are harvested, spread over several days.

At the same time of Bambara groundnuts, pineapples and sweet potato are planted around bambara plot. The sweet potato is planted around the plots of Bambara groundnuts on ridges (Figure 10). Sweet potato plants on the same ridge are distanced about 20-40 cm. The distance between two ridges is about 0.9-1 to 1.20-1.5 meters. Three weeks after planting, people start harvesting the young leaves to cook. Within three/four months they harvest the tuber.

When pineapple is present in the field it could be planted around the plot of bambara groundnut or in rows within the plot which is more common. The pineapples are planted at a distance of 1.5 to 2 meters (Figure 9). The pineapple harvesting happens 10 to 12 months later.

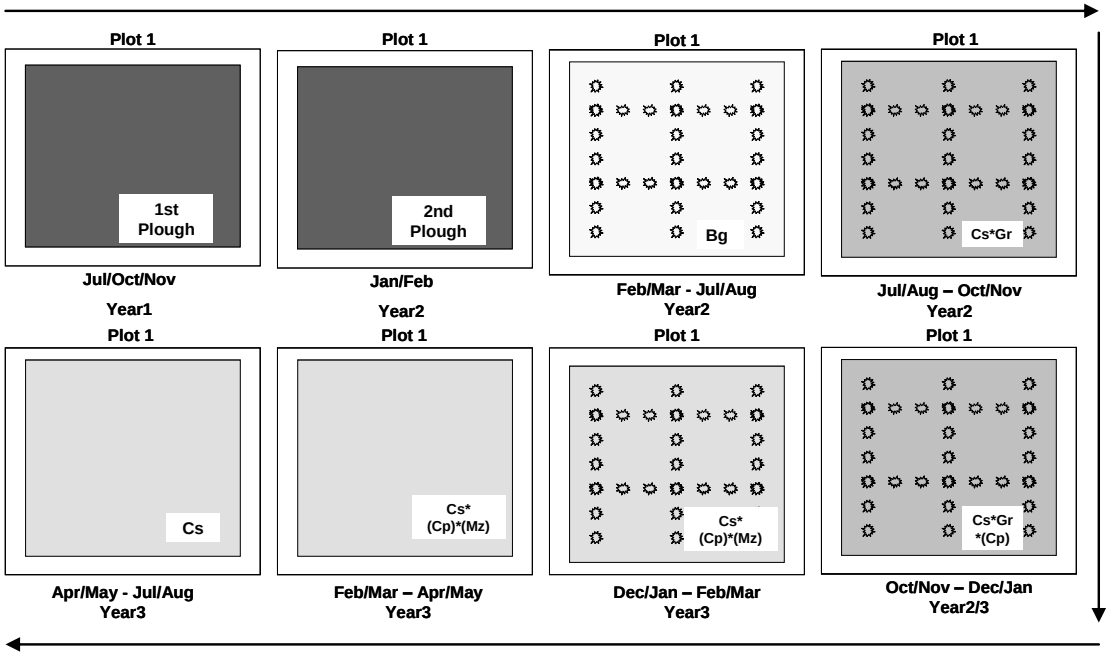

Figure 9 - Scheme of crops sequence in a field in Upland. The name of the crops within parenthesis means that these crops could be or not cultivated by the farmer. The different patterns merely clear that there are different crops in the field in different moments but do not mean a specific crop or farm activity. The symbols in the fields indicate the presence of pineapple in a certain pattern.

After bambara harvesting farmers use to plant cassava together with groundnuts in August/September. They burn or let rot the bambara stubble and no ploughing is done. The groundnuts can be sown on the same day as cassava or few days later within the free spaces between plants. The groundnut harvesting is in December/January. Also cowpea may be sown in November between the groundnuts. After the groundnuts harvesting, the cassava can remain in the field alone or mixed with cowpea or with pineapples (Figure 10). The young leaves of cowpea are harvested for cooking. In April/May the harvesting of the beans and some cassava starts. However, the complete cassava harvest is in August/September. The farmer could make a second cycle of cassava, cowpea, maize or groundnuts. The plot may be abandoned or cultivated with cowpea and groundnuts for few years more. However, farmers never repeat Bambara in the same field.

This cropping system implies that every year people use new land to sow Bambara groundnuts (every year people clear a new plot). However, the plots with more than three to four years are

abandoned due to decrease of soil fertility (for instance, for farmers an evidence of soil fertility decrease was the bad development of cassava roots after the second year) and labour availability (Figure 11). This means that the farmer keeps his field area or field number almost constant all over the years.

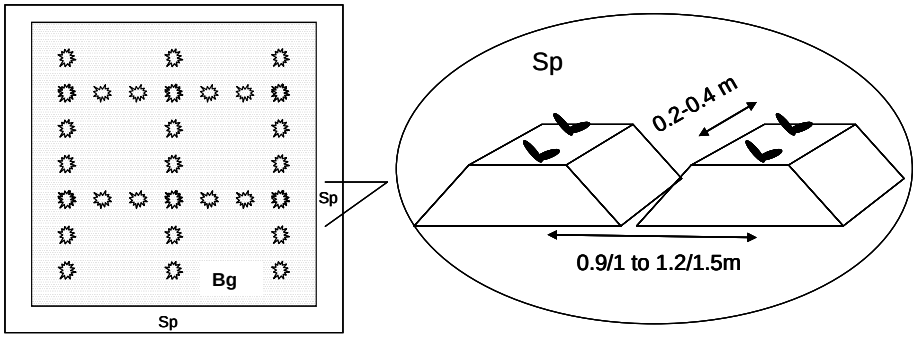

Figure 10 - Scheme of Sweet Potato system in Upland.

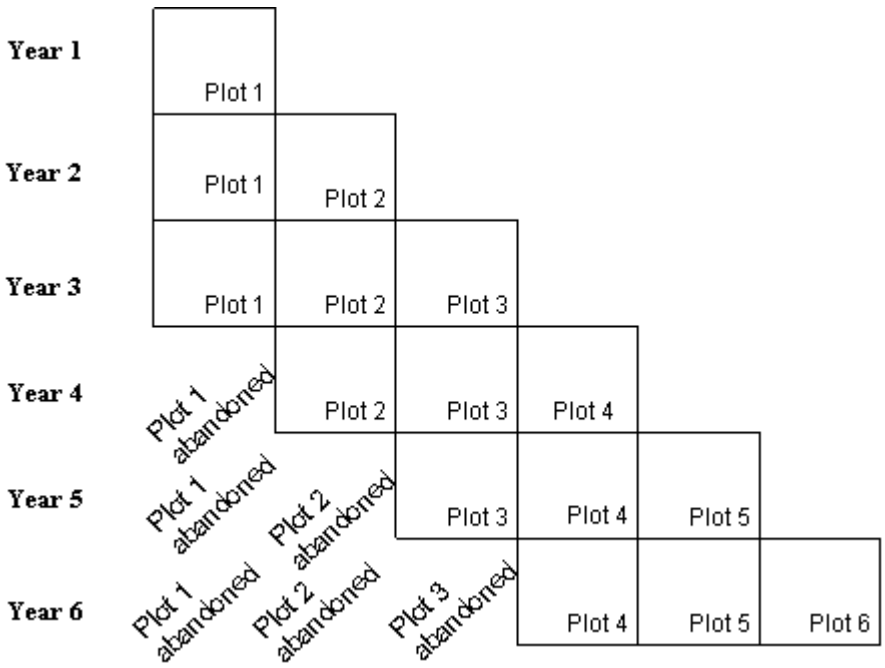

Figure 11 - Sequence of plots through six years of a farmer with labour availability to cultivate three plots at same time in Upland.

5.2.1.2. Cropping system II

In the Bottomland the soil is dark and wet *(*local name*: "matopa")*. In these conditions it is possible to grow banana and sugar-cane. The banana trees and sugar-cane are planted around the plot or have their own plot. Farmers also grow sweet-potato and cassava in the Bottomland. According to the people, the cassava is sweeter and easier to cook than the cassava grown in Upland, which is better to make flour. Some people might grow vegetables on Bottomland. Sweet potato can have its own field or be planted around a field with other crops in February/March (Figure 12). After sweet potato, vegetables are sown. Tomato, onions, lettuce or cabbage are the most common. They are sown in the cool and dry season (from April). The cassava is usually grown in monoculture. It is planted in August to be harvested from April to August the next year. The people may fallow the plots for few years especially if they have several plots at the Bottomland. The fields in Bottomland are surrounded by canals water and every three years it is necessary to clean and open new water canals to drain the water.

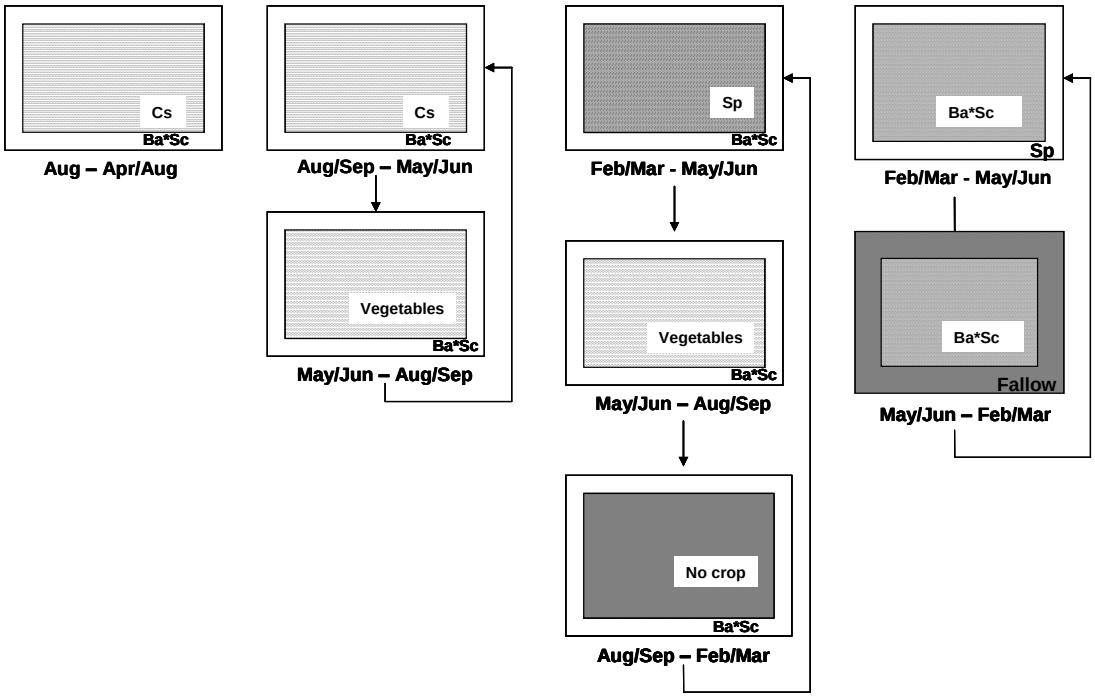

Figure 12 - Scheme of crop sequence in four different plots in Bottomland. The different patterns merely clear that there are different crops in the field in different moments but do not mean a specific crop or farm activity.

The access to Bottomland may be constraint due to space and land tenure. The Bottomland has rich soils and a lot of water so it is important that farmers own fields there to grow crops like vegetables and sugar-cane. However, the space in Bottomland is limited and the access to it also. In addition, complex land tenure reduced the number of people farming in Bottomland. If you are a member of family that owns land in Bottomland you can easily get plots there by splitting family fields (which also reduces the field size).

5.2.1.3. Cropping system III

The main difference between CS I and CS III is the absence of Bambara groundnuts in CS III. However all the other crops such as maize, cowpea, groundnuts, cassava or even few sweet potatoes are present on this land (Figure 13). CS III in the Midland also includes the fields that farmers may have around the house.

The maize is sown together with groundnuts and cowpea in December. In April/ May the products are harvested. Then, the farmer has different options. One, which is similar to CS IV, the plot could be in fallow until December and then it is sown again with maize, groundnuts and cowpea (Opt A, Figure 13). Another option, the plot could be fallow from Apr/May to August. In August either cassava is planted only (Opt B, Figure 13) or cassava with maize and groundnuts (Opt C, Figure 13). If the farmer decides planting only cassava it is harvested from April to August of the next year and there is a fallow from August to December. In December the plot could be sown with maize, groundnuts and cowpea again. When cassava is mixed with maize or groundnuts in August the later are harvested in December/January. After it, the plot could be or not sow again with maize and groundnuts. The cassava is harvested from April to August.

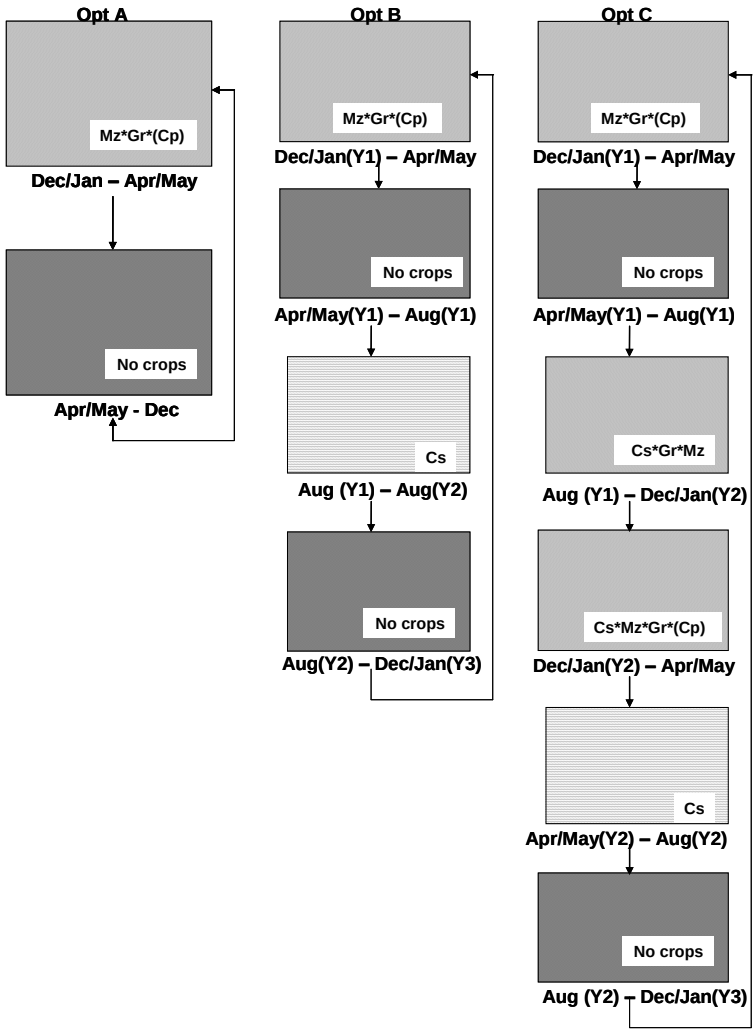

Figure 13 - Scheme of crops sequence in four different plots in Midland. The different patterns merely clear that there are different crops in the field in different moments but do not mean a specific crop or farm activity.

5.2.1.4. Cropping system IV

Cropping system IV is present in an area named Zone A (Figure 5). This zone is known has *Chiacho* and in older times was used for traditional ceremonies. It is an area with dense bush but crops are grown in the free spaces. The crops grown in Zone A are mainly maize, groundnuts and few cowpeas from December to April/May. During the year the weeds grow and in December farms cultivate it again. In Zone A any crop during approximately seven to eight months fields are not occupied by any crop. According to some farmers, maize grows a bit better than in other land, which could be related with the months without crops.

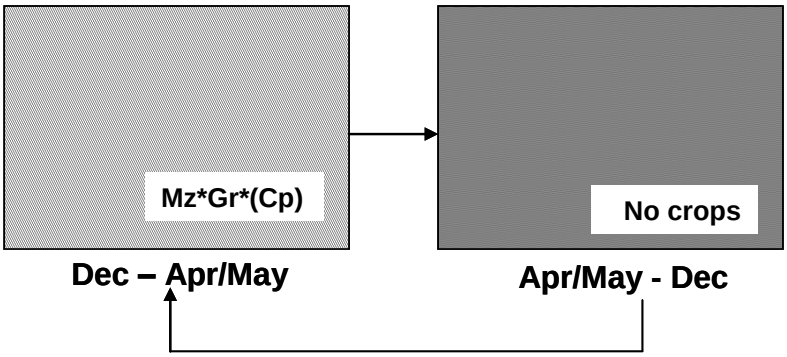

Figure 14 – Scheme of crops sequence of plots at Zone A, Midland. The different patterns merely clear that there are different crops in the field in different moments but do not mean a specific crop or farm activity.

5.2.1.5. Crop activity calendar

Figure 15 represents the main crop activities during a year for each cropping system. The CS I represents a rotation in a field (field a) during four years. In other cropping systems farmer can decide by different options (field a, b and c). On the firsts months (January, February and March) the farmers are mainly occupied with groundnuts and maize sowing (in CSIII and CS IV), ploughing and sowing of bambara (in CSI). In April/May is time of maize, cowpea and groundnuts harvesting (CSIII and IV). Bambara harvesting and cassava and groundnuts sowing occurs during July and August (CSI). November is ploughing time for cowpea, maize and groundnuts that will be sown in December (CSIII and IV). In December the groundnuts sown in August start to be harvested (CSI). In April/May is the sowing of vegetables in CSII. Vegetables follow the sweet potato (CSII- field b) or cassava (CSII – field c).

CS	Field	Crop	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec
I	a	Pk	y2	y2	y2	X	X	X	X	X	X	y1	y1	y1
		Wm	y2	y2	y2	X	X	X	X	X	X	y1	y1	y1
	a	Ba	y2	y2	y2	y2	y2	y2	y2	y2	X	y1	y1	X
		Sp	y2	y2	y2	y2	y2	y2	y2	X	X	X	X	X
		Pa	y2	y2	y2	y2	y2	y2	y2	y2	y2	y2	y2	y2
	a	Cs	y3	y3	y3	y3	y3	y3	y3	y2	y2	y2	y2	y2
		Gr	y3	X	X	X	X	X	X	y2	y2	y2	y2	y2
	a	Cs	y3	y3	y3	y3	y3	y3	y3	Y4	Y4	Y4	Y4	Y4
		Cp	y3	y3	y3	y3	y3	X	X	X	X	X	X	y2
		Mz	y3	y3	y3	y3	y3	X	X	X	X	X	X	y2
II	a	Ba	Y	Y	Y	Y	Every year		Y	Y	Y	Y	Y	Y
		Sc	Y	Y	Y	Y	Y	Every year		Y	Y	Y	Y	Y
	b	Sp	y1	y1	y1	y1	y1	X	X	X	X	X	X	X
		Vg	X	X	X	y1	y1	y1	y1	y1	y1	y1	y1	y1
	c	Cs	y2	y2	y2	y2	y2	y2		y1/y2	y1/2	y1	y1	y1
		Vg	X	X	X	X	y2	y2	Y2	y2	y2	X	X	X
III	a	Mz	y2	y2	y2	y2	y2						y1	y1
		Gr	y2	y2	y2	y2	y2						y1	y1
		Cp	y2	y2	y2	y2	y2						y1	y1
	b	Mz	y2	y2	y2	y2	y2	X	X	X	X	X	y1	y1
		Gr	y2	y2	y2	y2	y2	X	X	X	X	X	y1	y1
		Cp	y2	y2	y2	y2	y2	X	X	X	X	X	y1	y1
		Cs	y3	y3	y3	y3	y3	y2	y2	y2	y2	y2	y2	y2
IV	a	Mz	y2	y2	y2	y2	y2						y1	y1
		Gr	y2	y2	y2	y2	y2						y1	y1
		Cp	y2	y2	y2	y2	y2						y1	y1

Clearing land	Ploughing	Sowing	Harvesting/ Sowing	Harvesting leaves	Harvesting final product	Fallow

Figure 15- Main farm activities all over a year for all cropping systems. Bg=Bambara; Cs=Cassava; Gr=Groundnuts; Cp=Cowpea; Mz=Maize; Pa=Pineapple; Sp=Sweet potato; Sc=Sugar cane; Ba=Banana; Vg= Vegetables; Pk=Pumpkin; Wm=Watermelon. X-no presence of the crop on the field; yi=year1…year i.

5.2.2. Households categorization – general features

The questionnaire was used to categorize the households in groups based on land lost /no land lost to the Jatropha plantation (+L/-L) and work/no work at the Jatropha plantation (+JW/-JW) (Table 8). Then, four categories can be formed. In some situations, the data is analyzed

comparing those that lost land and did not land lose (+L/-L) separately than those that had a family member working at the Jatropha plantation or not (+JW/-JW).

Table 8 - Categorization of the households based on lost /no land lost to the Jatropha plantation (+L/-L) and work/no works at the Jatropha plantation (+JW/-JW).

Group	Lost Land	Work at Jatropha plantation
-L-JW	No	No
+L+JW	Yes	Yes
-L+JW	No	Yes
+L-JW	Yes	No

Fifty households were surveyed in Chilengue and twenty in Ngolene. More than half of the households surveyed in Chilengue had at least one family member working at the Jatropha plantation (categories +L+JW and –L+JW). In Ngolene five households had at least one member working at the Jatropha plantation (-L+JW) and nobody lost land since the Jatropha plantation is not there yet. However, still three families have fields in the area destined for Jatropha plantation.

Table 9 - Number of households surveyed in each category and village.

Group	Chilengue	Ngolene
-L-JW	5	15
+L+JW	18	0
-L+JW	8	5
+L-JW	19	0
Total	50	20

Table 10 shows the main features of all the households interviewed and the differences between categories.

Table 10- General features of households (HH) in the different categories –L-JW, +L+W, -L+JW. +L-JW (+L/-L: land lost /no land lost to the Jatropha plantation; +JW/-JW: work/no work at the Jatropha plantation)

Group	No HH	Family size[1] (no. of persons)			Dependency rate [2]			Cropping System I		Cropping System II		Cropping System III		Cropping System IV		FWJ/Rem [3]		Sell Cash Crops		Sell products from natural resources	
		$\bar{x}$	±	std	$\bar{x}$	±	std	No. HH	%	No. HH	%	No. HH	%	No. HH	%	No. HH	%	No. HH	%	No. HH	%
-L-JW	20	4.0	±	2.7 a	0.8	±	1.4	14	70.0	17	85,0	14	70.0	0	0.0	13	65	4	20	5	25
+L+JW	18	7.5	±	4.5 b	1.1	±	1.0	16	88.9	9	50,0	5	27.8	2	11.1	11	61	11	61	9	50
-L+JW	13	5.8	±	2.4 ab	1.2	±	1.3	12	92.3	9	69,2	4	30.8	2	15.4	4	31	4	31	5	38
+L-JW	19	6.9	±	4.2 ab	1.5	±	1.0	16	84.2	10	52,6	6	31.6	1	5.3	14	74	7	37	10	53
Total	70	6.0	±	3.8	1.1	±	1.2	58	82.9	45	64,3	29	41.4	5	7.1	43	61	26	37	29	41
p value	-	**0.017**			ns			-		-		-		-		-		-		-	

1-Total number of people living in the household, including children

2- Dependency rate = Number of children / number of adults

3- Formal wage job or a family member sending remittances from elsewhere. FWJ does not include working at the Jatropha plantation.

The average family's size had six members, but significant difference exists between those that did not lose land and did not work at Jatropha (-L-JW) and those that lost land and worked at Jatropha (+L+JW). Curiously, a significant difference was found between categories when grouped by land lost (+L) and no land lost (–L) (Table 11). The families that lost land (+L) are larger than those did not. Large families may have had more land in Upland I so the probability to lose land for the Jatropha plantation would have been high for them. Statistical analysis revealed that in Ngolene, families were consistently smaller than in Chilengue (Table 11).

The dependency rate is estimated dividing the number of children by number of adults in a household. In households with a lot of children dependent of few adults the dependency rate is more than one. The surveyed villages did not have a high dependency rate and in average the number of adults is quite equal to number of children (Table 10). The household organization changes over the time and several stages occurs during a family life cycle (Neighbour, 1985).Therefore, in seventy households there were families in distinct family life stages. For instance, there were young couples with babies' as well large families with a middle-age couple and older and younger children or old couples living alone.

Table 11- Family size comparison between villages (Chilengue and Ngolene), between households that work at Jatropha and no work at Jatropha (+JW and –JW) and between households that lost land and no land lost (+L and –L).

Group	No. HH	Family size (persons)			*p value*
		$\bar{x}$	±	std	
+JW	31	6.8	±	3.8	ns
-JW	39	5.4	±	3.8	
+L	37	7.2	±	4.3	**0.012**
-L	33	4.7	±	2.7	
Chilengue	50	6.9	±	4.0	**0.003**
Ngolene	20	3.9	±	2.1	
Total	70	6.0	±	3.8	

CS I was present in 58 households (83%), CS II in 45 (64%) and CS III and CS IV in 29 households (49%) (Table 10). Cash crops such as bambara, pineapples or watermelon come

from CSI or from CSII (sugar-cane and bananas) which may justify the importance of these cropping systems for the communities. Within each category the decrease of cropping systems importance form CSI to CSII and CSIII is observed except for the group "-L-JW". This group has a higher percentage of households with CSII and as well CSIII than the other groups. For this group all the cropping systems seem to have the same importance.

In spite of field measurements in 26 farms only in eight farms were measured in its totality. No significant difference in farm size exists between groups and the average farm size was found to be about 0.48ha (Table 12). The small number of samples did not allow conclusions relating the group and farm size. The farm size of those that did not lose land and did not work at the Jatropha plantation (-L-JW) was the largest and had about one hectare (Table 12), but as it refers to one farm only no conclusions can be made.

Table 12- Total farm size and field size in each cropping system for each category

Group	Total Farm Size		Cropping System I		Cropping System II		Cropping System III		Cropping System IV	
	No. farms measured	Area (ha) $\bar{x}$ ± std	No. Fields measured	Field size (ha) $\bar{x}$ ± std	No. Fields measured	Field size (ha) $\bar{x}$ ± std	No. Fields measured	Field size (ha) $\bar{x}$ ± std	No. Fields measured	Field size (ha) $\bar{x}$ ± std
-L-JW	1	1.13 ± 0.20	14	0.11 ± 0.15	4	0.02 ± 0.01	11	0.12 ± 0.11	0	Not measured
+L+JW	3	0.38 ± 0.11	18	0.12 ± 0.10	2	0.05 ± 0.01	2	0.20 ± 0.04	0	Not measured
-L+JW	1	0.18 ± 0.04	12	0.07 ± 0.04	0	Not measured	5	0.15 ± 0.02	0	Not measured
+L-JW	3	0.45 ± 0.10	18	0.16 ± 0.11	7	0.02 ± 0.02	6	0.13 ± 0.09	2	0.10 ± 0.02
Total	8	0.48 ± 0.11	62	0.12 ± 0.11	13	0.06 ± 0.08	24	0.13 ± 0.10	2	0.10 ± 0.02
p value	-	ns	-	ns	-	ns	-	ns	-	ns

Twenty one households had one cropping system only but the most common was a combination between them (Table 13). During the survey, it was clear that generally nobody stopped any cropping activity due to the Jatropha plantation. This means that farmers had the same cropping systems as before the biofuel company was established a Jatropha plantation. When the household had a single cropping system normally it was CS I and thirteen of these 16 households lost land due to Jatropha plantation (Table 13). They did not stop with this cropping system but just moved into another piece of land (Upland II). With CS I a family can produce cash crops and also food crops for home consumption. Two households had CSII only. From CSII they can grow and sell cash crops (bananas or sugar cane) and produce food crops for the family (vegetables, sweet-potato and cassava). However, these families with only CSII most probably had to buy other food such as maize or beans elsewhere since they do not produce it in their farm. The most common was a combination between CSI and CSII or between all the cropping systems. This combination allows various sources of food to the family and the production of different cash crops.

Table 13- Number of households with different combinations of cropping systems per group that work at Jatropha (+JW), no work at Jatropha (-JW) and lost land (+L) and no land lost (-L). The CS IV was considered together with CSIII so is not represented in the table.

Group	No HH	CSI	CS II	CS III	CS I + II	CS I + III	CS II + III	CS I + II + III
+JW	31	9	1	2	8	2	0	9
-JW	39	7	1	1	12	4	7	7
+L	37	13	2	1	10	4	2	5
-L	33	3	0	2	10	2	5	11
Total Sum	70	16	2	3	20	6	7	16

A high number of households (43 out 70) had cash income from formal wage jobs or from remittances sent by emigrants (Table 10). The formal wage job did not include work at the Jatropha plantation and they were mostly men working in tourism at Bilene Beach, construction or at Chissano farm (Table 31). The selling of products related with farm activities was quite common in the villages (more than a quarter of the households had this activity). The most common products from farm activities sold were bambara and pineapple.

The group with smallest family (-L-JW) had more households with multiple cropping systems than the others (95%) and at same time 70% of the households had an off-farm income. The woman's availability for farming labour (Table 18) and the man's labour allocation to a formal wage job (Table 32) allows the practising of multiple cropping systems and reduces the food insecurity risk. In general, if a family member works at the Jatropha plantation (+L+JW and –L+JW) the demand for additional off-farm income decreases. However, the group that lost land and work at the Jatropha plantation (+L+JW) had higher percentage of households with off-farm and on-farm income as well (Table 14).

Table 14- Average family size and percentage of households with a single or multiple cropping systems (independently of the cropping systems combination) and household income sources (on-farm and off-farm) for each category .

Group	No. HH	Family size[1]	% HH with single CS	% HH with multiple CS	% HH with on-farm income[2]	% HH off-farm income[3]
-L-JW	20	4.0	5	95	40	70
+L+JW	18	7.5	44	56	78	61
-L+JW	13	5.8	31	69	54	31
+L-JW	19	6.9	42	58	63	74
Total	70	6.0	30	70	61	23

l- Number of people living in the household. including children

2- On-farm income includes cash income from cash crops and from selling of products from natural resources.

3- Off-farm income includes formal wage job or a family member sending remittances from elsewhere. FWJ does not include working at Jatropha plantation

5.2.3. Livestock

Independently of working at Jatropha plantation (+JW) or not (-JW) the livestock exists in more than 65% of the all households interviewed (Table 15). Most of the households had chickens, followed by ducks. Other animals include pigs, goats, rabbits and doves. These animals were found in four distinct households. The household with one goat belong to the chief village of Ngolene. The pigs belong to a large family in Chilengue which household head worked with the village chief of Chilengue. The family with doves and other with rabbits mainly had them for fun or because they were a gift. No cattle were present in the communities. According to several

respondents, the main reason of total absence of cattle is the quality of the grass. According to them the cattle looses body weight, become weak and die after a while.

The number of chickens per household never exceeds 15 animals and no household had more than 10 ducks (Table 16). Commonly the families had between two and five animals independently of the category analyzed (between +JW and –JW or between +L and –L). The number of animals was frequently affected by high mortality due to disease and several families lost all their animals.

Table 15- Percentage and number of households where livestock was present and main animal species per category work at Jatropha (+JW), no work at Jatropha (-JW), land lost (+L) and no land lost (-L).

Group	No. HH	With Livestock		With Chicken		With Ducks		Other Animal	
		No. HH	(%)	No. HH	(%)	No. HH	(%)	No. HH	(%)
+JW	31	21	67.7	21	67.7	7	22.6	2	6.5
-JW	39	26	66.7	21	53.8	8	20.5	2	5.1
+L	37	27	73.0	24	64.9	11	29.7	2	5.4
-L	33	20	60.6	18	54.5	4	12.1	2	6.1
Total	**70**	47	67.1	42	60.0	15	21.4	4	5.7

The New Castle disease (local name: *muzungo*) is the main cause of chickens and ducks mortality. For 54.8% of the households with livestock this disease is reported the main cause of mortality for the chickens and for 27% for the ducks (Table 17). However, the disease does not occur every year and when it appears it is between October and December. Farmers usually keep chicken in hencoops at night to protect them against snake attacks. A comparison between villages revealed that there were more people from Chilengue complaining about the disease than in Ngolene. In Chilengue 65% of the households said the main reason of chickens' death was *muzungo* while in Ngolene only 18% complained about it (Appendix 9.5-e). In Ngolene 43% of the households did not mention problems with chicken's disease or other causes of death. Attacks by snakes were most common in Ngolene (Appendix 9.5-e). In spite of people complaining about the high mortality rate of chickens due to diseases nobody had veterinary

assistance or vaccinated their animals. Several people referred they use garlic or soap mixed with maize brain to cure the animals but normally without success.

Table 16- Number of households and number of chicken and ducks owned per category work at Jatropha (+JW), no work at Jatropha (-JW), land lost (+L) and no land lost (-L).

Animal	Group	No. of animals				
		<2	2 to 5	6 to 10	11 to 15	>16
Chicken	+JW	4	9	4	4	0
	-JW	1	10	5	5	0
	+L	4	11	6	3	0
	-L	1	8	4	5	0
Duck	+JW	2	4	1	0	0
	-JW	2	4	2	0	0
	+L	4	5	2	0	0
	-L	0	3	1	0	0

The hencoops were made of wood and they can be on the ground or elevated. In households with no hencoop the chickens sleep in trees. During the day the animals are free ranging and look for their own food around the house or in neighbour's garden. They are feed with household leftovers, mostly maize bran. The poultry production is exclusively for meat and nobody eats the eggs. Occasionally the household can sell chickens to a neighbour that needs it for a special situation (for instance, a birthday or an important visit).

The goat's owner uses its manure in a field where he grows tomatoes. Two people that had elevated hencoops use chicken's manure in their garden. However, the chicken's manure usually is not used but farmers could not say why they did not use the manure.

Table 17- Main reason of livestock mortality. "Muzungo": New Castle disease; "Snakes"-snake attacks; "Dogs": dogs attacks; "All": animal's death due to muzungo, snakes and dogs attacks; "None"- animals do not die due to any particular reason.

Animal	Total no. HH	Main reason of mortality	No HH	Percentage (%)
Chicken	42	Muzungo	23	54.8
		Snakes	2	4.8
		Dogs	0	0.0
		All	1	2.4
		None	16	38.1
Duck	15	Muzungo	4	26.7
		Snakes	0	0.0
		Dogs	0	0.0
		All	0	0.0
		None	11	73.3

5.2.4. Labour

5.2.4.1. Labour at farm level

Farm labour is family labour mainly by the women. The dominant role of women in farming activities is evident (Table 18). In 62 households out of 70 exclusively women labour was used. In the households with at least one member working at Jatropha (+JW) the woman was responsible for farming activities even if she was the Jatropha worker. In six households both man and woman participated in farming activities. The two households with exclusive participation of man belong to Ngolene village.

Table 18- Gender responsible for farming activities in the household expressed in number of households. "Female": farming activity by women; "Male": farming activity by men and "Female and Male": both man and woman participate in farming activities

Group	Total no. HH	Gender participant in farming activities		
		Female	Male	Female and Male
+JW	31	30	0	1
-JW	39	32	2	5
Total	70	62	2	6

Between neighbours exchange labour exists, which means that farmers exchange labour without payment. Hired labour involves payment in cash or products. Exchange labour or hired labour is used during peaks in labour requirement. More than fifty households had exclusively family labour and independently of work or not at Jatropha only twelve households hired labour (Table 19).

Table 19- Type of labour used in the household expressed in number of households with the specified type of labour. "Family": farm labour exclusively by family members; "Family; Exchange" : farm labour is family with help from neighbours during peak periods; "Family; Hire" : farm labour is family with hired labour in the peak periods.

Group	Total no. HH	Type of labour		
		Family	Family; Exchange labour	Family; Hire
+JW	31	22	3	6
-JW	39	30	3	6
Total	70	52	6	12

Table 20 shows the number of workers per farm and number of family workers, hired or exchange workers. There were 134 farm workers to farm 281 fields in the total of households surveyed. Table 20 refers to adult workers only but children participating in farming activities were observed also (see Chapter 4.4).

Table 20- Total number of workers and number of family, hired or interhelping workers for the total HH that work at Jatropha (+JW) and do not work at Jatropha (-JW).

Group	No HH	No of fields[1]	No of farm workers[2]	No of family workers	No hired workers	No. of exchange workers
+JW	31	118	61	56	2	3
-JW	39	163	73	65	6	2
Total	70	281	134	121	8	5

1- Total number of fields from all cropping systems.

2- Farm workers is the total number of workers at farm, including family, hire and exchange labour. Children labour is not included.

During the field research farmers that did not work at Jatropha plantation went to the fields from 6am to 10-11h. According to them, these 4-5 hours were farming activities hours. The total hours dedicated to farming activities would be about 20 hours/week (Table 21). However, we have to be careful analyzing this value for two reasons. Firstly, the hours indicated by the farmers include the time they spend to go to the fields and other activities (see further Chapter 4.4). Secondly, the hours indicated referred to the busy time at the moment of interviews and it does not comply with the hours they spend at farming activities in less busy months.

The female farmers that work at the Jatropha plantation go to their fields afterwards or during the weekends. The work at the Jatropha plantation takes from to 6am to 15h, with lunch time between 12 and 13h, from Monday to Friday. On Saturday it starts at 6am and finishes at 11 am. The women can work in their fields in the afternoon or on Sunday, if they do not go to the church. Hence, when women work at the Jatropha plantation the hours and days spent on farm activities is reduced. After establishment of the Jatropha plantation labour availability at the farm tends to be reduced (Table 21) but it is not statistically relevant. The average hours per week decrease from 21.4h to 17.4h for those that work at Jatropha (+JW). In the group that did not work at Jatropha (-JW) the farming hours remained the same (23h per week). The labour decrease will be larger on farms with women working at Jatropha, than on farms with men working at Jatropha, as on these last farms woman labour hardly competes with farming activities.

Table 21- Average hours spent on farming activities per week and per day per 0.48ha (average farm size) before and after Jatropha plantation during the busy months. The hours is per person and do not include hired/inter-helping labour. Also, it is not the total farming hours per household since some households had more than one family member work at their farm.

Group	Hours per week						Hours per day					
	Before Jatropha plantation			After Jatropha plantation			Before Jatropha plantation			After Jatropha plantation		
	$\bar{x}$	±	std	$\bar{x}$	±	std	$\bar{x}$	±	std	$\bar{x}$	±	std
+JW	21.4	±	8.7	17.4	±	9.3	4.2	±	0.9	3.7	±	1.0
-JW	23.9	±	6.4	23.0	±	7.7	4.2	±	0.9	4.2	±	0.9
Average	22.6	±	7.5	20.2	±	8.5	4.2	±	0.9	3.9	±	1.0

As said in Chapter 4.2.2, due to the low number of farms measured in total the average farm size per household cannot be estimated, neither can farming labour allocation. For that reason the

average area of all fields measured was used to calculate the allocation of farm labour per field area within the groups working (+JW), not working at Jatropha (-JW), lost land (+L) and not land lost (-L) (Table 22). The field area does not differ significantly between categories, nor does the number of labourers. However, the number of hours per week is smaller in those that work at Jatropha. In spite of fewer farming hours the field size is the same compared to the group that does not work at Jatropha. This may be caused by the gender engaged in Jatropha work. Even working the same hours per week those that lost land (+L) had larger fields than to those that did not lose land (-L). It is important to note that number of labourers did not include children' labour and those families that lost land had slightly more children than adults (Table 10). Perhaps children participation in farming activities leads to largest field size or the other way around (large field size leads to children participation in farming activities).

Table 22- Total number of hours per week per average field size for the categories work at Jatropha plantation (+JW) and no work at Jatropha plantation (-JW).

Group	Total no HH	No. HH with fields visit	Total no fields measured	Average Field size (ha)			Average no. labourers workers	Average hours/week		
				$\bar{x}$	±	std		$\bar{x}$	±	std
+JW	31	16	36	0.11	±	0.1	2.4	12.0	±	7.1
-JW	39	10	65	0.10	±	0.1	2.3	14.7	±	15.9
+L	37	13	52	0.13	±	0.1	2.4	15.2	±	10.5
-L	33	13	49	0.08	±	0.0	2.3	12.1	±	15.5

Thirty one households had at least one member working at the Jatropha. In total there were 37 Jatropha workers in the 31 households. Eighteen workers were women and nineteen were men (Table 23). The field size tends to be smaller if the Jatropha workers are female (Table 23). Since woman work less hours in the farm naturally the field area is reduced.

Table 23- Gender distribution within Jatropha workers and average field area. Six households had man and woman working at Jatropha plantation. Field measurements were made in one of these households. Its fields area was included in the Female group, since the farming activities were carry out by woman.

No HH JW	JW gender[1]	No. Workers	No. HH with field visited	No fields measured	Average field area (ha)			Average no hours/person/week		
					$\bar{x}$	±	std	$\bar{x}$	±	std
31	Female	18	5	16	0.08	±	0.04	9.3	±	6.7
	Male	19	5	20	0.16	±	0.03	14.7	±	7.0

5.2.4.2. Labour at field level

The cropping activities during a year are shown in Chapter 4.2.2.5. Comparing the crop calendar with the hours spend in a particular crop activity it is possible to have an idea of labour allocation to the farming activities during a year (Figure 16). Naturally, at household level the labour peak always depends on the cropping system adopted.

Figure 16 shows the hours spent in farming activities in a field with bambara, sweet potato and pineapple in CSI, in a field with groundnuts in CSII, in a field with cassava, maize and cowpea in CSIII and in a field with maize, groundnuts an cowpea in CS IV during one year. From the 62 fields measured on CSI only for twenty-seven fields it was possible to estimate the labour hours of crop activities such as clearing land, sowing or harvesting (Table 24). However, the data of clearing land, sowing and harvesting mainly refer to bambara since farmers were not able to estimate the hours spent with the other crops. Clearing the land is considered a bambara activity since this is the crop sown after this activity. The hours of clearing land for bambara were over valorised since it also refers to the next three years because no ploughing is made between the following crops. The hours of clear/plough was allocated to other crops as well and divided by three (three years).The same happened for CS III and values were estimated for a rotation of two years.

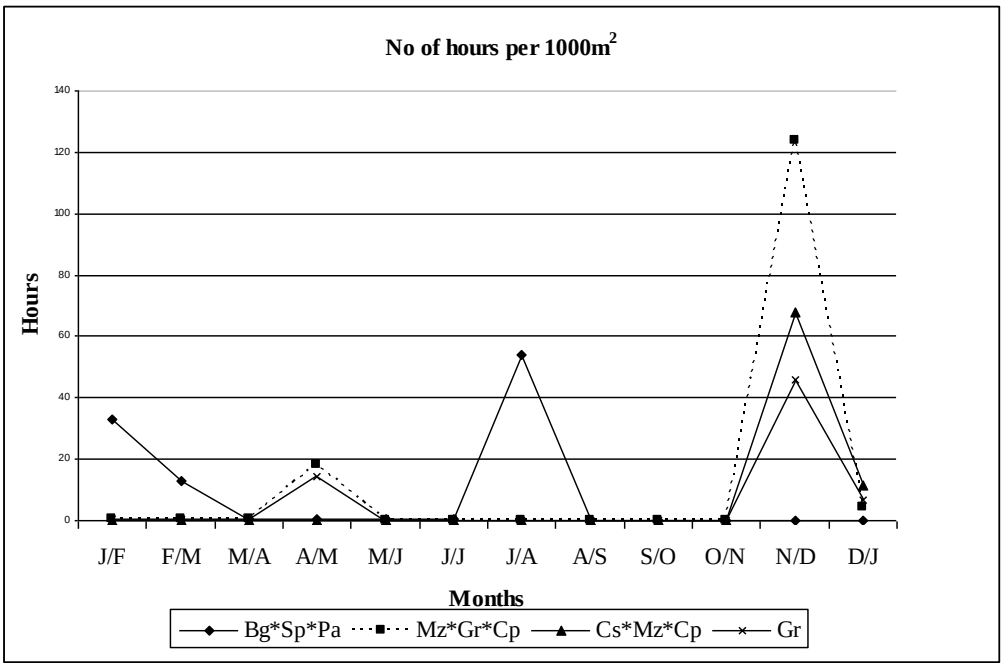

Figure 16- Labour hours per 1000m^2 of four cropping systems: bambara mixed with sweet potato and pineapples (CSI-Ba*Sp*Pa); Groundnuts in monoculture (CSIII-Gr); cassava mixed with maize and cowpea (CSIII-Cs*Mz*Cp) and maize mixed with groundnuts and cowpea (CSIV-MZ*Gr*Cp).

In CS IV labour input is estimated at a field with mixed maize, groundnuts and cowpea (CSIV-Mz*Gr*Cp). The data came from two fields only. The data of groundnuts crop activities (CSIII-Gr) came from four fields and data of CSIII-Cs*Mz*Cp from one field only. The harvesting hours for cassava, maize and cowpea of CSIII (CSIII- Cs*Mz*Cp) is missing since farmers could not tell how many hours they would spend harvesting. For all crops the soil preparation takes longer while the sowing is faster (Table 24).

Table 24- Number of hours per 1000 m^2 spent in crop activities for fields with mixed crops in different cropping systems.

CS	Crops	Total hours ploughing /year/1000m^2	Total hours sowing /year/1000m^2	Total hours harvesting /year/1000m^2
CSI	Bg*Sp*Pa	33.0	12.8	54.1
CS III	Cs*Mz*Cp	68.0	11.3	?
CS III	Gr	46.1	6.5	14.5
CS IV	Mz*Gr*Cp	123.8	4.2	18.2

Unfortunately, the data obtained do not cover all activities for the crops existent in the different cropping system. For instance, in CSI are missing the harvesting and sowing hours of cassava and groundnuts after bambara harvesting (Jul/Aug). For sure, these activities would increase the labour required at farm in July/August. Besides, no information about labour allocation to CSII is included in the graph. The sweet potato planting in January/February and the vegetables sowing in April/May will increase the demand for labour hours in these months. All these hours not included in the graph together with the data obtained, lead to a definition of four peaks of labour through a year. A first peak coincides with the beginning of the rainy season (Oct/Nov) when farmers prepare the soil for groundnuts, maize, cowpea. The second peak, in January, coincides with the clearing land/ 2nd ploughing of bambara and maize and groundnuts sowing. A third peak in April/May is due to maize, cowpea, groundnuts harvesting and vegetables sowing. In Jul/Aug is the harvesting time of bambara and planting of cassava and groundnuts sowing requires high labour.

The days with less labour ("Quiet Days") consisted of activities such as harvesting cassava for the daily meal, visits to the field to check on the crops growing or to do some weeding. The weeding was not considered an important farm activity since farmers could not say how many hours they spend weeding and the only thing they told was that they barely weed. "Quiet days" is the total number of days per year (not counting with 57 Sundays and 9 free days) minus the total number of busy days per years (ploughing, sowing and harvesting days are considered busy days). From Table 20 is known that farmers spend in average 3.9 hours per 0.48ha in farm activities during the busy months. Most probably, during the "Quiet Days" farmers spend fewer hours at farm. The labour hours per day during the quiet days was estimated considering half of the time at farm spend in busy days (1.95h/0.48ha).

5.2.5. Land use for farm activities

Chilengue population had to move their fields from Upland I to Upland II (Chapter 4.1). No soil survey or sampling was made to analyze soil fertility and it is difficult to know soil differences between the old land and new land. However, soil colour was taking into account to have an idea of soil characteristics. The Bottomland had dark soil which reflects high organic matter content. In Upland II the soil colour varied between grey, brown or white. The organic matter content decreased from grey to browner to white.

To understand the dynamic of land use by farmers through the time it was asked the number of fields in different location and was asked for how long farmers were cultivating that land (Table 25 and Figure17). Most of the fields lost by farmers in Upland I was in land cultivated for more than 20 years. In contrast, most of the fields in Upland II had less than five years. The Midland started to be more cultivated in the last fifteen years while the Bottomland had particular demand about fifteen to twenty years ago and, more recently, in the last five years.

Table 25- Number and age of the fields on different location of Chilengue village for the categories: No work at Jatropha (-JW); work at Jatropha (+JW); Lost land (+L) did not lose land (-L).

Group	Upland II				Midland				Bottomland				Upland I [1]			
	<5	5<15	15<20	>20	<5	5<15	15<20	>20	<5	5<15	15<20	>20	<5	5<15	15<20	>20
+JW	18	4	1	2	7	2	2	1	6	1	8	3	0	4	3	8
-W	15	9	1	0	2	6	1	0	4	7	3	2	0	5	2	5
+L	22	6	0	1	2	3	2	1	5	4	3	4	0	9	5	13
-L	11	7	2	1	7	5	1	0	5	4	8	1	0	0	0	0
TOTAL	**33**	**13**	**2**	**2**	**9**	**8**	**3**	**1**	**10**	**8**	**11**	**5**	**0**	**9**	**5**	**13**

1- The location of lost fields was in Upland I. All these fields were lost due to the Jatropha plantation

The use of the land at the different locations during the last years is also reflecting the country's history and the most recent impact of Jatropha plantation. The Civil War finished in 1992 (sixteen years ago). During the Civil War (>20years) people used to have their houses far from the road. They had most of the houses in Upland I (which is the reason for the old age of the fields in this location) and some houses were in Zone B, close to the Bottomland (Figure 4). The end of the Civil War (15<20years) coincides with more fields cultivated at Bottomland. More recently (< 15years) the land in Bottomland, Upland II and Midland have been more cultivated which coincide with the return of war refugees. The coming of the Jatropha plantation may have increased the number of fields in Upland II and Bottomland. However, several people were using the Upland II before Jatropha plantation already (5<15 years) and those farmers said they had to move to Upland II because they did not have space anymore in Upland I.

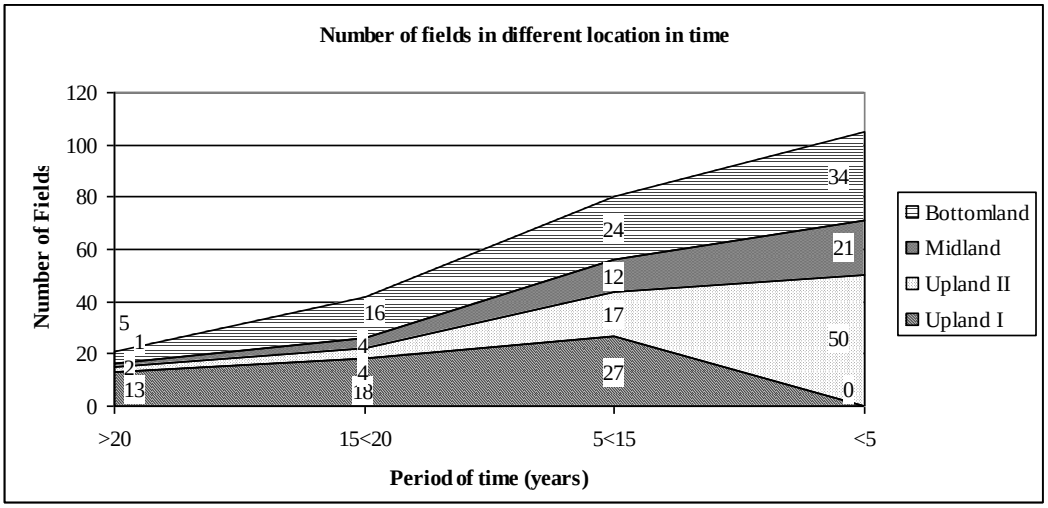

Figure 17- Number of fields in different location during the last twenty years. The number of fields increased in all location, except in Upland I due to Jatropha plantation.

5.2.6. Household cash income

5.2.6.1. Income generating farm activities

On-farm labour includes all the farm activities that bring cash income and food to the household. The main income of the households due to farm activities is the selling of cash crops and other products like charcoal or firewood.

Cash crops

The most important cash crops were Bambara groundnuts and sugar cane but the importance of the cash crop varied between the communities (Table 26). While in Chilengue bambara was the most important cash crop, followed by watermelon and pineapples, in Ngolene these crops were not even considered cash crops. At Ngolene, the most common cash crops were banana and sugar cane.

Table 26- Number of households and type of cash crops sold in the villages

Village	No. of HH	Cash Crops				
		Banana	Sugar Cane	Bambara	Pineapples	Watermelon
Chilengue	27	0	0	18	4	5
Ngolene	16	5	11	0	0	0

Thirty seven percent of the households sell cash crops (Table 27). Those that work at Jatropha (+JW) and those that lost land (+L) have higher percentage of households that sell cash crops. The people that lost land have larger families so perhaps the need of cash is higher for them than for smaller families. They also had in average the largest farm size, which means they may have area enough to feed the family and sell cash crops. The lower percentage of households that sells cash crops in the group that do not work at Jatropha (-JW) could be related with other sources of income (for instance, other formal wage job that assure income enough for the household and the need of sell cash crop is reduced) or they simply had more food production.

Table 27- Number of households that sell cash crops by work and no work at Jatropha (+JW and –JW) and by land lost no land lost to Jatropha plantation (+L and –L).

Group	Total HH	Sell cash crops	
		No. HH	%
+JW	31	15	48.4
-JW	39	11	28.2
+L	37	18	48.6
-L	33	8	24.2
Total	70	26	37.1

Other household activities

Other household activities are all the farm activities that bring money to the family except the cash crops. These activities are mainly the sale of charcoal, firewood, medicinal plants, honey and mats. All these activities use directly or indirectly natural resources. However, “others” also

includes the sale of non-natural products such as not-homemade alcoholic drinks and selling of ornamental plants (Table 28). One family had ornamental plants in vases made with Jambolan trunks to sell near the road. The man was responsible for the shop and benefited from the tourists that want ornamental plants in their holiday house garden. He sells flowers, cactus and palm trees. The palm seeds are collected on the beach. The seeds are taken to Bottomland where "nursery" is established. After three weeks, plants are transferred to the space near the road.

The medicinal plant that people sold near the road was *Hypoxis rooperi* (local name: *batata-africana*) and the roots were used to make an infusion. The honey was also an important natural product which, together with the others, was sold near the road. However, the honey was produced in villages far from the road and Chilengue farmers bought it to sell it near the road. It is important to mention that only in Ngolene people made and sold mats (Table 28). In Ngolene they did not sell charcoal or firewood as in Chilengue. Since Ngolene is further from the road, the trade of these heavy products is difficult. Contrary, the mats are made with soft material (a special grass that grows near the river spring and dried to make mats) and to carry them to Bilene is easier.

Table 28- Number of households and type of product from natural resources sold in both villages

Village	No. HH that sell products from natural resources						
	Charcoal	Fire wood	Honey	Mats	Medicinal plants	Building wood	Others
Chilengue	14	10	7	0	3	2	3
Ngolene	0	0	1	5	0	0	2
Total	14	10	8	5	3	2	5

Table 30 gives the number of activities and their location in Chilengue. The activities refer to making charcoal, collecting firewood and collecting medicinal plants. None of these activities ended because of the Jatropha plantation. The main change was the location of these activities. When people moved their fields from Upland I to Upland II they also moved the other activities there. Figure 18 shows that the number of activities decreases in Upland I. However, few people still use it together with the Upland II and Midland. After Jatropha plantation Upland II and Midland is more explored by the population to collect firewood, make charcoal or collect medicinal plants.

Table 29- Number of households that sell products from natural resources by work and no work at Jatropha (+JW and –JW) and by land lost no land lost to Jatropha plantation (+L and –L).

Group	Total HH	Sell prod natural resources	
		No. HH	%
+JW	31	14	45.2
-JW	39	15	38.5
+L	37	19	51.4
-L	33	10	30.3
Total	70	29	41.4

Table 30- Number of activities (make charcoal, collect firewood and collect medicinal plants) before and after Jatropha plantation and land location in Chilengue village by categories.

Location	-L-JW		+L+JW		-L+JW		+L-JW	
	Before Jatropha	After Jatropha	Before Jatropha	After Jatropha	Before Jatropha	After Jatropha	Before Jatropha	After Jatropha
Upland I	2	0	28	3	3	0	34	3
Upland II+Midland	4	8	2	33	16	19	0	40
Midland+, Upland I+II	5	3	12	6	0	0	11	3
No. of activities	11	11	42	42	19	19	45	46

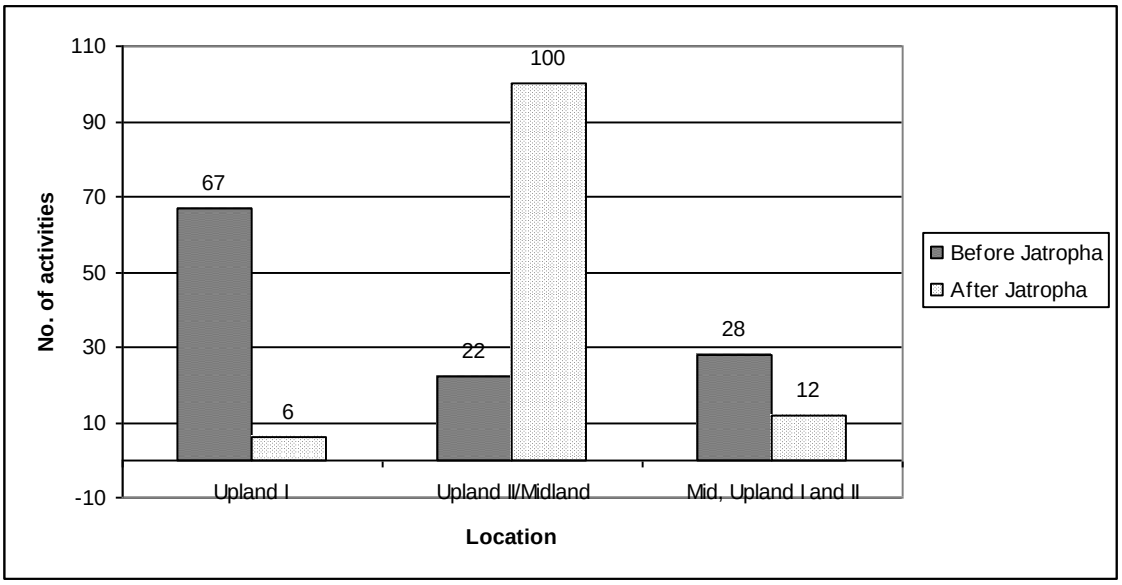

Figure 18- Total number of activities (make charcoal, collect firewood and collect medicinal plants) at different location of Chilengue village.

The Jatropha farm in Chilengue had areas with natural bush and without Jatropha. Some people considered it "forbidden" land to collect firewood or make charcoal but others did not. Some families assume that as soon that land was given to the Biofuels company they cannot go there since it is "private" land. However this mostly depends on the family values. Since there are still trees in Upland I few people can use it for making charcoal or collecting firewood.

5.2.6.2. Income generating off farm activities

The off-farm labour includes household labour not related to farming activities. The main goal of this off-farm labour is to bring cash income to the household. .It was considered a formal wage job (FWJ) if the job, wherever it was, implied a fix salary in the end of the month. Work at Jatropha plantation (+JW) is analyzed separately of formal wage job (Table 31). The emigration of a household member to another country (South Africa) or to a big city (as Maputo) is also an off-farm activity as soon the emigrant worker sent remittances to the household.

The main wage jobs available for people in the communities were the tourism activities, Chissano farm and construction (Table 31). It is important to note that Chissano Farm only employs people from Ngolene (Figure 19). In Ngolene, only one household had a member

working at tourism and seven households had at least one member working at Chissano Farm. Jobs such as Brick Company, Security guard, construction or truck drivers were responsible to employ people from Chilengue only. The tourism activity at Bilene Beach was the biggest employer in Chilengue and Chissano farm the main employer in Ngolene.

Table 31- Main employers of local people besides Jatropha Company in both villages surveyed.

Group	Tourism	Chissano Farm	Build construction	Security Guard	Brick company	Driver	Other
+JW	5	1	2	1	4	1	0
-JW	7	6	3	2	0	3	2
+L	9	0	3	3	4	2	2
-L	3	7	2	0	0	2	0
TOTAL	12	7	5	3	4	4	2

Formal wage job employed mainly men (Table 32). On the other hand, the biofuels company employed women and men equally. In general, there was only one Jatropha worker per household but in six households, both man and woman worked at Jatropha plantation.

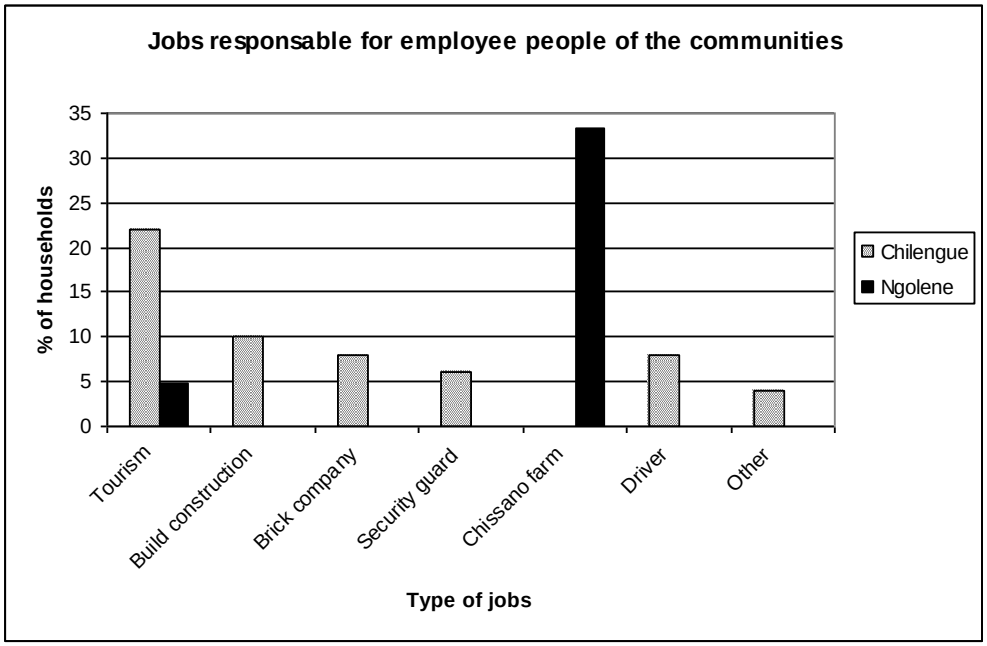

Figure 19- Type of formal wage jobs per village.

Table 32- Gender employed by formal wage jobs (FWJ) and at Jatropha plantation (+JW).

Work	No. of HH	No. of workers	% of female workers	% of male workers
FWJ	37	39	12.8	87.2
+JW	31	37	45.9	54.1

Immigrants sending remittances to the family occurred in 11% of the households (Table 33). More households that did not work at Jatropha (-JW) or that did not lose land (-L) received remittances. More than half of the households (53%) had at least a member with a formal wage job. The percentage of households with formal wage job was higher for those that did not work at Jatropha (-JW) and those that lost land (+L). The need of work at Jatropha plantation is reduced if the households had other formal wage job (59% of the households did not work at Jatropha and had a formal wage job). Still, 45% households have a formal wage job besides work at Jatropha which may reflect the need of more income for these families.

Table 33- Number of households with a formal wage job (FWJ) and with emigrants sending remittances (Remittances)for work/no work at Jatropha group (+JW / –JW) and for no land lost/land lost group (-L/+L).

Group	Total HH	FWJ		Remittances	
		No. HH	%	No. HH	%
+JW	31	14	45,2	1	3,2
-JW	39	23	59,0	7	17,9
+L	37	23	62,2	3	8,1
-L	33	14	42,4	5	15,2
Total	70	37	52,9	8	11,4

Some of the respondents came back to their natal village in the last years. Few of them were in Maputo others were in South Africa during the civil war and few years after it. Some of the returned emigrants were employed in the Jatropha plantation but nobody returned for purpose to be employed at the biofuels company. However, five people that had formal jobs or occasional jobs at the Bilene Beach switched for the biofuels company. All of them said the main reason was the short distance between the house and the work. The answers about salary earning at the Beach and at biofuels company varied. Some workers said the salary is lower at biofuels

company but is compensated by the reduced distance. For others the salary is the same or bit higher at the biofuels company.

5.3. Semi- structured interviews to key informants

5.3.1. Biofuels company

The Jatropha plantation is present in the region since 2007 and occupies about 2000ha. Firstly, a different company managed the Jatropha plantation. In August 2008, the current biofuels company became the responsible for the Jatropha plantation management and continued the work of the first company. The biofuels company has two large Jatropha farms and negotiates to acquire more land. One farm is situated in Chilengue community with about 1000ha, one third of which is natural bush. The other farm is situated in Nzêve community land (neighbourhood village of Chilengue). This farm has 860ha and it is expected to plant 350-400 ha with Jatropha. For economical and environmental reasons the remaining hectares are occupied by natural vegetation. Environmentally it is important to keep untouched areas to preserve the natural biodiversity and to reduce the impact of large Jatropha plantations on the environment (issues related with soil erosion) and wild life conservation. On the other hand, normally the untouched areas coincide with heavy bush and are expensive to clear it. All the clearing process involves tractors and manual work. This manual labour could be used in activities that are more useful for the company at the moment, such as planting more hectares in areas without bush.

In total, the company employs about 310 rural workers from the local communities. The company tries to allocate workers of a particular community to the nearest Jatropha farm. However, and especially in Nzêve, the community is too small to meet all labour required in the Jatropha farm. For that reason the company employs people from communities within 20km around Bilene Beach and has tractors with carts to transport the workers from the house to the farm and vice versa. The workers received monthly 1650 MZN (approximately 44 euros[1]).

[1] 1 euro = 37.14 MZN (www.bloomberg.com, July 6th 2009)

The work at the Jatropha plantation starts at 6am and finishes at 15h, with lunchtime between 12 and 13h, from Monday to Friday. Saturdays the work starts at six until 11am. However, the biofuels company changed the schedule in the lasts months. They opted to have daily goals and after meeting this goals the workers are free to go home. This means that the workers can leave earlier the work or stay there until 15h. According to the farm managers the people prefer this schedule and became more productive. Every day before working, the supervisors or farm managers have a meeting with workers to distribute and define daily tasks.

The plantations have roads every 100m for logistic farm operations, especially for the harvesting period. Since harvesting would be manual, fifty meters length was considered the suitable distance for a picker carrying a basket full of fruits (two workers per row). Since the plantation is not old the commercial harvesting did not start yet. However, they believe within one or two years the older plants have production enough to sell. In the commercial plantation plants were spaced 2 by 3, 2 by 2 or 1.5 by 4 meters. Besides the destinate area to commercial Jatropha plantation, the company has plots with Jatropha trials. In these plots plants were spaced 1.5 by 1.5 or 4 by 4 meters. There are also plots occupied with Castor plant (also an oil plant), which is being carefully observed since this plant is a weed on the region and has a good development under the local conditions.

Figure 20- Landscape of the Jatropha plantation of Nzêve farm.

In Chilengue farm the company has two hectares of a covered nursery to produce their own seedlings. A polyethylene net that reduces the sunlight by 40% covers the nursery. The seeds are sown with a density of 16*16cm in a substrate with a slow release fertilizer. The plants are ready

to be transplanted after eleven weeks. They were preparing a new open-nursery in Nzêve to meet the needs of plant material for the future plantations.

At the time of the interviews, the main farming activities were clearing bush, planting and weeding. The weeding was manual between plants and with a tractor between rows. The company wants to keep grass between rows by cutting the weeds. It is also looking for a proper herbicide to spray between jatropha plants. Depending on the rain, the weeding occurs once to twice a year. The biofuels company was planting 8ha/day using 40 workers (5workers per hectare) and the goal is to finish before the end of the raining season. The cuttings were planted manually and the company were using material from a farm in Sofala and a nursery in Xai-Xai. During the plantation, a hole with 15-20 cm deep was made and the unprotected cutting was planted without any fertilizer. The recently cutting planted is watering with about 5L of water using a water cistern coupled to a tractor. To promote the plants establishment the company used 300kg/ha of a fertilizer 2:3:2 (N:P:K) with N= 6.3% and with 0.5%Zn. After the well establishment of plants, the next concern is the pruning. The jatropha plantation had problems with two plagues: leave mines and golden flea beetles. The golden flea beetles affected more the Chilengue farm and the young plants at the nursery. They used an airplane to spread a pesticide over the plantation and young plants were periodically sprayed. In Nzêve farm the plants were attacked by leaves mines and had yellow leaves but after few weeks of rain they quickly developed new branches (occurred sort of “natural pruning”). In general, the plants of Nzêve farm were growing better than in Chilengue. According to the farm manager of Nzêve, the main reason is that land in Nzêve did not have so many fields of local people as Chilengue had. He said that soil in Nzêve seemed a bit darker (with more organic matter) than in Chilengue.

Figure 21- Clearing land, planting and weeding in Jatropha plantation.

All the activities are planned to be manual in the first years. However, according to a farm manager the need of labour will decrease in the future. For the maintenance activities (pruning and weeding) he said theoretically they need 1 worker /ha. If they increase the mechanization, this could be reduced to 0.3 people/ha. Still, the labour requirement for harvesting was not well known. However, the company expects high labour requirement and the need of three work shifts per day. The farm managers themselves admitted that a lot of research, knowledge and technology are needed to know Jatropha better and manage it properly. Also the workers knowledge about Jatropha and farming is an issue that the company wants to give attention later. According to a farm manager, some workshops are planned in the future to teach workers how to pruning, harvesting and so on. The company also intends to pay driver lessons to the tractor drivers that do not have it

5.3.2. Agricultural Extension Services

The Responsible of the Agricultural Extension Services (AES) was contacted in order to understand better the smallholder farmers' constraints. According to him at Bilene-Macia district there are six extension service offices in different Administrative Posts: Macia, Chisane, Messane, Macuane and Maselina. The Administrative Post of Bilene Beach does not have an extension service office and consequently the people from the surveyed villages do not have technical assistance.

According to AES, the agriculture in Chilengue is poor due to strong maritime influence. The presence of the Beach has consequences for agriculture at two levels: on the soil and climatic conditions and on the allocation of labour from small farms to the tourism activity. The soil characteristics (salty, according to the Extension technician) do not allow high maize yields but he observed that Administrative Post of Bilene Beach is the one that produces most Bambara groundnuts in the district. About Bambara groundnuts he explained a confusion with the name of this crop on the community. The population has a Portuguese name for this crop: "*gergeli*". However few people called it "feijão-jugo" (the correct Portuguese name for bambara groundnuts). The Technician did not know why the population called bambara as "*gergeli*" because this is another crop (*Sesamum* sp) that grows in the north of the country and not in the south. It will remain unknown why people switch the name of bambara but was clearly a lack of agricultural information most probably due to the absence of extension services in the

communities. AES said Chilengue is not a place with representative livestock and referred to the fact that the ex-president of Mozambique had cattle in Bilene. However, the animals started dying and he moved them to another place. He agreed it could be because of the soil and grass quality, but there were no studies. He explained that "*muzungo*" is the Newcastle Disease. In the Administrative Posts where there is technical assistance they have a vaccination schedule to avoid the disease. They vaccinate the chicken 3 times per year (March, June and November). He explained that Newcastle disease is a virus and there are no treatments, only preventive medicine. He was surprised that people of Chilengue give garlic or soap to save the chicken.

5.3.3. Veterinary Services

According to the veterinary technician the chicken breeds used by population are local breeds: "the white chickens are called *Landim* and the brown chickens with curl hair are called *Chitalo*. About the New Castle disease the veterinary technician did not understand why people did not ask in Macia for preventive drops to put in the chickens eyes. According to her "the vaccination is for free and when the vaccination campaign starts the new is spread by radio". She even said they distribute flyers in Administrative Post of Bilene Macia so that people can read how to prevent the disease. For her, if they do not know it is because they do not search for the problem solution. Other common diseases that affect the chicken in the region are the chicken pox and avian salmonellosis.

The most common cattle breed in the district (and the cattle breeds that were present in Chissano farm before moving them) were *Africand*, *Brahman* and *Landim*. *Africand* and *Brahman* are cattle imported from SA, Swaziland and Botswana. *Landim* is not a real breed but a Mozambican name given to animals without specific breed but which are considered from Mozambique. Again, the Veterinary Technician said the main cause of cattle death was the pasture quality "if you try to eat the grass you can even taste the salt" and "the entire breed are sensitive and get the same symptoms". The common diseases in the cattle present in Chókwè (the zone of Bilene-Macia District with high presence of cattle) are bloat, toxoplasmosis and rickettsiosis.

5.3.4. Chissano Farm Manager

The current Chissano Farm Responsible started to work at the farm three years ago. According to him the farm is present in Ngolene since 1992. The main activity was cattle breeding and animal food production and processing. The farm is divided in six blocks and they are also present in other communities. The total area is about 2500ha. Nowadays the farm only produces and processes animal food since the cattle and goats start dying: "...we used to have cattle in the beginning of the farm project. However after a year the animals decreased in weight and were in bad conditions. We had to move them to Mananga, another place. Within two weeks the animals showed large improvements in their body weight. Also the goats started to show weight lost and started dying. Now they are being moved also. There is something in the pasture that affects the animals development. It is also evident because wild life is not present in this place". The Responsible did not know whether soil were studied because he was not working in the farm since the beginning. One worker of Chissano farm said that when the grass was tall it started to develop some nodules that had bugs inside. He was the only person that referred to parasitism as the main cause of animal's death.

5.4. Observations

5.4.1. Farm labour, household activities and cultural issues

When farmers said they do farming everyday between 6 to 10-11am this is not the actual time on farming activities. In fact, this is the time they are out of home but doing other activities instead of farming activities only. The effective time of work on the field is perhaps about 3 hours. The plots in Upland II are far from home and they could take about 30 to 50 minutes to arrive there. On the way back they collect wood, fruits or medicinal plants. Before or after coming from the field they take a bath at the river spring, take water or wash clothes. The hygiene or carrying the water could also be made at the end of the day, on the less hot hours. All these activities take place during the mentioned period, from 6 to 11am. Besides, not all the people had a watch or mobile phone that allowed them to know exactly what time they leave and return home. This fact often constraint the field research too.

During the visits to the fields it was noticed that some plots were being cultivated by young girls (10 to 12 years old). One mother said children need to start farming early to know more about it and to assure land for them. However, if it was asked directly if the children help at the farm they were reluctance to answer. They replied that children do not help on farm activities or because they were too young or because they study at school. Still, it was evident that children participate in carrying water, cleaning the space around the house, taking care of the youngest kids or, as above mentioned, farming the fields. The girls of twelve year are old enough to plough and sow and the youngest may be responsible for burning weeds. A farmer also refers to the participation of children to scare monkeys and birds to protect the crops. When children go to school they may help during the free hours (at morning or at the afternoon, depending of school schedule) or during the holidays. The summer holidays at public schools are from December to the end of January, which coincides with a busy time at the farm, and it is why children participation was observed. The babies go with their mothers to the field and while she is farming they lay under tree's shadow. The same happens with female workers in jatropha plantation. They are allowed to take the babies to breastfeed them but babies had to wait under the trees. The baby stays at home when it has a person responsible for him (this person could be an older sister of 4years old).

Figure 22- Children taking water from the river spring

When a person of the community dies, nobody goes to the fields during the next three days. They can go there just to harvest food for the daily meal. However, ploughing or sowing is not allowed. During the field research at least four known deaths happened in the community. This means that at least during twelve days people did not farm or plough land for bambara. This cultural aspect affects the farming activities and could even affect the crop yields. If the sowing time is postponed and occurs in a less proper time the crop development may be affected as well as the production. In fact, during interviews people said bambara sowing was in February mainly. However, a lot of people were sowing it in March and perhaps it was due to the high mortality at community that lead to postponing this activity. Also several field measurements were affected by this cultural aspect.

In Chilengue, products such as charcoal, wood, honey, pineapples, watermelon or medicinal plants, used to be exposed near the road. When a client stopped near the products any member of the family quickly appeared to attend to the client, including the children. Bambara is bought at farms' door and buyers come from Macia, Xai Xai and Maputo. According to the Secretary of neighbourhood 1, Bambara demand increased since the eighties and from that moment people started to produce it not only for own consumption but also for the market. The road presence in Chilengue allowed the easy products trade and the transport to urban markets, especially Macia. However, it was a constant risk for the children that play and walk to the school. As consequence, cases of running over often occurred.

Figure 23- Honey and medicinal plants ("*Batata-africana*") to sell near the road.

During the field research, the role of the woman in the community was noted. Normally the woman was responsible for the farm and domestic activities (such as taking water, cooking or washing cloths). If the man had a job he was not at home and when he was, usually he was seated or drinking alcohol while the woman did the domestic activities. However, in Ngolene village men were observed working at the farm, especially in fields near the river spring. In these fields they had sugar cane from which they make alcoholic drinks. It seemed that the man was responsible for the production chain of alcoholic drinks. However, it was not observed the same

with the amarula juice. In Chilengue, the old women or wives were responsible for collecting and squeezing the fruits. Then the juice was fermented and after a while, the strong alcoholic drink was ready. During the whole year several wild fruits (for instance, jambolan plum and mafura) provide products for alcoholic drinks. This "alcohol culture" often affects the work at the Jatropha Company as a Jatropha plantation supervisor said. The decrease of labour productivity due to alcohol can be true for the biofuels company, as for other type of jobs and for farming activities. It even affected some of the interviews.

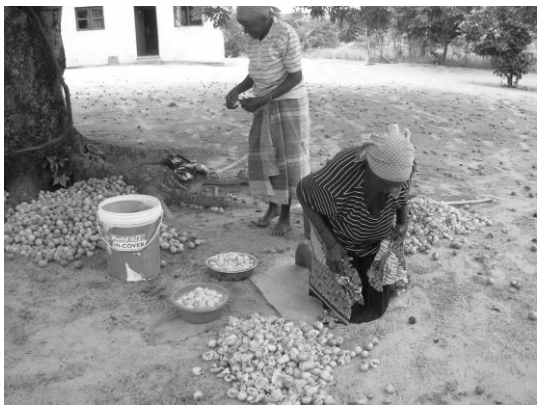

Figure 24- Old women preparing Amarula's juice in Chilengue village.

Amarula drink had a special importance in Chilengue. The community organizes a big meeting every year in January where the whole population is present and the party goes on until late night (or until the drink is finished, which can mean weeks). Amarula's drink is the main reason of this meeting but this year it was also a social event for the community and the biofuels company. People from neighbouring villages that were also engaged with the biofuels company (especially Nzêve) were also invited. A big party was prepared, speeches were made and the biofuels company offered a cow. The meeting was a precious event to provide meat for the whole population since they have a lack of it.

Three households had Jatropha plants in their garden. A man had the plant before the Jatropha plantation and got it from a friend's garden in Bilene Beach. He liked the tree and asked for seeds to sow it in his garden. Later, with the arrived of the company he knew that the plant could be use for biodiesel production. Two women also had Jatropha around the house. They use the juice to treat throat ache, stomachache and wounds. One of the women learned about the medicinal use of Jatropha during the years she lived in Maputo. She said that in Maputo there are a lot of *Galamaluco* (local name for Jatropha). They were not concerned with the toxicity of the

plant and they even said that some people ate the seeds. The only consequence of eating the seeds is "become very happy and crazy". The name *Galamaluco* may have derived from the word *maluco* (= crazy*)* in Portuguese. There were two local opinions for the origin of this name. One opinion is that if a heavy jatropha fruit falls on your head you become crazy (*maluco*). Another opinion is related with the hallucinogenic effect of eating the seeds (people become "happy and crazy"). Nobody knew about the potential of Jatropha to make soap but they were quite interested to know how to do it.

Figure 25- Speech of the chief of Chilengue during the Amarula's party. Behind him were members of Chilengue and members of the biofuels company.

5.4.2. Social relations between local communities and the Biofuels company

The biofuels company tried to promote social events to create good relationships with the community since the beginning of the project. The Amarula party was one social event in which the company took part. In Ngolene where Jatropha is not present yet, they had already a meeting between population and the biofuels company. Ngolene people look forward for the biofuels company presence. People believed it will bring benefits to them starting by job creation but also road access, an eventual school and even electricity.

Chilengue benefited of some wells since the presence of Jatropha plantation. Still, it was common to hear that the biofuel company did not accomplish the promises made. For instance, people expected new water holes, the building of a brick school, maternity or even ambulances to transport injured people to Bilene or Macia hospital. However, the biofuel company explained

they did not promise all these things and few of them were made such as opening water wells or ploughing land for those that lost land. In fact, the Jatropha Company said they ploughed land for farmers in the southeast part of the community, nearby Jatropha plantation. However, no farmer went to farm there and when farmers were questioned about it they did not know about any ploughed land. It seemed there was a lack of communication between the company and the population. Another example is with the brick school building. In Chilengue a brick primary school was being built and near it a water hole was opened but it was not working yet. Some villagers thought the builder responsible was the biofuel company, others said people from the village build it. People benefit from rides given by farm managers to Jatropha farms or to Bilene Beach, saving them one-hour walk. Cases of Jatropha workers taking water from company water deposits was observed, which means people did not need to go down to the river spring to take water.

Figure 256- New primary school in Chilengue. The primary school was in construction still.

In general, people's opinion about the Jatropha plantation varied in the population. By the time of field research, Jatropha workers were fighting for high salaries and holiday's definition so the atmosphere was tense and the dissatisfaction general. The farmers that lost land complained about the distance of new fields and about crops lost. Not all people lost crops and it mainly depended on their fields' location in Upland I. If the fields were near the place from where the biofuels company started the operations, the owners of those fields lost them first than farmers with fields further from that place. Some farmers as soon they know the company was taking the land they start farming in Upland II. However, some of them decided to continue farming in

Upland I and when the Jatropha plantation started they lost their fields and crops. The biggest complaint was on the pineapples lost. Nobody lost bambara because they had time to harvest it. However pineapple takes about one year so it was left on the field when people had to move for new land. Farmers with fields far from the plantation had time to harvest cassava and groundnuts. According to some farmers, the crops grew better in the land lost but others had a contrary opinion. No conclusion about soil characteristics and soil fertility can be made since no soil sample and analysis was carried out on the new land occupied by farmers neither in the old land. So, it is impossible to determine if the new land has poorer or richer soil than the land occupied by the private biofuels company. Information about the time that the land in Upland I was being cultivated by small farmers and Nzêve's farm manager opinion about soil characteristic gives the idea that the new land of small farmers is better. Firstly, this land only recently is being used by farmers which mean that soil naturally has more organic matter since it was never cultivated before. Besides it the new land is near Nzêve farm. Then, the "darker soil" observed by Nzêve's farm manager can also been extended to new land farming by small farmers.

As said in Chapter 4.2.2 in general nobody stopped a particular cropping system due to Jatropha plantation and the female workers of Jatropha mainly reduced their time in farming activities. Still, interesting cases were noticed. Two women that worked at Jatropha had maternity leave during January and February so they had time to clearing land and sowing bambara. Then, they did not finish doing this particular cropping system (CS I). However, the situation may be different the next year and can be equal to other two cases observed. According to two Jatropha women workers, they did not have too much time for the farm. One woman did not sow bambara this year and the other would sow it later. Both women will buy bambara from the neighbours. One woman said she hired labour for helping her at the farm but another said the salary she earned was not enough to hire labour. In spite of complaint about less time spent in the farm or less time to rest, both said that work at the biofuels company was good because the money they earned allow them to buy more food (especially rice) since the farm production is not always enough and constant. It is important to note that the husband of these two women also worked at the Jatropha plantation.

During the field research two women of a surveyed household initially without any member working at the Jatropha plantation started working there and many more were waiting for an answer to get a job there. Some Jatropha workers quit due to fights for better conditions (salary, holidays or because the work was hard in the hottest hours) but others wanted to work there.

People in the waiting list mostly could not get the job due to official papers needed (for instance, valid identity card) or because the workers selection (for especial the women) was not always made in a transparent way by a local worker. In spite of complaints, several people were happy with the coming of the Biofuel Company. Since the company is there, the community has "more life" because now the families have more activities besides to go every day to the farm. One person believed that a presence of a company in addition to employing people also attracts other companies to invest in the village: "especially now that the village has electricity [which is a government project] it seems that it is following the right path for development". The Brick Company started its activity in Chilengue since 2007 also.

Figure 26- Football game in Nzêve village during a meeting between the community and the biofuels company.

Chilengue seems to be a village in quick transformations since the past years, which is mainly related with its privileged location near Bilene Beach and road proximity. For its turn, Ngolene is far from everywhere and the access to it is difficult. If it was not the presence of Chissano farm or the interest by the biofuels company in its land, Ngolene most probably would be completely forgotten in the coming years. For those that worked at Chissano it was easy (but not cheap, according to the workers) to buy food in the small market the farm had for its workers. However, the cheapest and closest market for Ngolene population was in Bilene Beach which could be reached after four hours walk through the bush. Nzêve (where is located one farm of the biofuels company) was not part of this study but the village was visited during a social meeting of the community and the biofuels company. The time spent there and through conversation with the villagers seemed clear the importance that the company has for people's

mobility. People can now easily go to Bilene Beach in rides given by farm managers or in the tractors of the company. They were also happy with the balls and t-shirts given by the company for their football games.

6. Discussion

The main goal of this study was to identify the changes in farming systems due to establishment of a Jatropha plantation for biodiesel production. To understand and characterize the main changes it was intended to compare the situation before with the situation after establishment of the Jatropha plantation. Unfortunately, the village selected to be represent the situation "before Jatropha plantation" (Ngolene) did not fulfil the definition of a village unaffected by the biofuel company, as became clear during the field research. For instance, some villagers worked already at the biofuel company and part of their land was not being used because a year ago it was allocated to the Jatropha company. In addition, the villages showed differences in community size, family size, access and infrastructures that naturally influences the existent farming system. The cropping systems identified in both villages were similar but cash crops and types of formal wage job differed. So, answering the research question how farming systems were before Jatropha plantation is limited to informal data given by respondents three years after establishment of the Jatropha plantation. The analysis shows no changes in cropping system due to the plantation (for instance, farmers did not stop to grow a particular crop or any person finished the familiar farming). However, the households that did not lose land and did not have at least one family member working at Jatropha plantation (-L-JW) showed different trends (smaller families owning several cropping systems and the majority had a member employed in a formal wage job) in comparison with other categories. These characteristics together constitute a survival strategy for these families, which is also reported by INIA (1994). The family size, members age, members tasks, and psychological, physical and sexual issues change over the time through seven stages of the family life-cycle (Neighbour,1985): (1) pairing/marriage, (2) childbearing, (3) school-age children, (4) family with adolescent children, (5) family as a "launching ground", (6) middle years and (7) old age. Household's organization must be examined in time perspective in order to understand how households reorganize as members' age and their status changes in culturally prescribed ways during their life cycle and how it adapts to social, cultural, historical and political components that change over the time (Jelin, 1990). However, this study takes a static view of the household since the reality is what was reported at the moment of the survey. This fact, together with the complex character of household organization and its dynamic, become delicate to draw conclusion about different trends between categories.

The life cycle is a socially structured pattern of shifts over time and significant transitions qualitatively alter the life condition of the individual and the distribution of power and tasks in the household (Jelin, 1990). In this study, land used by small farmers and farm labour have changed or may potentially change due to the Jatropha plantation. The gender tasks described by Van Leeuwen (1987), INIA (1996) or MAP (1996) (see Chapter 1.3.3) were reported in this study as well. Traditionally the woman is responsible for farming and domestic activities while the man has a formal wage job. However, the panoramic would have changed for the women from the surrounded villages of Bilene Beach with the coming of the biofuels company. The biofuels company employs men and women as well. The men that had a job at Bilene Beach have now opportunities to work at biofuels company which is close their house. With the employment of women at the biofuel company the labour allocation to the farm is affected. The woman remains responsible for farm and household activities even with her job at the Jatropha plantation. Therefore, the time spent on farming activities is reduced and these female farmers had in average a smaller field size than female farmers that do not work at Jatropha plantation. However, further economic studies are needed to know if the salary earned in the biofuels company compensates the decreasing of land cultivated. Perhaps the salary allows the buying of food products traditionally consumed in the households (cassava or maize) or even allows buying different food products (for instance, rice).

The cropping systems identified in Chilengue and Ngolene were similar to the ones described by MAP (1996). The CS I and CSIII (in the upland and midland, respectively) were similar to the system “Mixed cereal/cassava/pulse and cashew” while CSII, in bottomland, was similar to the “Peat soil subsystem” (see Chapter 1.4). Generally, the households had multiple cropping systems and CSI and CSII were the most relevant systems. The importance of a cropping system seems to be related to the cash crops. Bambara is produced in Upland and the demand for this crop by external buyers is high according to the respondents. Van Leeuwen (1987) referred in his study that Bambara had disappeared in the surveyed study area (Maputo, Marracuene and Manhiça) but farmers would like to sow it again if they had seeds. In his study, he refers to Ponta de Malongane, Zavala district and communities around Bilene Beach as the only places where bambara in the south of Mozambique is still grown. He also referred the name “*gergelim*” given by population to this crop and some of the taboos around it (for instance, one of the taboos postulate that Bambara has to be grown in monoculture and it is “forbidden” to sow it before

November). Bambara seems to be a mystic crop which importance should be kept especially if its production in Mozambique is low and demand is high.

An interesting issue about land constraints may arise in Chilengue community, which is between two Jatropha farms. For cropping system I used in Upland, new fields are cleared every year to grow bambara. If this type of farming continues, there will be not enough land in the future for smallholders farmers to include the required fallow areas, since they use land between two Jatropha farms. This fact would oblige farmers to reduce fallow period, would affect soil fertility and in a worse scenario the ending of bambara groundnut in the communities. Van Leeuwen (1987) reported fallow periods in upland between two to ten years in south Mozambican farming systems. According to the same author, the fallow period varies depending on land availability for farmers and the minimum fallow that should be kept in zones with these poor soil characteristics are twenty years. It is difficult to determine within how many years the land would become scarce because it depends on number of farmers and field size cleared every year. If more women work at Jatropha plantation influence of these two aspects may decrease and sufficient land may available for longer time. Proper crop management and the use of fertilizers may allow the reduction of the required number of fallow years, which will reduces pressure on land. It seems urgent to change the soil management of small farmers with the introduction of new techniques and the use of fertilizers. It is important to develop agro - economic studies and to promote close contact between agricultural extension services and small farmers in order to find out which solution is financially credible for them in the local conditions.

According to Sitoe (2005) Gaza, Inhambane and Maputo provinces have the highest cattle concentration of Mozambique. In Bilene-Macia district livestock numbers increased from 11 000 animals in 2000 to 19 000 animals in 2004 (Perfis Distritais, 2005). However, no cattle were present in the surveyed villages. All the people interviewed said that the local conditions, especially the pasture quality, did not allow a good growth of cattle. This contradicts Perfis Distritais (2005) which reported good conditions for livestock production due to “good pastures and water sources”. However, the same report considers that livestock production is constraint by diseases, lack of monetary funds and limited extension services. No reference is made to high salt content in the pasture that may cause cattle mortality. Communication between extension services and veterinary assistance would induce proper livestock and crop management and a possible development of a sustainable mixed crop-livestock system. The surveyed villages were located about 6 kilometres from Bilene Beach. However the “Bilene system” described by MAP

(1996) is not present there. “Bilene System” is based on alluvial rich soils where crop production and cattle raising are intimately integrated. This system is typical from Chókwè The name Bilene is derived from *Bila*, which in local language means plains (large space without trees, which in fact is the landscape of the surveyed villages). However, no report or information about raising cattle in Bilene was found apart from Chissano farm. Still, in Chissano farm cattle breeding stopped since animals did not grow well and died after few months.

7. Conclusion

The Jatropha plantation affected the surrounded villages and traditional smallholder farming system since the beginning of its presence. Smallholder farmers of Chilengue lost their fields to the Jatropha plantation without compensation and had to move further away for new land. All other farming activities such as making charcoal or collecting firewood moved to another land as well. The consequences of the establishment of the Jatropha plantation raised a discussion in the community that was still going on during the time of the survey. Nevertheless, within the population, the opinion about the biofuel company differs and some villagers have a positive view about the presence of the company in the community. The presence of the two large Jatropha farms may cause changes in traditional cropping system, especially in upland since land availability for the smallholder farmers will be reduced. It can be expected that farmers have to reduce fallow periods, which can decrease crop yield and soil fertility, if soil management remains similar and no inputs are used. Unlike in other formal wage jobs, the biofuels company employs men and women equally. As the woman is the primary responsible for the farming activities, the time spent on farming activities decreases and leads to smaller field size if she starts working at the Jatropha plantation. Further research could clear the advantages and disadvantages in a household where the woman had reduced her farm activities but on the other hand receives a constant salary every month. The families depend on small-scale agriculture and own food production as well as on job opportunities. In spite of poor sandy soils, it is important to consider that the local population relies on agricultural activities and food production in the same area where the biofuels company is operating. The people in favour of the expansion of Jatropha plantation have to be conscious of the importance of small-scale agriculture as well of its social impact in the traditional role of each family member in a household. In this study, it was not a goal to analyse the environmental impact of the Jatropha plantation in the surrounded area. Still, the occurrence of pests or plagues in the Jatropha plantation may bring new difficulties to the local agriculture and affect the natural biodiversity, one of the biggest global concerns.

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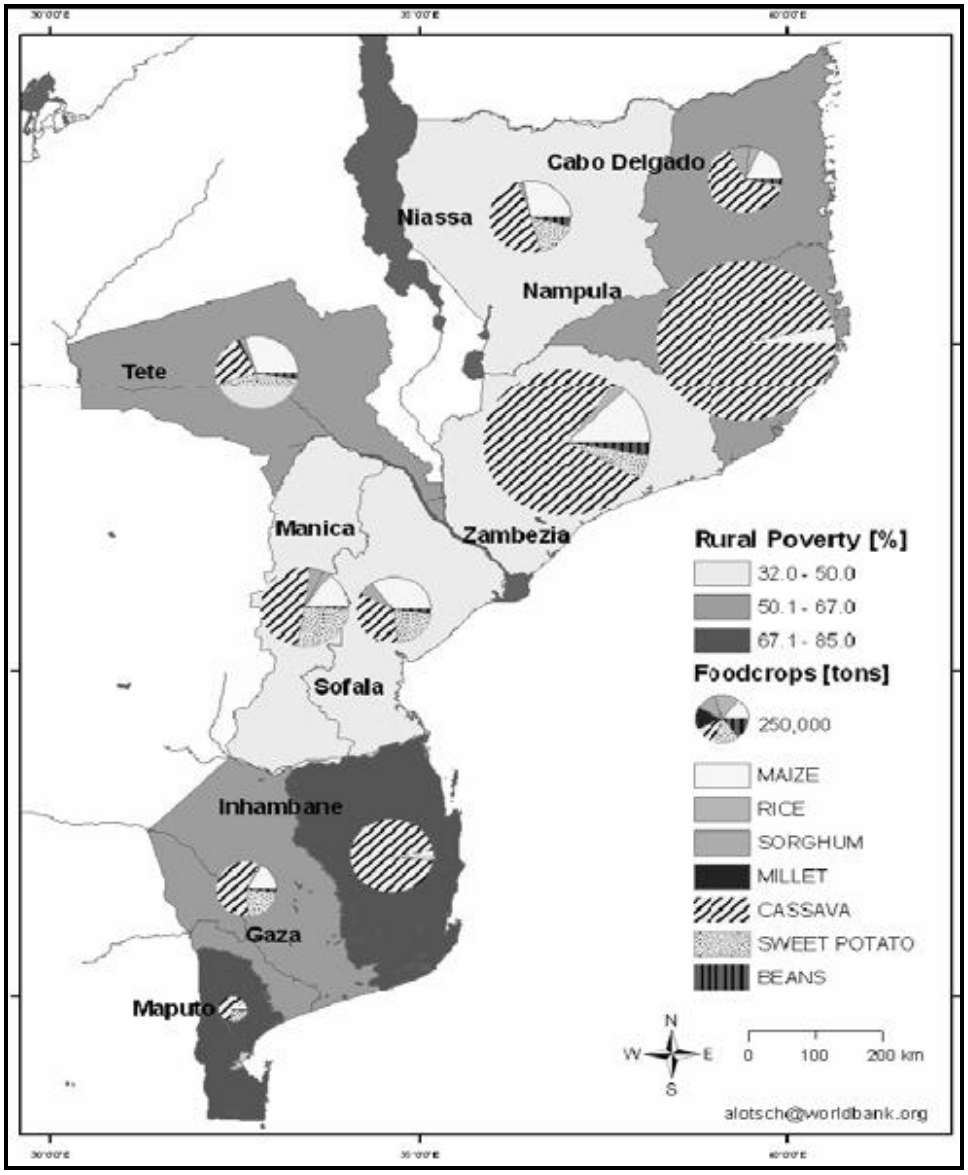
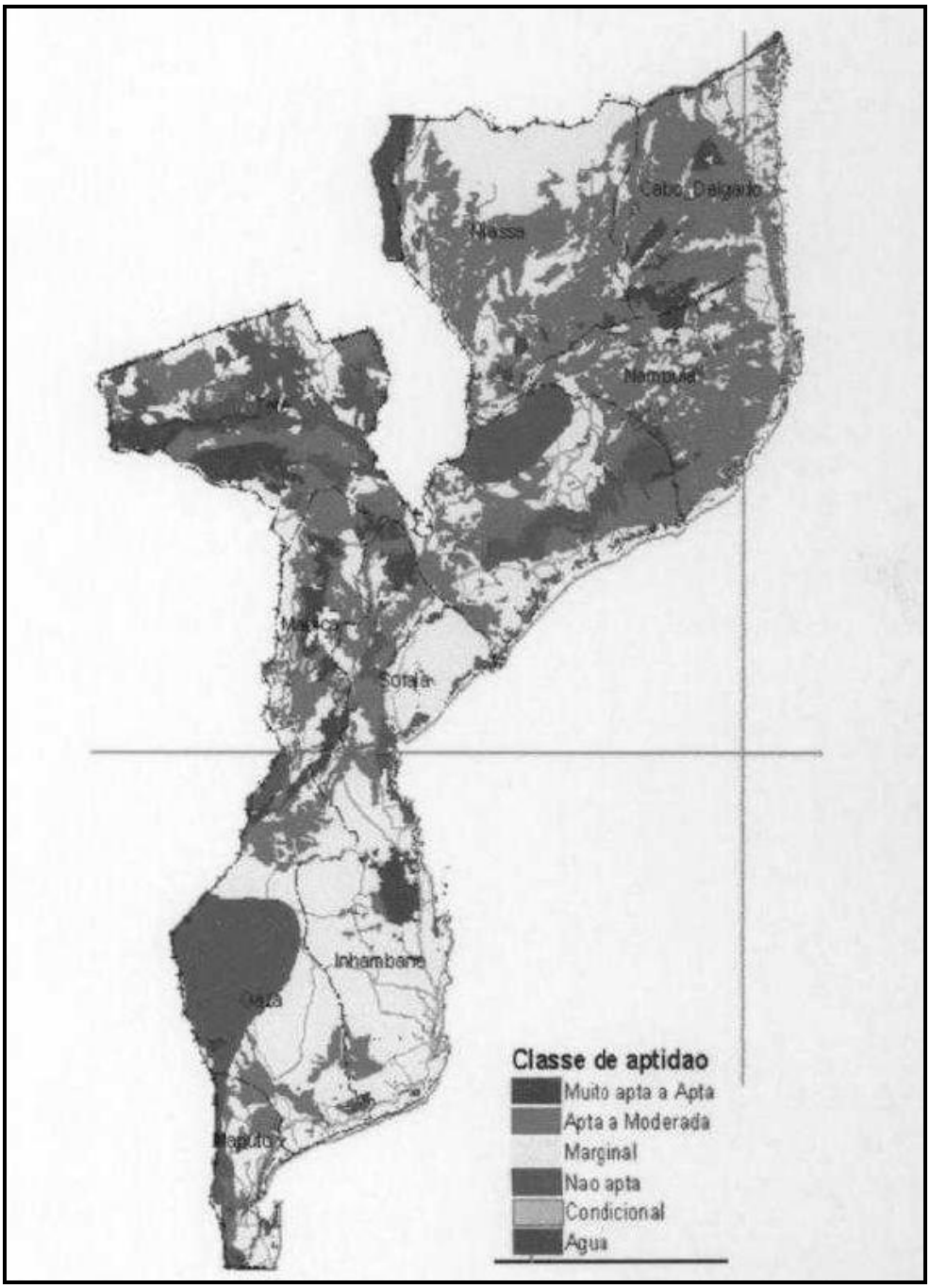
9. Appendices

9.1. Agro-ecological characteristics of Mozambique

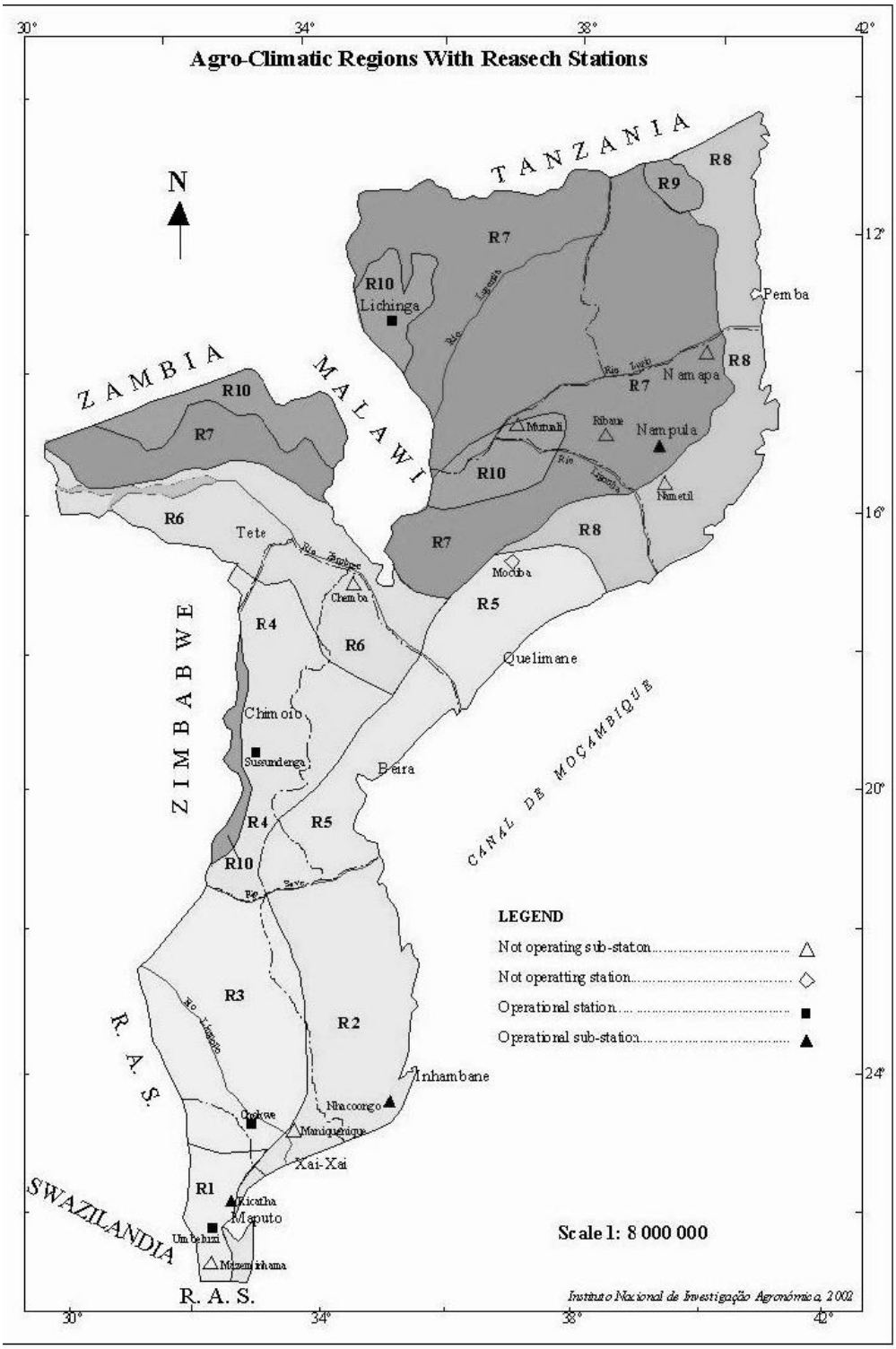


Appendix 9.1-a- Main food crops and rural poverty in Mozambique. *Source:*

www.fao.org/fileadmin/templates/tc/tce/pdf/Mozambique_factsheet.pdf



Appendix 9.1-b- Map of agrarian zoning of Mozambique (IIAM, 2007)



Appendix 9.1-c- Agro-ecological Zones in Mozambique. MAP, 1996.

Appendix 9.1-d - Soil characteristics of "Administrative Post of Bilene Beach"

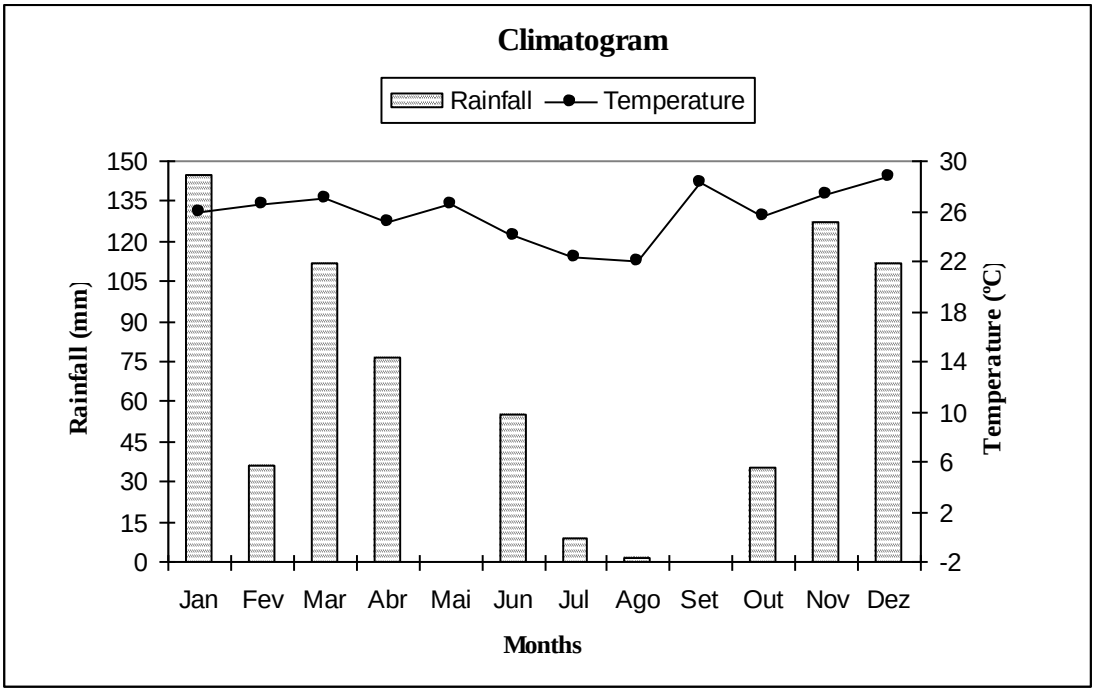
Soil type and characteristics of "Posto Administrativo de Bilene"

Soil Code	Soil group	Dominant characteristics of the soil	Geology and geomorphology	Shape	Topography Slope (%)	Superficial Soil texture and subsoil [1]	Depth (cm)	Drainage	OM of topsoil (%)
DC	Soil of coastal dunes	Sandy soil, brown or gray, deep soils	Coastal dunes holocenic sand	Coastal dunes	Very sloping 0-35	Ar / Ar	Generally >180	Excessive	Low 0.2-1
AJ	Orange sandy soil	Sany soil, orange; very deep soils	Sandy coverage, windy sand, pleistocenic	Sandy plains	Flat 0-2	Ar / ArF	>180	Good and excessive	Low to moderate 0.5 to 2
dAJ	Orange sandy soil, lunar phase	Sandy soil, orange; very deep soils	Sandy coverage, windy sand, pleistocenic	Inland dunes	Sloping > 2	Ar / ArF	>180	Good and excessive	Low to moderate 0.5 to 2
Soil Code	**Acidity and alkalinity of topsoil (pH H_2O)**	**Acidity and alkalinity of subsoil (pH H_2O)**	**Salinity of the topsoil (CEM: mS/cm)**	**Salinity of the subsoil (CEM: mS/cm)**	**Sodicity of the topsoil (PST (%))**	**Sodicity of the subsoil (PST (%))**	**Dominant classification (FAO/USDA 1992)**	**Vegetation type**	**Main constraints to agriculture**
DC	Moderately Acid 5-6;	Moderately Acid to strongly alcalin 5-9.5	Not salted 0.1	not salted 0.1	No sodic 1-5;	No sodic to slightly sodic 1-15	Haplic Arenosols/ Ustic Quatrzi.psaments	Heavy bush	Water Retention capacity and fertility
AJ	Moderately to slightly Acid 5-6.5;	Moderately to slightly Acid 5-6.5	Not salted 0.1	not salted 0.1	No sodic 0-1;	No sodic 0-2	Ferralic Arenossois / Ustoxic Quartzi-psamments	Remains of primary foresty and savannah	Water Retention capacity and fertility
dAJ	Moderately to slightly Acid 5-6.5;	Moderately to slightly Acid 5-6.5	Not salted 0.1	not salted 0.1	No sodic 0-1;	No sodic 0-2	Ferralic Arenossois / Ustoxic Quartzi-psamments	Remains of primary foresty and savannah	Water Retention capacity and fertility
Soil Code	**Classification of soil capability (t/SDA) [2]**	**Classification of irrigation potential [3]**							
DC	VII fs (IV+VII+VIII)fs	V – VI sdt							
AJ	IV fs	IV sd							
dAJ	IV fs (VII)tfs	V sdt							

1) Ar = sandy, ArF = loam-sandy
2) IV = Marginal aptitude; VII = Forestry, s = Fertility, t = Topograhy, d = Drainage
3) V = Not recommended but potentially capable ; IV = Special use (spraying watering, rice); VI = Not recommended

Appendix 9.1-e- Climatic data of 2006 and 2007 from the meteorological station of Bilene Beach.

Months	Rainfall (mm)		Average monthly temperature (°C)		Relative Humidity (%)	
	2006	2007	2006	2007	2006	2007
Jan	164.8	125.4	25.9	26	56	57
Fev	17.1	55	26.7	26.5	66	68
Mar	121.1	102.4	27.1	27.0	83	94
Abr	38.9	114.1	25.1	25.2	86	87
Mai	0	0	24.2	28.8	69	63
Jun	77.9	32.4	24.8	23.3	83	69
Jul	0	18.1	21.3	23.3	77	84
Ago	0	3.6	24.4	19.5	79	81
Set	0	0	27.6	29.0	75	73
Out	28.4	42	27.7	23.5	72	72
Nov	128.9	125	27.2	27.5	73	88
Dez	116.4	106.9	28.5	29.0	91	94



Appendix 9.1-f – Climatogram of Bilene Beach. The temperature and rainfall data are the average of 2006 and 2007.

9.2. Structured questionnaire applied during the survey

General Farm Characterization Questionnaire

Date:_____

Name of household head (HH): _____

Farm Code:_____

Date:_____ **Farm Code:**_____

Section I - General Household Characterization

A- Location *Remarks*

1. Region/District

2. Village

3. GPS record for the homestead : Latitude (N/S)
Longitude (E/W)
Altitude (m)

4. Markets
Closest local market Distance (km)
Closest urban market Distance (km)

5. Farm accessibility

6. Number of fiel

7. Observations:

B- Household Informations

1. Age of HH hea **2. HH head Education:**

3. Household hea M ☐ F ☐

4. Household head's marital status (circle):
☐ Single (S ☐ Widow(er) (W) ☐ Married (M) ☐ Separated (Sp)

5. Household members (ppl that eat and live in this home). Fill the following table

Relation to HH	Gender	Age	Education	Main Occupation	Tick the Month working on Farm											
					Jan	Feb	Mar	Apr	Mai	Jun	Jul	Ago	Sep	Oct	Nov	Dec
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																

Appendix 9.2-a- General Farm Characterization Questionnaire applied during the survey.

Section II - Farming System

A - Crop production

Remarks

1. Crop and area

Crop	Crop system	Area	Which crop	Which crop	Which crop	Frequency of rotation
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					
	Mono					
	Mix					
	Rotation					

2. Crop Outputs and destiny

Crop	Part used	Destiny				
		Human F.	Animal F.	Market	Other	Which?
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
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		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	

Appendix 9.2-b- General Farm Characterization Questionnaire applied during the survey (cont.).

A - Crop production

3. Crop Labour

Remarks

Crop	Activity	Period	Type of Labour		Gender		
			Hire	Familiar	Male	Female	Children
	Soil Preparation		☐	☐	☐	☐	☐
	Seeding/Planting		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Thinning		☐	☐	☐	☐	☐
	Fertilization		☐	☐	☐	☐	☐
	Insecticides/pesticides		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Harvesting leaves		☐	☐	☐	☐	☐
	Harvesting final product		☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
	Soil Preparation		☐	☐	☐	☐	☐
	Seeding/Planting		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Thinning		☐	☐	☐	☐	☐
	Fertilization		☐	☐	☐	☐	☐
	Insecticides/pesticides		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Harvesting leaves		☐	☐	☐	☐	☐
	Harvesting final product		☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
	Soil Preparation		☐	☐	☐	☐	☐
	Seeding/Planting		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Thinning		☐	☐	☐	☐	☐
	Fertilization		☐	☐	☐	☐	☐
	Insecticides/pesticides		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Harvesting leaves		☐	☐	☐	☐	☐
	Harvesting final product		☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
	Soil Preparation		☐	☐	☐	☐	☐
	Seeding/Planting		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Thinning		☐	☐	☐	☐	☐
	Fertilization		☐	☐	☐	☐	☐
	Insecticides/pesticides		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Harvesting leaves		☐	☐	☐	☐	☐
	Harvesting final product		☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
	Soil Preparation		☐	☐	☐	☐	☐
	Seeding/Planting		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Thinning		☐	☐	☐	☐	☐
	Fertilization		☐	☐	☐	☐	☐
	Insecticides/pesticides		☐	☐	☐	☐	☐
	Weeding		☐	☐	☐	☐	☐
	Harvesting leaves		☐	☐	☐	☐	☐
	Harvesting final product		☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐

Appendix 9.2-c- General Farm Characterization Questionnaire applied during the survey (cont.).

A - Crop production *Remarks*

4. Crop Inputs

Crop	Resources	How	Pests	Product	How much?	Treatment	Costs

B- Livestock Production

1. Animals

Animal	Total (class)*	Males	Breed		
			Local	Crossbred (%)	Imported
DA					
goat					
sheep					
chicken					
ducks					
donkey					

*

No Animal	Class
0	0
2	1
<5	2
6 to 10	3
11 to 15	4
16 to 20	5
21 to 30	6
>30	7

2. Livestock output

Animal	Production					
	Milk	Meat	Labour	Manure	Other	Which?
DA	☐	☐	☐	☐	☐	
cattle	☐	☐	☐	☐	☐	
sheep	☐	☐	☐	☐	☐	
goat	☐	☐	☐	☐	☐	
chicken	☐	☐	☐	☐	☐	
ducks	☐	☐	☐	☐	☐	
donkey	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	

3. Animal Feed

Animal	Food					
	Cereals	Straw/hey	Grazing	HH leftovers	Other	Which?
DA	☐	☐	☐	☐	☐	
cattle	☐	☐	☐	☐	☐	
sheep	☐	☐	☐	☐	☐	
goat	☐	☐	☐	☐	☐	
chicken	☐	☐	☐	☐	☐	
ducks	☐	☐	☐	☐	☐	
donkey	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	
	☐	☐	☐	☐	☐	

Appendix 9.2-d - General Farm Characterization Questionnaire applied during the survey (cont.).

B- Livestock Production *Remarks*

4. Livestock Labour

Animal	Activity	Period	Type of Labour		Gender		
			Hire	Familiar	Male	Female	Children
DA			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
cattle			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
sheep			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
goat			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
chicken			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
ducks			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
donkey			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐
			☐	☐	☐	☐	☐

5. Livestock Health

Animal	Regular Vacinations		Veterinary		Mortality Rate	Main Reason
	Yes	No	Yes	No		
DA	☐	☐	☐	☐		
cattle	☐	☐	☐	☐		
sheep	☐	☐	☐	☐		
goat	☐	☐	☐	☐		
chicken	☐	☐	☐	☐		
ducks	☐	☐	☐	☐		
donkey	☐	☐	☐	☐		
	☐	☐	☐	☐		

6. Livestock infra-structures

Animal	Animal-House		Hedges		Feeders	
	Yes	No	Yes	No	Water	Food
DA	☐	☐	☐	☐	☐	☐
cattle	☐	☐	☐	☐	☐	☐
sheep	☐	☐	☐	☐	☐	☐
goat	☐	☐	☐	☐	☐	☐
chicken	☐	☐	☐	☐	☐	☐
ducks	☐	☐	☐	☐	☐	☐
donkey	☐	☐	☐	☐	☐	☐

Appendix 9.2-e - General Farm Characterization Questionnaire applied during the survey (cont.).

C- Production orientation *Remarks*

1. Crop production this year was used

Only for subsistence ☐ For subsistence + market ☐ Mostly for market ☐

2. Livestock production this year was used

Only for subsistence ☐ For subsistence + market ☐ Mostly for market ☐

Section III- Livelihood System

A- Farm assets and infrastructure

1. Transport

---

2. Machines and agricultural equipement

---

3. Storage facilities

---

4. Type of house/s (e.g. semi-permanent)

---

5. Water well, irrigation system, etc.

B- Other household activities

1.

Activity	Relation to HH	Period

C- Income

1. Number of adults working full time in a formal wage job or owning a full-time business

2. Now? Y ☐ N ☐

3. How long? 0-5 yrs ☐ 5-10 yrs ☐ >10 yrs ☐

4. Number of adults working outside the area, sending remittances:

---

5. Farmer's estimation of the % of income generated on-farm/off-farm

---

Appendix 9.2-f- General Farm Characterization Questionnaire applied during the survey (cont.).

Section IV- Plantation of Jatropha and farmers' labour and land

A- Land *Remarks*

1. Did you lost land due to Jatropha plantation? Y ☐ N ☐

2. Did you have some compensation? Y ☐ N ☐

3. Which type of compensation? Financial ☐ New Land ☐ Other ☐ ----------

B- Labour

1. Do you have some member in your family working in J. Plantation? Y ☐ N ☐

2. How many? 1 ☐ 2 to 3 ☐ 3 to 5 ☐ >5 ☐

Who? ☐ HH head ☐ Wife ☐ Daughter ☐ Son ☐ Other.Which?_____

Section V - Sketch of the farm layout or transect

Appendix 9.2-g- General Farm Characterization Questionnaire applied during the survey (cont.).

9.3. Characterization table of the fields during the field visits.

Field Characterization Table

Farm ID:_____ Location:_____ Date: _____

Plot nr	Distance to Home (m)	Land				Crops				Soil				Landscape			Infrastructures
		Tenure [a]	Use [b]	Cropped since (year)	Last fallow (year)	Mono	Mixed	Density	Area (Ha/acres)	Drainage [c]	Depth [d]	Soil Colour	Local name	Slope class [e]	Land position [f]	Visible erosion [g]	

Instructions

a O = owned; R = rented; C = communal
b L1= annual crop; L2= permanent crop; L3 = pasture; L4 = trees; L5 = fallow; L6 = permanent fallow
c 1 = poor; 2 = good; 3 = excessive
d D = deep; S = shallow
e F = flat; S = steep; V = very steep
f U = upland; M = mid slope; B = bottomland
g 1 = no signs; 2 = moderate signs; 3 = severe signs

Appendix 9.3-a – Field characterization table

9.4. Guidelines for semi-structured interviews of key informants

Items to be covered during semi structure interview to AES

- What are the zones covered by AES?
- How many people (technicians) work in the AES?
- Chilengue village is included in the zones with AES?
- What are the main crops produced in Bilene Macia district?
- What are the main crops produced in Chilengue (or Posto Adminstrativo de Bilene)?
- What is the main agriculture constraint in Chilengue?
- What is the crop named "gergeli" by population?
- Do you know why they call it "gergeli"?
- Why people do not breed cattle?
- Is there any problem in the pasture?
- Do you have any study about soils in this district?or any study about the reason of cattle's death?
- What is the "muzungo"?

Appendix 9.4-a- Guideline for semi-structure interview of Agricultural Extension Services made on February 5th 2009.

Items to be covered during semi structure interview to Veterinary Service

- Why people do not breed cattle?
- Which breed cattle is present in the district?
- Is there any problem in the pasture?
- Do you have any study about soils in this district? or any study about the reason of cattle's death?
- What is the "muzungo"?
- Do you have any vaccination programme for New Castle Disease?
- Why people do not get the drops you that you offer to treat the chicken?
- Why people do not know about it?
- How do you spread your news about vaccination and cares needed for the chickens' well being?

Appendix 9.4-b- Guideline for semi-structure interview of Veterinary Technician made on Aril 9th 2009.

Items to be covered during semi-structure interview to biofuels company

Jatropha plant cycle

1. Vegetative and Generative period: when how long?
2. Flowering?
3. When fruits ripen?
4. If Jatropha lost leaves, when does that occur?
5. When the leaves start grow?

Nursery

1. How Energem propagate Jatropha in the nursery? By cuttings or sowing?
2. From where are coming the seeds? Do you use improved varieties?
3. How long the plants stay in the nursery and what is the stage/age that they are ready to transplant?
4. How is a labour calendar in a nursery (during the day and the year)?
5. How many people work in the nursery?
6. How many hectares the nursery has?
7. How many plants the nurseries produce per hectare/year?
8. What is the destiny of the plants propagated?

Plantation

1. How old is the plantation of Jatropha?
2. How is made the plantation?
3. How many people work per hectare during the plantation of Jatropha?
4. How many hectares are planted per day?
5. To plant one hectare how many hours is necessary?
6. How many hectares are planted up till now and what is your goal?
7. How many hectares with Jatropha and with natural vegetation?

Crop management

Soil maintenance

1. How do you keep the soil between rows?
2. How do you keep the soil within a row?
3. What is the frequency of weeding per year?
4. How many people work per hectare during the weeding?

Fertilization

1. Do you make any fertilization during the year? When?
2. Which frequency?

Appendix 9.4-c- Guideline for semi-structure interview of biofuels company

Items to be covered during semi-structure interview to biofuels company

Pests and diseases

1. Which pests are observed in Jatropha plantation?
2. Which diseases are observed in Jatropha plantation?
3. When are made the treatments (regular or occasional treatments)?
4. Which products are used for the treatments?
5. Which quantity of product is used in the treatments (kg or L s.a. per hectare)?

Pruning

1. With which age do you start pruning the plants?
2. In which season do you pruning?
3. How do you pruning?
4. How many people per hectare during the pruning?
5. How long it takes pruning a hectare?
6. Do you remove leaves from the plants? When?

Harvest

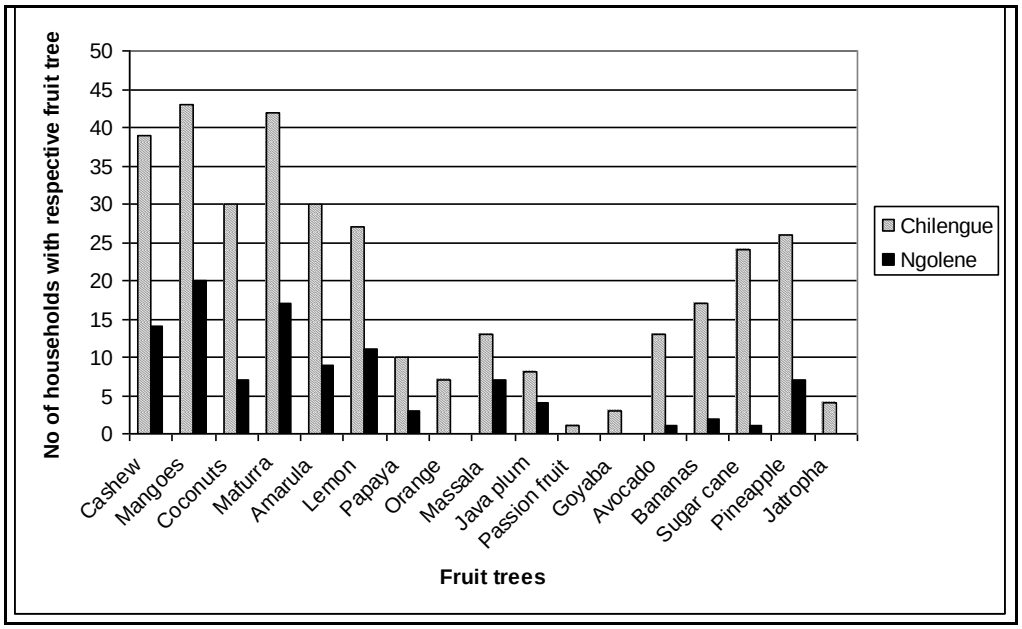
1. When is expected the plants start to produce?
2. When is made the harvest?
3. How is made the harvest?
4. How many people are necessary per hectare to harvest?
5. How many hectares are harvested per day?
6. How do you carry the fruits?

Appendix 9.4-d- Guideline for semi-structure interview of biofuels company (cont.)

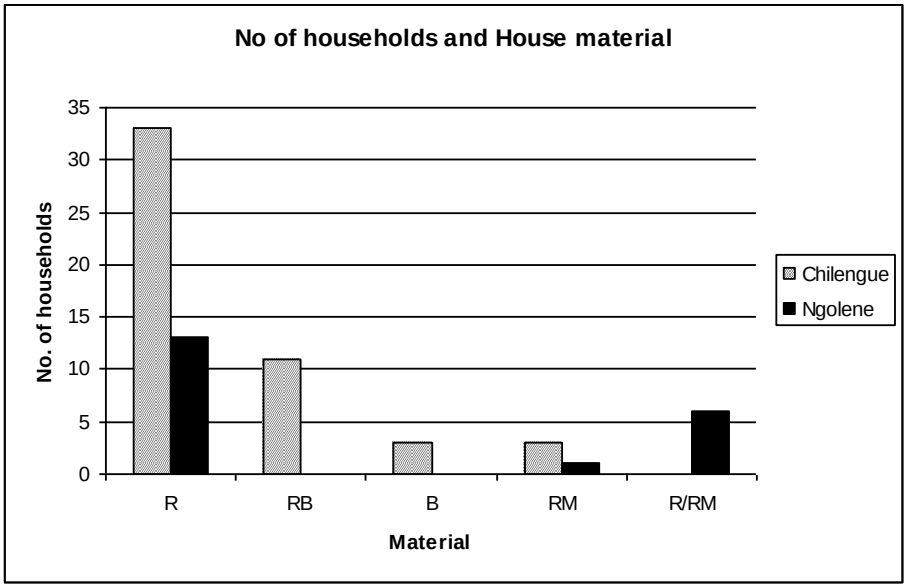
9.5. Other results from the structured questionnaire

Appendix 9.5-a - Level of Education of the HH head. L0 - no education; L1- 1st to 4th grade; L2- 5th to 9th grade; L3- 10th to 12th grade; L4- High Education

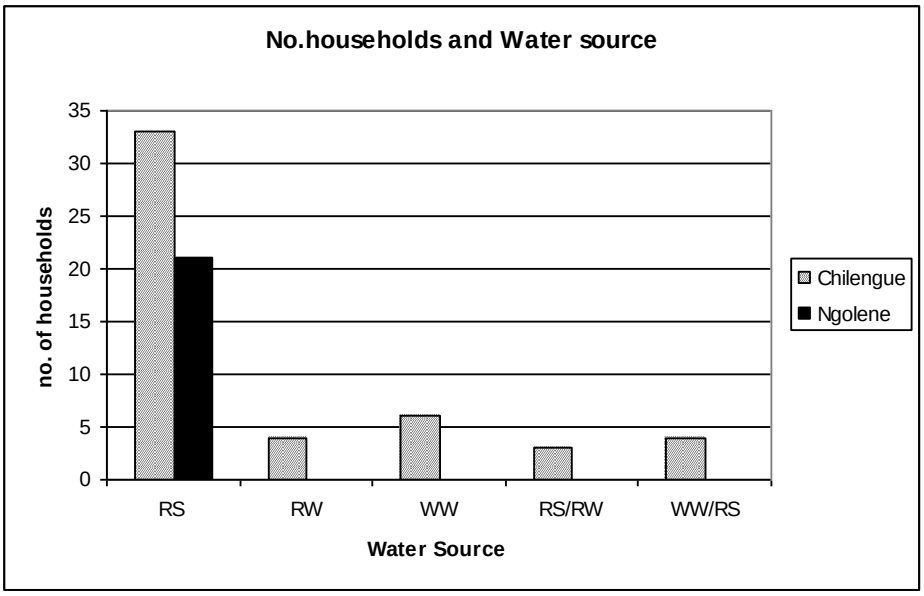
Level of Education	Chilengue		Ngolene	
	Number of HH	% of HH	Number of HH	% of HH
L0	5	10	9	43
L1	17	34	9	43
L2	21	42	2	10
L3	3	6	0	0
L4	2	4	0	0



Appendix 9.5-b – Number of households and plants around the house per village.



Appendix 9.5-c- Type of material used on the houses. R- houses in reed; RB- houses in reed and brick; B- houses in brick; RM – houses in reed and mud; R/RM – houses in reed and in reed and mud.



Appendix 9.5-d - Different water sources used by the population. RS- river spring; RW – Water from chief's hole; WW – water well.

Appendix 9.5-e- Main reason of mortality for chicken and ducks per village.

Village	Animal	Total no. HH	Main reason for mortality	No HH	%
Chilengue	Chicken	32	Muzungo	21	65.6
			Snakes	0	0.0
			Dogs	0	0.0
			All	1	3.1
			None	10	31.3
	Ducks	14	Muzungo	4	28.6
			Snakes	0	0.0
			Dogs	0	0.0
			All	0	0.0
			None	10	71.4
Ngolene	Chicken	11	Muzungo	2	18.2
			Snakes	2	18.2
			Dogs	0	0.0
			All	0	0.0
			None	7	63.6
	Ducks	1	Muzungo	0	0.0
			Snakes	0	0.0
			Dogs	0	0.0
			All	0	0.0
			None	1	100.0

9.6. Crop yield measurements

Appendix 9.6-a- Yield measurement of groundnuts.

Farm Code	Area of the plot (m^2)	Plot sample	Area of the sample plot (m^2)	Plant density (plnts/9m^2)	Total bulked fresh sample (kg)	Small fresh sample shelled (kg)	Small fresh sample unshelled (kg)
CH013	615	1	9	51	0.7	-	-
CH013	615	2	9	63	1.325	0.450	0.125

Appendix 9.6-b- Yield measurements of cassava.

Farm Code	Area of the plot (m2)	Plot sample	Area of the sample plot (m2)	Plant	No. Roots	Roots weight (g)	Roots lenght (cm)	Roots perimeter (cm)	Fresh Weight of whole plant (kg)
CH046	2244.04	1	9	1	1	225	20	14	1.200
CH046	2244.04	1	9		2		25	12.8	
CH046	2244.04	1	9		1		36	17	
CH046	2244.04	1	9	2	2	475	26	14	1.375
CH046	2244.04	1	9		3		8	11	
CH046	2244.04	1	9	3	1	600	27	18	1.500
CH046	2244.04	1	9		2		28	18	
CH046	2244.04	1	9		1		25	14	
CH046	2244.04	1	9		2		30	12	
CH046	2244.04	1	9	4	3	500	27	14	1.900
CH046	2244.04	1	9		4		11	10	
CH046	2244.04	1	9		5		8	10	
CH046	2244.04	1	9		6		11	8	
CH046	2244.04	1	9	5	1	300	24	18	1.200
CH046	2244.04	1	9		2		21	4	
CH046	668.96	1	9		1		40	13	
CH046	668.96	1	9	6	2	1600	22	11	?
CH046	668.96	1	9		3		40	12	
CH046	668.96	1	9		4		34	12	

Appendix 9.6-c- Yield measurement of cowpea

Farm Code	Area of the plot (m2)	Plot sample	Area of the sample plot (m2)	Plant	No. Pods	Pods Lenght (cm)	No beans in each pod	Plant fresh weight (kg)
CH046	2244.04	1	9		1	25	15	
CH046	2244.04	1	9		2	22		
CH046	2244.04	1	9		3	23	16	
CH046	2244.04	1	9		4	23		
CH046	2244.04	1	9		5	24		
CH046	2244.04	1	9		6	23		
CH046	2244.04	1	9		7	21	12	
CH046	2244.04	1	9		8	21		
CH046	2244.04	1	9		9	26		
CH046	2244.04	1	9		10	20	14	
CH046	2244.04	1	9		11	24	9 (MISS5)	
CH046	2244.04	1	9		12	21		
CH046	2244.04	1	9	1	13	26	17	1.300
CH046	2244.04	1	9		14	19	7 (MISS2)	
CH046	2244.04	1	9		15	28	16	
CH046	2244.04	1	9		16	29		
CH046	2244.04	1	9		17	21		
CH046	2244.04	1	9		18	12		
CH046	2244.04	1	9		19	28		
CH046	2244.04	1	9		20	23		
CH046	2244.04	1	9		21	17	11	
CH046	2244.04	1	9		22	14		
CH046	2244.04	1	9		23	24		
CH046	2244.04	1	9		24	26		
CH046	2244.04	1	9		25	10		
CH046	2244.04	1	9		1	21	18	
CH046	2244.04	1	9		2	15	11	
CH046	2244.04	1	9		3	18	12	
CH046	2244.04	1	9		4	22	17	
CH046	2244.04	1	9		5	17	17 BROKEN	
CH046	2244.04	1	9		6	16	5 (MISS7)	
CH046	2244.04	1	9		7	19	13	
CH046	2244.04	1	9	2	8	20	16	0.575
CH046	2244.04	1	9		9	18	17	
CH046	2244.04	1	9		10	16	13 (BROKEN)	
CH046	2244.04	1	9		11	18	13	
CH046	2244.04	1	9		12	20	20 (BROKEN)	
CH046	2244.04	1	9		13	25	17	
CH046	2244.04	1	9		14	18	16	

Appendix 9.6-d- Yield measurement of maize

Farm Code	Area of the plot (m^2)	Plot sample	Area of the plot sample (m^2)	Plants no.	Plant Lenght (m)	Maize ear Fresh Weight (kg)	Kernels Fresh Weight (kg)	Lenght (cm)	No. grains	Cob fresh weight (kg)
CH046	2244,04	1	9	1	1.18			26	289	
CH046	2244,04	1	9	2	1.5			23	Most grains eaten	
CH046	2244,04	1	9	3	1.10			28	Most grains eaten	
						0.75	0.40			0.25
CH046	2244,04	1	9	4	0.96			13	Most grains eaten	
CH046	2244,04	1	9	5	1.10			23	235	
CH046	2244,04	1	9	6	1.12			21	Most grains eaten	