THE IMPACT OF JATROPHA FARMING ON FOOD SECURITY IN TANZANIA: THE CASE OF RUKWA AND ARUSHA REGIONS

BY

LANGELIKA KALEBI

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ABSTRACT

The main objective of the study was to assess the impact of jatropha farming on food security to small-scale farmers in Rukwa and Arusha regions. To achieve that objective, a simple random sampling was used to obtain jatropha famers. Two hundred and sixty (260) respondents were randomly selected; among them were 130 jatropha farmers, which involved 60 jatropha farmers from Monduli district and 70 jatropha farmers from Mpanda district. Other respondents included in the sample were non jatropha farmers who amounted to 130. Descriptive statistics including the use of means, percentages, minimum and maximum were used to assess the impact of jatropha production on food security as well as socio-economic characteristics of farmers. Through Microsoft Excel, the analysis of the data was also done to assess the contribution of jatropha production to the total household income. The results indicated that intercropping jatropha with other food crops has negative impact on food security. This is because, as jatropha grows it develops canopy which makes it difficult for the intercropped food crops to develop. Eliminating intercropping when jatropha plants are big reduces food production leading to food insecurity. The results indicated also that, the contribution of jatropha to the total household income was smallest compared to other contributors including livestock, maize, black beans, beans and ground nuts. This might be due to the reasons that farmers in the study area do not regard jatropha as a cash crop hence production levels of jatropha in the area are low. In keeping with the major findings of the study the it was recommended that Jatropha stakeholders should consider expansion of jatropha farms goes hand in hand with exploring market for the produce to ensure that farmers gets enough cash from jatropha to be able to buy food for the family. Farmers in the study area should regard jatropha as a cash crop so that much emphasis is put on jatropha production.

DECLARATION

I, LANGELIKA KALEBI, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my own original work and it had never been submitted for a degree award in any other university

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Langelika Kalebi

(MSc. Candidate) Date

This declaration is confirmed by:

_____ _____

DR. R. M. J. Kadigi Date

(Supervisor)

_____ _____

PROF. Susan Nchimbi-Msolla Date

(Co-Supervisor)

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DEDICATION

I dedicate this accomplishment to my lovely husband Mr. Frederick K. Tarimo, Sister Catherine V. F. Lema, children Martin and Diana who supported me morally and financially from beginning of my Msc studies to this end.

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Johnson (1985) defines gross margin as the difference between the values of an enterprise gross output and the marginal cost of production. According to Philip (2001), the key advantages of gross margin analysis as an economic analytical tool

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LIST OF ABBREVIATION

^{0}C	Degree Centigrade
FAO	Food and Agriculture Organization
FAME	Fatty Acid Methyl Ester
IFPRI	International Food Policy Research Institute
JPT	Jatropha Production Technology
KAKUTE	Kampuni ya Kusambaza Teknolgia
LCD	Least Developed Countries
SJO	Straight Jatropha Oil
SPSS	Statistic Package for Social Science
TFNC	Tanzania Food and Nutrition Centre
TSHS	Tanzania Shilling
URT	United Republic of Tanzania
USAID	United States Agency for International Development
USD	United States Dollar

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Jatropha is a hardy shrub, traditionally known in many subtropical and semi-arid regions for its medicinal properties (JPT, 2007). Although jatropha comprises approximately 70 species, there is only one - the *jatropha curcas l. euphorbiaceae* which is suitable for jatropha oil production (Manyanga, 2006). In Tanzania, the most promising and well developed uses of jatropha include soap and candle making (Tigere *et al.*, 2005).

Nevertheless, according to Shorthouse, (2009) jatropha popularity and acceptance has been somewhat controversial in Africa; Many small farmers, who were led to believe that planting jatropha would bring a reliable income, have been disappointed with the yields. Further, jatropha seed prices have collapsed as the demand for research material and planting stocks dwindled. The price will have to drop further for the crop to reach price parity with petro-diesel or kerosene, making it virtually impossible for the average farmer to compete in the market. It seems that the crop will only be profitable if grown on a massive scale.

JPT (2007) pointed out that although the plant grows on marginal conditions, one requires water, fertilizers and good pest control measures for him/her to get reasonable amounts of oil-bearing seeds. This is in addition to the fact that fruits ripen at different times and must be inspected and harvested by hand to achieve maximum oil concentrations - this is a labour intensive process.

In recent years, the production of *jatropha curcas* has been widely promoted by international and local companies as one of the most viable crops for biofuel production in Tanzania (Philip, 2007). The major driving forces have been the ever increasing prices of fossil fuels, the need to expand agricultural production and improve the welfare of rural peasants through agricultural market development and increased income diversification opportunities and improvement of energy security (Marwa, 2008). Despite its high potential for biofuel production, currently there is no any reported record of commercial scale production of jatropha in Tanzania (Marwa, 2008).

However, there are many International and local companies which have invested on jatropha biofuel production in Tanzania. Some of these investors are in advanced stages while others are in initial stages of jatropha biofuel production (Manyanga, 2006). Some of these companies are KAKUTE and Diligent Tanzania from Arusha, PROKON –A German Company in Mpanda, Rukwa Region, Sun Biofuels- British Firm in Kilwa and Bioshape in Rufiji (Shorthouse, 2009).

1.2 Statement of the problem and justification of the study

In Tanzania, smallholder farmers play a big role in producing jatropha as biofuel feedstock. The problem is that, the benefits smallholder famers receive from their involvement in large-scale jatropha production for their livelihood improvements are not clear yet. Various studies on jatropha biofuels have been conducted in Tanzania for example, Philip (2007) carried a study on exploration of the potential of producing biofuels and the prospective influence of biofuels production on poverty alleviation among small-scale farmers in Tanzania.

Loos (2008) carried a study on socio-economic impact of a jatropha-project on smallholder farmers in Tanzania. Nevertheless, little has been researched on the impact

of jatropha farming on livelihood of jatropha farmers specifically on income and food security in Tanzania**.** Thus, this study sought to assess the impact of jatropha farming on food security and income to small-scale farmers in Tanzania. The results of this study would add to literature on land tenure, fragmentation and agricultural productivity. The study would also add to literature on food security and income from jatropha. Further, the study would inform policy markers on how best the jatropha crop could improve food security, national economy and environment management.

This study is also part of biofuel in Africa project that aims at enhancing information and knowledge basis upon which sustainable and pro-poor development strategies and policies can be designed and implemented by development partners and governments in both the North and the South, within a multi-objective decision-support system

1.3 Objectives of the study

1.3.1 General objective

To assess the impact of jatropha farming on food security of small-scale farmers in Rukwa and Arusha regions

1.3.2 Specific objectives

i. To assess the impact of jatropha production on household food security

ii. To assess the contribution of jatropha production to total household income

iii. To compare the profit margin earned from different jatropha cropping systems

iv. To analyze the factors that determine income from jatropha production

1.4 Hypotheses

i. Jatropha production has no significant impact on household food security

ii. Jatropha production contributes significantly to household income

iii. Jatropha production using fence results to highest profit margin

iv. Household assets are the major determinant of income from jatropha production

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter presents the literature review of the study. It is divided into ten sections. First section presents jatropha production systems. Second, third and fourth sections comprise of issues regarding agronomic practices, prices and food security for jatropha farming.

2.2 Jatropha and its production systems

Jatropha curcas is a drought-resistant perennial crop, growing well in marginal/poor soil, producing seeds with an oil content of 37% for 50 years. Being a perennial crop, intercrops can be raised in between the rows for the first two years. Crops like tomato, bitter gourd, pumpkin, ash gourd, cucumber and black gram can be intercropped with jatropha profitably (JPT, 2007). After having been introduced to Africa centuries ago, it is now widely observed in semi-arid lands throughout the drier area of continent. In East Africa, the crop is naturalized in bush lands and along rivers in the western, central and coastal parts of the Kenya, whereas in Kagera-Tanzania, jatropha is intercropped with vanilla (*Vanilla planifolia*) to serve as a pole for vanilla vines and to provide shade for vanilla leaves (Tomomatsu and Swallow, 2007). Further, Muchiri (2007) points out to minimize risks, most farmers in Kenya, currently practice intercropping through growing for example a mixture of mangos, cashews, coconuts and vanilla.

Figure 1: A jatropha plant

2.3 Yield of jatropha

According to JPT (2007), yield varies significantly depending on the water input, which determines the number of fruiting period per year, which can vary from one to three. Furthermore wherever *Jatropha* is cultivated under irrigated condition, the flowering is throughout the year, and economic yield starts from the end of third year and during this period it is estimated 3000 kg seeds of yield are obtained from acre at 3 kg of seeds per plant. Further, according to Rao (2006), the average yields of jatropha seeds in dry lands are unlikely to exceed 400 kilograms per acre per year.

Prajapati and Prajapati (2005) estimated jatropha yields in rain fed and irrigated conditions in India, and found after five years; the production per tree ranged from 1.2 kilogams under rain fed conditions to 3.2 kilograms under irrigated conditions. The yield

in rainfed conditions is as high as around 40% under irrigation, implying that jatropha can be grown in semi-arid lands but requires certain level of rainfall to produce high yields. A research done in Mali by Henning (2002) reveals, where jatropha was planted as a hedge, the production of seeds was about 0.8 kilograms per meter. KAKUTE (2006) also reveals in Tanzania the yield of jatropha is significantly less than 1600 kg/ha and is from the fifth year onwards.

2.4 Price and revenue of jatropha seeds and oil

The potential markets for Jatropha oil can emerge as a result of a national policy for biofuel. Unfortunately, there is currently no such policy in Tanzania. Nevertheless, with economies of scale, an increase of efficiency in the oil production as well as "learning-by-doing" in Jatropha agriculture, oil extraction and conversion, the price of jatropha oil may be able to compete with fossil fuels in the future (Messemaker, 2008). According to Tomomatsu and Swallo (2007), the feedstock for biodiesel could be any vegetable or animal fat; jatropha oil is only economically viable when its price is competitive with the available alternative oils.

In India, the price of jatropha seeds ranges from USD 0.13 to USD 0.18 (Rs.6 to 8) per kilogram, while the sales price of jatropha oil ranges from USD 0.41 to USD 0.56 (Rs.19 to 25) per litre (Tewari, 2007). According to Messemaker (2008), in Tanzania there has been a rise in seed prices over the past four years. Messemaker (ibid), observes further by presenting an illustrative example of Engaruka Ward in Monduli District, where factory gate prices, that are the prices farmers were paid to deliver the seeds to the collectors rose from Tshs 100 per kg of seeds in 2005 to Tshs 300 per kg of seeds in 2008.

2.5 Food security

2.5.1 The concept of food security

Food security exists where all the people at all times have physical and economic access to sufficient, safe, and nutritious food to meet dietary needs and food preference for an active and health life (USAID, 1992). This definition is widely accepted and is in this respect taken to embrace three specific aims: ensure production and adequate food supplies, maximizing stability in the growth of supplies, and securing access to the available supplies (FAO, 1995). According to LCD (1997), a country and people are food secure when their food system operates efficiently and in such a way that there would be no fear that there will be not enough to eat. In the view of LCD (ibid), food security will be achieved when the poor and the vulnerable groups of people particularly women, children and those living in marginal areas, have secured access to the food they need.

2.5.2 Food security at regional level

The concept of food security, however, takes different dimension at different levels. At the regional level, food security is equated to national and regional food balances (IFPRI, 1994). But food balances is now considered as an inadequate criterion for food security since availability may not guarantee access due to poor distribution or lack of purchasing power. Food security is therefore, defined by a combination of criteria that are not mutually exclusive such as the balance between availability and need; the absence of famine or temporary food insecurity; seasonal or chronic under nutrition; micro nutrient deficiency, especially of iron, iodine, and vitamin A; and nutrient depleting illnesses such as malaria, diarrhea, and internal parasites (IFPRI, 1994).

2.5.3 Food security at household level

At the household level, food security can be defined as the ability of the family of securing enough food to ensure adequate dietary intake for all of its members (FAO, 1983). At this level, food security is equated with sufficiency of household food entitlement, which, is whether food production resources, income availability for the purchase of food (through employment), and gift or assistance is sufficient to meet aggregate needs of all of the household members. In the urban areas, household food security largely depends on the level of the income earned by the family. In this case, achieving food security is largely determined by the assumption of minimum nutritional need, particularly energy (FAO, 1983).

According to URT (2003), food security at the household level is defined as the ability of the household to acquire food either through production, purchases, transfers or exchange that are adequate in quantity and quality to fulfill the nutritional needs of all members of the household. It is therefore concerned with intra-household microeconomics which describe the use of food in the household and the influencing factors such as culture, beliefs, practices and food preparation. Thus, for the household to achieve food security it must have the means to produce (land, production tools and inputs) or the ability to purchase (job and income) the food that the households need, and the time and knowledge to ensure that the nutritional needs of the family members are met.

Food security at an individual level is often not considered, and if it is considered at that level, it refers to nutritional security that also calls for consideration of the healthy status of individuals (IFPRI, 1994).

2.6 Determinants of household food security

Food security is affected by all factors related to the availability of food, access to food and risk related either to availability or access to food. In this respect, the factors associated with food production such as availability of land, access to credit, availability of qualified labour force and agricultural practices also do affect the food security situation. Similarly, the factors, which affect stability of the available food such as storage and processing, social sustainability and sustainable environment, can play crucial roles on food security. Also important are the conditions determining food access, which include physical, social and economic accessibility (Hubbard, 1995). Furthermore, macro and micro economic policies are known to have impact on household food security (Ehui, *at el.*, 2002).

2.7 Coping strategies to improve household food security

Over time, households facing regular episodes of food insecurity have developed complex strategies of coping mechanism. According to Carney (1998), rural households in developing countries have three broad options to improve their livelihoods; these include natural resource based activities, non-natural resource base activities, and migration to other agricultural areas or to urban areas. However, due to lack of resources, inadequate institutional support and other factors, household coping mechanisms are not always effective or efficient in offsetting the impact of production shortfalls and market uncertainties (FAO, 1992). Although coping strategies vary with local conditions, there is a common pattern on the sequence of responses. These include such as aspect as dispersed grazing, changes in cropping and planting practices, migration to towns in search of urban employment and increased petty commodity production (Cobett, 1988). Other coping strategies identified by Cobett (1988) include

collection of wild food, the use of credit from merchants and money lenders, migration to other rural areas for employment, rationing of current food consumption, sales of possessions, sales of firewood and charcoal, consumption of food distributed through relief programs, sale of productive assets, and breakup of the household and distressful migration.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Overview

This chapter presents the procedures that were adopted to conduct the study. The chapter includes; a description of the study, research design, sampling method and sample size, source of data and collection tools, methods for analyzing data, problem of parameter estimation and limitation of the study.

3.2 Location of the study sites

This study was conducted in Monduli and Mpanda districts in Arusha and Rukwa Regions respectively.

3.2.1 Monduli district

Monduli district lies between 35^0 25' and 37^0 29' East and between 2^0 09' and 4^0 12' to the sourth. The district has a total area of 24 894.11Km^2 (URT, 1995). The area is situated in Savannah and arid land dominated by *Acacia* and *commiphora* species (Ludwin, 2001). Above 75% of the area is flat land, 22% is rolling to moderately desert and 3% is hilly. Engaruka is among the Monduli wards where the study was conducted (Figure 3).

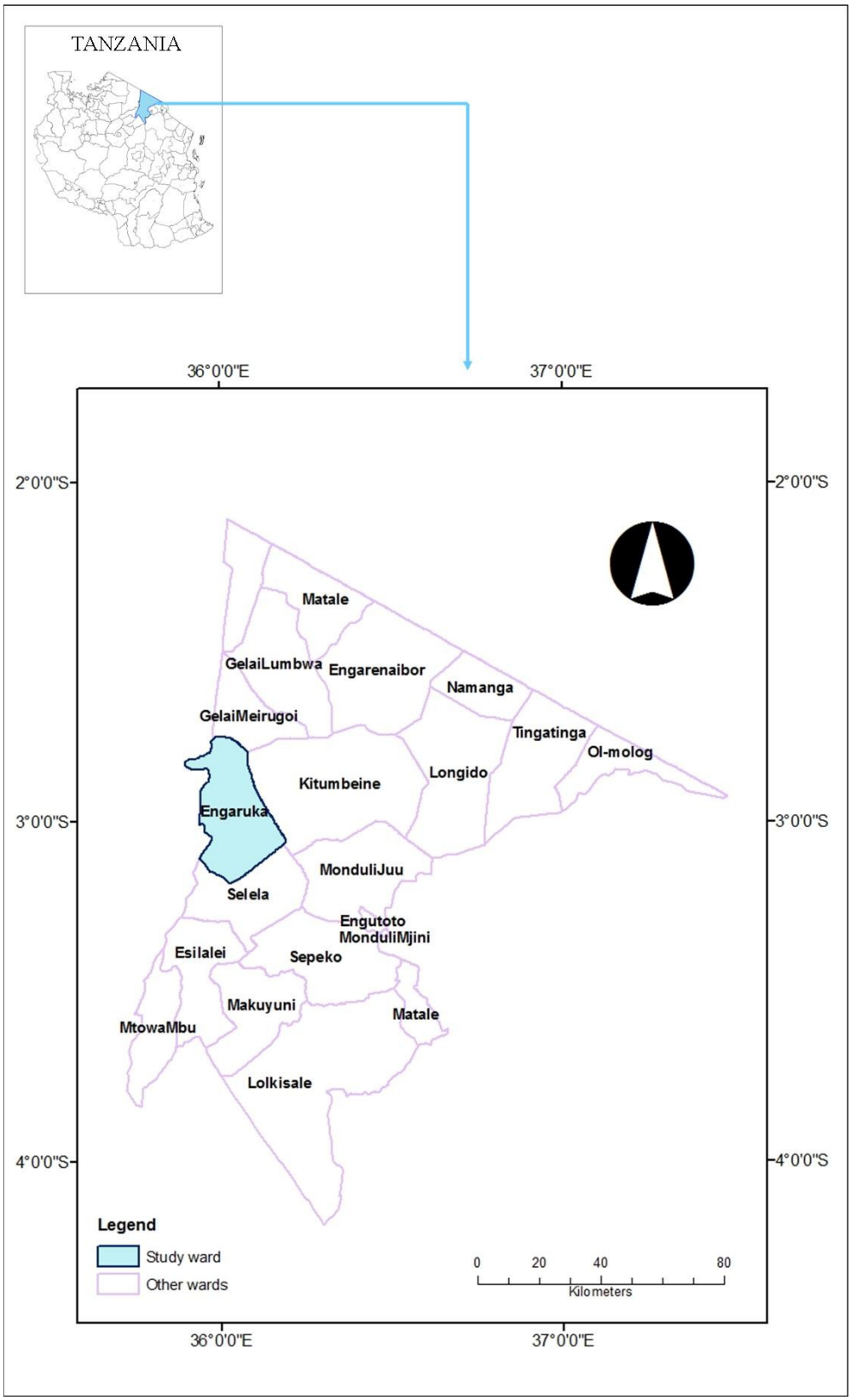

Figure 2: Map of Monduli District showing the study area (Source: Monduli District Council, 2005)

3.2.2 Mpanda district

Mpanda district lies between 5^0 15’ and 7^0 50’ South and between 30^0 0’ and 33^0 31’ East. The district has a total area of 47 527 km^2 (4 752 700 ha.) of which 932 136 ha are ideal for crop production, 2 801 163.7 are under Forest reserve, 860 000ha are under Game Reserve 168 400 ha are water bodies, and the rest are used for other activities. Usevya and Katumba are among the wards of Mpanda districts where the study was conducted (Figure 4).

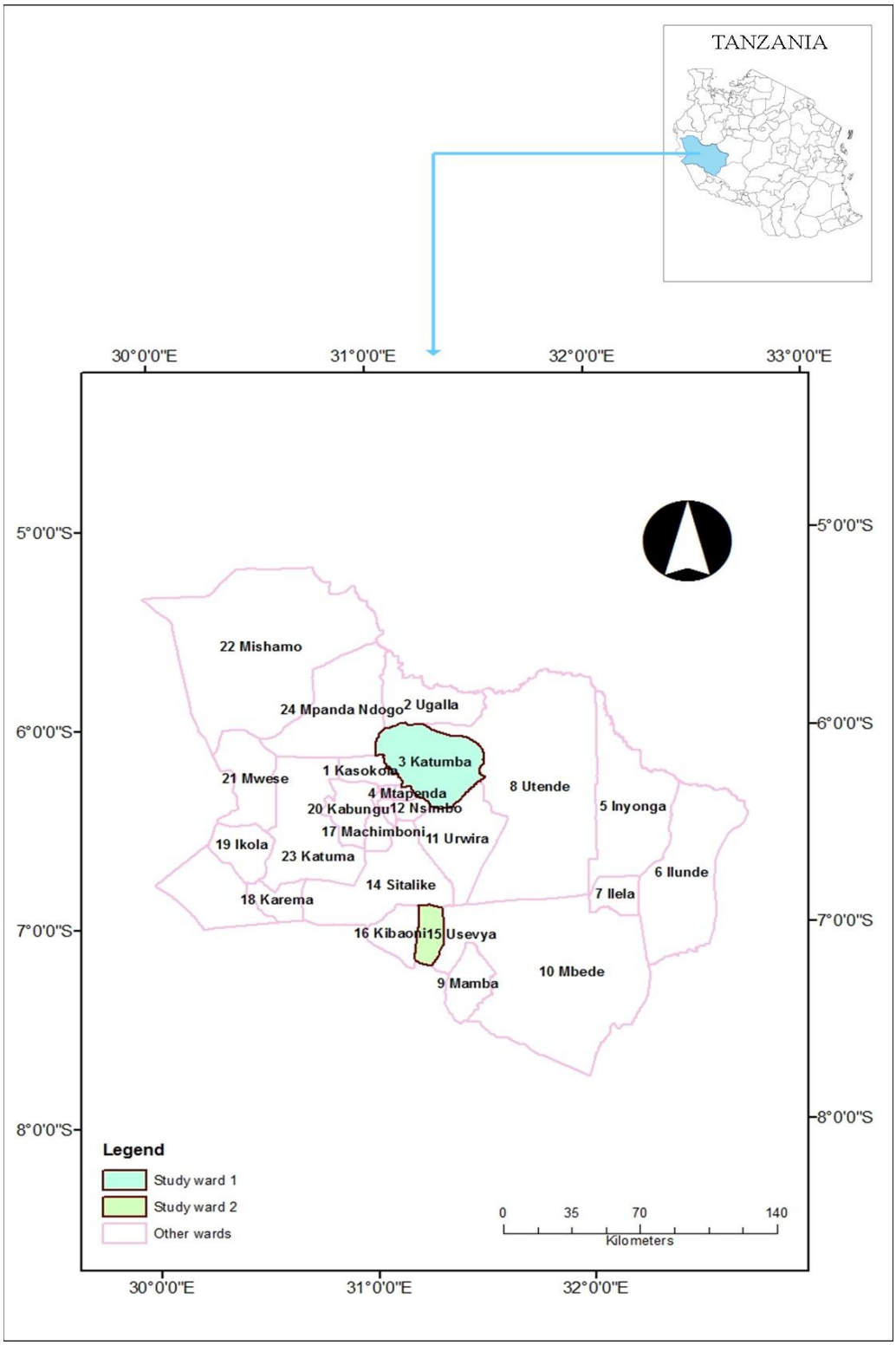

Figure 3: Map of Mpanda district showing the study areas (Source: Mpanda District Council, 2005)

3.3 Conceptual framework

Figure 1 presents the conceptual framework showing hypothetical relationships of the study objectives. It is assumed that the appropriate jatropha production may increase household income. The household may use the income for purchasing food, therefore attaining food assurances at family level leading to household livelihood. Household income may also be used to finance access to social services for example education, health services, resulting to livelihood. Further, jatropha production may lead to more land allocated for crop production and thus livelihood. The more land is allocated for crop production the more the food is produced which may in turn lead to improved livelihood. Furthermore jatropha production may lead to food availability if different jatropha cropping systems employed in line with the expansion of farm lands. This may also lead to improved livelihood.

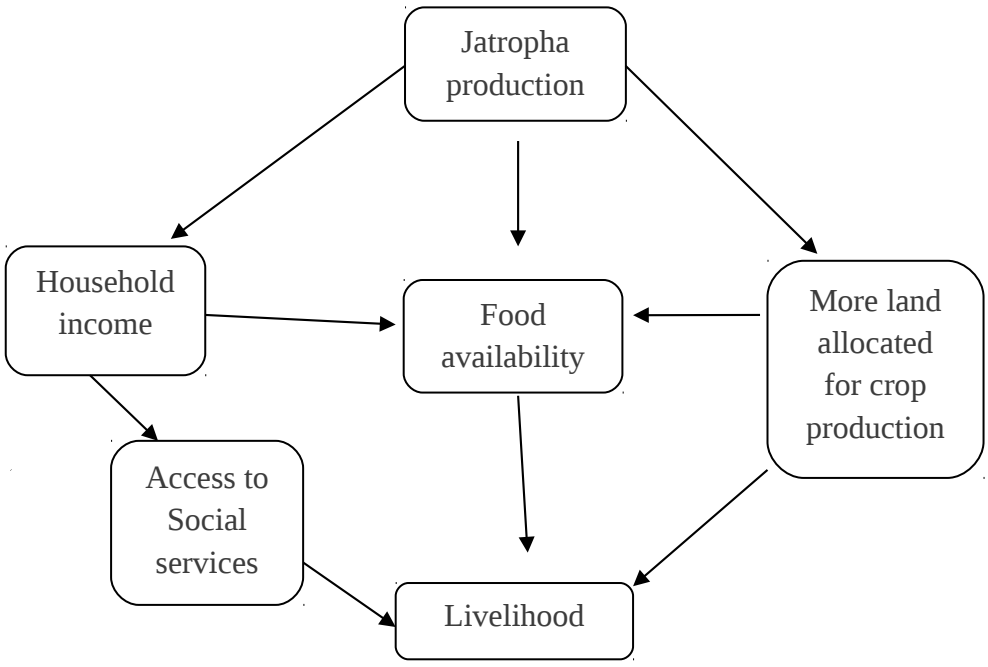

Figure 4: Jatropha production; conceptual framework

3.4 Research design

The study adopted a cross-sectional research design where the data were collected at one point at a time (Casley and Kumar, 1988). This design is relatively cheap, quick, and effectively utilizes limited resources in terms of cash, labour, transport, and time.

3.5 Sampling method and sample size

In order to obtain the desired sample of the population, a purposive sampling technique was used to obtain respondents, villages, and wards. The lists of major jatropha producing wards were obtained from Monduli and Mpanda District Agriculture and Livestock Development offices. The wards involved include Engaruka (in Monduli District), Usevya and Katumba (in Mpand District). These wards were purposefully selected. A simple random sampling was used to obtain jatropha famers. Two hundred and sixty (260) respondents were randomly selected; among them were one hundred and thirty (130) jatropha farmers, which involved sixty (60) jatropha farmers from Monduli district and seventy (70) jatropha farmers from Mpanda district. Other respondents included in the sample were non jatropha farmers who amounted to one hundred and thirty (130).

3.6 Source of data and collection tools

Both primary and secondary sources of data were used to gather information. The primary data were gathered through observation, discussion and use of structured questionnaires (Appendix 1). Also, household survey and Focus Group Discussion were conducted to obtain primary data. Kiswahili language was used to administer the questionnaires. Secondary data were obtained from relevant documents, books, reports, journals and internet.

3.7 Methods for analyzing data

The data collected were compiled, coded and analyzed using the Statistical Package for Social Sciences (SPSS) and Excel, Computer Programmes. Through SPSS; descriptive statistics (frequency, mean and standard deviation) was used to assess the impact of jatropha production on household food security. Microsoft Excel was used to assess the contribution of jatropha production to the total household income. Gross margin analysis was used to analyse and compare the profit margin earned from different jatropha cropping systems, whereas regression analysis was used to analyze factors that determine income from jatropha production.

3.7.1 Gross margin analysis

Gross- margin analysis was used in this study to analyze the profit margin earned from jatropha cultivated in different cropping systems. The profit margin was obtained by calculating revenues obtained from jatropha. The total revenue of each jatropha farmer was the product of the jatropha seed selling price and the yield. The selling price and yield were obtained directly from farmers. The revenues were then equated to profit with the assumption that no variable costs were involved in jatropha cultivation. This is

because the only cost involved in jatropha was labour which is provided by family members. For example in the study areas, famers do the pruning and collection of seeds (harvesting) only as part of the agronomic practices needed for jatropha production. Pruning is done by men and in most cases, is for the sake of allowing food crops to grow well. The collection of seeds is done by children and women. The gross margin was calculated for jatropha seed based on the following formula;

Gross Margin (GM) =Total Revenues (TR)-Total variable Costs (TVC)

Where:

GM=Gross margin (Tshs/kg)

TR=Total revenue (Tshs/ha)

TVC=Total variable cost (Tshs/kg)

Johnson (1985) defines gross margin as the difference between the values of an enterprise gross output and the marginal cost of production. According to Philip (2001), the key advantages of gross margin analysis as an economic analytical tool include its ability to draw logical interrelation of economic and technological parameters and its forecasting ability of rational variants for the operational structure of the enterprise. However, in the view of Phiri (1991), although gross margin is not a good measure of profitability, it remains the most satisfactory measure of resource use efficiency in small scale agriculture.

3.7.2 Regression analysis

Regression analysis was carried out to determine factors that determine income from jatropha. The key factors that were analyzed include age of the household head, years of

school (education level), the type of houses, land size, jatropha yield, jatropha cropping system, the time jatropha is planted, the buyer of jatropha (market) and the price of jatropha seed. Linear regression model or Ordinary Least Square (OLS) was used to estimate parameters and the problems of parameters estimation which often resulted from a violation of the basic assumptions of the liner regression model. The general function relationship between income and socio economic factors was denoted as:

$Y = \alpha + ß_iAG + \beta_iEd + \beta_iTH + \beta_iLS + \beta_iYD + \beta_iTCS + \beta_iAGJP + \beta_iPJS + \beta_iMK + \mu$

Where; Y= Income from jatropha

α = Constant term

$ß_i$= β_1, β_2, β_3, β_4, β_5 ,β_6 β_7, β_8 and β_9 which are coefficients of independent variables as follows ;

AG = Age of respondents (years)

ED= Education level of head of households (years in school)

TH= Type of houses

LS= Land size (ha)

$YD_=$ =Yield (kg/ha)

TCS=type of cropping systems

AGTP = Age of jatropha tree (year planted)

PJS = Price of jatropha seed (Tshs/kg)

MK = Market (buyer)

According to Gujarati (1995) in estimating liner and non-linear regression models, Ordinary Least Squares Estimation (OLSE) technique is commonly used as it is appropriate for single equation models. According to Gujarati (1995), the technique requires the selection of a population parameter estimator such that the ordinary sum of

squares errors is minimized. The errors are defined as the difference of the observed values; say Xi- E(Xi). By OLS the assumption is that the expected values of random error, E(U)=0. The technique is simple to use, eloquent, gives the best estimator, it does not require the knowledge of the probability distribution of the underlying population being studied, and it leads to Best Linear Unbiased Estimator (BLUE), and hence this accounts to its popularity in applied econometric. It is asserted by Jaume and Ortun (2003) that a positive sign on a parameter indicates that the associated variable has a positive effect on efficiency and a negative sign indicates a negative effect.

In regression, the coefficient of determination (R^2) is the percentage of the total sum of squares mean; the regression sum of squares divided by the total sum of squares. Where as Adjusted R^2 is an attempt to correct the weakness of R^2 by adjusting both the numerator and the denominator by their respective degree of freedom (Bollerslev, 1986). Whenever R^2 is greater than 50%, then the factors in the regression model have been explained well (Wooldridge, 2000).

3.8 Problem of parameter estimation

Regression equations are associated with a number of problems depending on the type of data used, and the nature and form of regression employed in the analysis. Under normal circumstances the common problems encountered in regression analysis include heteroscadasticity, multicolinearity and autocorrelation. Heteroscadasticity – indicates uneven distribution of error term; and multicolinearity describes a situation in which one or more independent variables are highly correlated. As Greene (2000) points out, it is a rule of thumb that a Variance Inflation Factor (VIF) of 5 or greater, or if condition number (CN) is greater than 20 –then this indicates severe multicolinearity. As Bollerslev (1986) explains, autocorrelation problem is often found in time series data,

where values of the dependent variables relate to their previous values. The rule of thumb for this is; if $0 < DW < 4$ – there is no autocorrelation problems.

Where; DW = Durbin – Watson

In this study, however, the expected regression problems are heteroscadasticity and multicolinearity. An Autocorrelation problem was not expected as it is often found in time series data.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the results, discussion, and findings of the study. It is divided into five sections. The first section presents and discusses the socio-economic characteristics of farmers. Included in this section are household characteristics and livelihoods indicators. The second section discusses the impact of jatropha on food security. The third and fourth sections comprise of economic uses of jatropha. Included in this section is the analysis of the income and profit margins earned of jatropha production. The fifth section presents the assessment of factors that determine income from jatropha.

4.2 Socio-economic characteristics of the study areas

4.2.1. Household characteristics

4.2.1.1 Sex of the head of a household

During the study a total of 260 households were surveyed in both Engaruka and Mpanda. The results show that in Engaruka and Mpanda 92% and 99% respectively of the households producing jatropha are male-headed (Table1). The results indicate further that female-headed households, which were non jatropha famers, were 38% in Engaruka while in Mpanda no households were female-headed. Furthermore, the overall results indicate that about 23% of the households were headed by women in Engaruka, which is by far a large proportion compared to that of Mpanda. This is because many husbands in Engaruka work as pastoralists and therefore are forced to move to other villages in search of pasture.

Table 1: Socio-economic characteristics of heads of household

Study sites	Engaruka			Mpanda		
Variable measured (%)	**Jatropha farmers (n=60)**	**Non jatropha famers (n=60)**	**All respondents (N=120)**	**Jatropha famers (n=70)**	**Non jatropha famers (n=70)**	**All respondents (N=140)**
Sex						
Male headed	92.0	62.0	77.0	99.0	100	99.0
Female headed	8.0	38.0	23.0	1.0	0.0	1.0
Marital status						
Married	90.0	73.0	82.0	90.0	100	95.0
Single	8.0	20.0	14.0	10.0	0.0	5.0
Widow	2.0	7.0	4.2	0.0	0.0	0.0
Age of respondent						
18-35 yrs old	40.0	22.0	31.0	31.0	59.0	45.0
36-45 yrs	40.0	38.0	39.0	27.0	27.0	27.0
46-60	17.0	25.0	21.0	27.0	11.0	19.0
>60	3.0	15.0	9.0	14.0	3.0	9.0
Education level						
Primary	47.0	50.0	48.0	86.0	86.0	86.0
Secondary	0.0	2.0	1.0	4.0	1.0	3.0
Adult	0.0	10.0	5.0	0.0	0.0	0.0
No school	53.0	38.0	46.0	10.0	13.0	11.0

4.2.1.2 Marital status

In this study, marital status was categorized as married, single, and widow. Marriages comprise both formal and informal. The results in Table 1 indicate that in both Engaruka and Mpanda, 90% of jatropha famers were married. The ratio is high because firstly, naturally in Africa marriage is a formal way of life and the rest is exceptional. Secondly, since married couples have family obligations such as taking care of the family, they get engaged in jatropha production to generate income and food. According to Sibuga and Lazaro (2004), the marital status of the head of the household influences the resource owned by the household and the capacity to work on the farm. Generally, a single person tends to have less own labour as compared to couples.

4.2.1.3 Age of respondent

The age distribution shows that 45% of the respondents were aged between 18-35 years, while those aged between 36-45 years accounted for 27% (Table 1). Further, the results indicate that the respondents aged between 46-60 years accounted for 19%, while old respondents aged above 60 years accounted for only 9% in Mpanda district. In Engaruka ward the age distribution shows that 31% of the respondents were aged between 18-35 years, whereas those aged between 36-45 years were 39%. In addition, the respondents aged between 46-60 years accounted for 21%, while the respondents aged above 60 years accounted for only 9%. According to FAO (2004), the age of the household head is related to the knowledge and experience of the person. Further, a study conducted by Zoungrana and Temu (1997) in the central zone of Tanzania showed that old members of the household had more local knowledge related to agricultural practice than young members. These results reveal that jatropha farming is mostly practiced by economically active age of between 18-60 years of age. Therefore, there is a possibility of introducing new innovations and increase production of jatropha in Tanzania.

4.2.1.4 Level of education

The results in Table 1 show that education level was very low in both study areas as majority completed standard seven only. Comparing the two study areas the literacy level was relatively higher in Engaruka than Mpanda. This implies that most of jatropha farmers in Engaruka are not educated, thus it might be difficult to implement new innovations easily. According to the TFNC (1988), the level of education has an effect on the capacity of utilizing various means of crop production and inputs to ensure stable food security at a household level.

4.2.1.5 Household size

The average household size in Engaruka was 7.5 persons per household of jatropha farmers while households of non jatropha farmers had 6.2 persons per household (Table 2). In Mpanda, jatropha farmers had an average of 8.1 persons per household whereas non jatropha farmers constituted of an average of 4.8 persons per household. The overall average household size in the two study sites is higher for jatropha farmers (7.5 and 8.1) compared to the average household sizes of 6.2 and 4.8 persons per households of non jatropha farmers. According to URT (2003), the national average household size was 4.9. That is, the overall average household size of jatropha farmers was higher than the national average household size. In all the study sites, the overall number of people per household ranged from 1 to 22 persons.

Table 2: Percentage of respondents by average household size

Study sites	**Engaruka**			**Mpanda**		
item	Jatropha farmers (n=60)	Non jatropha farmers (n=60)	All respondents (N=120)	Jatropha farmers (n=70)	Non jatropha farmers (n=70)	All respondents (N=140)
Minimum	1.0	1.0	1.0	2.0	2.0	2.0
Maximum	22	21.0	22	20	12	20
Mean	7.5	6.20	6.8	8.11	4.84	6.47
Standard deviation	4.5	3.52	4.12	3.60	2.19	3.39

Proportional wise, Mpanda has a large number of jatropha farmers (32.9%) declared to have household size of 7-8 persons per household compared to those jatropha farmers declared to have 7-8 persons per household in Engaruka (18.3%) (Table 3). Since the

size of household and age composition determine household labour availability and dependency ratio (as noted earlier in Table 2), it is can be concluded that the study areas have enough labour required to produce jatropha.

Table 3: Percentage of respondents by household sizes

Study sites	Engaruka			Mpanda		
Household size	Jatropha farmers (n=60)	Non jatropha farmers (n=60)	All respondents (N=120)	Jatropha farmers (n=70)	Non jatropha farmers s(n=70)	All respondents (N=140)
<3	1.7	6.7	4.2	2.9	17.1	10.
3-4	28.3	20	28.3	10	25.7	27.9
5-6	23.3	40	60	18.6	41.4	57.9
7-8	18.3	11.7	75	32.9	11.4	80
>8	28.3	21.7	100	35.7	4.2	100

4.2.2. Livelihoods indicators

4.2.2.1 Land possession

Table 4 shows that the average land size owned by jatropha farmers in Mpanda is 8.4 acres which is quite high compared to that of non jatropha farmers which amounts to 2.9 acres. The standard deviation of jatropha farmers is 13.4 acres which is by far large than that of non jatropha farmers amounting to 1.6 acres in Mpanda. The average land size owned by jatropha farmers in Engaruka is 2.9 acres as opposed to that of non jatropha farmers which is slightly lower (2.5 acres). The average land size owned by farmers in Engaruka is less than 2.7 acres compared to that of farmers in Mpanda (5.7 acres). The larger farm holdings of jatropha famers in Mpanda is attributed to the fact that 12.9% cleared new land for the expansion of jatropha production while many people in Egaruka are livestock keepers and therefore most of the land is allocated for grazing pastures than farming (Table 5). The results also show that none of the farmers in

Engaruka cleared their land for the expansion of jatropha production, nor replaced their own cultivated land by jatropha cultivation. This is because jatropha cultivation in Engaruka is through hedge (fence). In addition in Mpanda 87.1% of famers planted jatropha in their own cultivated land.

Table 4: Percentages of respondents by average land size (acres) owned

Study sites	**Engaruka**			**Mpanda**		
Land size	jatropha farmers (n=60)	Non jatropha farmers (n=60)	All respondents (N=120)	Jatropha farmers (n=70)	Non jatropha farmers (n=70)	All Respondents (N=140)
Minimum	0.5	0.5	0.5	1.0	0.5	0.5
Maximum	12	20	20	80	7.5	80
Mean	2.9	2.5	2.7	8.4	2.9	5.7
Standard deviation	2.3	2.7	2.5	13.4	1.6	9.9

Table 5: Percentage of type of land increase by respondents ratios

Types	Mpanda (n=70)	Engaruka (n=60)
Cleared land	12.9	0.0
Planted jatropha on their own cultivated land	87.1	0.0

Modes of land acquisition of jatropha farmers in the study areas vary (Table 6). The results indicate that among jatropha farmers, 48.3% and 98.6 %, in Engaruka and Mpanda respectively got land free. Very few jatropha farmers in Mpanda (1.4%) had land by lease. Further, none of the jatropha farmers in Mpanda had land which is from community or by rent.

Table 6: Percentage of jatropha farmers by mode of land acquisition

Land acquisition type	Engaruka (n=60)	Mpanda (n=70)
Inherited	48.3	98.6
Purchased	30.0	1.4
Allocated by village Government	18.3	0.0
Hire	3.3	0.0

Since the mode of land acquisition is considered as a critical production factor that determine the type of crop grown and the size of harvests, the mode of land acquisition is therefore expected to play a significant role in influencing livelihoods' of farmers.

4.2.2.2 Houses

Majority of respondents in Engaruka (87.5%) live in the houses made of simple mud walls with thatched roofing compared to those in Mpanda (59.3%) (Table 7). Approximately 12 % of jatropha farmers and 6.7% of non jatropha farmers in Engaruka have their houses made of mud and roofed with iron sheet. In Mpanda, among the jatropha farmers 50% have their houses made of mud and roofed with iron sheet compared to 17% of the non jatropha farmers. This indicates that jatropha income contributed to the household income resulted farmers development.

Table 7: Percentage of respondents by type of house

Study sites	Engaruka			Mpanda		
Item	Jatropha farmers (n=60)	Non jatropha farmers (n=60)	All respondents (N=120)	Jatropha farmers (n=70)	Non jatropha farmers (n=70)	All respondents (N=140)
Type of houses						
A	1.7	5	3.3	8.6	5.7	7.1
B	11.7	6.7	9.2	50	17.1	33.6
C	86.7	88.3	87.5	41.4	77.1	59.3

Note: The variable of the type of houses is defined as follows: 'A' is brick wall, tiled or iron sheet roof, 'B' is mud walls roofed with iron sheet, and 'C' is simple mud walls with thatched roof.

4.2.2.3 Livestock

Table 8 presents the average numbers and values of livestock of the respondents in the study areas. The average number of indigenous cattle kept by non jatropha farmers (11.6) is by far higher than that kept by jatropha farmers (7.9) in Engaruka. This can be explained by the fact that in Engaruka, non jatropha farmers are more engaged in livestock keeping whereas jatropha farmers prefer farming. Further, the average number of indigenous cattle of jatropha famers (27) is by far higher than that kept by to non jatropha farmers (2) in Mpanda. The small ratio of indigenous cattle owned and the land size owned (Table 4) by non jatropha farmers are an indication that, non jatropha farmers concentrate more in other business than they do in agriculture. Regarding livestock value, it is clear that there is no significant difference on the average values of indigenous cattle of jatropha farmers (Tshs 186 744/LUs) from that of non jatropha farmers in Engaruka (Tshs 189 677/LUs). In Mpanda, the average value of indigenous cattle of jatropha farmers was Tshs 227 273/LUs while for non jatropha farmers the

average value of indigenous cattle was Tshs 350 000/LUs. This implies non jatropha farmers know that the value of their indigenous cattle capture high market price.

The average value of indigenous goat of jatropha farmers (Tshs 26 228/LUs and 26 806/LUs) is low compared to that of non jatropha farmers (Tshs 30 453/LUs and Tshs 28 684/LUs) in the two study sites. This indicates that non jatropha farmers conduct better business of indigenous goat than is the case with jatropha farmers. Further, the average numbers of poultry kept by jatropha farmers (10.4 and 12.6) is bigger than that kept by non jatropha farmers (8.4 and 10.4) in Engaruka and Mpanda. This implies that jatropha famers are more interested in keeping poultry as one of the sources of income to their households.

Table 8: Percentage of respondents by average value of livestock

Study sites	Engaruka		Mpanda	
Item	Jatropha farmers (n=60)	Non jatropha farmers (n=60)	Jatropha farmers (n=70)	Non jatropha farmers (n=70)
Number of indigenous cattle				
Mean	7.9	11.6	27	2
Standard deviation	7.8	35.3	30.3	0
Value of indigenous cattle				
Mean	186 744	189 677	227 273	350 000
Standard deviation	70 769	759 59	95 822	0.0
Number of exotic cattle				
Mean	1	3	1.6	1
Standard deviation	0	0	0.9	0
Value of exotic cattle				
Mean	300 000	200 000	400 000	600 000
Standard deviation	0.0	0.0	212 132	0.0
Number of oxen				
Mean	0.0	4	24	0.0
Standard deviation	0.0	0	22.6	0.0
Value of oxen				
Mean	0.0	400 000	500 000	0.0
Standard deviation	0.0	0.0	141 421	0.0
Number of indigenous goats				
Mean	183	14	6.8	4.4
Standard deviation	19.4	22.3	6.3	2.4
Value of indigenous goats				
Mean				
Standard deviation	26 228	30 453	26 806	28 684
Number of exotic goats	6 889	17 881	6,985	8 138
Mean	0.0	0.0	2.1	0.0
Standard deviation	0.0	0.0	1.2	0.0
Value of exotic goats				
Mean	0.0	0.0	103 077	0.0
Standard deviation	0.0	0.0	29 548	0.0
Number of sheep				
Mean	15.9	9.2	8.7	0.0
Standard deviation	24.5	10.6	4.2	0.0
Value of sheep				
Mean	31 415	29 205	23 333	0.0
Standard deviation	35 881	17 880	7 638	0.0
Number of pig				
Mean	0.0	0.0	2.7	4.3
Standard deviation	0.0	0.0	3.2	3.8
Value of pig				
Mean	0.0	0.0	44 778	72 143
Standard deviation	0.0	0.0	11 745	45 447
Number of donkey				
Mean	3.4	3	0.0	0.0
Standard deviation	2.4	1.4	0.0	0.0
Value of donkey				
Mean	44 000	46 667	0.0	0.0
Standard deviation	5 477	20 656	0.0	0.0
Number of poultry				
Mean	10.4	8.4	12.6	10.3
Standard deviation	9.1	8.1	9.9	5.4
Value of poultry				
Mean	6 182	4 357	4 844	4 786
Standard deviation	6 694	2 648	1 204	3 236

4.2.2.4 Other assets owned by household

Apart from the assets indicated in the previous sub-sections the other assets owned by households at the study areas include radios, bush knives, hand hoes, mobile phones, and televisions. Others were motorbikes, bicycles, tractors, and solar panels. The results show that 9% of jatropha farmers in Engaruka and Mpanda owned radios, bush knives and hand hoes. The results further indicate that 10% and 5% of jatropha farmers in Engaruka owned a radio and a bicycle only. Having a radio, is an indication that famers need news and intertwinement

4.2.2.5 Access to information regarding agriculture

The results in Table 9 indicate that, fellow farmers play a role in the provision of information to famers in both Engaruka (64.2%) and Mpanda (25.7%). The results further indicate that extension officers play a key role in disseminating information to famers in Mpanda (74.3), whereas none of the extension officers provided information to Engaruka farmers. This might be explained by the reason that extension officers don't play their role in disseminating information to famers in Engaruka without motivation and facilitation.

Table 9 Percentage of respondents by means of information

Study sites	**Engaruka**			**Mpanda**		
Means of information	Jatropha farmers(n=60)	Non jatropha farners (n=60)	All respondents(N=120)	Jatropha farmers (n=70)	Non jatropha farmers(n=70)	All respondents (N=140)
Fellow farmers	73.3	55	64.2	56.4	87.1	25.7
Extension officers	0.0	0.0	0.0	43.6	12.9	74.3
Community based organization	20	45	32.5	0.0	0.0	0.0

4.3 The impact of jatropha production on food security

4.3.1 Status of food security in study areas

During the study, food security was regarded as having a sufficient supply of staple food. The main staple food in the study areas is maize. Therefore, food shortage in the study areas is equal to insufficient supply of maize within the households. Table 10 shows per capita food consumption per week in kg. The results also reveal that the maximum per capita consumption in Engaruka (100kg) is higher than that of Mpanda (70kg). Since per capita consumption is influenced by household size, characteristics of household members (for example sex) and availability, it implies that Mpanda had high per capita food consumption as it had families with a high proportion of men compared to Engaruka.

Table 10: Per capita food consumption /week (kg)

Study sites / **Item**	**Engaruka**			**Mpanda**		
	Jatropha farmers(n =60)	Non jatropha farners (n=60)	All respondents(N=120)	Jatropha farmers (n=70)	Non jatropha farmers(n =70)	All responden ts (N=140)
Minimum	8	5	5	6	5	5
Maximum	100	80	100	70	60	70
Means	27	26	27	26	22	24
Standard deviation	15	16	15	14	12	13

The assessments of the number of months with food shortage during the year 2009 are presented in Table 11. The results indicate that jatropha farmers on average experienced many months (10.4 and 3.2) with food shortage compared to non jatropha farmers (8.6 and 3.1) in Engaruka and Mpanda respectively. Further, the results show that there is on

average a minimal difference in months with food insufficient between jatropha farmers and non jatropha farmers. This is an indication that jatropha farmers had limited food which might lead to little per capita food consumption.

Table 11: Percentage of respondents by years with food shortage

Study sites	Engaruka			Mpanda		
Years	Jatropha farmers(n=60)	Non jatropha farners (n=60)	All respondents(N=120)	Jatropha farmers (n=70)	Non jatropha farmers(n=70)	All respondents (N=140)
2009	10.4	8.6	9.5	3.2	3.1	3.2
2008	7.4	7.2	7.3	3.1	3.1	3.1
2007	8.9	8.3	8.6	3.3	3.1	3.2

4.3.2 Factors related to food shortage

During the study, it was learned that the price of staple food increased over the last three years (2009, 2008, and 2007). About 10% of jatropha farmers in Mpanda mentioned jatropha cultivation as one of the causes of the increase in the prices of the staple food (Table 12). In addition, jatropha farmers in Engaruka (100%) and Mpanda mentioned long drought and poor soil fertility respectively as the causes for food shortage.

Table 12: Percentage of respondents by causes of food shortage

Study sites	Engaruka		Mpanda	
Causes	Jatropha farmers (n=60)	Non jatropha farmers (n=60)	Jatropha farmers (n=70)	Non jatropha farmers (n=70)
Long drought	100	100	0.0	0.0
Poor soil fertility	0.0	0.0	90.3	100
Jatropha cultivation	0.0	0.0	9.7	0.0

4.3.3 Jatropha farming practices and food security

Based on the observation during the study, jatropha was cultivated in monoculture, fence and intercropping systems. Famers intercropped jatropha mainly with maize, beans, black beans and ground nuts. Intercropping and monoculture cropping systems were practiced mainly in Mpanda, whereas, fence system was practiced in Engaruka. The results in Table 13 show that 63% jatropha farmers in Mpanda intercropped jatropha with other food crops. The intercropping system for jatropha has positive and negative impacts on food crops. Negatively, intercropping jatropha with other crops is only for a short period when jatropha plants are still small; as jatropha grows it develops a canopy which makes it difficult for the intercropped food crops to develop. Eliminating intercropping when jatropha plants are big reduces food production leading to food insecurity. According to JPT (2007), intercrops in jatropha can be raised in between the rows for the first two years, where crops like tomato, bitter gourd, pumpkin, ash gourd, cucumber and black gram can be grown profitably. JPT (2007) points out further that when jatropha tree is three years old it develops canopy, which hinders crop growth.

The results show that 13 % of jatropha farmers in Mpanda, cleared new land to produce jatropha. In keeping with the cropping practices for jatropha, it is clear that the expansion of land would on the one hand increase food security. On the other hand, the results reveal that 37% of jatropha farmers in Mpanda cultivated jatropha in monoculture system. When cultivating jatropha in monoculture system, it means no other crops are grown on that same land. It is clear that areas which could have been used for food crop production would only be used for jatropha cultivation. The implication here is that if a jatropha farmer has no other field for food crops, and other factors such as purchasing power remain constant, this might lead to food insecurity.

Table 13: Percentage of respondents by type of jatropha farming systems

Item	Engaruka (n=60)	Mpandau (n=70)
Cleared new land	0.0	13
Replaced own cultivated land by jatropha	0.0	87
Monoculture	0.0	37
Intercropping	0.0	63
Hedge	100	0.0

4.3.4 Copping strategies during food shortage

The strategies to cope with food shortage problem are presented in Table 14. The results reveal that 100% of jatropha farmers in Engaruka cope with food shortage through food aid, whereas the copping strategy used by among the jatropha farmers (64%) in Mpanda was through buying food. The other copping strategy used by jatropha farmers (29.4%) in Mpanda was borrowing food, followed by selling of assets (5.9%).

Table 14: Percentage of respondents by food shortage copping strategies

Study sites	Engaruka			Mpanda		
copping strategies	Jatropha farmers (n=60)	Non jatropha farmers (n=60)	All respondents (N=120)	Jatropha farmers (n=70)	Non jatropha farmers (n=70)	All respondents (N=140)
Food aid	100	100	100	0.0	0.0	0.0
Gifts	0.0	0.0	0.0	0.0	1.6	1.0
Sale of asset	0.0	0.0	0.0	5.9	0.0	2.0
Borrowing	0.0	0.0	0.0	29.4	3.1	12.2
Buying food	0.0	0.0	0.0	64.7	95.3	84.7

4.4 Contribution of jatropha to total households income

The results from study reveal that the total land under jatropha production were 50 hectors in Engaruka and in Mpanda 41ha hectors . The study results also showed that during year 2009 the total yield of jatropha were 10449kg/ha in Engaruka and in Mpand 1492kg/ha

Table 15 showed that in the study sites the sources of household income were livestock, maize, black beans, beans and ground nuts. The results show that the percentage of the contribution of jatropha to the total household income of jatropha farmers in Engaruka and Mpanda is 3 and 2 which is equivalent to Tshs 1 912 063 and Tshs 449 875 respectively. The jatropha contribution to the total household income is the smallest compared to other contributors including livestock, maize, black beans, beans and ground nuts. This might be because the farmers have no access to market information

which would give them better chance of getting high market price and earn high income from jatropha. In Engaruka the greatest contributor to the household income is black beans and livestock. This is because the crops are predominantly produced as cash crops.

Table 15: Percentage of respondents by sources of households income

Sites	**Engaruka**		**Mpanda**	
Income sources	**%**	**Tshs**	**%**	**Tshs**
Livestock	20	13 617 600	11	2 933 000
Maize	18	12 628 460	52	13 674 208
Black beans	59	40 497 753	-	-
Beans	-	-	14	3 605 612
Ground nuts	-	-	21	5 556 502
Jatropha	3	1 912 063	2	449 875
Total	100	68 655 875	100	26 219 197

4.5 The profit margins earned from different jatropha cropping systems

The cropping systems practiced for jatropha production in the study areas were fence, inter cropping and monoculture (Table 16). The cultivation of jatropha in a fence system is practiced in Engaruka, and the cultivation of jatropha in intercropping and a monoculture systems are practiced in Mpanda. The results show that jatropha cultivated in a fence system has a higher profit margin of Tshs 1 912 603/ha than has jatropha cultivated in an intercropping system (Tshs 298 417/ha) and a monoculture system (Tshs 151 458/ha). Further, the results show that the total yields of jatropha cultivated in a fence system is 10449 kg/ha, which is also higher compared to the total yields from jatropha cultivated through intercropping (1 492kg/ha) and monoculture systems (757 kg/ha). The reason for this is because of water retention along the jatropha faces and also around the cattle kraals due to manure. For example, in Engaruka jatropha is used as

fence in cattle kraals and farm boarders where high yield was observed.Furthermore, the results show that farmers in Engaruka sell their jatropha seeds at a maximum price of Tshs 250/kg whereas in Mpanda the maximum price is Tshs 200/ kg. This is because of differences in demand and supply in two study areas. In Engaruka there are number of buyers involved in the purchase of jatropha, for example Diligent and KAKUTE companies and famers groups where as in Mpanda there is only one buyer, the PROKON Company.

Production costs for jatropha was not a subject of investigation in this study. This is because farmers are not yet regarding jatropha as a business venture due to low returns, resulting famers paying little attention to the production of jatropha. For example pruning and harvesting (collection of seeds) are the only agronomic activities practiced in the study areas. Other production practices for jataropha such as weeding and spraying, which are also important for good productivity were not practiced. Pruning and harvesting are done by family members without involving any hired labour**.** Pruning is done by men and collection of seeds is done by female and children. So it is difficult for them to estimate the cost involved in jatropha production.

Table 16: Profit margins of jatropha from different cropping systems

Category/Cropping system	Fence	Intercropping	Monoculture
Total yearly yield (kg/ha)	10 449	1 492	757
Minimum price	100	200	200
Maximum price	250	200	200
Total return Tshs/ha	1 912 063	298 417	151 458
Production costs*			
Gross profit margin Tshs./acre	1 912 063	298 417	151 458

Note:* It was assumed that no production costs were involved in jatropha production for instance labour used in jatropha production was from family members.

4.6 Factors that determine income from jatropha

A regression model used has been based on the linear regression function as explained in Chapter Three. The results show that coefficient of determination (adjusted R^2) was 0.971, meaning that 97.1.% of variation of income from jatropha was due to the independent variables included in the regression model, whereas the other 2.9% was due to variables that are not included in the equation (Table 17). The results further show that Variance Inflation Factor (VIF) is less than 5 to all factors which indicate that the data are free from multicolinearity problem. Furthermore, the estimated coefficients for age, land size, yield, cropping system, and price are positive. This indicates that an increase in any one of them would increase the income from jatropha if other factors are held constant. Price has a positive coefficient and was significant at $P<0.01$. This means the higher the price of jatropha the higher the income. However, the coefficients of education level, the type of houses and market were negative implying that there is an indirect relationship between the dependent variable and the independent variables.

Table 17: Regression analysis

Model	Un standardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
	B	Std error	Beta			Tolerance	VIF
(Constant)	-282 385	246256.5		-1.553	0.125		
Age of head of household	132.749	64.820	0.045	2.048	0.044**	0.784	1.276
Years of school	-753.359	437.026	-0.042	-1.724	0.089***	0.640	1.562
Type of houses	-434.233	1274.613	-0.008	-0.341	0.734	0.727	1.376
Land size (ha)	2436.404	1808.374	0.029	1.347	0.182	0.816	1.225
Yield (kg/ha)	184.920	5.487	0.863	33.703	0.000*	0.574	1.742
Cropping system	8534.124	1245.014	0.204	6.855	0.000*	0.427	2.343
Jatropha age	157.551	121.943	0.027	1.292	0.201	0.854	1.171
Market	-1707.268	1424.535	-0.044	-1.198	0.235	0.278	3.599
Price (Tshs/kg)	252.437	32.539	0.291	7.758	0.000*	0.267	3.738

Note: Adjusted R square (R^2) = 0.971

* = Significant at P<0.01

** =Significant at P<0.05

*** =Significant at P<0.1

Sig. =Significance

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter presents a summary of the study findings, conclusion and recommendations from the study. The general objective of this study was to assess livelihood and economic impact of jatropha production to famers in Rukwa and Arusha Regions. Specifically, the study aimed at assessing the impact of jatropha production on food security, and the contribution of jatropha production to household income. The study further compared the profit margin earned from different jatropha cropping systems, and analyzed the factors that determine income from jatropha production.

5.2 Conclusion

i. In attempt to assess the impact of jatropha production on food security, it was hypothesized that jatropha production has no significant impact on household food security. The hypothesis was rejected because the cropping systems for jatropha cultivation have an impact on food security. Based on results, jatropha farmers in Mpanda intercropped jatropha with other food crops. The intercropping system for jatropha has negative impacts on food crops, as jatropha grows it develops a canopy which makes it difficult for the intercropped food crops to develop. Eliminating intercropping when jatropha plants are big reduces food production leading to food insecurity. In monoculture system areas which could have been used for food crop production would only be used for jatropha cultivation. The implication here is that if a jatropha farmer has no other field for food crops, and other factors such as purchasing power remain constant, this might lead to food insecurity.

ii. The assessment of the contribution of jatropha production to the total household income reveals that the hypothesis that jatropha production contributes significantly to the total household income was rejected. The reason is that the contribution of jatropha to the total household income was the smallest compared to other contributors including livestock, maize, black beans, beans and ground nuts. This might be due to the reasons that farmers in the study area do not regard jatropha as a cash crop hence production levels of jatropha in the area are low. Another reason is that jatropha farmers have no enough information on jatropha market (demand, supply, competitors and prices) which would give them motivation to produce jatropha commercially.

iii. In comparing the profit margins earned from different jatropha cropping systems, the results show that jatropha cultivated in fences have highest profit margins vis-à-vis jatropha cultivated in intercropping and monoculture systems. These results support the hypothesis that jatropha production using fences results into highest profit margin. The reason for high profit margin could be due to high quantities and quality and demand in Engaruka as compared to Mpanda.

iv. Factors that determined income from jatropha were age, education level, type of houses, land size, yield, cropping system, age of jatropha plants, price and market of jatropha. It was hypothesed that household assets are the major determinant of income from jatropha production. The hypothesis was not rejected. The reason is that the coefficient of land size showed a positive coefficient, hence it can be concluded that an increase in land size increases the income from jatropha.

5.3 Recommendations

In keeping with the major findings of the study the following recommendations are made in order to promote jatropha production in the study areas and which would then contributed to household livelihood:

i. Jatropha stakeholders should consider expansion of jatropha farms goes hand in hand with exploring market for the produce to ensure that farmers gets enough cash from jatropha to be able to buy food for the family.

ii. Farmers in the study area should regard jatropha as a cash crop so that much emphasis is put on jatropha production.

iii. Government and private sector to identify and provide training needs, extension services and accessibility to proper information on jatropha market (demand, supply, competitors and prices) to jatropha farmers.

iv. Government to improve road infrastructure to allow easy transportation of farm input and transportation of produces in jatropha farming areas.

5.4 Suggestions for future research

It is still not clear whether there is potential in jatropha production. Thus, there is need for undertaking further study on jatropha production to verify whether or not potential is only confined in the study area or it is also prevalent in other areas in Tanzania.

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APPENDICES

Appendix 1 *Jatropha* in East Africa – HH questionnaire

1. GENERAL INFORMATION

Please fill out section 1 before starting the interview.

	Date (DD/MM)	Time (HH:MM)	Completed (cross)	Not completed
1. visit	1a	2a		
2nd visit	1b	2b		

Number all printed questionnaires prior to field work using the following code:

Country Code	Area Code	Questionnaire Number
Ethiopia (ET):	01 = Bati (BA); 02 = Mieso (MI); 03 = Wolayita (WO);	001-xxx
Kenya (KE):	05 = Bondo (BO); 06 = Kibwezi (KI); 07 = Shimba Hills (SH)	001-xxx
Tanzania (TZ):	08=Arumeru (AR); 09 = Monduli (MO)	001-xxx

3. Country Code (ET, KE, TZ)_____4. Area code (01-09)_____
5. Questionnaire Number (001)_____6.Division/Woredas/Distrikte_____
7. Location:_____8. Sub-location/Kebele/Wards: _____
9. *If GPS available*: Longitude _____10. Latitude:_____
11. Altitude:_____
12. What is the distance from your house to the nearest tarmac road? _____ km
13. Nearest market_____ km

2. RESPONDENT'S DETAILS

PROVIDE THE FARMER WITH INFORMATION ABOUT THE PROJECT / QUESTIONNAIRE (separate sheet)

Respondent's Name & Contact (= normally Household Head)
Note: It is mandatory that the household head is informed about the interview and agrees to it. If possible try to arrange for the household head and the spouse to attend the interview. If the household head is not around, interview the spouse. If neither the HH head nor the spouse are available, interview household member, who is able to response (be sure that he is able). Otherwise arrange to pass by again if logistically feasible, otherwise drop household.

14. Respondent's Name_____15. Age:_____16. Gender: M / F

17. Relation to HH head_____ 18. Marital status HH head:_____

19. Gender HH head: M / F 20. Years of school:_____

21. Mobile Phone No.:_____22. Postal Address:_____

23. How many people live in your homestead? _____

24. Female >15 years:_____25.Male >15 years:_____

26. Female <15 years:_____27.Male <15 years:_____

28. Type of shelter owned by respondent. *(If more than one, please characterize the main building)*

☐ Brick walls, tiled or iron sheet roofing

☐ Consolidated mud walls, with iron-sheet roofing

☐ Simple mud walls with thatched roofing

General Comments:

3. GENERAL FARMING ACTIVITIES

29. Do you grow food crops and/or rear livestock? *(Please select only one answer)*

☐ Crops ☐ Livestock ☐ Both

30. How much land do you own and/or rent?

Description	**Size**	**Value (local currency per**
Owned land	a.	b.
Rented land	c.	d.
Others:	e.	f.

31. What is the total size of your farmland under agriculture (size in acres)?

_____

32 - 34. What are the major crops you grew, what were the respective acreage under cultivation, the yields and the usage of your crops? *(Note: If household grows less than three crops, list the crops he is growing and write zero in remaining fields!)*

Description	Name of the crop	Area under cultivation (acres)*	Production costs (labour & other inputs) (local currency/ acre)	Yield (kg/acre)	Selling (kg)
Main Crop 1	32a.	32b.	32c.	32d.	32e.
Main Crop 2	33a.	33b.	33c.	33d.	33e.
Main Crop 3	34a.	34b.	34c.	34d.	34e.

** If intercropped, list only the area of the main crop.*

35. If you cultivate more than three crops, please list the rest:

1)_____2)_____
3)_____

36. How many livestock do you keep and what is their value?

Description	Number of heads	Value (local currency per head)
Local cow	a.	b.
Exotic cow	c.	d.
Oxen	e.	f.
Local goats	g.	h.
Exotic goats	i.	j.
Sheep	k.	l.
Donkey	m.	n.
Horses	o.	p.
Pigs	q.	r.
Poultry	s.	t
Others: _____	u.	v.
Others: _____		

37. How much income did you get from selling livestock products last year?

Livestock	Product	Value (local currency/prod.)	Livestock	Product	Value (local currency/prod.)	Livestock	Product	Value (local currency/pr.)
1. Cow	Live	a.	3. Sheep	Live	g.	5. Goat	Live	l.
	Meat	b.		Meat	h.		Meat	m.
	Milk	c.		Wool	i.		Milk	n.
2. Chicken	Live	d.	4.Pig	Live	j.	6. Other		o.
	Meat	e.		Meat	k.			
	Eggs	f.						

4. *JATROPHA* FARMING

38. Do you currently grow the following energy crops and if yes, since when?

Energy Crop	Yes	No	Comments
a. Jatropha			d.
b. Castor			
c. Other: _____			

If household does <u>not grow ENERGY CROPS move to Question 110</u>, otherwise move on to next question.

39. Who introduced you to energy crops? (*Multiple answers pos sible)*

☐ Other farmers in the region started with it ☐ A biofuel company proposed to buy seeds from us

☐ Government encouraged us to plant energy crops

☐ Others*

☐ An NGO encouraged us to plant energy crops

**Specify others and provide comments:*

If household <u>does not grow JATROPHA move to Question 102</u>, otherwise move on to next question.

40. Why do you cultivate *Jatropha*? (Multiple answers possible)

☐ Rehabilitating degraded land ☐Own energy supply ☐Hedge for wind breaker/protection

☐Diversify income sources □Other reasons*

**Specify other reason:*

41	**On how many different plots do you grow *Jatropha*?** *(A plot can be a field or a hedge/fence)*	*Number (0; 1; 2; …)*			If there are more than 2 plots, chose the largest two!
42	What is the size of the plot?	*Acre (field), m (hedge/fence)*	a.	b.	c.
43	What is the land tenure system?	*a = Freehold b = Leasehold c = communal land d = Others**	a.	b.	c.*Please specify others:
44	Which cropping system have you adopted?	*a = monoculture b = intercropping c = hedge d = others**	a.	b.	c.*Please specify others:
45	…if intercropping: what crops are intercropped?	*Name of intercrop*	a.	b.	c.
46	…if intercropping: what land allocation for JC (in %) and what allocation for other crop (in %)?	*Ratio (x% JC; y % other crop)*	a.	b.	c.
47	When did you start growing *Jatropha* on this plot?	*Year*	a.	b.	c.
48	What propagation method did you use?	*A = seeds B = seedlings C = cuttings*	a.	b.	c.
49	How many trees did you initially plant on the plot? *(for hedges estimate all trees)*	*Number per total plot*	a.	b.	c.
50	How many trees are	*Number per*	a.	b.	c.

	currently on the plot? (survival) *(for hedges estimate all trees)*	*total plot*			
51	Did you have to increase the size of your farm to grow *Jatropha*?	*a = cleared own land* *b = replaced own cultivated land* *c= bought extra land* *d =rented extra land*	a.	b.	c.
52	What was the land use on this plot before you started cultivating *Jatropha*?	*food crops* (acre)*	a.	b.	c.* What food crop(s)?
		grassland(acre)	d.	e.	
		bush land (acre)	f.	g.	
		forest (acre)	h.	i.	
		degraded (acre)	j.	k.	
		Fallowed (acre)	l.	m.	
53	How many working days did you use to prepare the land for *Jatropha* cultivation (clear and plough)?	***Hired labour** (Personday per total plot area)*	a.	b.	c.**Cost of labour:*
54		***Family labour** (Personday per total plot area)*	a.	b.	
55	How many working days did it take to plant the *Jatropha* seeds/saplings/cuttings/..?	***Hired labour** (Personday per total plot area)*	a.	b.	c.**Cost of labour:*
56		***Family labour** (Personday per total plot area)*	a.	b.	
57	How many working days did you use last year to weed?	***Hired labour** (Personday per total plot area)*	a.	b.	c.**Cost of labour:*
58		***Family labour** (Personday per total plot area)*	a.	b.	
59	How many working days did you use last year to prune?	***Hired labour** (Personday per total plot area)*	a.	b.	c.**Cost of labour:*
60		***Family labour** (Personday per total plot area)*	a.	b.	
61	What is the soil type?	a = sandy b = loamy c = clay d = black cotton e = others*	a.	b.	c.* please specify others:

62	How is soil quality on *Jatropha* plots as compared to other parts of your farm?	a=good b=same c=poor	a.	b.	c.
63	Did the soil quality and fertility change on these plots since you started growing *Jatropha*?	a= improved b=stayed the same c=decreased	a.	b.	c.
64	**Fertilizer 1:** What kind of mineral fertilizer is used for *Jatropha* cultivation? *(write "0" if none is used)*	*Name of fertilizer*	a.	b.	c. If only fertilized during the first year, comment!
65		*Amount (kg /plot / year)*	a.	b.	
66		*Personday per year*	a.	b.	
67		*Cost (local currency / kg)*	a.	b.	
68	**Fertilizer 2:** What kind of mineral fertilizer is used for *Jatropha* cultivation? *(write "0" if none is used)*	*Name of fertilizer*	a.	b.	c. If only fertilized during the first year, comment*!*
69		*Amount (kg / plot / year)*	a.	b.	
70		*Personday per year*	a.	b.	
71		*Cost (local currency / kg)*	a.	b.	
72	What pests and diseases did you encounter in the field?	*A = red spider mite* *B = golden beetle* *C = fungus* *D= powdery mildew* *E = leaf spotting* *F = others**	a.	b.	c.*please specify others
73	**Pesticide 1:** What kind of pesticide did you apply on your *Jatropha* plantations? (write "0" is none is used)	*Name of pesticide*	a.	b.	c.
74		*Amount (kg /plot / year)*	a.	b.	
75		*Personday per year*	a.	b.	
76		*Cost (local currency / kg)*	a.	b.	
77	**Pesticide 2:** What kind of pesticide did you apply on your *Jatropha* plantations? (write "0" is none is used)	*Name of pesticide*	a.	b.	c.
78		*Amount (kg /plot / year)*	a.	b.	
79		*Personday per year*	a.	b.	

80		*Cost (local currency / kg)*	a.	b.	
81	**Machinery / Plough:** What machinery do you use for *Jatropha* cultivation? (i.e. tractor)	*Type of machine**	a.	b.	c. * *state if oxen ploughing is used!*
82		*hours per year*	a.	b.	
83		*Cost (local curr. / day)*	a.	b.	
84	**Irrigation:** How many times do you irrigate per year? (write 0 if not irrigated)	*Number of months*	a.	b.	c. *If only irrigated during the first year, comment!*
85		*Frequency per month*	a.	b.	c.* *amount of irrigated water (m3/plot/month):* _____
86		*Costs to set up irrigation (local curency)*	a.	b.	
87		*Cost to run / maintain irrigation (local currency)*	a.	b.	
88	What irrigation technique did you use?	*a = drip b = spraying c = flooding d = others**	a.	b.	c.**please specify others*
89	How may times did you harvest seeds last year? Yield 2009 (de-husked)	*a = Once** *b = Twice** *d = More** *e = Never*	a.	b.	c.*Specify "more": * In which months?
90	How many person days did you spend to harvest the seeds last year?	***Hired labour** (Personday per total plot area)*	a.	b.	c.**Cost of labour:*
91		***Family labour** (Personday per total plot area)*	a.	b.	
92	**Yield 2009:** □ husked □ de-husked *(a husk covers usually 3 black seeds)*	*kg / plot*	a.	b.	If possibly fill out the yield per plot (field or hedge) and per tree, if not possible at least one!
93		*kg / tree*	a.	b.	
94	**Yield 2008:** □ husked □ de-husked	*kg / plot*	a.	b.	
95		*kg / tree*	a.	b.	
96	**Yield 2007:** □ husked □ de-husked	*kg / plot*	a.	b.	
97		*kg / tree*	a.	b.	

98. Is there a change in the work load after you started cultivating *Jatropha* compared to before?

☐Increased*

☐Stayed the same

☐Decreased*

**What are the reasons for the change in workload?*

99. Since you started harvesting *Jatropha* seeds to sell them, did you always find buyers?
one answer possible)

(Only ☐Yes ☐No

100 - 102. How many kg seeds did you sell at what price?

Year	Amount (kg/year)	Husked	De-husked	Price (local currency/kg)	Comments
2009	a.	b.	c.	d.	e.
2008	a.	b.	c.	d.	e.
2007	a.	b.	c.	d.	e.

103 a. Are you satisfied with the price of seeds?

☐Yes ☐No*

*b.*If no, what would be the appropriate price in your opinion? (Local currency):*

_____

104 a. To whom are you mainly selling *Jatropha seeds or products*?

☐Farmers ☐Company* ☐Government

☐Traders (regular) ☐Agents (irregular) ☐Exporters

☐Others*

*b.*Please specify the name of the company and others. Also indicate how you trade.*

5. CAPITAL ASSETS

105. Which of the following items does your household own? *(Multiple answers possible)*

☐Car ☐Plough ☐Mobile phone

☐Tractor ☐Television ☐Water tank

☐Motor cycle ☐Satellite dish ☐Bicycle

☐Radio ☐Solar panel/dish ☐Others*

*Please specify others:

106. Do you have the following financial assets?

☐Support from children (e.g. in town or abroad) ☐Savings ☐Money from credits

6. OFF FARM ACTIVITIES

107. Do you have any of the following sources of off-farm income?

Source of income	**Frequency /yr**	**Income (Local currency per period)**	**Comment**
Salary from employment	a.	b.	
Salary from business	c.	d.	
Salary as agricultural worker	e.	f.	
Salary from public work	g.	h.	
Remittances from family/ friends	i.	j.	
Income from sale of charcoal	k.	l.	
Income from renting land	m.	n.	
Other (Specify):_____	o.	p.	q.

7. FOOD PRODUCTION/CONSUMPTION

108. What is your most important staple food?

109. How much of this staple food do you need per week to feed your family? (kg/week) _____

110 a. Has the price of staple food changed over the last 3 years?

☐Increased* ☐Stayed the same ☐Decreased*

*b.*If there was an increase/decrease in the last 3 years: What are the likely causes of changes in price of this staple food?*

111 a. Do you think *Jatropha* production in the area had an impact on the food prices?

☐Yes* ☐No ☐**Not sure**

b. If yes, give reasons how Jatropha influences food prices.*

112 - 114. How many months of food shortage did your household experience in the last 3 years?

Year	Number of months with food shortage	Comment
2009	a.	b.
2008	a.	b.

115 - 117. What were the main causes for shortage in each year? (Insert codes

below)

Year	Cause	Comment
2009	a.	b.
2008	a.	b.
2007	a.	b.

Codes:
a = weather (drought, ...)
b = propagation of energy crops like *Jatropha*
c = poor quality of seeds
d = lack of land*
e = lack of on-farm labour*
f = conflicts
g = damage
from wildlife
h = illness
I = others

**If d or e, please ask if lack of labour or land is related to Jatropha cultivation:*

118. How do you cope with food shortage? *(Multiple answers possible)*

☐Food aid ☐Sale of assets ☐Borrowing

☐Gift ☐Migrate ☐Others

**Please specify others:*

8. ENERGY SECURITY

119. Please rank these energy sources according to their importance for your household?
1= very important, than decreasing importance. Writeot used)
(rank, 0 if not used)

☐*Jatropha* oil ☐*Jatropha* diesel ☐Gas (butane/propane)

☐Kerosene ☐Diesel/Petrol ☐Batteries

☐Firewood ☐Charcoal ☐Solar Energy

☐Electricity ☐Other (please specify):_____

120. How much of the following fuels do you consume, for what purpose and how accessible are they?

(Only ask for the fuels indicated in the previous question!)

Energy source	**Amount (unit per time period)**	**Costs (local currency per unit)**	**Purpose 1: lightning, 2: cooking, 3: heating, 4: transport, 5: communication, 6: production, 7: others**	**Access (distance in km)**	
Jatropha oil	a.	**Litres /week**	b.	c.	d.
Jatropha diesel	e.	**Litres /week**	f.	g.	h.
Kerosene	i.	**Litres /week**	j.	k.	l.
Diesel/Petrol	m.	**Litres /week**	n.	o.	p.
Gas(butane/propane)	q.	**Cylinders/month**	r.	s.	t.
Firewood	u.	**Loads/week**	v.	w.	x.
Charcoal	y	**Bags/week**	z.	Za.	Zb.
Electricity	Zc.	**Local currency/ month**	Zd.	Ze.	Zf.
Batteries	Zg.	**Local currency/ month**	Zh.	Zi.	Zj.
Others:	Zk.		Zl.	Zm.	Zn.

121. Could energy from *Jatropha* in your opinion play a role to cover the local energy needs?

☐Yes* ☐No*

**Why do you think so?*

9. COMMUNITY

122 a.How do you get information on farming and on *Jatropha* farming? *(Multiple answers possible)*

☐Other Farmers ☐Extension officer

☐Community based organization ☐Radio / TV

☐Local authorities / local leaders ☐Others*

*b.*Please specify others:*

123 a. Are you a member of a farmers' association or community based organization?

☐Yes* ☐No

*b.*If yes, please specify what type of association:*

124. What are the main changes that took place in the local community since *Jatropha* is grown in the region?

125. What challenges do you face in growing and selling *Jatropha*?

126. What in your opinion can be done to deal with the challenges?

127. Is there any additional information you'd like to provide us with?