ECONOMIC POTENTIAL OF BIODIESEL PRODUCTION: A CASE OF SMALL SCALE FARMERS IN MERU AND MONDULI DISTRICTS IN ARUSHA REGION, TANZANIA

BY

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ABSTRACT

Tanzania is among the countries which depend entirely on imports for their crude oil requirements. This dependence on imported oil requires a lot of foreign currency. This dependence on imported crude oil necessitates looking for alternative sources of energy. The present study aims to assess the economic potential of biodiesel production among small scale farmers. The study was conducted in Arusha region, in northern Tanzania. Two Districts namely: Meru and Monduli were purposely selected basing on jatropha production in these areas. A cross sectional survey was conducted to collect primary data from 120 households. Secondary data were secured from Meru and Monduli Districts, SNAL and internet sources. Descriptive and quantitative analytical techniques were used. The findings show that the profit accrued from Jatropha production was the smallest compared to other crops in the study area. Black bean has the largest margin, followed by coffee, maize, beans, banana, and lastly Jatropha. Cattle contribute 78% while 9.1% from goats and sheep and 3.8% from chicken to the household income. The factors such as extension services and price influence profitability of Jatropha production and were statistically significant ($P<0.01$). The smallest of costs of producing biodiesel by using Jatropha as a feedstock is TZS 1469 to be competitive with landed oil price of TZS 1120 per litre. The current landed oil prices of around TZS 1120 a litre requires biodiesel production costs to be around TZS 1469 a litre for the production of biodiesel to be profitable in the country. This study recommends Jatropha production on contour and fences.

DECLARATION

I, **BOAY DAHAYE,** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and it has not been concurrently submitted for degree award in any other institution.

16/11/2010

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Date

The declaration is confirmed.

16/11/2010

Dr. D. Philip
(Supervisor)

Date

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I make a special dedication of my thesis to my beloved Uncle Peter P. Mao and his lovely wife Basilisa Mao, who put the foundation stone of my education and who brought me to this level. May Almighty God bless them and work of their hands. Amen.

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ABBREVIATIONS AND ACRONYMS

BIA:	Bioenergy in Africa
FAAP:	Framework for African Agricultural Productivity
FAO:	Food and Agriculture Organization
FOB:	Free on Board
GDP:	Gross Domestic Product
GHG:	Green House Gases
GM:	Gross Margin
GJ:	Giga Joules
Ha:	Hectare
IFPRI:	International Food Policy Research Institute
hp:	Horse power
IFAD:	International Fund for Agricultural Development
IMF:	International Monetary Fund
IRR:	Internal Rate of Return
JPTL:	Jatropha Products Tanzania Limited
KAKUTE:	*Kampuni ya Kusambaza Teknolojia*
Kg:	Kilogram
Km:	Kilometre
KSH:	Kenyan shillings
kW:	Kilowatt
MAFSC:	Ministry of Agriculture Food Security and Cooperatives
M:	Metre
mm:	Millimetres
NPV:	Net Present Value

OPEC:	Organisation of the Petroleum Exporting Countries
pH:	Potential hydrogen
REPOA:	Research on Poverty Alleviation
RISE:	Research Institute for Sustainable Energy
RLDC:	Rural Livelihoods Development Company
ROI:	Return on Investment
SDC:	Swiss Agency for Development and Cooperation
SNAL:	Sokoine National Agricultural Library
SPSS:	Statistical Package for Social Science
TaTEDO:	Tanzania Traditional Energy Development and Environment Organization
TR:	Total Revenue
TVC:	Total Variable Costs
TZS:	Tanzanian shillings
UN:	United Nations
URT:	United Republic of Tanzania
USH:	Ugandan Shillings
US$:	United States Dollars
US:	United States
WWF:	World Wide Fund for nature

CHAPTER ONE

BACKGROUND TO THE STUDY

1.1 Introduction

Tanzania is among the countries which depend entirely on imports for their crude oil requirements. This dependence on imported oil requires a lot of foreign currency in order to fulfil these requirements. The country burns its currency for buying oil to run its industries and machineries. This makes the country to set aside huge budgets for oil instead of using that money for other economic development activities. Mngodo (2008) pointed out that, the crude oil is dominated by unpredictable prices at the world market. This has created insecurity and uncertainty in the sectors that entirely depend on them and has significant impact on the overall performance of the economy. According to Songela (2008) the promotion of biofuels had started in Tanzania with focus to improve energy security in order to reduce oil imports and foreign exchange savings.

The country is looking for alternatives to diesel and petrol as sources of energy mainly because it has no proven reserves and also due to the rapid increase of crude oil prices. One of the most talked about alternatives is biofuel production. Large areas of the land in the country are being identified and evaluated for their suitability for growing crops for agro-fuel production including Palm oil, Jatropha and others. This alternative source of energy will provide energy security in the country (Isidro *et al*., 2009). Therefore the focus of the present study is to evaluate the potential of producing biodiesel as an alternative source of energy and income to small scale farmers.

Biodiesel is monoalkyl ester of long chain fatty acids produced from the Trans-esterification reaction of vegetable oil with alcohol in the presence of catalyst and can be used as fuel (Mahindra, 2008). Muok and Källbäck (2008) explained biodiesel as a liquid substitute for petroleum based diesel fuel made using vegetable oil derived from a wide variety of oil bearing plants such as castor (*Ricinus communis*), coconut (*Cocos nucifera*), croton (*Croton megalocarpus*), Jatropha (*Jatropha curcas*), rapeseed (*Brassic napus*) and sunflower (*Helianthus annuus*). Waste vegetable oil can also be used for biodiesel production. Unlike ethanol, which has several markets aside from energy, biodiesel's only use is as an alternative and renewable source of fuel for transport and stationary power. The production of biodiesel involves crushing seeds to extract the oil and then converting this vegetable oil into fatty acids. The fatty acids are subsequently converted to methyl or ethyl esters directly using an acid or base to catalyze the reaction. They are normally blended with diesel (Ejigu, 2008).

The study conducted by WWF (2009) pointed out that the potential crops for use as feedstocks for biofuels production are Jatropha, palm oil, *Croton megalocarpus*, sugarcane and sweet sorghum. Some of the crops that are being harnessed for biofuel production in Tanzania include coconuts, Jatropha; sugarcane, wheat, cassava and sunflower (Nairobichronicle, 2008). According to SDC (2007) biofuels are mainly produced from feedstocks with high sugar or starch content, or from plants yielding oil. These feedstocks include sugarcane (*Saccharum officinarum*), maize (*Zea mays*), sugar beet (*Beta vulgaris*), rapeseed (*Brassic napus*), palm (*Chrysalidocapus lutescans*), soy (*Glycine max*), Jatropha (*Jatropha curcas*) and palm oil (*Elaeis guineensis*). The focus of this study is particularly on Jatropha feedstock as a raw material for producing biodiesel. The choice of the crop is based on the fact that it can tolerate harsh conditions and therefore it is not likely to compete with food crops which are mostly grown in high potential areas.

Biodiesel production from Jatropha has been considered for partial substitution of diesel fuel for transportation and other activities. It is one of the important renewable energy sources being promoted in the world. Jatropha oil has been considered as a prospective feedstock for biodiesel production, particularly due to the possibility of cultivation in dry and marginal lands (Traore and Thiam, 2006).

There is increasing interest in biodiesel production due to its use as an alternative to fossil fuels. Jatropha was mainly favoured due to its high potential for biodiesel feedstock production. The oil content of Jatropha seeds is high and ranges between 30 - 40% and a productivity of 1892 litres or 1590 kg of oil per hectare (Abienwi, 2008). Biodiesel production from Jatropha has been considered for partial substitution of diesel fuel for transportation and other activities. According to Philip (2007) Jatropha has gained a high attention to farmers who cultivate this crop as a living fence with no other economic uses. The main attraction to farmers is the assurance of market of Jatropha seeds which are used as feedstock for biodiesel production. Therefore, it is due to this potential Jatropha was selected as a substitute source of energy and income for small scale farmers.

1.2 Problem Statement and Justification

Biofuels have assumed significant importance globally as the world addresses changing patterns in energy supply and demand. Growing world energy demand, the insecurity of long term supply and the consequences of fossil fuel use for climate change are driving governments to look for alternative sources of energy (Muok and Källbäck, 2008). According to WWF (2009) the potential feedstocks for biofuels production are Jatropha, palm oil, *Croton megalocarpus*, sugarcane and sweet sorghum. In Tanzania crops that are being harnessed for biofuel production include coconuts, Jatropha; sugarcane, wheat, cassava and sunflower (Nairobichronicle, 2008). With the drive to find alternative and renewable sources of fuel, oil from Jatropha seeds has arisen as a good source of biodiesel. Therefore Jatropha is the feedstock of interest in the present study.

Jatropha is an oil plant which is scattered and known by majority of Tanzanian for a long time, but its utilization was limited to the use of the plant as protection hedge around homestead gardens and graves (Henning and Rothkreuz, 2004). *Jatropha curcas*, in this case simply referred to as Jatropha, is a wild plant that can grow up to five meters high. The plant produces seeds which contain oil (Messemaker, 2008). Jatropha was previously an underutilized tree species in smallholder farming systems but is fast gaining formal recognition as a very important tree crop in improving rural livelihoods. Currently it is the most wanted feedstock for producing biodiesel. Jatropha is more and more under attention as a sustainable source of biodiesel (Blesgraaf, 2009).

The household income is obtained from the Jatropha chain (sale of seeds, production and sale of oil, production and sale of soap). Despite the increasing importance of the crop there are no data concerning the financial effect of Jatropha processing to small scale farmers, especially members of the women groups (Bagani and Henning, 2009).

Biodiesel manufactured from Jatropha was found to represent around 30% reduction of Green House Gas (GHG) emissions in Europe compared with fossil diesel and in Thailand the estimated GHG emission reduction is 77% compared to fossil diesel (Romijn, 2009). Also in Australia biodiesel has the potential of reducing about 80% of the greenhouse gas emissions. According to Marwa (2008) the extent of emission reduction will depend on the feedstock used to produce the particular biodiesel.

The demand for the crop is growing because it is needed to produce biodiesel as an alternative source of energy. Hence, production of Jatropha could help to create additional income and provide a source of energy for rural poor. However, it is not well known how much Jatropha could contribute to the incomes of smallholder farmers and hence the effort to alleviate poverty. Therefore this makes grounds for undertaking an economic analysis to determine its potential to small scale farmers in both Meru and Monduli Districts.

1.3 Study Objectives

1.3.1 General objective

To determine the potential of Jatropha production in improving small scale farmers' income in Meru and Monduli Districts.

1.3.2 Specific objectives

i. To assess the contributions of various crops to small scale farmers' income.

ii. To determine the factors influencing the profitability of Jatropha production.

iii. To establish threshold production cost for biodiesel produced by using Jatropha as a feedstock.

1.4 Hypothesis

i. Jatropha production has no significant contribution to small scale farmers' income.

ii. Factors such as education, land size, extension services and Jatropha price do not significantly affect profitability of Jatropha production.

1. 5 Organization of the Study

This study has five chapters. The first chapter presents background of the study, the problem statement and justification, study objectives and hypotheses. Chapter Two presents literature review to this study. Chapter Three presents research methodology.

Chapter Four presents the results and discussion of the study, and finally Chapter Five has the conclusions and recommendations emanating from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Jatropha Production in Tanzania

Biofuels are fuels of biological and renewable origin, such as fuelwood, charcoal, livestock manure, biogas, biohydrogen, bioalcohol, microbial biomass, agricultural waste and by-products, energy crops, and others. The main sources of bioenergy are agricultural residues and wastes, purpose grown crops, and wild vegetation. Biofuels can be produced from a variety of feedstocks for instance cassava, maize, oilseeds, sugar cane, wheat and sugar beet. Ethanol can be produced mainly from starchy and sugar crops such as sugarcane and sugar beet. The most common feedstocks for biodiesel production are generally vegetable oils derived from oilseed crops such as oil palm, Jatropha and rape seed (IFPRI, 2009).

In Tanzania the main biofuel production feedstocks include Jatropha, Sugarcane, Oil palm, and sisal. Other potential biofuel producing crops in the country are cassava, sweet sorghum and sunflower (Mngodo, 2008). Most areas currently are marked for development of bio-energy crops are around the periphery of the country. These include mainly oil seeds, grains, root crops and industrial fibre crops. There are several crops that are being harnessed for biofuel production in Tanzania includes coconuts, Jatropha; sugarcane, wheat, cassava and sunflower (Nairobichronicle, 2008). The main focus of the present study is on biodiesel production using Jatropha feedstock as an alternative source of energy.

Currently many farmers in Arusha, Singida, Rukwa, Mara, Mbeya, Ruvuma, Iringa, Morogoro, Dodoma, Kigoma, Tabora, Tanga, Coast, Kagera, Lindi, Shinyanga and

Mtwara regions and other regions cultivate Jatropha (Mngodo, 2008; Nairobichronicle. 2008). Most of farmers in the country grow Jatropha as a live fence around their plot boundaries for example in Arusha region.

According to MAFSC, (2009) biodiesel production in Tanzania is still in an infancy stage. However some initiatives exist for both local and international investors. In Tanzania there are some areas which are practicing Jatropha plantation these areas are Kisarawe, Mpanda and Kilwa. The crop is still mainly used as hedge though people have started to realize the importance of the crop. There is a company which processes Jatropha seed for biodiesel production in Arusha region. This company is called Diligent. KAKUTE and Jatropha Products in Tanzania limited (JPTL) they process Jatropha oil for soap making. According to the study conducted by Philip (2007) on the potential of biofuel production in Tanzania Jatropha rank high priority followed by palm oil. This is due to its potential significant as it reported with other researcher to be un-edible plant that does not compete with food crops especially when grown in marginal land. It is hoped that, biodiesel production will be put into consideration in country due to the need for alternative source of energy though there is no policy in place guiding biodiesel production.

2.2 Jatropha Description

2.2.1 Climatic condition and soil type

Although Jatropha is a tropical species, it grows well in subtropical conditions. It can tolerate extremes of temperature but not frost and water stagnation. Jatropha grows well in tropical areas with temperature ranging between 20 and 32 degree Celsius (TaTEDO, 2008). It grows almost everywhere even on sandy, acidic and alkaline soils having pH ranging from 5.5 to 8.5. It can thrive in poorest stony soils. The minimum average rainfall requirement is about 250 mm per year and it can grow well under average rainfall 900-

1200 mm (Kritana and Gheewala, 2008). Jatropha is highly adaptable to different ecological conditions. It is well adapted to semi-arid and arid conditions and its occurrence has been observed in an annual rainfall range between 250 and 3000 mm. In Nicaragua, it can grow from sea level up to 1800 m. The plant is not sensitive to day length, however is not resistant to frost.

Jatropha can grow in various soil types. Sandy or silty soils are preferable since the root formation is not hampered. In heavy clays or vertisols Jatropha cannot grow (Blesgraaf, 2009). Clay soils are unsuitable for Jatropha if water logging or saturation occurs due to climatic conditions. In general heavy clay soils that swell and shrink are not suitable because root system development is impaired. Acid (Ph < 6) or Alkaline (> 8.0, 8.5) soil are not suitable for Jatropha. Sandy to Loamy soils seems to be a best fit (Kees, 2007).

2.2.2 Jatropha varieties

According to FAO (2010) *Jatropha L.* was first described by Swedish botanist Carl Linnaeus in 1753. It is one of many species of the genus *Jatropha,* a member of the large and diverse *Euphorbiaceae* family. Also Mendoza *et al.* (2007) pointed out that Jatropha is locally known as tuba tuba, tubang bakod (Tagalog), galumbang (Pampanga), Jatropha belongs to the family Euphorbiaceae, subfamily Crotonoideae and tribe Jatropheae. FAO (2010) added that the Cape Verde variety is the one commonly found throughout Africa and Asia *Jatropha L.* has many vernacular names including: physic nut or purging nut (English), *pinhão manso* or *mundubi-assu* (Brazil), *pourghère* (French), *purgeernoot* (Dutch), *Purgiernuss* (German), *purgeira* (Portuguese), *fagiola d'India* (Italian), *galamaluca* (Mozambique), *habel meluk* (Arab), *safed arand* (Hindi), *sabudam* (Thai), *bagani* (Ivory Coast), *butuje* (Nigeria), *makaen* (Tanzania), *piñoncillo* (Mexico), *tempate* (Costa Rica) and *piñon* (Guatemala). The genus Jatropha contains approximately 170 known species (Bagani and Henning. 2002), (Henning and Rothkreuz, 2004). Mendoza *et al.* (2007) also added that there are approximately 175 species under the genus Jatropha and, there are least 4 important species. namely *J. curcas. J. gossifolia. J. podarica, and J. multifada.* According to TaTEDO (2008) there are more than 12 species of Jatropha which are found in Tanzania. The first plants were brought to Tanzania from Latin America in the 15^{th} century. Jatropha curcas was probably distributed by Portuguese seafarers via the Cape Verde Islands and former Portuguese Guinea (now Guinea). Up to the present there is no one who can differentiate among these 12 varieties due to their morphological similarities.

2.2.3 Jatropha propagation

Jatropha can be propagated by generative (direct seeding or pre cultivated seedlings) and vegetative (direct planting of cuttings) methods. The crop shows high initial establishment success and survival. For quick establishment of living fences and plantations for erosion control, direct planting of cuttings is considered easier, although the plants propagated from cuttings do not develop a taproot. These plants only develop thin roots that do not grow deep into the soil, which makes the plants more susceptible to uprooting by wind. In agro forestry and intercropping systems direct seeding should be preferred over pre-cultivated Jatropha plants, as the taproot of directly seeded plants is believed to penetrate in deeper soil layers where it can assess extra nutrient resources and where it gets less competition from the roots of the other crops (Blesgraaf, 2009).

2.2.4 Number of Jatropha tree per acre or hectare

A density of 2 500 plants per hectare (spacing of 2 X 2m) is optimal for commercial plantations. In areas with poor rain or poor soils a plant density to be down-adjusted: 1 660 plants (spacing 2 x 3 m), 1 110 plants (spacing 3 x 3 m) or even 625 plants (spacing 4 x 4 m). Optimal plant density for hedge rows is 25 cm x 25 cm in two alternate rows, although in rain fed areas on poor soils adjust to e.g. 40 cm x 40 cm (5 000 plants/km).

Spacing of seeds has major impact on yield and soil properties. Experiments were done with spacing of 1m x1m (10 000 plants per ha), 2m x1m (5 000 plants per ha), 1.5m x1.5m (4 444 plants per ha), 2m x2m (2 500 plants per ha) and 3m x2 m (1 666 plants per ha). The wider grids gave better results. The Jatropha handbook advises a grid of 3m x3 m, since more dense vegetation affects seed production (Blesgraaf, 2009).

2.3 Biodiesel Production

2.3.1 World biodiesel production

According to RISE (2006) biodiesel can be produced from seed crops that contain a high proportion of oil, which are crushed to extract the oil. This can be used directly or after esterification, to replace diesel (derived from fossil fuels) or can also be used as heating oil. There is a wide range of crops that can be used for biodiesel production, but the most common used crop is rape seed. Other raw materials used are oil palm, sunflower oil, soy bean oil, Jatropha, tallow (animal fat) and recycled frying oils. Biodiesel production trend in the world as from 1991 to 2005 has been presented in Figure 1. The figure shows that biodiesel production has almost quadrupled since 2000, with European countries, notably Germany contributing most of the growth, followed by France. The biodiesel production in litres per hectare is still increasing in the world as shown in Figure 1.

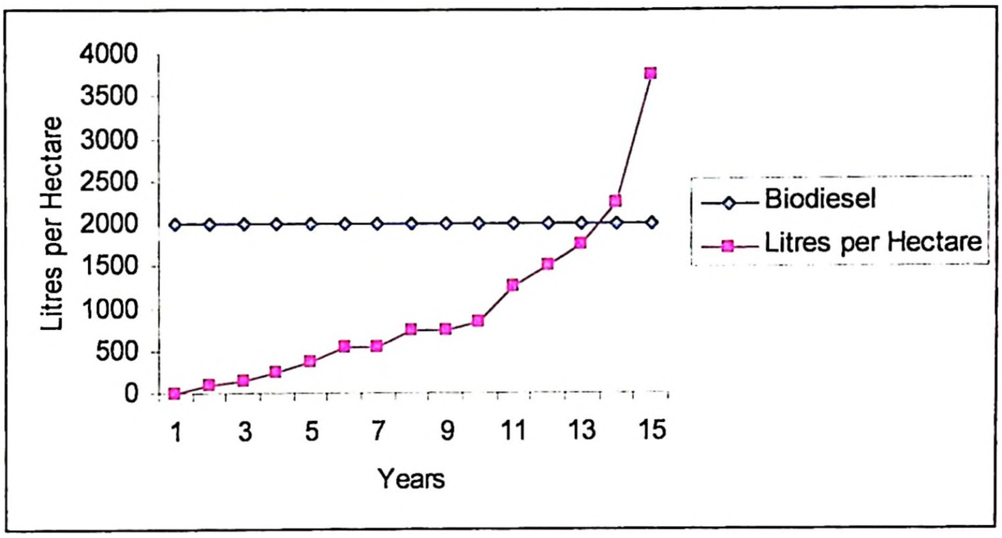

Figure 1: World biodiesel production 1991- 2005

Source: F.O. Licht: Ethanol: World biodiesel production in 2005

Table 2. 1: World biodiesel production from 1975-2005: 30 years

	BIODIESEL	
Country	**Million gallons per year**	**Feed stocks**
Germany	507	Rape seed
France	135	Soy bean
United states	77	Rape seed
Italy	60	Rape seed
Austria	22	Rape seed

Source: Earth Trends 2007

Biodiesel production, which started from a smaller base, quadrupled (Earth Policy Institute, 2006). Europe is currently the leading producer of biodiesel, which is processed from vegetable oils that are derived from soy beans, oil palm, and rapeseed, among other crops. Germany is the leading producer of biodiesel which produces 507 million gallons using rape seed from 1975 to 2005. This rank was followed by France 135, United States 77, Italy 60 and Australia 22 million gallons of biodiesel by using Rape seed while France used Soy beans as a feedstock. Germany and Italy are the leading countries in the world due to the institutional support and provision of subsidies for biodiesel production.

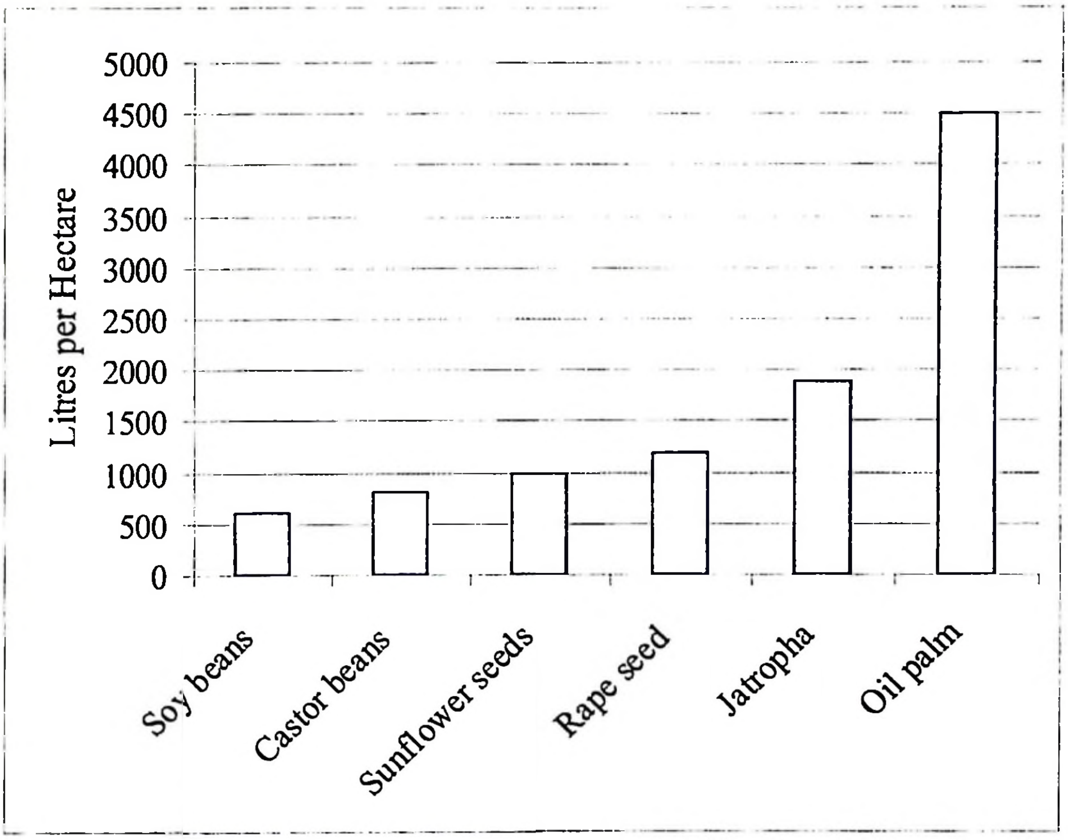

Figure 2: Oil yields for Selected Biodiesel Feedstocks
Source: Earth Trends 2007

Biodiesel feedstocks are increasing in the world though most of these feedstocks are food crops. Oil palm has the highest litres per hectare. It could be used as food crop and feedstock as well. Of non food crops, Jatropha is the most promising crop which has high oil producing feedstock per hectare compared to other non food crops. Most of the feedstocks are producing litres of biodiesel per hectare bellow 1000 while Jatropha feedstock produces 1900 litres of biodiesel per hectare. Therefore it is plausible to assume that Jatropha is the best feedstock compared to other non food crop feedstocks.

2.3.2 Potential of producing Jatropha in Tanzania

There is possibility of producing feedstocks for biofuels production such as sugarcane, Jatropha, sisal, oil palm and sunflower as major feed stocks in the country as mentioned earlier. Tanzania provides good climatic condition that supports the growth of these energy crops which provide high yield (MAFSC, 2009). Jatropha grows well in tropical and subtropical regions of which Tanzania is the best for its cultivation. Also according to Songela (2008) Tanzania has a significant potential to produce biodiesel and become a major supplier due to availability of high yield biodiesel feedstocks, land resource, availability of labour force. Due to the rising needs of feedstock for biodiesel production in the world, the large scale production of feedstock is essential. Tanzania like other countries in the world has identified large areas for biodiesel production in the country. There is the possibility of replacing food and cash crops with Jatropha production especially in Mpanda, Kilwa and other regions which are practising in Jatropha production in large scale.

The companies practising biodiesel are Diligent Tanzania limited, Prokon, DI oils, Sun Biofuels, SEKAB Bioenergy Tanzania limited, KAKUTE Tanzania limited and Jatropha Products Tanzania limited (Songela, 2008). Tanzania has potential of producing about 1726.80 million litres of biodiesel. The local annual demand for biodiesel is estimated at 886 million litres. This means, the country has annual export potential to the world market of biodiesel of about 840 million litres (Philip, 2007). The land for Jatropha production as they claim that it grow in marginal land, semi arid, drought areas in Tanzania such areas are there, but the worry is that arable land and forest may be invaded for biodiesel production which may compete with food crops. This is due to the rising interest in biodiesel production for both local and international investors.

2.4 Investment Costs and Processing Technologies

The study done by Adriaans (2006) comments that the size of the operation is the most important factor in determining which kind of process will be used. For intermediate scale operations (operations that process up to 200 tons per day), the choice is between batch solvent extraction and expeller (pressure extraction) systems. He added that expeller machine is more efficient than batch solvent extraction.

The initial investments costs of Jatropha production industry were assumed basing on the cost of: Screw press machine was TZS 3.5 million, this machine is used Jatropha seeds processing. De-husking machine costs TZS 700 000, which is used to remove husks from the seeds in order to obtain Jatropha beans. Presses filter TZS 1.5 million which used to filtration purposes. Bag and candle filters which cost TZS 500 000 in total. These were used to filter Jatropha oils; they also used for high biodiesel extraction activities. There is vibrating machine which is used for sorting out de-husked Jatropha beans and un-husked fruits. This machine approximately cost TZS 500 000. Briquette machine cost about TZS 500 000. This machine is used for making briquette, which is used as charcoal for cooking purposes. These machines were used by Diligent Company which has capacity of processing up to 400 tones in a day. The electricity cost 3 Kilowatt per hour. The initial cost depends on production capacity and type of machine to be used by a particular biodiesel company. Ram press machine costs TZS 250 000. This was most commonly used KAKUTE and women groups in rural areas.

According to Cardillo and Nesta (2006) the production cost related to Jatropha production varies accordingly from place to place or country to country. For example in Pakistan 1000 Jatropha saplings are enough for half a hectare which cost about 75 euro. In India 1 kg of seeds costs only 0.1 euro. Assuming 20% of seedlings planted do not survive. After

5 years a typical annual yield of a Jatropha tree is approximated to be 3.5 kg of beans. The oil pressed from 4 kg of beans is needed to make 1 litre of biodiesel. If we assume to obtain a crop of 10 tons of beans (half the optimistic quantity) according to this statistics we could estimate that one hectare of Jatropha is able to produce about 2 500 litres of fuel annually. This also can apply in Tanzania for investing in biodiesel production.

4 Kg of beans → 1 litre of biodiesel

10 tons = 10 000 Kg → 10 000 Kg / (4 Kg/l) = 2 500 litres

Assuming one hectare produces 10 tons of beans per year. The 30% of the seeds produces 2 500 litres of fuel, the remaining 70% of seedcake can be sold to produce soap and glycerine. Once the seeding is completed, one person is enough to manage 4 hectares of plants. From a preliminary analysis the production of biodiesel seems to be more convenient than the importation of the diesel, which costs more than 1$/litre. If we want to save the crushing cost, another important investment is the purchase of an Expeller machine that can be used to produce itself oil from seeds. The characteristics of such a machine and its price are presented in appendix 1. Taking an assumption that a machine in a day has possibility of pressing about 2.4 tones of seeds; which is equivalent to 600 litres of oil. In these calculations the oil prices were not taken into consideration. It means that less than 5 days of work should be enough to produce oil from one hectare of Jatropha using this type of machine.

2.5 Cost of Production

George *et al.* (2000) in his study conducted in Georgia found that, there is strong relationship between the final product cost and the feedstock cost. He said that if Georgia wishes to compete and produce biodiesel a relatively cheap ($.10 to $.15) feedstock needs to be used in the biodiesel production. According to Weber *et al.* (1994) the cost of production per gallon of esterified biodiesel from soybean, sunflower, tallow and yellow grease ranged from $0.96 to 33.39 subject to feedstock and chemical cost, by-product credit and system capital cost.

According IEA (2007) biodiesel is still costly to produce; currently it is 1.5 to 2 times more than ordinary diesel. Biodiesel prices dependent upon the feedstock prices such as rapeseed, sunflower, Jatropha and soybeans. The total amount of feedstock available for biodiesel production is limited due to land constraints and economic reasons. Therefore biodiesel is seen as a future niche fuel or low blending fuel. Current biodiesel production is dependent on government subsidies and regulations.

2.6 Revenue Derived from Biodiesel using Jatropha Feedstock

Revenue is the total quantity produced multiplied by the price per unit quantity. Revenue is provided by the value of biodiesel and by-product glycerin sold represented by their price per gallon. Biodiesel production adds the price of averaged $3.69 while glycerin added 3 cents per gallon to total revenue (Urbanchuk, 2009). According to the study conducted by Tomomatsu and Swallow (2007) smallholder farmers in Kenya are likely to generate US$150-180 of revenue per acre after the 8th year under rain fed conditions and US$ 320-384 per acre after the 5th year under irrigation. Based on the size of the biodiesel industry at the end of 2008, biodiesel adds nearly $12.0 billion, or about 9 percent, to Iowa Growth Domestic Product (GDP), generates $2.8 billion of household income for Iowa households. The biodiesel industry puts $220 million into the pockets of Iowa consumers on the annual basis (Urbanchuk, 2009).

The study conducted by CHIBAS (2009) comments that, Jatropha is an agricultural crop for both sustainable production by small scale farmers and a creating a local supply chain, creating added value in rural Haiti. It is well suited to Haiti's economy and has strong potential to sustainable increase rural income through small scale agricultural, job creation resulting in increased energy security and an improved national economy. Jatropha offers an economically viable solution to restoring eroded top soil while increasing income to small scale farmers.

The small scale farmers can also derive income from the processing of biodiesel by-products, such as soap production, fertilizers, cattle cakes, etc. The market for Jatropha seeds or oil is still very small at the moment and biodiesel produced from Jatropha seeds on a larger scale is still a dream of the future. an important question is if and in which timeframe the investment in Jatropha production can become economically viable (RLDC, 2007). This should lead to more economically sustainable agriculture and prices in developing countries, encouraging local production and allowing farmers to live from production.

2.7 Jatropha Profitability

Profit is defined as the difference between total revenue and total costs. According to Philip (2001) profit is what is left over after the variable cost and fixed cost have been accounted for and is the return to all resources that have not been rewarded in the calculation. This is called operating profit and when it is expressed in terms of percentage of total capital invested in the activity then it is a measure of economic efficiency of the use of that capital. Assuming that farmers can neither influence the price of their product nor the price for the inputs applied, it is clear that the only way they can optimize their profit is through reducing the amount of inputs and/or by increasing the output quantity. Input prices and the market price for his product depend on the market situation, namely supply and demand. The profit obtained depends on the quantity produced, the obtained price per unit and production costs. Some production costs are fixed, *i.e.* not varying with the quantity produced others are variable, *i.e.* increasing with an increasing output.

Progress in technology can also play an important role to either increase production or decrease production costs (Wahl *et al.*, 2009).

Also Tomomatsu and Swallow (2007) pointed out that biodiesel production is considered to be economically feasible when it is price competitive with petroleum products. The cost of biodiesel production is greatly affected by the cost of feedstock production. As the feedstock for biodiesel could be any vegetable or animal fat, Jatropha oil is only economically feasible when it is price competitive with available alternative oils. It then examines the profitability of Jatropha production as biodiesel feedstock for smallholder farmers. The factors such land holding, number of trees and access to agricultural services such as extension and credit mainly influence crop productivity of Jatropha as a feedstock (Kingstone. 2009).

2.8 Approaches to Measure Profitability

It is essential; however, that the method enables choice of an investment that will probably deliver a greater return than any alternative that is discarded as a result of the analysis. The methods to measure profitability of an enterprise include; Net Present Value (NPV), Internal Rate of Return (IRR), Return On Investment (ROI), Payback Period, Economic Value Added and Return on Assets (AACE, 2008). The more useful ways to assess the profitability of farm business are well established in farm management economics. Methods such as gross margin analysis, economic farm surplus, return on investment, the benefit-cost ratio, IRR and marketing margin are among the most common ways to measure profitability (Philip, 2001). Of the above mentioned techniques, gross margin analysis has been widely used in economic analysis for agricultural crops enterprises. The present study adopts the gross margin analysis in order to obtain profit from Jatropha and other crops contributing to the household income.

2.9 Gross Margin Analysis

Gross margins provide a simple way for comparing the profitability of enterprises that have similar requirements for capital and labour. Gross margins are essentially the first step in deducting business costs from gross income when calculating total farm business profit. Farm business profit is arrived at by adding gross margins from all enterprises and taking away overhead costs, interest, lease charges and owner's salary (Murray, 2005).

Gross margin (GM) analysis is thereby a simple and in many cases a sufficiently powerful tool for economic analysis of introduced technologies Makeham and Malcolm (1986). It is the analytical tool that has been widely used in finding the profit in farm activities. Mutayoba (2005) used gross margin of vanilla, coffee, tea, banana and maize in order to establish the relative economic profitability of various smallholders' production in Bukoba District.

2.10 Strengths and Weakness of Gross Margin

The gross margin is simple to understand, logical interrelation of economic and technical parameters forecast of rational structure of an enterprise are the key strengths of gross margin as an economic analytical tool. Regardless of its advantages, gross margin has inability to take account variations in fixed cost structure with and/or among enterprise and to make allowance of complimentarily and supplementary relationships between enterprises. Economic farm surplus was used alongside gross margin analysis in order to take care of the inability of the gross margin technique to take into account the variations of fixed cost for different farms (Philip, 2001).

2.11 Jatropha yield

Byiringiro (1995) pointed out that under optimal conditions Jatropha gives about 2 kg of seed per plant, on poor soils 1 kg per plant while on lateritic soils the yield is 0.75 kg/plant

(2.2 – 5 ton seeds / ha / year). If planted in hedges, the reported productivity of Jatropha is 0.8-1 kg of seed per meter of hedge (2.5 – 3.5 tons per hectare (Ha) per year. Seed production ranges from about 0.4 tons per hectare in the first year to over 5 tons per hectare after 4 years. Assuming an oil content of 30% and 94% extraction (modern oil expeller), 1ha will give between 750 kg and 1.6 tones of oil. Old oil press up to 40% of oil extracted.

According FAO (2010) there is little data available for seed yields from mature stands of Jatropha. Previous reported yields used largely inconsistent data, and claims of high yields were probably due to extrapolation of measurements taken from single, high-yielding older trees (Jongschaap *et al.*, 2007). Individual tree yields are reported to range from 0.2 to 2.0 kg of seed annually. On the other hand, Openshaw (2000) reported seed yields between 0.4 to 12 tonnes per ha. Mostly, these yield figures are accompanied by little or no information on genetic provenance, age, propagation method, pruning, rainfall, tree spacing and soil type or soil fertility.

2.12 Linear Regression Analysis and Factors of Profitability

Regression is based on the concept of the simple proportional relationship between variables. In general terms, the linear model states that the dependent variable is directly proportional to the value of the independent variable. This study used linear regression model to find relationship between socio-economic variables as independent variables and profitability as dependent variable. According to Gujurati (1995) that the linear regression technique is simple to use, expressive and gives the best estimator and it does not require the knowledge of the probability distribution of the underlying population being studied hence, its popularity in applied economics. Philip (2001) on economic analysis of medium scale agricultural enterprises in a predominantly smallholder agriculture sector, used linear regression to determine factors affecting the profitability of farms. The key factors that were examined were size of the enterprise, education level of the farmers, and access to credit and extension services. The study found positive relationship between the factors and the profit accrued by farmers.

However, the regression models are usually associated with problems of heteroscedasticity and multicollinearity. Heteroscedasticity is a disturbance variance that differs across observations. Multicollinearity is a situation in which one or more of the independent variables are highly correlated. Menard (1995) used correlation matrix to show that no pair of independent variables that correlates with a correlation coefficient value approaching 0.8, hence confirming the absence of the effects of multicollinearity.

2.13 Land Size and Productivity

According to study conducted by Kingstone (2009) low returns to land, labour, and capital, smallholder farmers in dry land areas have long maintained indigenous strategies and options to manage risk and to deal with poor overall productivity. Landholding or farm size has been commonly considered in most adoptions and it seems that a certain threshold farm size has to be attained for a farmer to reach certain productivity. Also Byiringiro (1995) in his study comments that, there is inverse relationship between farm size and land productivity. Smaller farms have a lower opportunity cost of labour and a higher shadow price of land compared to larger farms. These disparities are the results of constraints faced by smaller farms due to access to land and to access to labour market opportunities. Kiani (2008) in his study found that, there is negative but insignificant correlation between output per cultivated area and farm size. The smallest and largest farm size had the highest land productivity while middle farmers using inefficient combinations of inputs that yield lower marginal productivity. Smallest farmers managed to produce outputs per acre equivalent to those obtained by the largest farmers.

2.14 Market and Price of the Commodity

There are also other factors that have been considered in Kingstone analysis, such as perception about market conditions, cost of production, (especially commodity price) and purpose for which Jatropha was initially planted to serve (Kingstone, 2009). In the study area Jatropha were planted as living fence to demarcate one plot boundary and another. The market for Jatropha seeds or oil is still very small at the moment and biodiesel produced from Jatropha seeds on a larger scale is still a dream of the future, an important question is if and in which timeframe the investment in Jatropha production can become economically viable (RLDC, 2007). The price of Jatropha per kilogram is still very low. The price ranges between 100 to TZS 250 per kilogram. There is no reliable market for Jatropha seeds. This discourages farmers to produce the crop at its potential in the study areas.

2.15 Agricultural Services

FAAP (2006) comments that, at the production level, agricultural productivity measures the value of output for a given level of inputs. To increase agricultural productivity, the value of output must increase faster than the value of inputs. Gains in overall agricultural productivity an therefore come from changes in the physical productivity level through change in technology employed in the production process, which results in more output per unit of input such as land (yields) or labour, or from changes in production and market costs and hence the increased profitability of farmers.

Agricultural extension services are under constant pressure to be responsive to ever-growing challenges of, and to show impact in, food production. The pressure in responsiveness is giving rise to calls for changes in the traditional public extension systems which are now seen as outdated, top-down, paternalistic, inflexible, subject to bureaucratic inefficiencies and therefore less able to cope with the dynamic demands of modern day agriculture. There are even calls for re-examining the term extension as it is seems to re-enforce the thinking in terms of downward technology development and transfer (dissemination) processes have been reported by Semana (2001).

The growth of production in agriculture largely depends on the transfer of technology to the farming community. Agricultural extension is one of the driving forces that are responsible for the growth of agricultural productivity by transferring latest and improved technologies to the farmers and ultimately strengthens the national economy (Sadaf *et al.*, 2005).

Also they pointed out that in Pakistan agricultural extension services are responsible to enhance the process of agricultural development to meet the food needs of rapidly growing population. The aim of agricultural extension are to provide farmers (of both sexes) with information that enables them to make good decision in farming, to transfer appropriate technologies from research and other sources and ultimately to eliminate poverty and hunger by improving their production and food security.

2.16 Access to Credit

According to Muhammad *et al.* (2003) in developing countries where savings are negligible especially among the small farmers, agricultural credit appears to be an essential input along with modern technology for higher productivity. Technological change is the result of research and development efforts, while technical efficiency with which new technology is adopted and used more rationally is affected by the flow of information, better infrastructure, and availability of funds and farmers' managerial capabilities. Higher use and better mix of inputs also requires funds at the disposal of farmers. These funds could come either from farmers' own savings or through borrowings. Also Amani (2005) has pointed out that agricultural credit for production is limited. The access to credit to small scale farmers has a crucial role to play. The increase in agricultural production will lead to increase farmer's income and food security.

2.17 World Oil Price

Oil prices associated with bouts of inflation and economic instability over the last 30 years. The inflationary consequences of a rise in oil prices depend upon the policy response of the monetary authorities. They can improve the short term impacts on output, but only at the cost of higher inflation. In the short term the size and distribution of output effects from an increase in oil prices depends on the intensity of oil use in production and on the speed at which oil producers spend their revenue (Ray and Olga, 2004).

Japan has the highest proportion of its energy needs served by oil, deriving close to 50 percent from oil in 2001; but this is down from almost 60 per cent in the early 1980s. By contrast, China is one of the least oil dependant countries, with oil meeting less than 20 per cent of the country's energy consumption in 2000. As the country continues to industrialize, its oil needs exhibit a growing trend. On the other hand Asian countries follow a trend similar to China, although they have a much greater share of oil in their energy supply over 30 per cent in the beginning of the current decade (Ray and Olga, ibid).

According to De'es *et al.* (2005) oil demand depends on domestic economic activity and the real price of oil. Oil supply for non Organisation of the Petroleum Exporting Countries

(OPEC) producers, based on competitive behaviour, is constrained by geological and institutional conditions. Oil prices are determined by a price rule that includes market conditions and Organization of the Petroleum Exporting Countries behaviour. Policy simulations indicate that oil demand and non-OPEC supply are rather inelastic to changes in price, while OPEC decisions about quota and capacity utilisation have a significant, immediate impact on oil prices. Due to the presence of a dominant producer and a high degree of volatility, the real price of oil is difficult to model. Several studies have tried to assess the factors that determine oil prices. In addition to market factors such as oil inventories, the behaviour of the dominant producer is an important determinant of oil prices.

Rising exports by fuel producers have been matched by rising imports elsewhere. The increase in the oil import bill between 2002 and 2005 amounted to almost 4 percent of GDP for China, and over 1 percent of GDP for the United States, other advanced economies, and other developing countries. The rise in world oil prices worsens the trade balance, leading to a higher current account deficit and a deteriorating net foreign asset position. At the same time, higher oil prices tend to decrease private disposable income and corporate profitability, reducing domestic demand; along with a depreciation of the exchange rate, this acts to bring the current account back into equilibrium over time. The speed and output cost of adjustment depends on factors such as the degree of trade openness, structural flexibility, and central bank credibility, as well as the shock's expected persistence and the speed with which it is allowed to feed through into domestic fuel prices. Among other things, these determine the extent to which rising oil prices raise inflationary pressures, necessitating a monetary tightening that could lead to a more pronounced slowing in growth (IMF, 2006).

2.18 Threshold Cost of Jatropha Production

According to Kingstone (2009) for successful Jatropha commercialization to be realized and the smallholder farmers' livelihoods improved, there is need to put in place a complete package of incentives that will stimulate optimal exploitation of the Jatropha plant. These incentives should include, among others, adjusting the selling price in commensurate with the level of inflation and promoting investment in Jatropha by private players so that there is competition and viability for the farmer. Value addition should also be promoted for the supply of cheaper and cost saving household products. The price for a kilogram of seed will have to be attractive relative to prices of other cash crops. Any increased demand for the output of live hedges will encourage their establishment and increase environmental benefits. Jatropha should not be taken as an alternative to conventional crop production but a necessary complement to it.

An estimate of costs and returns from cultivation of Jatropha plantations or hedgerows' scenarios is crucial to analyzing its role in rural development. Costs, as well as returns are involved at different stages of the growing and harvesting of Jatropha and the manufacture/use of different plant products and include both tangible and intangible components of each. The production cost of Jatropha oil depends very much on the local labour costs (about 2 hours of work for 1 litre of oil). Mechanical harvesting is not possible because Jatropha is a bush with many branches; has flowers, unripe and ripe fruits at the same branch at the same time. Jatropha oil cannot be produced industrially therefore its oil production as a source of renewable energy will create new work to the people (IFAD, 2008). The study done by Philip (2007) also shows that the prevailing world oil prices of around US$ 60 a barrel require biodiesel production costs to be around TZS 600 a litre for the production of biodiesel in the country to be feasible. The study also shows that, the costs of producing biodiesel in the country have been estimated to be TZS 601 a litre when using Jatropha as feedstock.

2.19 Landed Oil Prices

The landed prices of petroleum products are determined by the developments in the world oil market. Shipping petroleum products in the country incurs costs for freight, insurance, wharfage (charge assessed against cargo for usage of a wharf or pier and its facilities), inspection, demurrage (charge for detaining a ship over and above the time normally given to unload), and marine transit losses (the amount unloaded in the country would always be slightly less than the amount of fuel loaded). Overcrowded ports, slow customs clearance, and any other factor delaying discharging of the fuel could incur large demurrage costs. Once landed and sent to a bulk oil terminal, petroleum products incur additional costs, including storage, transport, retailing, and wholesalers' and retailers' profit margins (World Bank, 2009).

The retail prices of oil based fuels are determined by fuel prices in US dollars, freight costs, and the exchange rate against the US dollars, wholesale margins on fuel imports, the tax regime and the retailer's margin. Because crude oil and petroleum products are quoted in U.S. dollars, exchange rate fluctuations affect domestic prices. The petroleum products are subject to import, excise, and value-added taxes and a small specific tax. Taxes make up a sizable fraction of retail fuel prices in many countries. Taxes on petroleum products are a critical source of government revenue for low-income countries because taxing fuel is one of the easiest ways to get revenue, collecting fuel taxes is relatively straightforward and there is generally a robust relationship between consumption of fuels as a group and income consumption tends to go up at the same rate as income.

CHAPER THREE

METHODOLOGY

3.1 Geographical Location of the Study Area

Meru District is one of the Districts which form Arusha region in northern Tanzania. It is bordered to the north and east by the Siha District and to the west by the Arusha municipal council and to the south by Simanjiro District. The District lies between latitudes $36^0 5''$ and longitudes $37^0 5''$. Administratively, the District is divided into 3 divisions, 17 Wards and 69 villages, 275 sub-barbs and there is only one election constituency of eastern Arumeru. Monduli is located in the northern part of the country. It is bordered to the north by Kenya, to the east by the Kilimanjaro region and Meru District, to the south by the Manyara Region and to the west by Ngorongoro and Karatu Districts (URT, 2002). These Districts were purposely selected because they have many number of small holder farmers practicing in Jatropha production. The study areas of the current study were Engaruka, Leguruki, King'ori and Maji ya Chai wards. The map showing these study area is presented in Figure 3.

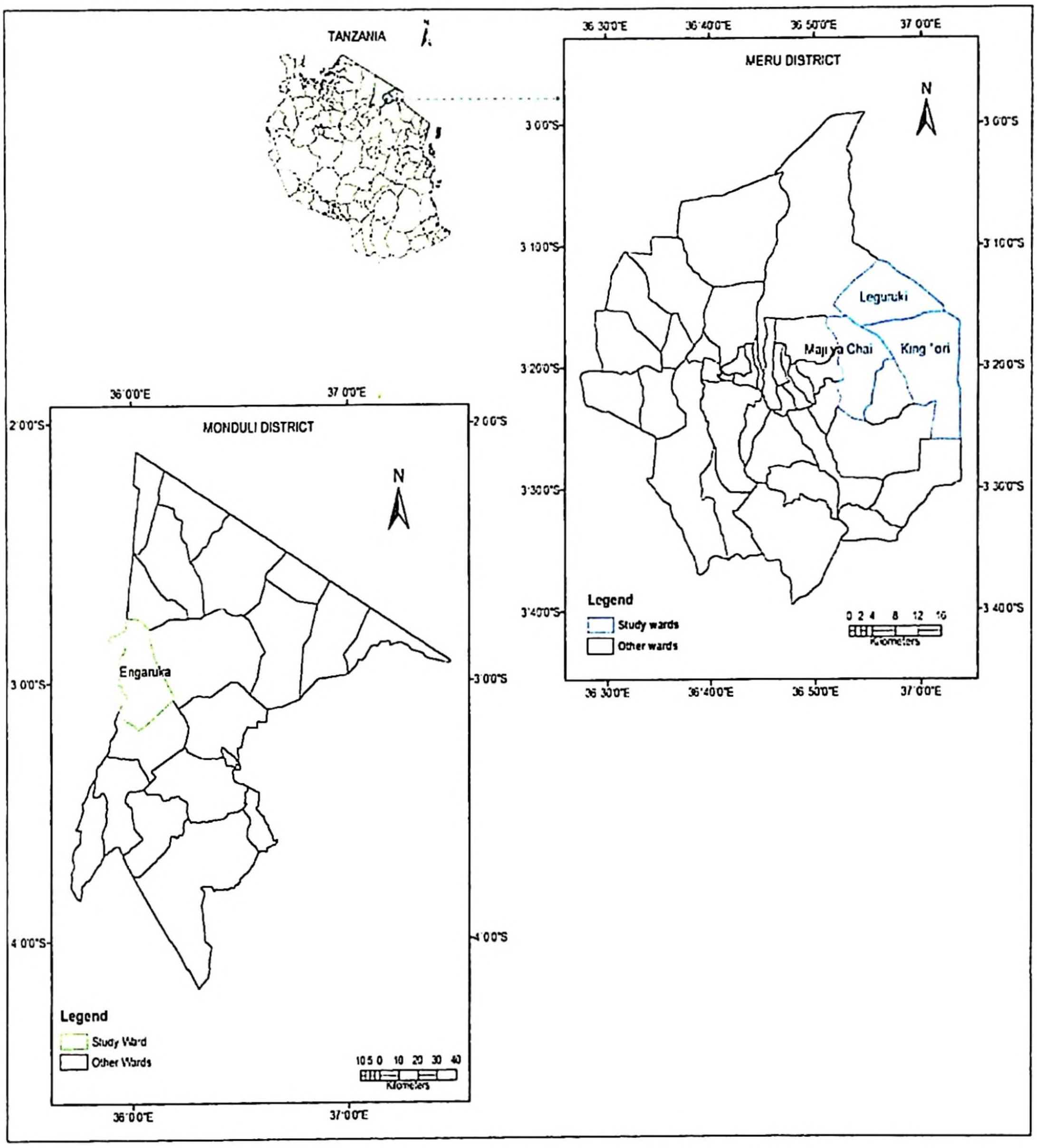

Figure 3: Map of Arusha showing main study sites

3.2 Land Use Types in the Study Area

Meru District has an area of 1 278.2 square kilometres which is about 2% of the area of Arusha region of which total area is 82 424 square kilometres. The suitable for agriculture production in the District was 166 785.2 ha. The land under cultivation was 117 622 hectares equivalent to 71 percent of suitable land (URT, 2002). The District has a total of 18 745 hectares of land which is suitable for irrigation in the area. but the irrigated land is only 11 132 hectares which is equivalent to 59 percent of suitable for irrigation. Area suitable for pasture land counted 10 591 hectares and the same amount of land is utilized for grazing purposes equivalent to 100% percent of pasture land. Water accounts for 570 hectares. natural forest accounts for 16 371 hectares. planted forest 3 000 hectares and accounts for 20 433 hectares for national park. On the other hand Monduli District has 105 547 hectares of arable land. The area of 87 632 hectares was under cultivation. The area covered with forest account 37 496 hectares of land in Monduli District. Water covered area of about 12 838 hectares in the District and grazing land covered an area of 398 385 hectares of land. The potential area for irrigation in Engaruka was 1 500 hectares of land. Out of this only 354 hectares were under irrigation.

3.3 Population Size and Ethnicity

Meru District has a total population of 225 611.The District is expected to have total population 355 892 in 2010 of which 171 511 will be males' equivalent to 48% and females 184 381 equivalent to 52%. According to the 2002 census the population growth rate of 3.1 percent per year is expected. The population of Engaruka ward was presented by villages as follows: - Engaruka Juu has a total population of 3 864 individuals, of which 1 836 were males and 2 028 were females. On the other hand Engaruka Chini has a total population of 3 373 of which 1 527 were males and the remaining 1 846 were females.

The major ethnic groups in the study areas were Maasai in Engaruka, Meru and Chagga people in Meru District (URT, 2002).

3.4 Economic Activities

Meru District is divided into upper, middle and lower zones. The upper zone lies within 1 350 and 1 800 metre above sea level and it receives rainfall of 1 000mm per year. Major crops grown in zone are coffee, maize, beans, banana, vegetables and Irish potatoes and zero grazing. The middle zone lies within 1 000 and 1 350 metres above the sea level and it receives rainfall of 500mm per year. Crops grown in this area are sweet potatoes, banana, maize, beans, vegetables, flowers, zero grazing and open land grazing. The lower zone lies within 800 to 1 000 metres above the sea level and receives rainfall of an average 300mm per year. Crops grown in the area include maize, beans, banana, vegetables, rice and also the residents engage in dairy farming. In Monduli the major crops grown are maize, beans, lablab beans and others. The majority of the residents are livestock keepers. Most of the livestock kept in Monduli, particularly Engaruka are local cattle. Both farming and livestock keeping activities are the major economic activities in the study area.

3.5 Research Design and Sampling

A cross-sectional research design was applied in this study. The design allows data to be collected once at a single point in time that can be in descriptive analysis and for determination of relationships between variables. This design was used due to the limited time and financial constraints.

3.6 Conceptual Framework

Developing a conceptual framework for the study on Jatropha production among small scale farmers was essential as guideline to identify independent variables for successful and efficient data gathering. The conceptual framework shows independent variables, intermediate and dependent variables. The independent variables are mainly factors of production such as land, labour and capital. These have direct relationship with agricultural inputs like fertilizer, pesticides and seeds. These have strong relationship with agricultural services such as extension, access to credit and training. Therefore factors of production, agricultural inputs and agricultural services have significant relationship with intermediate variable Jatropha production *i.e.* increased production, feedstock market, hence profit which have direct relationship with income as a dependent variable. The background variables have indirect relationship to independent variables, intermediate variable and dependent variable respectively. The explained relationships have been presented in Figure 4.

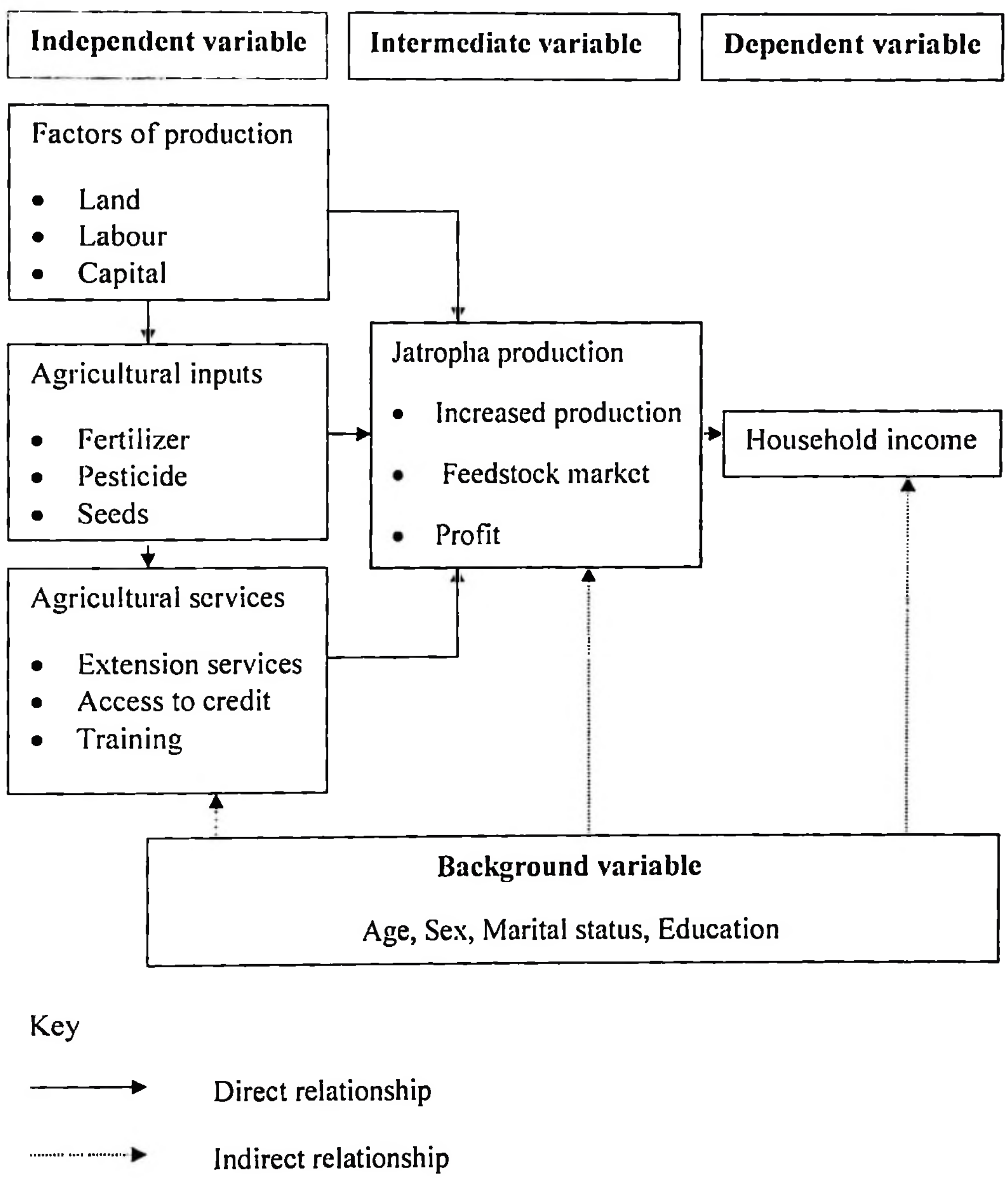

Figure 4: The conceptual framework

3.7 Sampling Techniques and Sample Size

The purposive sampling technique was employed. This sampling technique was used to select Districts with most potential for Jatropha production in the region. For this reason Meru and Monduli Districts were purposely selected basing on Jatropha production. In order to obtain the desired representative sample from the population, purposive and random sampling techniques were employed. The first stage involved purposive selection of three divisions based on the availability of households practicing Jatropha farming. The second stage involved purposive selection of wards producing Jatropha in order to obtain at least a ward from each division depending on crop production. The third stage involved simple random selection of villages to get one village from each ward. The last stage involved simple random selection of 60 households from Engaruka and the remaining 60 from King'ori, Leguruki and Miririni. Each of the selected village where practicing Jatropha farming. Therefore from six villages a total of 120 households were involved in this study. This is due the resources constraints such as time and money.

3.8 Data Collection

Primary data in this study were collected from selected Jatropha farmers using structured questionnaires. The questionnaires were designed to collect both quantitative and qualitative data on production and marketing of Jatropha. On the other hand primary data were obtained through personal observations and informal discussion with key informants. Secondary data were obtained from various publications such as books, journals, and research workers. For example biofuel powered energy services platforms for rural energy services (TaTEDO), African Journal of Biotechnology, Volume 8, number 3 (2009) and Mutayoba (2005) Economic analysis of vanilla production and marketing: A case study of Bukoba District, Kagera Region, MSc. Dissertation Sokoine University of Agriculture. These publications were found in different sources such as District Agricultural and

Livestock Development Officer (DALDO), Monduli and Meru District Councils, Sokoine National Agricultural Library (SNAL) and internet sources.

3.9 Questionnaire Administration

The present study was conducted by the researcher from mid November 2009 to early January 2010. The data were collected from Jatropha farmers. The farmers were interviewed using structured questionnaires. The structured questionnaires used in the survey were prepared in English however had to be translated in Kiswahili during the field interview. This was done in order to communicate with respondents using the common Kiswahili language which is familiar to most respondents. The content of structured questionnaire was designed to collect sufficient data intended to address the objectives of the study.

3.10 Description of the Data

3.10.1 Estimation of production costs

The production costs for crops were computed from the field survey data. The production costs of biodiesel include feedstock and processing costs were also computed using data from the field survey. Feedstock cost was estimated by using the survey data. The processing cost was estimated by using the data obtained from TaTEDO and Diligent Companies in Tanzania. The processing costs include labour, depreciation and maintenance, trans-esterification, energy, and various services. Estimate of Jatropha feedstock cost per kilogram was TZS 200 and processing cost was TZS 1335 per litre of oil. The Jatropha biodiesel price was TZS 1469 per litre. This price was estimated using one biodiesel energy equivalent of 0.89 in order to obtain market price of biodiesel per litre.

3.10.2 Estimation of average yield

The yield for crops was estimated by using field survey data. Average yields of Jatropha, which was used as feedstock for biodiesel production was calculated by using data from the field. The biodiesel quantity was computed by using the average yield for Jatropha feedstock per kilogram. The estimated yield of Jatropha on average is 43 kilograms per year per unit area.

3.10.3 Estimation of average return

The average return per kilogram, for Jatropha which was used as feedstock for producing biodiesel, was estimated by using the average yield, price and production cost. The average return of Jatropha was estimated by using its gross margin per kilogram. This was done by considering the production costs of the feedstock. The return is what remained after subtracting all costs from the revenue obtained per kilogram of Jatropha seeds. The average return from Jatropha was TZS 164 per kilogram.

3.11 Analytical Tools

The study employed two analytical techniques to test the stated hypotheses. The analytical techniques were GM Analysis, Linear Regression Analysis, Landed oil pricing formula and Profit margin analysis in this study.

3.11.1 Gross margin analysis

The gross margins were calculated for different crops. The gross margin was used as the basic unit of analysis in evaluating the enterprise profitability. The gross margin of the enterprise profitability was based on gross margin per bag, kilogram and bunch. GM analysis was employed to test the hypothesis that Jatropha has no significant contribution to small scale farmers' income. The gross margin is the difference in values of gross sales and gross variable costs. This was used to determine profitability of each crop grown by farmers. A gross margin refers to the total income derived from an enterprise, less the variable costs incurred in the enterprise. Gross margins provide a simple way for comparing the profitability of enterprises that have similar requirements for capital and labour. Gross margins are essentially the first step in deducting business costs from gross income when calculating total farm business profit. Farm business profit is arrived at by adding gross margins from all enterprises and taking away overhead costs, interest, lease charges and owner's salary (Murray, 2005).

Formula

Gross Margin formula

GM = TR - TVC

Where:

GM = Gross margin per bag

TR = Total revenue per bag

TVC = Total variable costs per bag

3.11.2 Linear regression analysis

Linear regression analysis was used to test the hypothesis that factors such as education, land size, extension services and access to credit do not significantly affect profitability of Jatropha production. The independent variables that were examined include; education, land size, extension services and jatropha price to Jatropha profitability. These factors were used in order to test how much they influence Jatropha profitability (that is either positively or negatively). These were examined against the Jatropha profitability which was the dependent variable.

$Y = \alpha + \beta_i X_i + \mu_i$

Where;

Y = Jatropha profitability

α = an intercept

Xi = Education

Xii= Extension services

Xiii= Land size

Xiv = Jatropha price

β_i-β_n = parameters attached to the explanatory variables X_i-X_n

X_i-X_n = variables assumed to be linearly related to profitability

μ_i = An error term

Summary of independent variables used in regression analysis;

Education = years of schooling (number of years)

Land size = area under jatropha production (acres)

Extension = agricultural extension services received by Jatropha farmers (1=yes, 0=no)

Jatropha price= Price of jatropha seeds (TZs/kg)

Expected signs for the variables' coefficients

Education: Level of education

The increase in years of schooling of farmer was expected to significant increase in Jatropha production. Therefore, as the farmer is getting more education, profitability is expected to increase. A positive sign was expected for the parameter attached to this variable.

Land size: Area under jatropha production

The increase in acreage of land from small to medium scale leads to increase in yield per unit area. Consequently, as farm size increases from small to medium scale production, profitability is expected to increase. A positive sign was expected for the parameter attached to this variable.

Extension: Agricultural extension services

The increase in agricultural extension services leads to increase in production. Therefore, as extension services increases profitability is expected to increase. A positive sign was expected for the parameter attached to this variable.

Jatropha price: Price of jatropha seeds

Farmers expect to have better prices of jatropha in order to getting more profit from Jatropha due to the fact that good prices will enable farmers to manage properly their farms *i.e.* use of fertilizers, pesticides, weed properly and timely seed collection. A positive sign was expected for the parameter attached to this variable.

3.11.3 Landed oil pricing formula

The landed oil pricing formula was used to establish threshold production cost of Jatropha production as a feedstock for biodiesel production and oil price. This was done by taking current world oil price per barrel, the landed prices plus government taxes per litre of diesel. The same formula was used to compare landed oil prices and threshold production cost of biodiesel produced by using Jatropha as a feedstock. The oil pricing formula has been presented in Appendix 2.

3.11.4 Profit margin analysis

Profit margin analysis was used to establish economic profitability of biodiesel production. It was used to indicate how much an individual farmer obtains from producing per litre of biodiesel. Therefore profit margin was obtained by subtracting the estimated total costs *i.e.* fixed cost as well as variable costs of production a litre of biodiesel from the value of total output as shown in the following formula:

$PM = TR - TC$

Where by

PM= Profit margin per litre of biodiesel

TR= Total revenue per litre of biodiesel

TC= Total cost (Total variable costs + Total fixed cost) per litre of biodiesel

3.12 Limitations of the Study

i. Data were collected in Engaruka and Meru study sites, therefore language of some of the respondents especially Maasai was not familiar, which needed to be interpreted so that the researchers understood what they exactly meant.

ii. A number of the respondents had no records on costs of various farm operations. Therefore it was difficult to know precisely the cost of production. As a result, costs presented are actually estimates given by the respondents.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Characteristics of the Farmers

This section describes the general characteristics of the study population. In particular, the age structure, gender, marital status, household size and education level of the respondents are being described.

Results in Table 4.1 show that age-range of the respondents was from 18 to a maximum of 66 years with mean age of 42.3 years. The mean age indicates that most of the farmers belong to the productive group. The majority (60%) of the farmers were in the 31 to 45 age category while 24.2% of the farmers belonged to 46 - 60 age category, only 5% of the respondents were aged above 60 years and 10.8% of the farmers were between 16 and 30 age categories. The study conducted by Okwu and Umoru (2009) highlighted that age of the respondents has significant influence to their access to agricultural information. According to Echebiri and Mbanasor (2003) the productive age of the labour force ranges between 15 to 40 years. This range of years has positive correlation to productivity. The fact that only 5% of the respondents are above 60 years old suggest low life expectancy. It also implies that production activities are not mainly carried out by old people in the study areas.

Moreover results shows that the majority (63.3%) of the respondents are male, signifying societies with male headed households. In male headed households in the study areas, it is a man who concentrates more on production than a woman. The women are pre-occupied with home duties and consequently reducing their time on production activities. According to Mung'ong'o (1999) women in the village spend their time provisioning for their families, fetching water, cooking and cleaning the house. That means they spend little time in production activities.

The marital status depicts the behaviour of the household in terms of social stability and responsibilities the household has, thus is expected to influence the behaviour of household on Jatropha production either as a fence or monoculture. Out of 120 respondents, 94.2% were married, 3.3% were widowed, 0.8% were divorced and 1.7% were not married. Most people in range of 18 to 66 years old were married. This shows that the married couple had higher priority to engage in production than unmarried or separated ones.

Results from Table 4.1 show that, 99.2% of the households were male headed while the remaining 0.8% were female headed households. The high proportion of men in the sample can be attributed to the male headed households having access and ownership rights to land than females headed households. This implies that households headed by male have land use decisions and they are food secure than female headed families ceteris paribus. This is due to the fact that most of the households in the study area are male headed.

Table 4. 1: Characteristics of the respondents in percentages (N=120)

Characteristics	Frequency	Percent
Age distribution:		
Young age (18-30 years)	13	10.8
Middle age (31-45 years)	72	60.0
Elder age (46-60 years)	29	24.2
Old age (>60 years)	6	5.0
Total	**120**	**100**
Gender distribution:		
Male	76	63.3
Female	44	36.7
Total	**120**	**100**
Marital status:		
Married	113	94.2
Single	2	1.7
Widowed	4	3.3
Divorced	1	0.8
Total	**120**	**100**
Household head:		
Male	119	99.2
Female	1	0.8
Total	**120**	**100**
Household size:		
Small size 1-3 people	6	6.7
Medium size 4-8 people	70	77.8
Large size 9-11 people	14	15.5
Total	**120**	**100**
Education level:		
Informal	13	10.8
Primary	96	80
Secondary	7	5.8
College	1	0.8
Adult	3	2.5
Total	**120**	**100**

Family size per household is important in determining the levels of Jatropha production. Family size is used to determine the available labour for farm work basing on the extent of contribution of each in farm work. Results show that, household size of the respondents ranged between 1 and 11 members with the average household size of 6 members. Household labour force ranged between 1 and 11 members with the average of 6 members working on the farm. Echebiri and Mbanasor (2003) comment that large family size favoured crop production. This means that majority of the people are employed in the agricultural sector. The study conducted by Alabi and Aruna (2006) in the Niger Delta found that the family size on average has 8 household members.

The majority of the households (77.8%) had medium family size of 4 to 8 members followed by large size (15.5%) and very few small size households (6.7%). On household labour force, the majority (77.8%) of the households had medium size family work force followed by large size (15.5%) and very few (6.7%) had small size family labour. This implies that majority of the households in the study areas had medium family labour for crop production.

The level of basic education in the study areas is relatively high. Out of 120 respondents, 80% had attained primary education, 5.8% had secondary education, 0.9% had college education and 2.5% had adult education while 10.8% had informal education. This implies relatively high literacy level among the farmers in the sampled communities. Duryea and Pagés (2002) highlight the fact that a tangible expansion in education can bring increase in productivity and earnings as well as reduction in poverty. The study done by Hua (2003) pointed out that education exerts a positive impact on efficiency change, technical change and productivity growth.

4.2 Farming System used in Study Areas

Also it has been found that respondents in Engauka and Meru were using Jatropha as a living fence. This was the common farming system in the study sites. They used Jatropha fence to demarcate their plot boundaries. There was no any other farming system. Monoculture and intercropping farming systems were not practiced in the study sites. According to the study conducted by Tomomatsu and Swallow (2007) there are three different modes of Jatropha production which are monoculture, intercropping and hedges. Also FAO (2010) documented that Jatropha farming systems includes monoculture, intercropping and hedges. The study conducted by Wahl *et al.* (2007) commented that intercropping with annuals is often done during the first years when the Jatropha trees are still small and do not cover the whole plot. This is very important to maintain the productivity of the land until Jatropha reaches maturity and starts to produce itself.

4.3 Land Size Owned by Respondents

The results in Table 4.2 show that many people (36.7%) of the respondents owned 0 to 2 acres of land. Also 30% of the respondents owned 2 to 3 acres of land for different activities such as farming and livestock keeping. Further more 16.7% of the respondents owned 3 to 4 acres. Moreover 5% of the respondents owned 4 to 5 acres of land. The results in Table 4.2 also show that (11.7%) of the respondents owned more than 5 acres of land. This implies that most of the farmers have farm size not more than two acres while few farmers had more than five acres of farm. This, however, shows that most of the farmers were small scale farmers.

Table 4. 2: Land size owned by respondents in acres

Acres	Frequency	Percent
0-2	44	36.7
2-3	36	30.0
3-4	20	16.7
4-5	6	5.0
>5	14	11.7
Total	**120**	**100**

4.3.1 Land acquisition

The results from the findings show that most of the respondents (97.5%) acquired their land traditionally. This implies that most of the respondents in the study areas own land in the customary way. In other words they own the land in the customary way. Also 2.5% of the respondents had the title deeds. The study conducted by REPOA (2003) shows that majority of those who work on land. do not have title deeds to the land they use and own. This implies that most of respondents in the study area own land without title deeds.

4.3.2 Total land size in production

Results in Table 4.3 depicts that majority (39.2%) had between 0 and 2 acres of land in production of different crops. It shows that 33.3% of the respondents had 2 to 3 acres of land in production activities as well. This implies that most of the respondents' production activities were taking place on land between 0 to 3 acres. It was also noted that 15.8% of respondents had 3 to 4 acres of land for production. Further more results in Table 4.3 show that (6.7%) of the respondents were having 4 to 5 acres of land in production. Also 5% of the respondents had more than five acres of land for different farm activities. The study conducted by Byiringiro (1995) found that, there is inverse relationship between farm size and land productivity. Smaller farms have a lower opportunity cost of labour and a higher shadow price of land compared to larger farms. This depicts that very few respondents use large acreage of land for production activities. Keeping other factors constant the smaller the piece of land the lower the yield per unit area and the larger the land put in cultivation the higher the yield per unit land. This only applies when the land is properly managed, well distributed rainfall (good weather condition), irrigation systems and other related factors of production.

Table 4. 3: Total land size in production in acres

Acres	Frequency	Percent
0-2	47	39.2
2-3	40	33.3
3-4	19	15.8
4-5	8	6.7
>5	6	5.0
Total	**120**	**100**

4.3.3 Land size grown Jatropha

Results in Table 4.4 depicts that (50%) of the respondents were growing Jatropha between 0 to 2 acres of land. Also 26.7% of the respondents planted Jatropha between 2 to 3 acres of land. Moreover the 14.2% of the respondents planted the crop in land ranging between 3 and 4 acres. In addition 11.8% of the sampled population planted the crop in 4 acres of land. Also 5.8% of the people in the study sites were growing Jatropha in 4 to 5 acres. Further more 3.3% of population of the study areas planted the crop in more than 5 acres of land. The crop is grown in the study areas as a living fence around the respondents' plot boundaries. This was the common farming system in the study sites. Thus it is not surprising that most farms were very small.

Table 4. 4: Land size grown Jatropha in acres

Acres	Frequency	Percent
0-2	60	50.0
2-3	32	26.7
3-4	17	14.2
4-5	7	5.8
>5	4	3.3
Total	**120**	**100**

4.4 Main Sources of Respondents' Income

According to the results in Table 4.5 most of the respondents' (76.7%) source of income is agriculture. This means that respondents were obtaining their income from both farming activities and livestock keeping. Results also show that 13.3% and 8.3% of the respondents got the income from farming activities and livestock respectively. This means that number of individuals who earn income from farming only was higher than those who earn their income from livestock only. Also 1.7% of the respondents earned their income from self employment rather than from farming and livestock.

Table 4. 5: Main sources of income

Source	Frequency	Percent
Farming	16	13.3
Self employee	2	1.7
Livestock	10	8.3
Farming and livestock production	92	76.7
Total	**120**	**100**

4.4.1 Types of crops grown by respondents

Results in Table 4.6 show that 17.5% of the respondents were growing maize and black beans as their main source of income. In addition it shows that 10.8% of the respondents were practicing maize, cow peas and black beans production. Furthermore results show that crops grown by individual farmers were extremely diverse as Table 4.6 shows here under. According to FAO (2005) households generate more than 50 percent of their income from agriculture. Moreover 9.2% of the respondents had grown maize, banana and coffee, 8.3% grown maize, 8.3% had grown maize, banana, beans and coffee, 6.7% of the respondents were growing maize and coffee and also 6.7% of the respondents were growing maize and banana while 4.2% grown maize, onion and black beans, 3.3%grown maize, sun flower and black beans, 5.0% grown maize, banana and beans, 2.5% grown maize, pigeon peas and black beans, 3.3% grown maize and cow peas, 0.8% grown maize, banana and cow peas, 0.8% grown maize, banana and black beans and finally 5.8% of the respondents grew maize, beans and coffee.

Table 4. 6: Types of crops grown by farmers

Crop (s)	Frequency	Percent
Maize	10	8.3
Maize and Black beans	25	20.8
Maize and Coffee	8	6.7
Maize, Banana and Coffee	11	9.2
Maize, Onion and Black beans	5	4.2
Maize, Cow peas and Black beans	13	10.8
Maize, Banana and Beans	6	5.0
Maize and Beans	8	6.7
Maize, Pigeon peas and Black beans	3	2.5
Maize and Cow peas	4	3.3
Maize, Banana and Cow peas	1	0.8
Maize, Banana and Black beans	1	0.8
Maize and Banana	8	6.7
Maize, Beans and Coffee	7	5.8
Maize, Banana, Beans and Coffee	10	8.3
Total	**120**	**100**

4.4.2 Costs, yields and prices for various crops grown in the study area

The average costs of production in TZS for each crop are presented in Table 4.7. These costs were per bag, kilogram, and bunch for the common crops in the study area. Also Table 4.7 shows the average yield in bags, kiliogrames and bunch for each crop and the price of each individual crop. The average farmer gets 43 kilogrames of Jatropha seeds per year. Variations in costs of production for various crops depend on level of technology used in production of each crop. Mechanization is costly than labour for small scale farmers but vice versa for large scale. The use of machine increases costs of production followed by ox-plough and finally hand hoe which is the cheapest technology. The variations in yields were due to the weather condition (drought), crop management, use of fertilizers and timely planting.

Table 4. 7: Average costs, yields and prices for various crops grown in the study area

Crop	Average Costs (TZS/bag/bunch/kg)	Average Yield/acre	Unit	Price (TZS/bag/bunch/kg)
Maize	16 893	5	Bag	42 000
Beans	41 920	0.9	Bag	100 000
Banana	601	48	Bunch	3 500
Coffee	153	191	Kilogram	1 000
Black beans	8 901	2	Bag	120 000
Jatropha	36	43	Kilogram	200

4.5 Various Crops Gross Margin Analysis

Table 4.8 shows estimated costs of operations for various crops grown in the study area. These costs included land preparation, seeds, planting, weeding, spraying, fertilizer application and harvesting for each. Table 4.8 also shows revenue per bag per bunch and per kilogram for each of the crop. The average yields per bag per bunch and per kilogram for each crop per acre are presented in Table 4.8. Furthermore Table 4.8 shows total revenue per acre and the annual contribution of each crop to the household income in the study area.

Table 4. 8: Gross margins for various crops grown in the study area

Description	Maize	Beans	Banana	Coffee	B.beans	Jatropha
Land preparation	7 560	13 107	201	-	3 176	11
Seeds	2 930	10 860	-	-	-	-
Planting	1 105	5 910	197	-	2 161	6
Weeding	1 670	5 090	135	51	1 620	-
Spraying	-	-	-	23	-	-
Fertilizer	820	3 100	-	-	-	-
Harvesting	2 808	3 853	68	79	1 944	19
Total variable costs/bag/bunch/kg	16 893	41 920	601	153	8 901	36
Total revenue/ bag/bunch/kg	42 000	100 000	3 500	1 000	120 000	200
Gross margin/ bag/bunch/kg	25 107	58 080	2 899	847	111 099	164
Average yields/bag/ bunch/kg per acre	5	0.9	48	191	2	43
Total revenue/acre	210 000	90 000	168 000	191 000	240 000	8 600
Contribution to household income (%)	21.60*	9.00*	2.30*	27.80*	38.20*	1.20*

*Significant at 1%

4.5.1 Contribution of various crops to household income

The results for the contributions of different crops to the household income are presented in Table 4.8. The crops which were contributing to the household income were maize, beans, banana, coffee, black beans and Jatropha. Each crop has its own contribution to the household income. In addition each individual crop's GM per bag per bunch and per kilogram is presented in Table 4.8.

The results in Table 4.8 show that TVC incurred in maize production was at TZS 16 893 per bag. The TR accrued from maize was TZS 42 000 per bag. Thus, the GM was at TZS 25 107 per bag. This implies that maize contributes 21.6 percent to each of the household in study areas. Maize accounts for 21.6% of the annual total household income. The study conducted by Moraa *et al.* (2009) on cost benefit analysis, the maize gross margin was Ksh 17 789.53 which is slightly higher compared to the present gross maize margin. Also the study done by Bagamba *et al.* (2008) obtains the maize gross margin of Ush 389 000 and Ush 601 700 per hectare respectively. This gross margin looks slightly higher compared to the present gross margin though it was not computed per bag.

Also the results in Table 4.8 depict that TVC incurred in beans production was at TZS 41 920 per bag. The TR accrued from beans was TZS 100 000 per bag. Therefore, the GM was TZS 58 080 per bag. This means that beans contribute 9.0% of the annual total household income in the study areas. The study done by Tomomatsu and Swallow (2007) reported that the beans gross margin of 62 US$ equivalent to Ksh 4 522 at farm level per acre. This value is slightly lower than the present study beans gross margin. The study done by Bagamba *et al.* (2008) obtain the beans gross margin of Ush 469 700 per hectare. This value is slightly higher compared to the current study gross margin.

The results in Table 4.8 reveal that TVC incurred in banana production was at TZS 601 per banch. The TR accrued from banana was TZS 3 500 per bunch. The GM was TZS 2 899 per bunch. This implies that banana contributes 2.3% of the total household income to each of the household in the study areas. In additional terms banana production contributes 2.3% to the individual households as an income. According to the study done by Bagamba *et al.* (2008) in central region and south Uganda, they obtain the banana gross margin of 1

190 000 and Ush 1 844 000 per hectare respectively. The current study gross margin is lower than the Bagambas' study.

Furthermore the results in Table 4.8 show that the TVC incurred in coffee production was TZS 153 per kilogram. The TR accrued from coffee is TZS 1000 per kilogram. As a result, the GM was TZS 847 per kilogram. This means that coffee accounts for 27.8% of the total household income to each of the household. Therefore coffee production contributes 27.8% to the individual household as the annual income. In the study done by Bagamba *et al.* (2008) in central region and south Uganda they obtain the banana gross margin of 95 600 and Ush 1 255 500 per hectare respectively. This gross margin is slightly lower compared to that of the present study. Also the study conducted by Linh and Baulch (2009) found out the coffee gross margin of 20 750 per hectare. This gross margin is far lower compared to the current study gross margin.

Moreover the results in Table 4.8 show that the TVC incurred in black beans production was at TZS 8 901 per bag. The TR accrued from black beans is TZS 120 000 per bag. Accordingly, the GM is TZS 111 099 per bag. This means that black beans accounts for 38.2% of the total household income to each of the household in the study areas. In other words black beans production contributes 38.2% to the individual households as an annual income.

In addition, the results in Table 4.8 show that TVC incurred in Jatropha production was at TZS 36 per kilogram. The TR accrued from Jatropha was TZS 200 per kilogram. Thus, the GM was TZS 164 per kilogram. This implies that Jatropha accounts for 1.2% of the total household annual income to each of the household in the study areas. In other words Jatropha's production contributes 1.2% to the individual household's income. The study done by Moraa *et al.* (2009) on cost benefit analysis of Jatropha out growers scheme, reported the Jatropha gross margin of (Ksh 42949.11). This value is low compared to the gross margin of the current study. Also Freim (2008) found out that the Jatropha gross margin of 111 705 per hectare. According to the study done by FAO (2010) found Jatropha gross margin was TZS 5 347 per 40kg of seeds. This gross margin is slightly lower compared to Jatropha gross margin in the present study. In general Jatropha has small gross margin which accounts for 1.2% of the total household income which is lower compared to black beans gross margin which accounts for 38.2% of the total household income in the study area. Though its contribution is smaller in terms of percentage compared to other crops, paired t-test revealed that its contribution to the household income seemed to be significant at $p<0.01$. Jatropha requires little or no inputs such as fertilizers, seeds, labour, pesticides and herbicides especially when it is grown as live fence. The costs involved were the planting cost and harvesting only, in most of the cases these tasks were carried out by family labour. Another reason is that jatropha is drought tolerant plant compared to other crops. This makes the yields of the crop stable and hence it an assured source of income to small scale farmers.

4.5.2 Livestock keeping

Results in Table 4.9 show that 27.5% of the respondents keep cattle and goats in the study areas. In addition (25.8%) of the respondents keep cattle, sheep and goats. Also 14.2% of the respondents keep cattle, goats and chicken. Furthermore out of 110 livestock keepers, remaining 29 livestock keepers (24.2% of respondents) are accordingly distributed in Table 4.9 as cattle, goat, chicken and donkey, goats, cattle, goat, chicken and donkey, cattle, goat, and Donkey, cattle, goat and duck, goat and chicken, goat and duck, sheep and goat, cattle, sheep and chicken, cattle, sheep, goat and chicken, cattle and chicken and sheep, goat, duck and chicken respectively. Moreover results in Table 4.9 show that 8.3% of the respondents do not engaging themselves in livestock keeping activity. This implies that they are not interested in keeping livestock in their households. In other words they do not realize the importance of keeping livestock as one of the income generating activity.

Table 4. 9: Types of livestock kept by respondents

Type	Frequency	Percent
Cattle	6	5.0
Goats	3	2.5
Cattle, Sheep and Goat	31	25.8
Cattle and Goat	33	27.5
Cattle, Goat, Chicken and Donkey	1	0.8
Cattle, Goat, and Donkey	2	1.7
Cattle, Goat and Chicken	17	14.2
Cattle, Goat and Duck	1	0.8
Goat and Chicken	5	4.2
Goat and Duck	1	0.8
Sheep and Goat	1	0.8
Cattle, Sheep and Chicken	4	3.3
Cattle, Sheep, Goat and Chicken	2	1.7
Cattle and Chicken	2	1.7
Sheep, Goat, Duck and Chicken	1	0.8
Non livestock keepers	10	8.3
Total	**120**	**100**

4.5.2.1 Income from livestock

According to the results in Table 4.10 majority (73.3%) of the respondents accrue TZS 85 000 annually per cattle among the cattle keepers. Also 26.7% of the respondents in study area receive TZS 120 000 per cattle annually. This means that cattle keepers on average obtain TZS 102 500 annually as their income. Cattle accounts for 78% of the household income from livestock keeping activity. The study done by FAO (2005) pointed out that livestock plays an important role as an income source in the household of more agriculture based households. It also added that the share of income generated from livestock ranges between 20 and 25 percent of household income. Furthermore the results show that all the respondents (100%) accrue TZS 12 000 per goat as an income. This implies that goats account for 9.1% of the total household income from livestock keeping. Moreover the results show that all the respondents (100%) get annual income of TZS 12 000 per sheep. This means that sheep accounts for 9.1% of the total household income from livestock keeping. This implies that the income from goats or sheep annually depend on the number (goats and sheep) sold in a particular household yearly.

In addition, results in Table 4.10 show that majority (57.9%) of the respondents receive TZS 5 000 per chicken annually. Also the respondents' (31.6%) in study areas obtain TZS 6 000 as an annual income per chicken. The remaining 10.5% of the respondents were accrue TZS 4 000 per chicken annually. The total annual average of TZS 5 000 per chicken is annually obtained by each of the household keeping chicken. This implies that chicken account for 3.8% of the total household income from livestock keeping activity.

Table 4. 10: Income from livestock

Income	Frequency	Percent	Average Income	Contribution (%)
Income from cattle				
(Milk and cattle sale)			Cattle	
120 000	22	73.3		
85 000	8	26.7	102500	78
Total	**30**	**100.0**		
Income from goats			Goats	
12 000	74	100.0	12 000	9.1
Income from sheep			Sheep	
12 000	14	100.0	12 000	9.1
Income from chicken			Chicken	
4 000	2	10.5		
5 000	11	57.9	5 000	3.8
6 000	6	31.6		
Total	**19**	**100.0**		**100.0**

4.6 Factors Influencing Jatropha Profitability

4.6.1 Linear regression analysis

A multiple linear regression model was estimated to determine factors, which were hypothesized to influence Jatropha profitability among small scale farmers. Table 4.11 presents the results of regression analysis. The Jatropha profitability was used as the dependent variable and independent variables were education level, extension services, land size and jatropha price.

Table 4. 11: Dependent variable: Jatropha profitability

Variable	β	P-Value	VIF	Significant level
(Constant)	1051.547	0.000		0.01
Education (X1)	25.929	0.486	1.12	NS
Extension (X2)	156.082	0.000	1.02	0.01
Land size (X3)	5.073	0.803	1.11	NS
Jatropha price(X4)	835.302	0.000	1.02	0.01

NS= Not significant, R square = 73%, Adjusted R square= 72%

The factors influencing profitability of jatropha production were analysed using regression analysis as shown in Table 4.11. All variables had theoretically appropriate expected signs. The results in Table 4.11 show that coefficients: land size, extension service, education and jatropha price were positively related to the Jatropha profitability. Table 4.11 also shows that extension and jatropha price were positively related with jatropha profitability of Jatropha production and statistically significant at ($p<0.01$). The positive relationship between prices and Jatropha profitability can be attributed to the fact as price increases the profitability of the crop increases *ceteris paribus*. Furthermore Table 4.11 shows that education and land size were positively related with jatropha profitability. The positive relationship between the land size and jatropha profitability can be attributed to the fact that as land size increases the profitability of jatropha production also increases. This implies that there is strong association between land size and jatropha profitability in the study areas.

In the case of extension services in jatropha production and jatropha profitability, the positive association is because of the increase in information disseminated for jatropha production and hence increased quantity and quality of jatropha output that lead to high profit. The study conducted by Kiani *et al.* (2008) found out that agricultural services have positive and significant impact on crop production. Therefore there is significance association between jatropha profitability and extension services.

Education level of small scale jatropha farmers has positive relation to jatropha profitability as postulated earlier. This implies that without training farmers on jatropha productions, its productivity will be low, hence low profitability. Therefore farmers need to be educated in order to improve their productivity and eventually profitability. According to Carter (1984) education positively affects agricultural profitability which is similar to the present study. Also Table 4.11 shows that there was no problem of serious multicollinearity observed in this study and thus, as VIF less that 5.

4.7 Marketing of Jatropha Seeds

Table 4.12 shows that 43.3% of the respondents sell their seeds to different companies. This means that farmers sell their seeds directly to the company. Also 38.3% of the respondents sell the produce to the local traders. These local traders are the company's agents who buy seeds from farmers on behalf of the companies. The remaining 17.5% of the respondents sell seeds willing to their respective groups. And 0.8% of the respondents have not yet harvested Jatropha seeds. This means that most of these groups process seeds themselves for different uses such as soap making.

Table 4. 12: Jatropha seeds marketing in the study area

Selling to		**Frequency**	**Percent**
Companies		52	43.3
Local traders		46	38.3
Group		21	17.5
Not selling		1	0.8
Total		**120**	**100**
Number of times			
Not selling		1	0.8
	1	106	88.4
	2	12	10.0
	3	1	0.8
Total		**120**	**100**
Price per kilogram			
	100	10	8.2
	150	28	23.3
	200	63	52.6
	250	18	15.1
Not selling		1	0.8
Total		**120**	**100**
Uses of Jatropha seeds			
Market		83	69.0
Making soap		36	30.2
Not selling		1	0.8
Total		**120**	**100**

Most of the respondents (88.4%) sell Jatropha seeds once in a year. This implies that these people harvest Jatropha seeds once in a year that is why they sell once a year. Furthermore 10.0% of the respondents sell Jatropha seeds twice in a year. In addition 0.8% of the respondents were selling three times the Jatropha seeds in market. This implies that a small number of respondents harvest Jatropha seeds and sell seeds to the market more than once a year.

According to the results in Table 4.12 (100%) of the respondents were paid immediately when they sell the Jatropha seeds to different buyers. The respondents were paid on cash basis. This means that the payment conditions were good to the Jatropha farmers' *ceteris paribus*.

The results in Table 4.12 show that majority (52.6%) of the respondents sell their Jatropha seeds in TZS 200 per kg. Also 23.3% of the respondents sell their seeds at TZS 150 per kg. In addition, 15.1% of the respondents sell their seeds at TZS 250 per kg. Furthermore the remaining 8.2% of the respondents sell their Jatropha seeds at 100 shillings per kg. According to Wahl *et al.* (2009) the price of Jatropha seeds ranges between 100 and TZS 300 per kilogram. This implies that all respondents sold their Jatropha seeds at very low price, of which farmers do not benefit much from Jatropha production. This pricing system is very exploitative to the producers who were the main owners of the product.

4.8 Access to Supporting Services

4.8.1 Jatropha production training

According to the results in the Table 4.13 majority (82.4%) of the respondents attended training on Jatropha production in the sampled areas. This implies that at the initial of commercialization of Jatropha plant respondents were given training on the plant production. Only 17.6% of the respondents did not attend any training on Jatropha production.

The results in Table 4.13 depict that majority (82.5%) of the respondents were given Jatropha production courses by KAKUTE company. It seems KAKUTE Company penetrated the sampled areas to provide the importance of the crop to the society. In addition results show that 22.3% of the respondents received Jatropha production training from TaTEDO Company. This company not only provided training but also the processing machines to the community in the study areas. Furthermore 8.4% of the respondents received Jatropha production training from Diligent Company. All these companies are outsiders except the KAKUTE Company which is of Tanzanian origin.

Table 4. 13: Training attended on Jatropha production

Response		Frequency	Percent
Yes		99	82.5
No		21	17.5
Total		**120**	**100**
The training organizers			
KAKUTE		82	68.3
TATeDO		28	22.3
Diligent		10	8.4
Total		**120**	**100**
Day's training conducted			
	7	120	100
Total		**120**	**100**

Results in Table 4.13 show that all respondents (100%) were given Jatropha production training for seven days in the study area. This implies that each of the companies organized its course delivery to the community in the study sites for seven days. It also means that most of the members of the society attended Jatropha training organized by the companies.

4.8.2 Agricultural extension services

Results in Table 4.14 reveal that 5.7% of the respondents got extension services once in a year. This percent looks very small compared to the sample selected in the study area. This implies that majority of the people in the study area do not get extension services as required. Also 2.5% of the respondents received extension services twice a year and 0.8% of the respondents received extension services three times a year. Generally speaking the extension services were poorly delivered to the community. Results in Table 4.14 show that only 11 respondents were visited by extension workers at different times in a year. This means the remaining 109 respondents (91%) were not visited by extension workers at all. Thus it is not surprising that the yields are low for the crop.

Table 4. 14: Access to agricultural extension services

Frequency of times	Frequency	Percent
Without access	109	91.0
Access once	7	5.7
Access twice	3	2.5
Access trice	1	0.8
Total	**120**	**100**

4.8.3 Financial services

Access to credit is an important element for producers of all level, whether small or large scale production. Farmers in the study area were not accessing any loan from either government or private organizations. The access to financial services motivates the producers to increase production of the crop. A study conducted by Muhammad *et al.*

(2003) pointed out that increase in credit provision would induce an increase in agricultural gross domestic product. Access to credit is an important component to the development of jatropha crop. Due to the financial constraints jatropha farmers do not concentrate on its production. This in turn leads to low production for the crop in the study area.

4.9 Threshold Production Costs for Biodiesel Production

4.9.1 Biodiesel threshold production cost with landed oil prices

The present study has established threshold biodiesel production costs and landed oil prices. It is crucial to establish the threshold in order to know the lowest landed oil prices at which biodiesel produced by using jatropha feedstock would compete with fossil diesel. Therefore Table 4.15 shows the feedstock and processing costs for producing one litre of Jatropha biodiesel.

Table 4. 15: Feedstock, processing costs and landed diesel price per litre

Description	Unit			One biodiesel energy equivalent	
Amount of seed required	Kg	4			
Price per Kg of seed	TZS	200	800	0.89	712
Transportation cost	TZS	12	48	0.89	43
Processing costs					
Labour for oil expelling per 4Kg	TZS	70	70	0.89	71
Labour filtering oil per 4Kg	TZS	40	40	0.89	32
Depreciation and maintenance (expeller)	TZS	40	40	0.89	32
Processing expenses per litre	TZS		400	0.89	356
Trans-esterification cost per litre	TZS		100	0.89	89
Total costs per litre of biodiesel	TZS				1335
Price per litre of Jatropha biodiesel	TZS		1650	0.89	1469
Landed Diesel price per litre	TZS				1120

Results in Table 4.15 depict that the feedstock production cost was TZS 712 per four kilograms of jatropha seeds and the transportation cost of four kilograms was TZS 43 which make the total costs of TZS 755. The cost of processing four jatropha kilograms was TZS 580, which include: labour cost, depreciation and maintenance, processing expenses and trans-esterification cost. The feedstock cost which was TZS 712 and processing cost TZS 580 which make the total of TZS 1335. The profit margin was not included in this section. In order to estimate biodiesel market price one biodiesel energy equivalent was used. One biodiesel energy equivalent which was used is equal to 0.89. This was done by multiplying actual cost with one biodiesel energy equivalent. Therefore the total cost of producing one litre of biodiesel is TZS 1335 without including the profit margin.

4.9.2 Threshold production cost per litre of Jatropha Biodiesel

The results in Table 4.15 reveal that the threshold production cost for one litre of biodiesel was TZS 1469. This amount is the summation of feedstock cost which is TZS 755, processing cost TZS 580 and profit margin which TZS 134. This is the optimal production cost for a litre of biodiesel produced using Jatropha feedstock. The results in Table 4.15 reveal that the threshold production cost of jatropha biodiesel per litre is TZS 1469 while the landed price of diesel per litre is TZS 1120. The biodiesel should be produced at cost of TZS 1469 per litre in order to compete with landed diesel price per litre in the country. According to Philip (2007) the cost of producing biodiesel in the country has been estimated to be TZS 648 a litre when using Jatropha as feedstock. This production cost is lower compared to the biodiesel production costs.

Biodiesel production using jatropha feedstock requires reasonable production output in the country so that it can be competitive with landed oil prices. This is only possible if the government could provide subsidies and other incentives such as tax exemption for producing biodiesel using jatropha as a feedstock. The increase in biodiesel production could increase the income of the small scale farmers. As a result of biodiesel production and income increase among smallholders, hence poverty reduction. The study conducted by Tomomatsu and Swallow (2007) pointed out that the production of jatropha becomes attractive for small scale farmers with subsidies or large increase in petroleum products and oil palm prices and more farmers will convert their land into jatropha production. Therefore, if the price of petroleum products increases without corresponding increase in the price of vegetable oils, biodiesel will become more and more price competitive with petroleum diesel or fossil diesel in the country.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was designed to analyze the economics potential of biodiesel production among small scale producers. Particularly, the present study aimed at assessing contribution of various crops to the household income where Jatropha was the target crop among others. This also focused on the factors influencing profitability of Jatropha production among small scale farmers and to establish the relationship between the world oil prices and threshold production cost for biodiesel produced by using Jatropha as a feedstock in the country. Conclusion made is based on the tested hypotheses that: Jatropha production has no significant contribution to small scale farmers' income. Factors such as education, land size, extension services, and jatropha price do not significantly affect profitability of Jatropha production.

The crucial question on how much jatropha contributes to the small scale farmer's income in the study area was raised several times. The tested hypothesis that: Jatropha production has no significant contribution to small scale farmers' income, was rejected ($P<0.01$). The tested hypothesis that: factors such as extension services and jatropha price do not significantly affect profitability of jatropha production, was rejected ($P<0.01$). This implies that extension services and prices significantly influence Jatropha profitability in the study area.

The threshold production cost of jatropha biodiesel per litre is TZS 1469 while the landed price of diesel per litre plus government taxes is TZS 1120. Biodiesel produced using jatropha as a feedstock and to be able to compete with fossil diesel when the landed oil price has to be at TZS 1120 per litre. Therefore, the lowest amount of the landed oil price that is required for competitive biodiesel production, by using jatropha as a feedstock, is TZS 1120 per litre while that biodiesel from jatropha is TZS 1469. At these costs the biodiesel from jatropha can compete with fossils fuels. Consequently, it is rational to say that at the current world oil price; there is small profitability of producing biodiesel in the country by using jatropha as a feedstock. The current landed oil price of around TZS 1120 a litre requires biodiesel production cost to be around TZS 1469 a litre for the production of biodiesel to be profitable in the country.

5.2 Recommendations

It is apparent from the findings of this study that there is no simple or sole recommendation that will make biodiesel production profitable to the small scale farmers in the study area. Conversely, there are several possible recommendations which the researcher hopes, if well implemented, could have positive impact on biodiesel production using jatropha feedstock. Therefore the present study recommends that:-

(i) Jatropha production is profitable; hence it should be promoted as a live fence in the country.

(ii) In relation to factors influencing profitability of Jatropha production the study recommends provision of appropriate agricultural supportive services. This will facilitate farmers to produce more of the feedstock and generate income from the crop.

(iii) The findings reveal that, the current landed oil price of around TZS 1120 per litre requires biodiesel production cost to be around TZS 1469 a litre for the production of biodiesel to be profitable in the country. In order biodiesel production to be competitive with fossil diesel the government should provide subsidies and tax exemption to the producers.

(iv) In order jatropha to be more profitable to farmers, they should be able to engage in oil extraction process using ramp press; otherwise the benefit to local communities will be negligible. The small scale farmers must be provided with processing equipments in order to extract oil themselves.

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APPENDICES

Appendix 1: The characteristics of a machine and its price

Costs	
Seeds crushing	40 $ /tone
Oil refinement	125 $ /tone
Profits	
Seedcake sold	100 $ /tone

Thus we can compute the final cost per litre of oil.

Costs

Seeds crushing 40 $ /tone x 10 tones = -400 $

Oil refinement 125 $ /tone x 10 tones = -1250 $

Profits

Seedcake sold 100 $ /tone x 10 tones x 70% = 750 $

Then the final cost is estimated to be 900$ and the unitary cost of 900$ / 2 500 litres is 0.36 $ /litre (about 0.22 euro/litre).

Machine capacity	about 100 Kg of seeds /hour
Required Power	3.5 kW
Engine motor	8 hp
Type of seed	any hard seed with more than 25 % of oil
Residual oil content	10 % – 12 % in the press cake
Machine price	Approx 2000 $ (about 1330 euro)

Appendix 2: Indicative petroleum pricing formula

	Indicative Petroleum pricing formula			
		Diesel		Diesel
	Description	**Convention**	**Price**	**Unit**
	Average Platt's FOB		669	USD/MT
Plus	Freight		24.86	USD/MT
Plus	Premium		7.39	USD/MT
	Insurance (0.1% C&F)	0.001	25.53	USD/MT
Sub total	**Cost CIF DAR**		**726.78**	**USD/MT**
	Local costs payable to other authorities			
	SUMATRA USD 0.25 per MT		0.25	USD/MT
	TBS 0.20% of C&F	0.002	26.20	USD/MT
	Surveyor's costs (USD O.15/MT)		0.15	USD/MT
	Financing cost (1.750% CIF)	0.0175	12.72	USD/MT
Sub total	**Local costs (LC)**		**39.32**	**USD/MT**
	Landed cost DAR (CIF+LC)		**766.10**	**USD/MT**
	Landed cost TZS per Litre		**1120.79**	**TZS/L**
	Government taxes			
	Fuel levy		200	TZS/L
	Excise duty		314	TZS/L
Sub total	Total government taxes		**514**	TZS/L
Plus	EWURA levy		6.8	TZS/L
Plus	Overheads Margins		101.11	TZS/L
	Wholesale Prices		**1742.70**	**TZS/L**
Plus	Dealer Margin		53.49	TZS/L
Plus	Transport charges (local)		10	TZS/L
Price	**Average DAR pump prices**		**1806.19**	**TZS/L**

Appendix 3: Questionnaire

Farmers Questionnaire

Ward ....Village......................Date....................................

Section 1: Background variables.

This section needs the respondent's background information.

1. Name of the respondent.....................
2. Sex of the respondent.......................
3. Household head.............................
4. Age of respondents..........................
5. Marital status of the respondent...........

   a) Married ( )

   b) Single ( )

   c) Widowed ( )

   d) Divorced ( )

6. Level of education ....

   a) Adult education ( )

   b) Informal education ( )

   c) Primary ( )

   d) Secondary ( )

   e) College ( )

   f) University ( )

7. Age distribution

Years	Number
0-10	
11-15	
16-30	
31-45	
46-60	
Above 60	

Section 2: Contribution of various crops to household income

This section requires information on the contributions of various crops to small scale farmers.

1. Do you own land   Yes/No

2. If yes, what is the total land you own........

3. How did you acquired the land

   a) Title deed ( )

   b) Customary/Traditional ( )

   c) Rented ( )

   d) Others (specify)

4. What is the total land in production.......acre?

5. What are your sources of income?

   a) Farming government ( )

   b) Employee ( )

   c) Private employee ( )

   d) Self employed ( )

   e) Animal keeping ( )

   f) Others (specify..........................)

6. Estimate the ANNUAL costs (TZS) of farming activities in the household from the major crops in 2008/2009.

Crop	Land preparat	Planting (TZS/	Weeding (TZS/	Fertilizer (TZS/	Harvesting	Labour		Land size	seeds (Kg)	Cost (TZS/
						Family	Hired			
Maize										
Beans										
Banana										
Coffee										
Jatropha										
Vegetables										
Others										

7. What is your major source of income in 2008/2009 for each of crop?

Crop	Year 2008			Year 2009		
	Average	Output (bags)	Price (TZS)	Average	Output (bags)	Price (TZS)
Maize						
Beans						
Banana						
Coffee						
Livestock						
Jatropha						
Vegetables						
Others						

8. Annual income from livestock ....TZS

9. What are your three main livestock you keep and how much do they give you annually?

Type of livestock	Size of herds	Number sold in market (TZS)	Total income (TZS)

10. Annual income from other activities (business, piece work) ....TZS.

Section 3: Factors influencing profitability

This section needs the information on the factors influencing the profitability of Jatropha among small scale farmers in the study area.

1. Are you growing Jatropha on your farm? 1. Yes 2. No
2. If yes, when did you start growing the crop? ....
3. If no, why you are not growing Jatropha?
    a) Seed market
    b) Oil as source of energy
    c) Fence
    d) Others (specify......................)

4. What is purpose of growing the crop?
5. What is the total land grown Jatropha ………….acre?
6. How you grow Jatropha on your farm?
    a) Monoculture
    b) Intercropping
    c) Hedge
    d) Others (specify………………………...)
7. Which kind of labour do you use? 1. Family labour 2. Hired labour
8. Which stage did you use hired labour?
    a) Cultivation
    b) Weeding
    c) Harvesting
    d) Others (specify…………………..)
9. From the activity above, how much do you pay them? .... TZS man day/ha/year
10. Do you apply fertilizer in your farm? 1. Yes 2. No
11. If yes, what type of fertilizer do you use?

Type of fertilizer used	Kg/Ha	TZS/Kg/Ha	Yield (Kg/Ha/Year)

12. Do you apply any pesticides in your farm? 1. Yes 2. No

13. If yes, what types of pesticides do you use?

Type of pesticide used	Kg/Ha	TZS/Kg/Ha

14. How much do you harvest last year?.....................Kg/acre

15. Are you selling your Jatropha seeds? 1. Yes 2.No

16. Where do you sale your Jatropha seeds?

a) Company

b) Local traders

c) Direct to the market

d) Others (specify.........................)

17. How many times do you sale Jatropha in a year? ....

18. What are their payment conditions?

a) Cash

b) Installments

c) Other mention..........

19. What is the market price of 1kg of seeds? ....TZS.

20. How far is the market for Jatropha seeds ....Km.

21. What are the main uses of Jatropha seeds?

a).......................

b).......................

c)........................

d)........................

22. What are factors influencing Jatropha production in 20008 and 2009?

a)....................

b)....................

c) ....

d).....................

23. Are you satisfied with the price? 1. Yes 2. No

24. If no, why? ....

....How many times an extension worker visits your field? ....

25. Did you attend any training for Jatropha production? 1. Yes 2.No

26. If yes, who organized it............ and days......................

27. Did you access any credit for Jatropha production in the past three years? 1. Yes 2. No

28. Where did you get it? ....and how much................TZS.

THANK YOU FOR YOUR COOPERATION