

**ECONOMIC PROSPECTS OF JATROPHA PRODUCTION: A CASE OF
SMALLHOLDER FARMERS IN ARUMERU DISTRICT, TANZANIA**

BY

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
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ABSTRACT

The study was carried out to investigate the production potential for oil crop called jatropha (*Jatropha curcas*) in Arumeru district. A total of 111 farmers were randomly selected for interview. The study involve estimates of profitability of jatropha farming compared with maize farming, investigating household factors that influence adoption of recommended jatropha cultivation practices and identify opportunities and challenges for the development of jatropha industry in Tanzania. The data were collected from primary and secondary sources. The tools of analysis used include descriptive statistics, logistic regression and cost benefit analysis. A binary logistic regression employed to test the influence of household factors on the adoption of recommended cultivation practices in the study area. The cost benefit analysis used to estimate relative profitability of jatropha enterprise against maize enterprise. Survey results show that average seed yield per jatropha tree was 2 kg for the 1st harvest and 1 000 kg for 1 ha of maize field. The BCR of 1.76, NPV of TZS 55 199 and IRR of 58% were obtained when jatropha enterprise was discounted at 20%. Results show that BCR of 1.06, NPV of TZS 34 713 and IRR of 27% were obtained when maize enterprise was discounted at 20%. The logistic regression showed that household factors such as education, land availability and extension services influence farmer's adoption significantly at $p < 0.05$ level. The results show that jatropha production opportunities include rural income generation, domestic energy security, utilization of waste lands, employment opportunities whereas the challenges include land availability and food security. The study concluded that jatropha production was found to be profitable compared to maize production. Furthermore, the study recommends that Tanzania government needs to review its role in

promoting jatropha industry through technology development. Secondly, non-governmental institutions should support Government's efforts in promoting jatropha crop.

DECLARATION

I ANDERSON ISAYA TWEVE do hereby declare to the Senate of Sokoine University of Agriculture that this is my own original work and has neither been submitted nor being currently submitted for a degree award in any other university.

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Date

The above declaration confirmed.

Dr. D. M. Gabagambi
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Date

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DEDICATION

This work is dedicated to Jesus Christ and my late sisters, Esteriche Tweve and Loyce Tweve. Thanks for your love. Your love has been of valuable contribution to my success in education.

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LIST OF ABBREVIATIONS AND ACRONYMS

BCR	-	Benefit cost ratio
CAMARTEC	-	Centre for Agricultural Mechanization and Rural
		Technology
CBA	-	Cost benefit Analysis
CJP	-	Centre for Jatropha Promotion and Biodiesel
CIMMYT	-	International Centre for Maize and Wheat improvement
EU	-	European Union
FACT-Foundation	-	Fuels from Agriculture in Communal Technology-
		Foundation
FELISA	-	Farming for Energy for Sustainable Livelihood
GDP	-	Gross domestic product
GHG	-	Green House Gas
GMA	-	Gross margin analysis
GTZ	-	German Technical Co-operation
Ha	-	Hectare
IRR	-	Internal Rate of Returns
JPTL	-	Jatropha Products Tanzania Limited
KAKUTE	-	Kampuni ya Kusambaza Teknologia
MAC	-	Ministry of Agriculture and Co-operatives
MDB	-	Marketing Development Bureau
MDGs	-	Millennium Development Goals
NBS	-	National Bureau of Statistics
NGOs	-	Non Governmental Organizations
REA	-	Rural Energy Agency
REF	-	Rural Energy Fund
SARI	-	Selian Agriculture Research Institute
SNAL	-	Sokoine National Agriculture Library
SUA	-	Sokoine University of Agriculture
TZS	-	Tanzania shilling
TATEDO	-	Tanzania Traditional Energy Development and
		Environmental Organization
TBS	-	Tanzania Bureau of Standards
TIRDO	-	Tanzania Industrial Research and Development
		Organization
UDSM	-	The University of Dar es Salaam
URT	-	The United Republic of Tanzania
USDA	-	United States Department of Agriculture
VYAHUMU	-	Vyakula na Huduma za Mashine za Usindikaji

CHAPTER ONE

INTRODUCTION

1.1 Background

Jatropha (*Jatropha curcas*) is a drought resistant perennial crop that can be grown in marginal land. *Jatropha* grows in bushes up to 6 m in height and can live up to 50 years and its seeds produce non-edible oil that can be used to lubricate machines, run machines and produce soap. Selling of *jatropha* seeds and processing generate additional income to the local communities. Therefore due to its value, *jatropha* can be grown as commercial crop (Diligent, 2007).

Diligent (2007) reported that *jatropha* plant can be grown in too dry or too arid areas or areas previously utilized by human being through excessive agriculture. The plant requires little water, fertilizers or pesticides. Many parts of *jatropha* plants have been used historically by local cultures. The oil from the seeds has application in medicine, a lubricant or as a fuel. Currently, it is known as a feedstock for biofuel or soap production. *Jatropha* plant is not eaten by animals such as goats due to its toxicity. This means a hedge of the *jatropha* plant keep animals outside the fields where food crops are grown. Intercropping *jatropha* with food crops provide shadow in harsh condition, allowing more delicate crops to be grown in between.

In Tanzania, most of Non- Governmental Organizations (NGOs) working in rural areas are interested in the income generating possibilities by utilization of the *jatropha* plant through oil and soap production. Related Government organizations, national NGOs and private companies are interested in the energetic aspect by using

jatropha oil for the large-scale production of biodiesel. Tanzania has started to consider alternative source of fuel such as development of biofuel sector in commercial perspective. Several stakeholders are working to research and develop biofuel from jatropha including University of Dar es Salaam (TATEDO, 2007).

The recent rise in the world oil prices, coupled with interest in combating green house gas emissions and concerns about energy security has led to a sharp increase in biofuels production (Hertel *et al.*, 2008). Business interest in biodiesel has also grown in the United States of America (USA), Brazil and Indonesia. A total of 3.75 million tonnes of biodiesel was produced in the European Union (EU) in 2005. The EU market leader is German with a production of 300 000 tonnes in 2002, 1.06 million tonnes in 2003, 1.20 million tonnes in 2004 and 1.95 millions tonnes in 2005 (Ledebur *et al.*, 2008).

In 2000, households in Sub-Saharan Africa consumed nearly 470 million tonnes of wood and charcoal. This is far more than any other continent. Wood or crop residues are the primary source of energy for 94% of rural households and 41% of urban households in the region (Renewable energy policy network, 2005 cited by Eijck and Romijn, 2006).

The economy of Tanzania heavily depends on agriculture which account for about half of the Gross Domestic Product (GDP), provides 85% of exports and employs 80% of the work force. Over 77% of the populations live in rural areas where alternative energy sources such as jatropha biofuel is limited that leads to 97% of

national energy consumption from fuel wood which in turn creates environmental problems including soil erosion and deforestations (Eijck and Romijn, 2006).

1.2 Problem Statement and Justification

The majority of working people of the world live on less than 2 US\$ per day and the crop yields in Sub-Saharan Africa are projected to fall by 20% under global warming (CJP, 2008). The high cost and inaccessibility of fossil fuels, leaves approximately 2 billion people worldwide without reliable energy sources, heat or even light. The two-thirds of people in the developing world derive their income from agriculture which includes jatropha production, although the relative competitiveness of jatropha with other crops and its potential as a source of income and fuel in rural communities is little covered. The lack of information on the potential of jatropha as a source of fuel and income in rural communities significantly hold back progress of the Millennium Development Goals (MDGs) and restrict the degree to which poor people can benefit for economic growth currently being enjoyed by other developing countries.

Tanzania's demand for petroleum products is growing rapidly at a rate of more than 30% per year. The country is one of the consumers and importers of fossil fuels. Since petroleum is expensive and finite source, jatropha production as a source of renewable fuels will help to alleviate the dependence on petroleum imports (GTZ, 2005). In spite of the high contribution of biomass as a source of fuel, Tanzania energy development priorities have concentrated on fossil fuel sources such as petroleum products (URT, 2004). This is done while there is favourable environment

for income generation and production of oil as a source of energy from jatropha plant. In order to reduce poverty status and meet the high demand of energy, jatropha production has enormous potential to change farming community to better livelihood and poverty can be broken by jatropha cultivation (Henning, 2004).

Many rural communities in Tanzania are still unable to use existing opportunities of jatropha production. This hinders the ability of the people to participate fully in jatropha production to increase their income and ultimately contribute to economic growth of the nation. The jatropha plant is widely seen to have ability to reduce the green house effect, help to stop local soil erosion, create additional income for rural poor and provide a major source of energy both locally and internationally (Eijck and Romijn, 2006).

The available opportunities of jatropha production are not accessible by rural communities perhaps due to constraints from household factors such as level of education, extension services availability, age of farmers and land availability. The limited research studies on relative profitability of jatropha against other traditional crops and the existing challenges at household levels limit jatropha production. Therefore, this study aims at generating information on the production potential for jatropha (*Jatropha curcas*) as a source of energy (such as lightning, cooking) and income generation to rural communities (such as selling of jatropha seeds, soap production).

1.3 Overall Objective

The overall objective of the study is to investigate prospects and constraints of jatropha production in rural communities of Tanzania using Arumeru district as a case study.

1.3.1 Specific objectives

The specific objectives of this study are;

- i. To identify opportunities and challenges in jatropha production in Arumeru district.
- ii. To investigate household factors which influence adoption of recommended jatropha cultivation practices.
- iii. To examine profitability of jatropha production in economic terms.
- iv. To recommend sustainable intervention strategies to enhance jatropha production.

1.4 Research Hypotheses

The research will be guided by two hypotheses;

- i. Adoption of recommended jatropha cultivation practices are influenced by household factors such as level of education.
- ii. Production of jatropha is a profitable venture from an economic stand point.

1.5 Limitation of the Study

Most data were obtained mainly through interviewing farmers whose replies were subject to error due to inadequate knowledge, or faulty memory or because of

untruthful replies evolved by consideration of pride or suspicious. Jatropha growers under this study are homogeneous so it is expected to have the same shortcomings thus reliability of the collected data could somehow be carrying the same weakness. The problem was minimized by careful probing the interviewee to enable him or her to disclose and remember more information on prospects and constraints of jatropha production. Conversion of unit was also a problem since some farmers use local units. However, estimation had been done to convert local unit into conversional ones such as kilogram and tonne. In spite of the above limitations, the researcher was confident that data collected were reliable and have adequately addressed the objectives of the study.

1.6 Organization of the Report

The report is organized into five chapters. The first chapter represents background information for the study including problem statement, objectives of the study and hypotheses. The second chapter reviews literature on jatropha production and constraints. The third chapter presents the methodology used in the study. The fourth chapter presents results of the study and discussion. The last chapter presents conclusion and recommendations emanating from findings of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Role of Agriculture in the Tanzania's Economy

Agriculture has a dominant position in the economy of Tanzania, providing some 48% of GDP, and employment for some 84% of the population. Recent studies by World Bank have found that about 50% of the Tanzanians live below international poverty line of US\$ 2 per day. It has been observed that over 80% of the poor live in the rural areas and depend on agriculture for their livelihood (MAC, 2003). Agriculture continues to be the back bone of Tanzanian economy. World Bank (2001) reported that agriculture prominence is due to the fact that it contributes to the non-farm sector by providing food and raw materials for agro-processing industries. The futures of small-scale farmers depend largely on the availability of agricultural technology and ability to apply improved technologies in agriculture production.

2.2 Tanzania Oil Seed Production

Until today, research and extension services for oil seed crops have been inadequate causing an insufficient performance of oil seed sub-sector. Therefore, there is need to improve these services in order to increase production of oil seed crops in Tanzania by private sector in growing and processing of oil seeds, whereas government attention must be directed to assist the sector to accelerate the growth of oil seed industry.

According to MDB (1989) as cited by Madadi (1998), oil seeds production is influenced by the relative profitability compared to other crops like maize which are

grown on main oil seed producing areas. It is argued that oil seed production has relatively lower variable cost outlays and crop returns to labour which compete favourably with other crop like maize. Most studies emphasize that lack of clear policy on agricultural produce prices and market opportunity are the main reasons for low productivity in crop production in Tanzania. Jones and Muthuura (2002) found that the availability of market for agricultural produce assists farmers to sell their produce at an attractive price.

Tanzania has a favourable environment to grow large number of oil crops of which only few are grown on large scale. Some important oil crops produced in Tanzania are jatropha, cashew nuts, palm oil, groundnuts, simsim, coconut and sun flower. Variety of oil plants which could be potentially produced for biofuels and their favourable climatic condition and identification areas are shown in Appendix 4.

2.3 Description of Jatropha Plant

2.3.1 Historical perspective of jatropha plant

According to Henning (2004), jatropha (*Jatropha curcas*) is a bush or small tree up to 5 m height. Jatropha originates from Central America from Caribbean and probably distributed by Portuguese seafarers via the Cape Verde Islands and Guinea Bissau to other countries in Africa and Asia. Today, the plant is cultivated in almost all tropical and subtropical countries as protection hedges around gardens and fields. Jatropha grows well with more than 600 mm of rain fall per year and with stands long drought period.

2.3.2 Jatropha system and attributes

Henning (2004) has explained advantages of jatropha and jatropha system in developing countries. Jatropha system is integrated rural development approaches which focus planting jatropha as hedges to protect gardens and fields against roaming animals, the oil from seeds for soap production, lightning, cooking as well as fuel in special diesel engine. Jatropha system covers four main aspects of rural development including promotion of women (local soap production), poverty reduction (protecting crops and selling seeds, oil and soap), erosion control (planting hedges) and energy supply for household and stationary engines in the rural area. The obvious advantage of this system is that all processing procedure and the added value can be kept within rural area.

2.3.3 Benefits from jatropha plant

In accordance to Henning (2004), jatropha plant has several uses. Jatropha plant is used as medicinal plant (the seeds against constipation, the sap for wound healing and the leaves as a tea against malaria). Most of jatropha trees are planted in the form of hedges and gardens or field to protect the crops against roaming animals like cattle or goats. The jatropha hedges are planted to reduce erosion caused by water or wind. Moreover, farmers plant jatropha to demarcate the boundaries of field and homesteads. The plant is used as a source of shade for coffee plant like in Cuba. The jatropha plant is also used as support plant for vanilla plant like in Comoro islands, Papua, New Guinea and Uganda.

In addition, Pavitt and Bester (2007) reported that jatropha plant is grown to produce seeds that are used to make biodiesel. Jatropha seeds contains between 35% and 37%

oil. *Jatropha* can be planted 2500 trees/ hectare at 2 m apart for commercial purposes. With good planning, quality planting materials, standard farming practices and good crop management, *jatropha* should yield approximately 10 000 kg of seeds/ hectare from the fifth year onwards. At an extraction rate of 37% it will produce 3 389 litres/ hectare. *Jatropha* can also be intercropped with other crops.

2.3.4 *Jatropha* products

Jatropha cultivation makes a significant contribution to the biofuel production and in sustainable development of the country. *Jatropha* can promote the development of several sister industries (soap, cosmetics, pharmaceuticals, fumigants and insecticides). By-products obtained upon oil extraction have tremendous scope for the use by local communities as well as market value. Economic gain can be experienced through the sale or direct use of these by-products such as oil cakes extraction. *Jatropha* is among renewable energy sources in terms of the potential benefits that can be expected to result from its widespread use. Fuels from Agriculture in Communal Technology (FACT) Foundation (2006) and other authors reported that *jatropha* is a promising species because many products from the plant can be made useful.

2.3.4.1 *Jatropha* oil in lamps and cooking stoves

The oil can be used to fuel cook stoves and oil lamps. Properties of *jatropha* lamps differ considerably from ordinary lamp oil or kerosene. Modified *jatropha* cooking stoves have been developed in Tanzania, although research has not been completed. According to Eijck and Remijn (2006), there are NGOs which promote production of

oil lamps in Tanzania. Households in remote Masai areas such as Selela and Engaruka use jatropha oil lamps. The results from experiment of modified cooking stoves show many barriers to use jatropha oil in stoves due to various reasons including dangerous emission.

2.3.4.2 Feed stock for soap production

In accordance to FACT-Foundation (2006), it is fairly easy to produce soap from jatropha oil due to its lipid contents. The components necessary for soap making and their ratios are 1 litre of jatropha plant oil, 0.75 litre of water and 150 g of caustic soda per litre of oil. Singh *et al.* (2006) reported that seed extracts give a very good foaming white soap with positive effects on the skin, partly due to the glycerine content of soap. The soap produced out of jatropha seed extracts is useful for both human and veterinary purposes.

2.3.4.3 Direct fuel for engines

Jatropha has a requisite potential of providing a promising and commercial viable alternative to diesel as it has the desired physio-chemical and performance characteristic comparable to petro-diesel. Jatropha oil has 51 cetane number higher compared to other oils. The cetane number for diesel ranges from 46 to 50 and therefore makes jatropha oil as an ideal alternative fuel and requires no modification in engine (Singh *et al.*, 2006).

2.3.4.4 Seed cakes

When seeds are pressed to oil, about 20 to 30% of oil is gained. The rest remains as seed cake. Seed cakes contain a considerable amount of energy of about 20 to 25 MJ/kg (FACT-Foundation, 2006).

Singh *et al.* (2006) reported that seed cake, a by product of extraction of jatropha oil can be value as an organic fertilizer or as a raw material in manufacturing. Being rich in Nitrogen, the seed cake is an excellent source of plant nutrients. This residual de-oiled cake contains 38% protein, 3.2 to 44% Nitrogen, 1.4 to 2.09% Phosphorous and 1.2 to 1.6% Potassium. Sale of seed cake can be a source of additional income and as fertilizer can be beneficial for unfertile and nutrient poor soil and makes it suitable for crop cultivation.

2.4 Production Chain of Jatropha

In accordance to FACT Foundation (2006), jatropha can be planted through generative propagation (direct seeding) and vegetative propagation (cuttings). Jatropha currently seems to have little difficulty with diseases and pests. The ideal spacing of jatropha in Agro-forestry block plantation under rain fed condition could be 3 m x 3 m (or 2.5 m x 2.5 m under dense vegetation). The lifespan of this perennial bush is more than 50 years and it can be grown on marginal soils with low nutrient contents.

Eijck and Romijn (2006) reported that the yield ranges from 0.1 to 15 t/ ha/ yr of seeds, and depends on a range of factors including water, soil conditions, altitude, sun and temperature. Harvesting of seeds takes place during the dry season where

seeds contain 30% of oil. The production (processing) stage involves pressing of seeds by use of small manual ram-presses and power operated screw processors to expel oil, leaving seedcake. About 5 kg of seed is needed for one litre of oil. The oil and seedcake are consumed or further processed to generate final products. The seedcake can be used to produce biogas for cooking or used as fertilizer or in briquette form as cooking fuel. The jatropha oil can be used for production of soap or used in oil lamps (Fig. 1). In addition the jatropha oil can be used in cooking stoves.

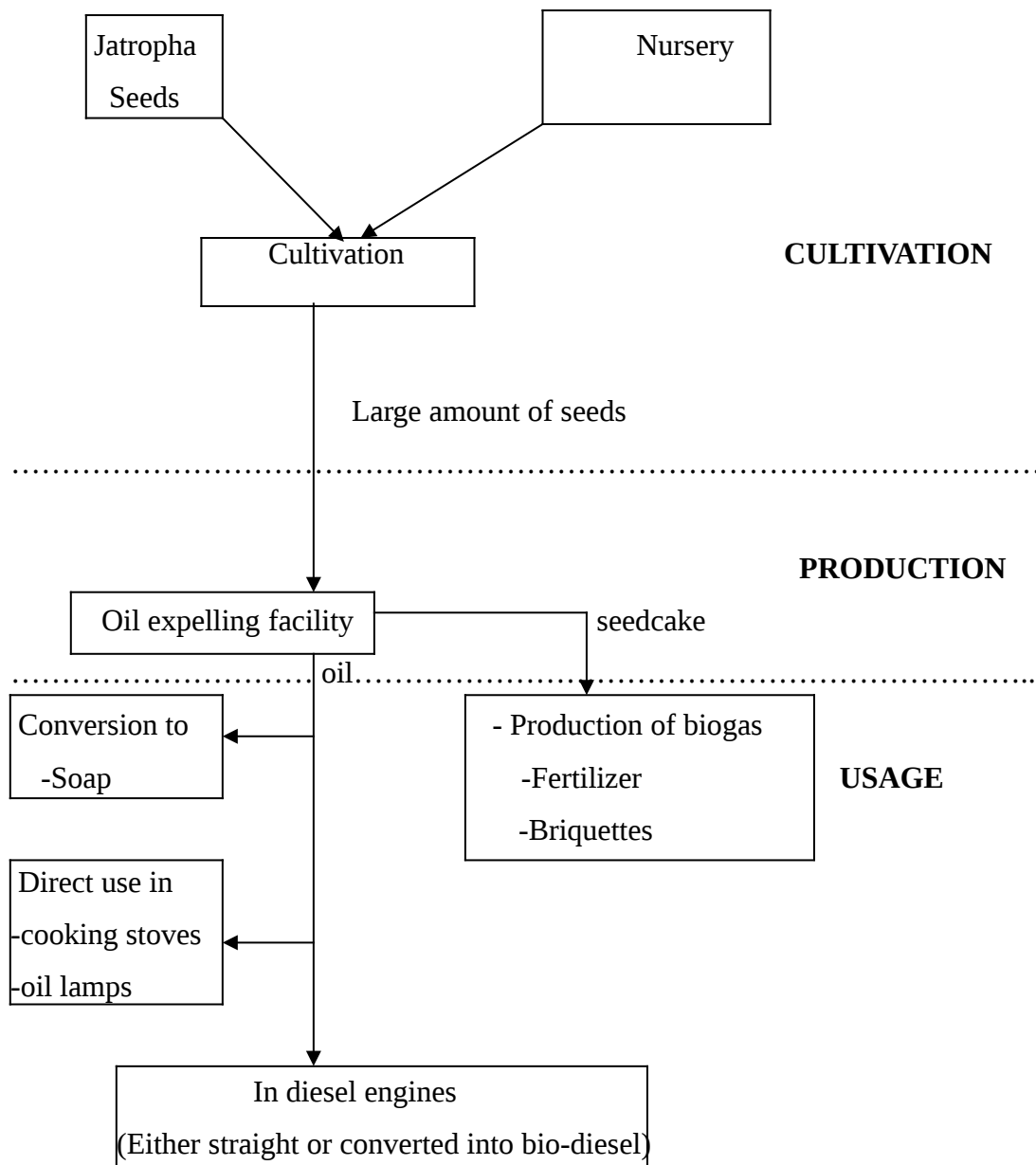


Figure 1: Jatropha production chain

Source: Eijck and Romijn (2006)

2.5 Jatropha Promotion in Tanzania

According to Henning (2004) jatropha is promoted by several African countries including Tanzania, Benin, Egypt, Ethiopia, Ghana, Guinea, Madagascar, Mali, Mozambique, Namibia, South Africa, Sudan, Uganda, Zambia and Zimbabwe. In Tanzania several stakeholders are involved in the promotion of the crop through various programs and activities. “*Kampuni ya Kusambaza Teknologia (KAKUTE)*”, disseminate technology regarding jatropha system and produces soap in industrial scale. The dissemination is also done by a project called Alternative Resources of Income for Monduli women (ARI - Monduli) which is engaged in jatropha soap production and plant jatropha to control soil erosion. In Mto wa Mbu, jatropha is produced as a medicinal soap by women within a dispensary and in other dispensaries. In Engaruka village almost all gardens within the villages are surrounded or protected by jatropha hedges. Women in this village do produce oil and sell soap. “*Vyakula na Huduma za Mashine za Usindikaji (VYAHUMU)*” -Trust is a project of Evangelical Lutheran Church of Tanzania (ELCT) aimed at improving income of Tanzania farmers by enabling them to produce oil including sunflower and jatropha oil (Henning, 2004).

2.6 Rural Energy Situation in Tanzania

Energy is the major and significant component in economic development of any nation. The demand for oil as an energy source is increasing but the production is very low resulting in mismatch between demand and supply of oil. The main source of primary energy in urban and rural areas is woody biomass. It is estimated that its

consumption per capita is 1 m³. Tanzania spends up to 25% of its foreign currency earnings on petroleum imports to secure demands for energy services in transportation and domestic use. The government is in the process of establishing a Rural Energy Agency (REA) and Rural Energy Fund (REF) to ensure accessibility to rural energy services in order to secure socio-economic improvement of the majority of Tanzanians (Lyimo, 2005). Therefore, the most significant benefit to biofuel will be enabling the rural poor majority to have access to modern energy services that enable the marginalized rural to be productive, have quality social services and in that way contribute to achieving the MDGs. In this way efforts are being made to explore plant based fuel resources as substitute for fossil fuels which are renewable and environmentally safe.

2.7 Jatropha Biofuel Production Potential

Biofuels represent a subgroup of biomass which can either be in liquid form such as ethanol or biofuel or in gaseous form such as biogas. Bioenergy is renewable energy made available for materials derived from biological sources. Bioenergy is among the renewable energy sources considered to play a key role in improving global energy efficiency. Bioenergy generated from organic substances usually referred to as biomass. Agricultural or agri-forestry products are among the renewable energy sources (Ledebur *et al.*, 2007). Ludema *et al.* (2005) investigated potential of biofuel in Latin America and the Caribbean using quantitative assessment method found that there is suitable land for growing oil crop. The demand and prices for energy crops motivate farmers to increase production.

According to GTZ (2005) jatropha oil production in Tanzania takes place in small quantity only where potential of jatropha for biofuels production in Tanzania is 18 000 to 58 000 t/ yr with 33 to 60% oil content and grown in tropical and sub-tropical climates in Arusha, Bukoba and Kilimanjaro. The current biofuels activities and opportunities in Tanzania can be divided into large-scale and small scale approaches where large scale biofuels production such as production of ethanol from sugar cane promoted by sugar industry with companies such as D1 Oils in the plant oil sector while small scale activities by organizations such as FELISA (Farming for Energy for Sustainable Livelihood), KAKUTE aimed at rural income creation through production of soap from oil seed crops. The small-scale activities are mainly concerned with income earning and supporting creation of rural-income and opportunities from oil seed crops through production of plant oils (for food or other commodities such as soap production from jatropha).

2.8 Demand of Jatropha as a Source of Biofuel

In long run, demand for jatropha biofuel will be influenced by a wide variety of factors including the prices of substitutes, income levels, tastes or preferences and lifestyle factors. According to CJP (2008), the global biofuels is growing steadily with biodiesel market estimated to reach 37 millions gallons by 2016 growing at an average annual rate of 42%. This rapid development of the global biodiesel industry has been caused by countries interested in stimulating economic growth, improving environment and reducing dependence on imported oil. In Tanzania fossil fuel prices are surging upwards unpredictably with consumers bearing burden of rising international oil prices because Tanzania does not produce its own petroleum oil and

all requirements are met by imports. Production of biofuels will gain increasing economic importance due to the high and growing of crude oil prices. The estimation of crude oil prices until 2015 is shown below (Fig. 2).

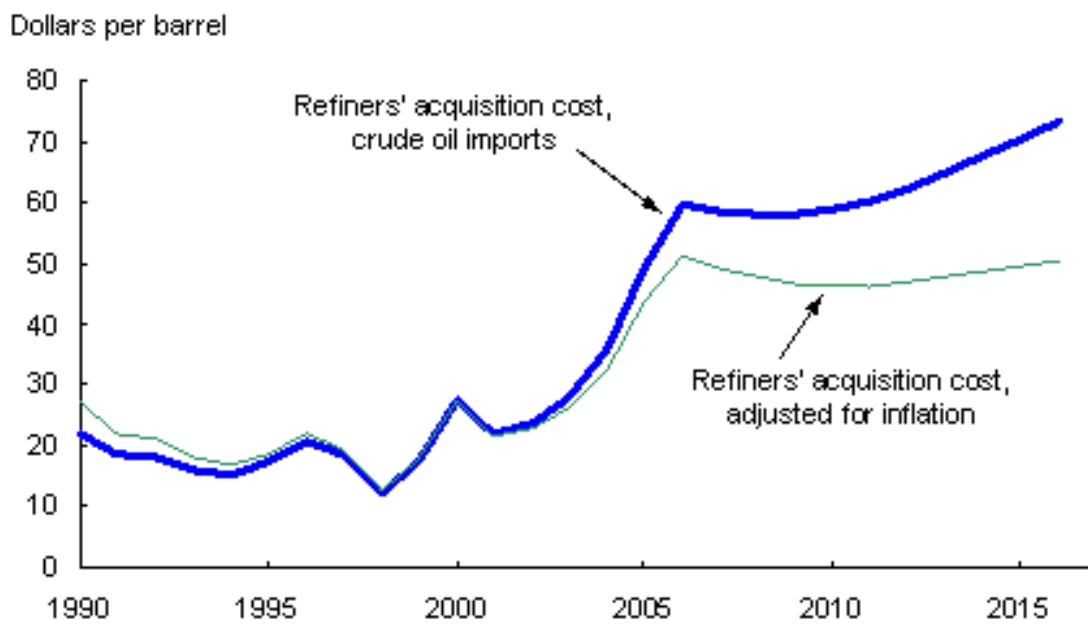


Figure 2: Crude oil prices estimation until 2015

Source: USDA (2006) cited by Zeller and Grass (2007)

2.9 Supply of Jatropha as a Source of Biofuel

In the long run, the supply of jatropha oil will be influenced by factors such as policies, regulations, cost of production, technology of production and world crude oil prices. Swallow and Tomomatsu (2007) considered jatropha production is economically viable if the price of biofuel is competitive with petroleum products. The cost of biofuel production is greatly affected by the cost of feedstock production. The feedstock for biofuel could be any vegetable oil, animal fat and jatropha oil.

Therefore, jatropha production will be economically viable when its price is competitive with available alternative oil.

2.10 Agricultural Marketing in Context

The need for price and cost data to make adequate farm management decisions is necessary for expertise in the field of marketing (Kohls and Uhl, 1990). In order to maximize income to farmers in crop or livestock production, they must buy inputs and sell the product at the prices that result in a profit. The ability to analyze the market and to reflect changing market expectations in production schedules, input purchasing and product selling strategies are essential components of a profitable farm. Hence farmers must be aware of the supply and demand relationships for the particular product, the impact of consumer incomes and the availability of substitutes on product prices as suggested by income and cross price elasticity of demand and the expected response of other producers to current prices.

2.11 The Role of Marketing in Agricultural Productivity

Agricultural marketing is the performance of all business activities (marketing function) involved in the flow of goods and services from the point of initial agricultural production until the same goods are in the hand of ultimate consumers (Kohl and Uhl, 1990). A well functioning marketing system is a pre-requisite for an increased agricultural productivity and hence a fast economic development. The system of production and marketing of agriculture can be described as the interaction and outcome of decisions by various actors (stakeholders) in pursuit of a number of specific activities, each following certain economic principles. In this setting, the

system of production and marketing fulfils three basic functions; utility generation, resources allocation and welfare generation (Gabagambi, 1998).

2.12 Marketing Potential for Jatropha as a Source of Biofuel

GTZ (2005) reported that despite of high potential for biofuel in Tanzania, there is no any reported commercial scale biofuel production in Tanzania, however, there are several local and international stakeholders invested in the development of biofuels. These stakeholders include KAKUTE, FELISA, Diligent ltd, D1 Oils and PROKON as well as sugar companies (Kilombero Sugar Company, Mtibwa sugar estate, Kagera sugar ltd, Tanganyika Planting Company) in the field of sugarcane based bioethanol production. Jatropha oil in Northern Tanzania (Arusha, Engaruka, Mto wa Mbu) is traded around 2 US\$ per litre while 1 kg of jatropha seeds range from TZS 80 to TZS 150. In addition, PROKON is a German company investing in jatropha in Tanzania which buy produced jatropha oil at prices comparable to the current world market price of other plant oils, thereby ensuring market and additional income to farmers in Mpanda district in Tanzania.

2.13 Potential for Jatropha Products in Tanzania Market

According to Manyanga (2005), jatropha soap is only product of jatropha tree, which has penetrated market in Tanzania and final consumers of jatropha soap are mainly people with skin diseases and allergic to toilet and perfume soap. The threat of jatropha soap substitute is neem soap and other natural soap. Jatropha soap already sold in Dar es Salaam, Mwanza and other town centres of Tanzania. However, there is no well established market for jatropha products and difficult to quantify the

volume of soap entering the market due to various limitations, but mainly due to inaccessibility and scattered data.

2.14 The Role of Stakeholders in Jatropha Sub-sector Development in Tanzania

Most smallholder farmers in Sub-Saharan Africa practice either subsistence farming or operate largely in local markets due to lack of connection to more lucrative markets. As a result, incentives remain weak; investments remain low resulting into low equilibrium poverty trap. Due to the nature of small farmers and the commodity they produce, various institutions and institutional support are needed to link small scale farmers to markets (Mutakubwa, 2007).

GTZ (2005) reported that in the field of biodiesel development efforts are spearheaded by KAKUTE, FELISA, D1 Oils, UDSM, TATEDO, PROKON and other stakeholders. KAKUTE disseminate knowledge of jatropha production and processing and assist small holder farmers to produce jatropha soap, FELISA ensure oil from palm trees will be produced in big quantities and used as alternative fuel in Tanzania while TATEDO facilitate promotion of biofuels production and marketing as substitute for imported fuels and means to support poverty reduction whereas D1 Oils initiate the large scale exploitation of oil plant products and UDSM conduct research process, development and provide expert professional services to industry, government and other organization. PROKON is also a German company invested in jatropha production in Mpanda district.

2.15 Jatropha Research and Development (R&D)

Research and Development (R&D) programs are important in technology development and supply of jatropha. The need of research in improvement of jatropha seed base, supply and market chain is a vital. The jatropha development plans for weighing the magnitude and allocation of costs, benefits and risk associated with risks associated with jatropha development are important. Manyanga (2005) reported that various actors were collaborated with KAKUTE and contributed to technology development at different levels of jatropha chain in Arusha and Manyara region. In nursery propagation (KAKUTE, JPTL, TATEDO, WOMEN GROUPS), farming systems were KAKUTE, JPTL, SARI, TATEDO (growing jatropha in gullies and valleys), SUA, UDSM Research on potential of jatropha production in other regions), Processing technologies were KAKUTE, CAMARTEC, VYAHUMU, Product development were KAKUTE, TATEDO/ TIRDO, UDSM (Distribution of seedlings and lamps), SARI (Jatropha cake as fertilizer), UDSM (biodiesel), Diligent Tanzania (renewable energy), TBS.

2.16 Prospects and Challenges of Jatropha Production

Among the diversity of potential energy crops, jatropha (*Jatropha curcas*), an oil-bearing plant has emerged as high potential biodiesel feedstock because it grows on marginal land and thus does not necessary compete with food crops. Tennigkeit and Weyerhaeuser (2007) analysed the opportunities and challenges for establishing economically and environmentally sustainable markets for jatropha oil in South West China and assessed of how jatropha oil production fits into Chinese central and provincial market government and socio-economic development goals. Jatropha is

drought resistant perennial oil-plant grown in diverse soil types and in variety of climatic condition and requires comparatively low physical and human inputs and does not necessary compete with food production systems. Harvested jatropha seeds are crushed pressed, and their oil is extracted and separated. Pure filtered jatropha oil can be used directly in modified engines while jatropha blended diesel has several advantages over pure petroleum-based diesel in particular due to jatropha oil's higher cetane number, higher flash point and lower sulphur content as indicated in Table 1 below.

Table 1: Comparing petroleum-based diesel and jatropha

Parameter	Petroleum-based diesel	Jatropha oil
Density	0.84 to 0.85 kg / l	0.91 to 0.92 kg / l
Cetane number	47.8	51.0
Flash point	80 °C	110 to 240 °C
Sulphur content	1.0 to 1.2%	0.13%

Source: Tennigkeit and Weyerhaeuser (2007)

Tennigkeit and Weyerhaeuser (2007) proposed that jatropha supply chain dominated by risk-averse smallholder and large natural oil companies with high hurdle rates, the challenges of developing viable markets for jatropha. The sufficient quality and quantity of land to meet reasonable scale of feedstock demand and lack of clear information on effects of quality of seeds and yield in growing jatropha in marginal land. Institutional innovation including contractual arrangements, incentives and other policy tools are important in assisting overcome obstacles in jatropha

production and marketing. Institutions will also be key leader in determining the fairness of and allocating of risk in these markets. Appropriate levels of government support to jatropha markets determine to large extent by how small markets determine how small markets can be and cost effective. The design of jatropha programs and biofuel programs depend on research fund versus how much to subsidize industry growth. Once jatropha growing begins on a commercial scale, costs are likely to fall at some level. Therefore, subsidies are needed to spur the establishment of jatropha biodiesel markets, decisions on how fast and at what level to support the growth of jatropha biodiesel industry should be based on a systematic, intensive research support.

GTZ (2005) identified various benefits of displacing gasoline and diesel fuels with liquid biofuels. Some of benefits include rural development due to creation of jobs and income opportunities, reduction of oil imports in order to increase exchange savings, improved energy security, creation of new industries, reduction of air pollution and GHG emissions. According to Zeller (2007), biofuels hold a number of promising prospects and challenges especially for developing countries. Among prospects for producing biofuels includes renewable energy source, reduction of greenhouse gases, enhancing national energy security. The biofuel also pose some important challenges including expansion of biofuel which creates upward pressure on food prices and deforestation. Pannel (1995) identified factors affecting farmers decisions on crop production in Australia, these factors includes yield performance of the crop, output prices and associated input costs which reflect profitability of the crop. Lyatuu (1994) cited by Mkude (2003) noted that despite its importance many

credit institutions are not accessible to farmers. This is due to lack of adequate collateral, the high incidence of default and administrative costs associated with small loan.

Meena and Sharma (2006) identified the various constraints perceived by farmers in the adoption of recommended jatropha cultivation practices. These constraints includes lack of technical guidance and information, non-availability of improved varieties of jatropha plants, lack of finance facilities, unawareness about economic value of jatropha seeds, lack of irrigation facilities for raising seeds, non-availability of manures, fertilizers, chemicals and insufficient labour during dry season and lack of marketing facilities for sale of produce.

2.17 Food Security and Energy Provisions

Biofuel production is said to cause food security risks or challenges for poor people in developing countries. The use of cereals (corn, sugar cane) for industrial purposes including biofuel production will increase food prices. This is because it is said poor people spend much a bigger share of their budgets on food than they do to energy. According to Bell and Monbiot (2005) cited by GTZ (2005), world food stocks (particularly cereals) are approaching an historic low leading many analysts to conclude that any expansion of biofuels production will directly impact on global food security. These concerns are based on the premise that biofuels production would lead to competition for land that would otherwise be used for food production. The use of non-food crops such as jatropha is essential because jatropha can be grown on land that is not capable supporting food cropping, no competition with

food crops and can rehabilitate the degraded land and possible to return some of this land to food production.

2.18 Investment Appraisal in Previous Studies

Bernard (1993) assessed the viability of the wheat in state owned large scale mechanized farms in Tanzania. The cost benefit analysis used as analytical tool to assess the worthiness of wheat project. The benefit-cost ratio (BCR), the net present value (NPV) and the internal rate of returns (IRR) were used to estimate profitability. The study found that through use of BCR, the value of discounted benefits exceeds the discounted present value costs, then it was worthwhile to invest fund most effectively in the long term wheat activities in anticipation of an expected flow of future benefits over a series of years. Basing on the study, IRR justified economically investing in wheat production activities.

Orota (1993) assessed the socio-economic problems that under project development and expansion of lower Moshi Irrigation project in the Kilimanjaro region. Descriptive and economic analyses were used as analytical tools in the study. Economic analysis used to assess worthiness of investment project. The results showed that BCR of 2.5, NPV of TZS 235 millions and IRR of greater than 50% when discount rate of 18% used. These results implied that investment and projects costs can be recovered at the end of 25 years and the possibility that the whole economy will benefit from the project was high. Profitability of jatropha was assessed by Eijck and Romijn (2008) using cost benefit analysis to the selected five projects. The BCR, IRR at real discount rate of 9.8% were estimated and eventually

found growing jatropha was economic viable enterprise. The IRR for Kikuletwa farm, Jesus the good shepherd and Ismael Manang were 359%, 26% and 384% respectively. This meant the rate of returns was above the opportunity cost of capital which implies the project was economically viable. The NPV obtained from Kikuletwa farm, Jesus the good shepherd, Ismael Manang, village and Women's group were TZS 511 000 745, 878 294, 102 881 245, 12 054 828 and 3 185 704 respectively. Therefore, the NPV were positive meant project costs can be recovered at the end of five years.

Madadi (1998) investigated constraints affecting oil seed crop production and marketing in Tanzania with emphasis on sunflower. The probit analysis and Gross Margin Analysis (GMA) were used to analyse data. The GMA used in farm management as a guide to selection of enterprises basing on enterprise profitability. Results from the study revealed that beans enterprise had more profit compared to other crops. The probit model used to determine the constraint which had a strong effect on yield of sunflower. Results revealed farmers perceived these factors (age, farm size, improved technology) affecting sunflower production.

Mutayoba (2005) analysed the factors influencing Vanilla production and marketing in Tanzania. The Gross Margin Analysis (GMA), descriptive analysis was used as analytical tool for the study. Descriptive analysis used to describe the responses, characteristics and trend of some data and information. The focus of the study was to calculate the Gross Margin (GM) in TZS/ hectare in order to assess profitability and

financial feasibility of the crop enterprises. The study found vanilla enterprise was more profitable than any other crop enterprises such as coffee, tea, banana and maize.

These are the earlier studies about factors influencing various crops in marketing and production context. However, the primary focus of this study was evaluating the potential of producing jatropha to small scale farmers in Tanzania. Basing on the reviewed analytical models the study employed cost benefit analysis for assessment enterprise viability or profitability.

2.19 Previous Studies Relate to Logistic Regression

Some studies have used logistic regression such as Chilimila (2006) examined socio-economic factors influencing small holder dairy farmers and processors in Morogoro and Dar es Salaam to access supermarkets. The author found that, socio-economic factors had a positive effect on access to supermarkets. James (2004) studied socio-economic factors influencing the adoption of agro-forestry practices in Nyaja district, Musoma rural district in Tanzania by use of logistic regression model. The factors which the author studied include labour, land size, knowledge, time and food sufficiency.

A binary logistic model was also used by Sango (2003) in Dar es Salaam and Morogoro Municipality to see the impact of socio-capital in the reduction of food vulnerability. The author was interested in the relationship between household level of socio-capital and food security. Mbise (2004) analysed coffee marketing system in Arumeru district in Tanzania by employing logistic regression model to determine

factors influencing the adoption of either marketing channel. Age, time taken to reach market place, education level, information on market price, buyer trustworthy and hours spent in negotiations were factors discussed by the author.

Mekuria (1994) analysed farmers' characteristics, economic and institutional factors and farmer's perceptions on recommended technologies that influence adoption to production. Partial budgets were used to compare profitability of recommended technologies. Descriptive and ordered probit analyses were used to identify and estimate quantitative impact of variables influencing adoption and classify farmers into adopter categories

The above mentioned studies were a bit more scientific in that they used some statistical means like percentages in determining the magnitude of various variables. Among the variables under reference were related to household factors such as age, education, income, occupation and awareness. Proper sampling methods namely simple random sampling, systematic sampling and stratified sampling were used in these different studies. Data analysis methods varied depending on the nature of the study. Descriptive statistics and logistic regression model was adopted because past studies have found these formulations adequate in explaining the relationship sought by this study.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

The study was carried out at Arumeru district in Arusha region. Arumeru district lies on the slopes of mount Meru. Arumeru district is one of the five districts of Arusha region. The district is located north east of the region, bordering Kilimanjaro region to the east, Manyara region to the south and Monduli district to the west. It lies between latitude 3°00' to 3°40' South and longitudes 36° 15' to 36° 55' East.

3.1.2 Climate and topography

The district has bimodal type of rainfall, that is, short rains and long rains which fall in November to January and March to June respectively; thus the district has two agricultural seasons. The district is divided into three agro-ecological zones/belts:

3.1.2.1 Highland/ upper belt

This is a mountainous area rising between 1 400 m and 1 800 m above sea level. It has an average annual rainfall of about 1 000 mm. Most of the land area is covered by forest forming water catchments for most streams. The economic activities are agriculture and zero grazing of livestock. Crops grown include coffee, pyrethrum, jatropha, bananas and round potatoes.

3.1.2.2 Middle zone/ belt

This belt rises between 1 000 m and 1 350 m above sea level, receiving an average annual rainfall of 500 mm. The economic activities in this zone are livestock keeping and agriculture. Crops grown in this belt are coffee, banana, jatropha, beans, wheat/ barley, rice, fruits and horticultural crops.

3.1.2.3 Lower zone/ belt

This belt rises between 800 m to 1 000 m above sea level, receiving an annual rainfall of about 300 mm. Most of the rivers and/or streams originating from the upper belt spill their water in this zone making irrigation the mainstay of farmers. Agriculture is the most important activity and the major crops include rice, maize, beans, banana, cassava, sisal and horticultural crops.

3.1.3 Soils

Soils in Arumeru district are relatively new, fertile and mainly of volcanic origin. The soils are well drained dark sandy loams with moderate to high natural fertility and favourable moisture holding properties.

3.1.4 Demography

The 2002 census reported that Arumeru district population was 516 814 consisted of 263 671 females and 253 143 males. It was estimated to have 113 002 households with average of five members and the population growth is 3.4%. Akyoo (2004) reported that regional household size stands at five members and population growth rate is four.

3.1.5 Economic activities

According to Nyange (1993) as cited by Mbise (2007), the district has a total area of 2900 km² and agricultural land is about 18% of the total district land where as 49% is used for grazing, pasture, forests and water. The remaining 33% is barren land of no major economic value.

3.2 Justification for Selecting the Study Area

King'ori and Mbuguni were divisions selected in Arumeru district. The selected villages from King'ori division were Ngurdoto, King'ori and Leguruki whereas Karangai village was selected from Mbuguni division. The villages were purposefully selected because jatropha is grown by smallholder farmers and its proximity to private jatropha buyers or biofuel processors such as Diligent limited.

3.3 Research Design

A Cross-sectional Research Design was employed. This enabled researcher to save time, collect data at a single point in time and used in descriptive study for determination of relationship between variables (Bailey, 1994). Therefore, a big sample can be obtained within a short time.

3.3.1 Sampling technique and sample size

The populations of the study were smallholder farmers involved in jatropha and maize production in the selected wards of Arumeru district. By using multistage sampling, two divisions namely Mbuguni and King'ori were chosen purposely to obtain a representative sample. Mbuguni and King'ori were divisions growing

jatropha and maize crop in Arumeru district. Karangai village was selected from Mbuguni division while Ngurdoto, King'ori and Leguruki villages were selected from King'ori division purposively. The choice of the divisions is based on the fact that it has smallholder farmers which constitute the main focus of this study.

According to Boyd *et al.* (1981) a random sample should at least constitute 5% of the total population for it to be representative. Basing on 5% logic, sampling intensity for farmer's questionnaires were 111 as there were about 2 229 farmers in sampled villages. The total of 27 farmers from Ngurdoto, 28 from King'ori, 30 from Leguruki and 26 from Karangai were selected randomly and interviewed (Table 2 below).

Table 2: Sample selection

Village	Number	Percent
Ngurdoto	27	24.4
King'ori	28	25.3
Leguruki	30	26.9
Karangai	26	23.4
Total	111	100.0

3.3.2 Data collection

Primary data were collected through interviews and direct observations. Primary data from smallholder farmers were collected using structured questionnaires with open ended and closed ended questions. Secondary data were obtained from secondary sources, mainly publications, report from agricultural districts offices and Sokoine National Agricultural Library (SNAL).

3.4 Data Analysis

Descriptive, qualitative and quantitative analyses were employed in this study, based on the objectives stated. Descriptive analysis was employed by use of means, percentages, range and cross tabulation. Cost benefit analysis and logistic regression were employed in this study.

3.4.1 Cost benefit analysis

Bernald (1993) reported that farm's worthiness can be assessed using cost benefit analysis by employing Benefit Cost Ratio (BCR), Net Present Value (NPV) and Internal Rate of Return (IRR). The cash flow method used in this study to estimate the BCR, NPV and IRR in MS Excel sheet. There are discounted and non-discounted cash flow based methods of evaluation of enterprise or project. This study adopted the discounted cash flow method to determine the BCR, NPV and IRR. The project's worthiness can be assessed by one or a combination of these criteria. Projects that last for several years which have different shapes of future benefit and cost streams must be discounted to their present worth. The calculations, limitations and interpretations of discounted measures are the same regardless whether they are used for economic or financial analysis. The difference occurs only when given technique is applied to financial or economic value respectively. However Gittinger (1982) noted that there is no one best technique for estimating project worthiness, although some are better than others. For that reason this study considered the BCR as its main tool of analysis of jatropha enterprise. Two more discounted criteria namely the NPV and IRR were chosen to supplement the main criterion which is BCR.

3.4.1.1 Benefit cost ratio

Gittinger (1982) defined the benefit cost ratio (BCR) as the ratio of the discounted project benefits to discounted project costs. The ratio is one of the most widely used criteria in project appraisal especially for economic analysis. Orotu (1993) reported that parameters that provide some indication of degree of desirability of the project. Any ratio above unit at the opportunity cost of capital is considered economically justified. This means the project will yield greater direct benefits than it will cost, provided the discount rate used truly reflects the risks involved in the project. A ratio of exactly one indicates that project is marginal. The higher the discount rate the smaller the resulting benefit-cost ratio, and if high enough discount rate is used on the project, the ratio is likely to be driven down to less than one which a case the investor can not recover the investment costs. The merits of this criterion is that, it considers the cash flows over the entire life of enterprise while the weakness of this criterion is difficult to use, understand and not give unique answers in all situations.

BCR used to compare benefits generated by enterprise and costs incurred. The present worth of the benefit stream was divided by the present worth of cost stream to get the BCR.

BCR can be expressed through the following formula:

$$BCR = \frac{\sum_{t=1}^n \frac{B_t}{(1+r)^t}}{\sum_{t=1}^n \frac{C_t}{(1+r)^t}}$$

Where by;

B_t = the benefits in each year

C_t = the costs in each year

n = the useful life of jatropha farming

r = the interest rate

3.4.1.2 Net present value

With reference to Patel (2000), net present value (NPV) refers to discounted cash flow measure of a project worth or present worth of cash flow stream. In economic analysis it is the present worth of the incremental income generated by investment. The formal selection criterion for the NPV is to accept all projects with zero or greater NPV when discounted at the opportunity cost of capital. The advantage of NPV, it recognise the time value of money and consider all cash flows over entire life of the enterprise. The demerits of NPV Method is the difficult to use, presupposes the discount rate and it may not give satisfactory results when enterprises compared involve different amount of investment

NPV can be expressed through following formula:

$$NPV = \sum_{t=0}^n \frac{B_t}{(1+r)^t} - \sum_{t=0}^n \frac{C_t}{(1+r)^t}$$

Where by;

B_t = the benefits in each year

C_t = the costs in each year

n = the useful life of jatropha farming

r = the interest rate

3.4.1.3 Internal rate of return

Patel (2000) argued that a discount rate can be found at which the present value of cash inflow matches the present value of outflow. This discount rate is called the internal rate of return (IRR). Therefore, IRR is the discount rate where the net present

worth of costs is equal to net present worth of benefits. The formal selection criteria for the IRR is to accept all projects with IRR greater than the required rate of returns and reject all projects with IRR less than required rate of return.

3.4.1.4 Choosing discount rate

In this study, the cost-benefit analysis estimate profitability for jatropha and maize production. Since costs and benefits of these crops have different features and occur for a long time, it is essential to convert the future costs and benefits into present value by discounting. Gittinger (1982) suggested that in order to be able to use discounted measures of project worth, we must decide upon the discount rate to be used for calculating the NPV, BCR and IRR. A discount rate that might be chosen for economic analysis is the borrowing rate that the nation must pay to finance the project. Therefore, the discount rate used in this study is 20% because many farmers have relationship with local commercial bank where lending discount rate of 20% used as an opportunity cost of capital.

3.4.1.5 Handling inflation

Mankiw (2007) defined inflation as an increase in the general price level of goods and services in the economy. Gittinger (1982) suggested that no project analysis can escape to deal with inflation and therefore the useful approach to deal with inflation is to work the project analysis at constant prices. By use of constant prices, the main assumption is that inflation will affect all costs and benefits equally at specified period of time. The use of constant prices will allow the analyst to avoid making risk estimate of future inflation rates.

3.4.2 Logistic model

Logistic model were used to examine the influence of household factors which have strong effects in adoption of recommended jatropha cultivation practices. This study examined the influence of independent variables on adoption recommended jatropha cultivation practices.

3.4.2.1 The model

Principally, most of farmers choose recommended jatropha cultivation practices by which they can benefit in various ways. The binary logistic regression model using maximum likelihood method was used to estimate probability of adoption of recommended jatropha cultivation practices. The Statistical Package for Social Science (SPSS) was used to estimate the model.

The model was specified as follows;

$$\ln[p/1-p] = Z = \alpha + \sum \beta_n \chi_n + \mu \dots\dots\dots (2)$$

$$Z = \alpha + \beta_1 \chi_1 + \beta_2 \chi_2 + \beta_3 \chi_3 + \dots\dots\dots + \beta_k \chi_k \dots\dots\dots (3)$$

Z = Probability of adoption of recommended jatropha cultivation practices given set of factors.

(1= for adopters and 0 = otherwise)

χ_1 = Age of the farmer (years)

χ_2 = Education of the farmer (number of years spent in school)

χ_3 = Land availability (1= available 0=otherwise)

χ_4 = Extension services (1=received 0=otherwise)

α = Intercept constant

P = Probability of technology adoption

's = Regression coefficients explaining importance of variables

μ = Standard error or disturbance term

The logistic regression was chosen in this study because it is useful in describing the relationship between one or more influential factors (e.g. age, education etc) to the adoption of recommended technology in order to improve jatropha production.

3.4.2.2 Description of variables in the regression model

The dependent variable (adoption to recommended cultivation practices) is measured using proxy. Based on the proxy, the jatropha farmer observed to adopt positively recommended cultivation practices ($Z = 1$) and adopt negatively the recommended cultivation practices ($Z = 0$). The independent variables of the regression analysis include;

(a) Age of the farmer (X_1)

Age is thought to be an important variable in deciding which recommended cultivation practices to adopt. The more aged farmer is the more likely to adopt recommended cultivation practices. This is supported by Mwanga (2002), argued that aged farmers may have more resources and likely to access the improved technologies.

(b) Education of farmer (X_2)

Years spent in school were used to measure the level of education of household head. Education assists farmers to interpret information about new recommended cultivation practices and its importance. Machumu (1995) suggested that education make a farmer more receptive to advice from an extension worker or more able to deal with technical recommendations that require a certain level of literacy.

(c) Land availability (\mathcal{X}_3)

Land availability has influence for farmers to adopt new recommended cultivation practices in order to increase production. Hussain *et al.* (1992) argued that the available land in terms of farm size can determine the level of a given household's economy and utilization of new agricultural technologies. The available land for production is important to adopt recommended cultivation practices in a given area.

(d) Extension services (\mathcal{X}_4)

The role of extension is to influence the farmer's decisions in regard to his farm enterprise. The influence is done by introducing new technologies which will improve the farmer's condition. This is also argued by Mwanga (2002) that access to effectiveness of extension services is crucial in uptake and adoption of improved technologies. Therefore, the availability of extension services is important in farmer's decision to adopt or otherwise.

3.4.2.3 Expected signs of coefficients for logistic model

The coefficient β_1 in the model represents marginal change in the odd ratio due to unit change of age. It is expected that as age increases the probability of respondents

to adopt recommended technology to increase. Thus, odd ratio will therefore expect to be positive and thus expected signs of β_1 be positive.

Coefficient β_2 in the model stands for marginal change in the odd ratio resulting from a unit change in the level of education. Theory assumes that as the level of education increases the probability of respondents to be familiar to issues related to improved technology. Thus, it is expected that as the level of education increases the odd ratio becomes positive. Thus, the expected sign will be positive.

Coefficient β_3 in the model stands for marginal change in the odd ratio resulting from a unit change in the land availability. It is expected that as the land availability increases then probability of respondent to adopt improved technology increases. Thus it is expected that as more available land then more farmer would adopt recommended technology to increase production. Therefore, the expected sign will be positive.

Coefficient β_4 in the model stands for incremental change in odd ratio resulting from a unit change of extension services. It is expected that as the increase of extension services to respondents then the probability of adopting new technology increase and the expected sign for the coefficient be positive.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents results and discussion of the study. The findings are presented in four sections. Section 4.2 describes individual's socio-economic characteristics while section 4.3 identifies the opportunities and challenges in jatropha production. Section 4.4 tries to examine investment appraisal for the jatropha enterprise by determining whether the investment is beneficial to smallholder farmers and the

whole economy. The analysis of jatropha enterprise was based on the economic concept of scarce resources. Section 4.5 explains the household's factors that influence adoption of recommended cultivation practices or technology.

4.2 Socio-economic Characteristics Impact on Jatropha Production

The characteristics of respondents interviewed have important social and economic implications towards jatropha production. For example, family characteristics of respondents usually influence the volume of agricultural output. Therefore, this section describes the characteristics of sampled respondents focusing on age, gender, level of education, marital status and household size. The section further examines the association of these socio-economic variables with jatropha production.

4.2.1 Effects of age on jatropha production

The results of distribution of respondents according to age show that majority of interviewed farmers in Ngurdoto, King'ori, Leguruki and Karangai village were above 36 years of age. The majority of respondents (63.1%) in 36 to 55 years category have jatropha seed yield less than 500 kg. In addition, most of respondents (65.8%) in 36 to 55 years category have jatropha trees less than 200 trees (Table 3). The observed age distribution among respondents implies that jatropha production is dominated by a large number of economically active populations who form the potential labour in agriculture production.

People who are capable of being involved in jatropha production activities are those within certain age limit of 36 to 55 years while the young and old members of

society can not be engaged fully in production due to their physiological incapacity. This is supported by Mutakubwa (2007), that the availability of economically active farming population will promote more agriculture production. In this study, results indicate that jatropha production does not depend much on age. This may be due to the fact that most of jatropha farmers in all age categories still use traditional farming method.

Table 3: Age of respondents against jatropha yield (kg)

Variable	Age category			
	15 to 35 years	36 to 55 years	Above 55 years	Overall
Yield (kg)				
Less than 500	11.7 (13)	63.1 (70)	6.2 (7)	81.0 (90)
500 to 1000	0.9 (1)	12.6 (14)	0.0 (0)	13.4 (15)
Greater than 1000	0.0 (0)	3.6 (4)	1.7 (2)	5.6 (6)

Note: Figures in parentheses are number of respondents and those out of parentheses are percentage for each yield category.

4.2.2. Effects of gender on jatropha production

Survey results shows that there is significant relationship between gender of respondents and the jatropha production. The overall results show that, women dominated jatropha production business (Fig. 3). Hayami *et al.* (1988) reported similar findings in their study on soya bean processing in Indonesia that female dominate on-farm activities. This indicates potential of the oil-seed sub-sector in poverty alleviation among unprivileged women.

CIMMYT (1993) argued that women play a key role in most of agricultural systems and women tends to adopt new technology earlier than men. This situation also

prevails in jatropha survey that majority of women are the ones who own jatropha field and automatically show-up during interview session in all the study villages. The survey results shows majority of respondents in female category have high jatropha seed yield compared to the male category.

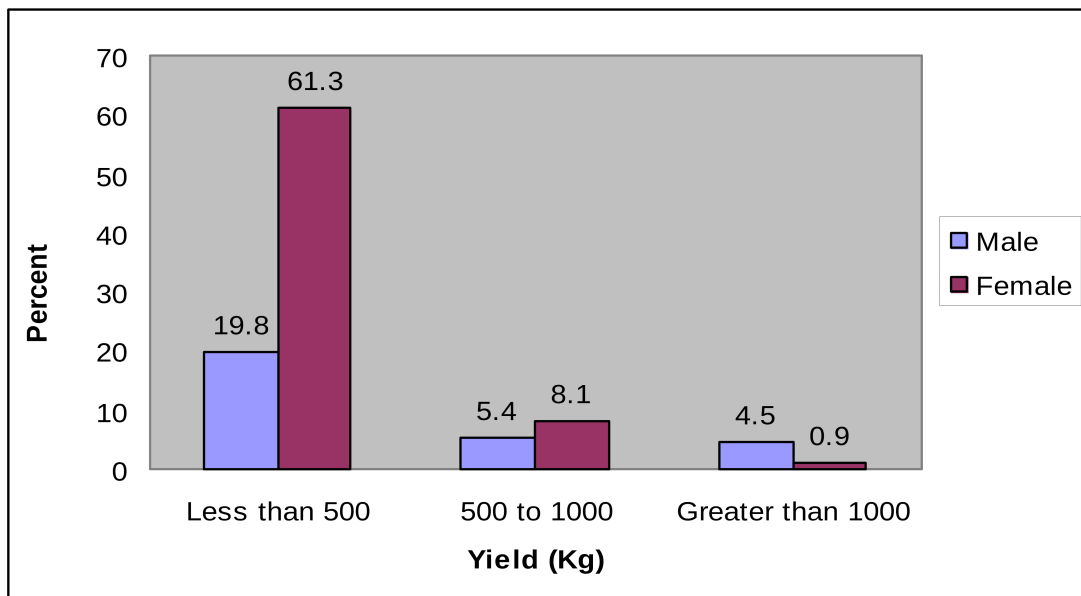


Figure 3: Gender of respondents against jatropha yield (kg)

4.2.3 Effects of education level on jatropha production

Education is one of the factors that influence jatropha production. According to Katani (1999), education increase the awareness, creates positive attitude and values which may motivate people to manage resources. Therefore, a farmer with formal education is likely to be more innovative than a farmer with no formal education when other factors remain constant. The study revealed a moderate rate of literacy in the study area. Results on the level of education showed that most of respondents in the study area attained formal education. The majority (70.3%) of sampled farmers in the study area had attained primary education and producing jatropha seeds less than 500 kg (Table 4). These findings imply that the level of education could be limiting

in jatropha production because most of farmers have attained primary education. Farmers with low level of formal education are less likely to adopt recommended agronomic practices. Therefore, farmers in the study area produce jatropha for subsistence and not for commercial production.

Table 4: Education level of respondents against jatropha yield (kg)

Variable	Education category				Overall
	No formal education	Primary education	Secondary education	Post-secondary education	
Yield (kg)					
Less than 500	2.7 (3)	70.3 (78)	7.2 (8)	0.9 (1)	81.1 (90)
500 to 1000	0.0 (0)	12.6 (14)	0.0 (0)	0.9 (1)	13.5 (5)
Greater than 1000	0.0 (0)	4.5 (5)	0.9 (1)	0.0 (0)	5.4 (6)

Note: Figures in parentheses are number of respondents and those out of parentheses are percentage for each yield category.

4.2.4 Effects of marital status on jatropha production

The overall results shows that, majority of respondents in Ngurdoto, King'ori, Leguruki and Karangai villages were married (Table 5). The marital status of the respondents was found to have relationship with the jatropha output. The results show that married people from all respondents dominate other marital status categories in jatropha production. The study revealed that the higher the number of married people (72.9%), the higher proportions of households engaged in jatropha production. This is supported by Mwanyika (2001) that married people venture into micro-enterprises as a way of finding means of relieving financial problems facing their families or increasing their family income. In this regard married households

are stable and can fully participate in every stage of jatropha production activities comfortably.

Table 5: Marital status of respondents against jatropha yield (kg)

Variable	Age category				Overall
	Single	Married	Divorced	Widowed	
Yield (kg)					
Less than 500	2.7 (3)	72.9 (81)	5.4 (6)	2.7 (3)	83.7 (93)
500 to 1000	0.0 (0)	15.3 (17)	0.0 (0)	0.0 (0)	15.3 (17)
Greater than 1000	0.0 (0)	0.9 (1)	0.0 (0)	0.0 (0)	0.9 (1)

Note: Figures in parentheses are number of respondents and those out of parentheses are percentage for each yield category.

4.2.5 Effects of household size on jatropha production

It would be expected that the increases in household size have a significant association with increases in jatropha output. The majority of respondents (57.7%) in Ngurdoto, King'ori, Leguruki and Karangai village had household size of 4 to 6 people producing less than 500 kg of jatropha seeds (Table 6). According to the 2000/01 Tanzania Household Budget Survey, the average household size of Tanzania mainland is about five people (NBS, 2002). The study revealed that study areas had relatively high household size. However, it is expected that an increase in household size to have significant relationship with jatropha yield. The bigger the household size led to less produce in the study area. The findings are contrary to what is expected and therefore suggesting the low yield would be results from practising traditional farming system (Table 6).

Table 6: Household size against jatropha yield (kg)

Variable	Household size category			
	1 to 2	4 to 6	Above 6	Overall
Yield (kg)				
Less than 500	6.3 (7)	57.7 (64)	17.1 (19)	81.1 (90)
500 to 1000	0.0 (0)	7.2 (8)	6.3 (7)	13.5 (15)
Greater than 1000	0.0 (0)	3.6 (4)	1.8 (2)	5.4 (6)

Note: Figures in parentheses are number of respondents and those out of parentheses are percentage for each yield category

4.3 Opportunities and Challenges of Jatropha Production

Despite the driving forces behind jatropha production, there are emerging challenges on how to strike a balance for jatropha production for increased rural income and domestic energy security without reducing efforts for food security. Jatropha production in this study holds a number of promising opportunities including income generation, domestic energy security, land utilization, employment opportunities, technology development and market accessibility.

(i) Income generation

The study shows majority (88.3%) of farmer's relied on income from crop farming while 11.7% relied on income from both crop farming and livestock keeping. This implies that crop farming is a major economic activity in the study area. This finding is supported by URT (2005a) that crop production is the main economic activity for majority of rural households in Tanzania. Results in the Table 7 indicates that 27.9% of farmers were growing jatropha as a source of income while 72.8% were growing jatropha as fence or protective hedge. This indicates that majority of farmers are planting jatropha as a fence or protective hedge. This finding is emphasized by

Henning (2004), that farmers planting jatropha tree as a fence around their land to protect food crops from wild animals. Planting jatropha as a live fence for marking boundaries between houses and farms could also generate revenue that could be steady, if there is a vibrant market.

Table 7: Major reasons for growing jatropha

Reasons	Number	Percentage (%)
Income generation	31	27.9
Fences or protective hedge	80	72.8
Total	111	100

(ii) Domestic energy security

Results in Fig. 4 indicates that the dominant source of energy for cooking was fuel wood (82.9%) whereas charcoal (7.2%), fuel wood and charcoal (7.2%) and kerosene (2.7%). Eijck and Romijn (2006) reported that households in Sub-Saharan Africa consumed wood and charcoal as the primary source of energy for 94% of rural households and 41% of urban households. The study also revealed that kerosene was dominant source of light energy (92.8%) while solar (6.4%) and jatropha (0.9%). Tanzania's rural dwellers have low household income and therefore not able to afford other sources of light energy such as solar, electricity and kerosene. Therefore, jatropha production is regarded as cheap source of energy for lighting and cooking compared to other sources such as electricity and kerosene.

The study revealed that only 6.3% of farmers are satisfied with energy while 93.7% of a population not satisfied with available energy. It is also observed that energy was

accessible to 2.7% of total farmers while the remaining 97.3% of farmers were not accessing available energy source. This justifies the notion that jatropha can be planted as alternative source of energy in the study area. Most of farmers (95.2%) were unsatisfied with the available energy sources due to shortage of fuel wood and expensive energy sources. Therefore, the use of efficient jatropha stoves, lamps, biogas system or seedcakes as source of energy for cooking and lightning will reduce dependent of other sources of energy which are expensive and not easily accessible in rural communities.

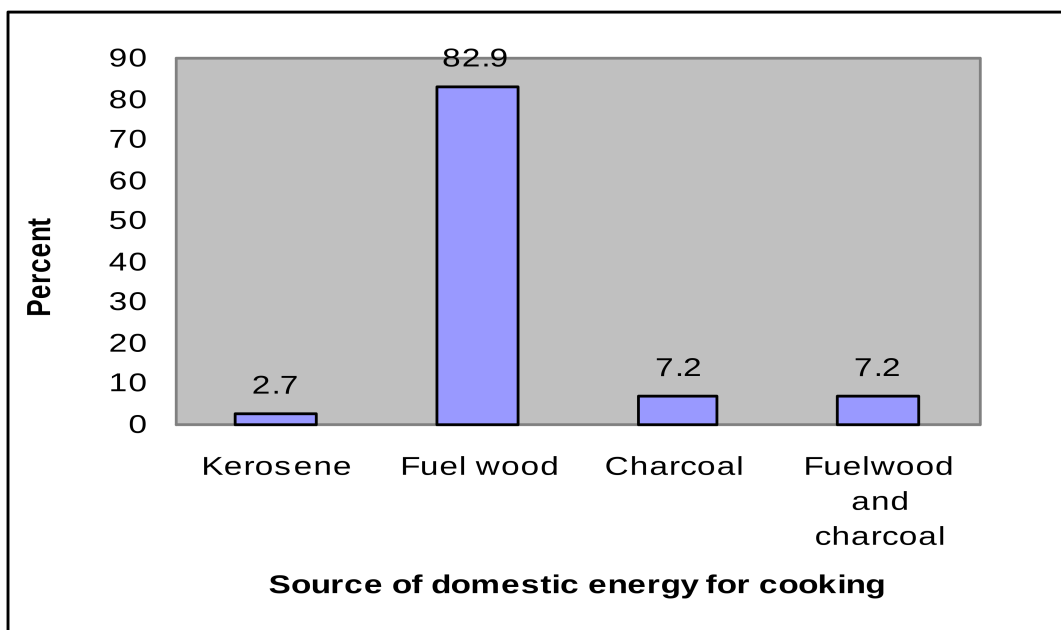


Figure 4: Source of domestic energy for cooking

(iii) Land utilization

Singh *et al.* (2006) argued that waste land can be described as degraded land such as land with gullies and saline/ alkaline soils which is underutilized due to lack of appropriate water and soil management practices. Waste lands can result from inherent or imposed disabilities such as location, environment, chemical and physical

properties of the soil or financial and management constraints. This type of land can be brought under vegetative cover with measurable efforts to make it economic beneficial. The study identified that all farmers interviewed did not utilize waste land in crop production. Planting of jatropha in waste land changes land from unproductive to productive land. Therefore, planting jatropha in wasteland could alleviate soil degradation, desertification and deforestation in the study area and in turn land into economical useful land.

(iv) Employment in small scale agro-allied industry

Survey results indicate 85.6% of farmers were belonging to soap production association or groups. This implies that processing jatropha seeds to oil will have economic benefit on employment and impressive profit. This finding supports observation by Henning (2004) in which it was reported that the economy of soap production create employment opportunities to rural poor in Tanzania.

(v) Technology utilization

Technologies in jatropha production and processing were supported by local and international institutions to encourage jatropha sub-sector development (Manyanga, 2005). The survey identified various institutions involved in developing jatropha production and processing technology in the study area. These technologies includes agronomic packages, oil extraction, soap making, use of jatropha products in lamp, biogas production. The results from interviewed farmers show that KAKUTE trained jatropha production, processing and soap making to majority of interviewed farmers (90.4%) whereas 5.8% of farmers trained by KAKUTE and JPTL and 3.8% of

farmers trained by JPTL (Table 8). In addition, results show that 85.6% of farmers trained jatropha field management training. It was also observed that most of interviewed farmers (95.5%) trained to use jatropha seed processing equipment such as ram-press. This implies that the use of available recommended technology will lead jatropha plant and products to have many uses that benefit health, environmental protection, income generation and livelihood security to farmers and as a base for expanding small scale social infrastructure.

Table 8: Institutions engaged in technology development and transfer

Institutions	Number of beneficiaries	Percentage (%)
KAKUTE	101	90.4
JPTL	4	3.8
KAKUTE and JPTL	6	5.3
TOTAL	111	100.0

(vi) Market accessibility

Results from survey showed that farmers in the study area sell their jatropha seeds to individual private traders and private companies including Diligent (T) ltd and JPTL. Results indicate that 9.0% of farmers sold their products to individual private traders and 91.0% of farmers sold their products to individual companies because individual companies provide farmers with a guaranteed market for their seeds. The average distance from farmer's field to jatropha market was 217 m and hence the majority of farmers (83.8%) went to market place on foot whereas 16.2% use bicycle to market place (Table 9). This accessible market is considered as opportunity for jatropha production.

Table 9: Means of transport to market place

Means	Number	Percentage (%)
On foot	93	83.8
By bicycle	18	16.2
Total	111	100.0

The major challenges identified in the study area regarding jatropha production including availability of land, food security, government support and institutional framework.

(i) Availability of land

The survey revealed that all interviewed farmers owned land for crop production. Farmers perceived ownership of land as a pre-condition of growing jatropha because jatropha is the perennial crop which can stay up to 40 years in the field. Survey results in Table 10 show that dominant method for acquiring farming land in the study area was through inheritance (76.6%). The acquiring of land through village government was 3.6% while free access (9.9%) and purchase (9.9%). As the land owned mainly through inheritance usually taken as family land and jatropha production would be subsistence. This is supported by Mwanga (2002), that the model of acquisition of land through inheritance does not attract long term commitment of resources to improve productivity of land.

The survey results indicate that farmers who were able to expand land for crop production were only 5.4% while 94.6% were not able to expand land for crop production. The survey data also indicated that reasons for not expanding land for

crop production includes the limited land (97.2%) and financial problem (2.8%). Therefore, land availability is regarded as one of challenge for production of jatropha in the study area.

Table 10: Methods of acquiring farming land

Methods	Number	Percentage (%)
Inherited	85	76.6
Given by government	4	3.6
Accessed freely	11	9.9
Purchases	11	9.9
Total	111	100.0

(ii) Food security

Food security has been given different definitions in the past. URT (2001) reported that food security as access by all people at all times to enough food for active and healthy life. Food insecurity exists when people are undernourished due to physical unavailability of food, their lack of physical, social and economic access to food (URT, 2005b). The survey results in Table 11 indicate that most of farmers (81.1%) were growing maize and beans while maize (12.6%) and beans (6.3%). Maize and beans were the major food crops for domestic use in the study area. The survey also revealed that household getting their staple food through own production and purchases (72.1%), own production (22.5%) and purchases (5.4%). This indicates insufficient food stocks at household level because farmers do not rely food supply from crop production alone. Therefore, jatropha production will likely increase food shortage at household level basing on the fact that resources will be shifted from food to jatropha production. The survey results showed that 6.3% of farmers were food insecure while 93.7% were food secured in 2005/2006 - 2006/2007 season. The

main causes of food insecurity were drought (42.9%), crop pests and diseases (28.6%), poor crop husbandry (14.3%) and low soil fertility (14.3%). This implies the main cause of food insecurity was drought condition not jatropha production. The study justified production jatropha in a fence or protective hedge can not cause food insecurity.

Table 11: Main staple food in household

Crop type	Number	Percentage (%)
Maize	14	12.6
Beans	7	6.3
Maize and beans	90	81.1
Total	111	100.0

(iii) Government support

Mutakubwa (2007) reported that most of smallholder farmers in Sub-Saharan Africa practice either subsistence farming or operate largely in local market due to lack of government support. As a result, incentives remain weak, investment remain low resulting into low equilibrium poverty trap. Tennigkeit and Weyerhaeuser (2007) suggested that appropriate levels of government support to small scale jatropha production and market is important to a large extent. Government determines how jatropha small scale production will be and still be cost-effective. Government support like modern jatropha production training and motivation or incentives such subsidy to jatropha industry is essential. The study revealed all jatropha farmers interviewed were not supported by Government institutions. Therefore, the Tanzania Government needs to consider carefully its role in promoting jatropha industry.

(iv) Institutional framework

Institutional innovations including contractual arrangements, incentives and other policy tools can help to overcome obstacles of viable jatropha production and market. Small holder farmers are unwilling to take risk of paying for, planting and maintaining jatropha plants unless they have secured source of demand in long term (Tennigkeit and Weyerhaeuser, 2007). There is some risk that if the price of fossil fuels decline will lead the price of jatropha seeds and products to decline too (Swallow and Tomomatsu, 2007). The results from the study showed that 93.7% of the interviewed farmers were accessible with institution support while 6.3% were not accessible to institution support. The study indicated that all interviewed farmers were in risk because did not have jatropha farming contract. Therefore, institutions play key role in reduction of risk in jatropha production and marketing.

4.4 Investment Appraisal

Investment appraisal involves identifying the circumstances in which jatropha investment will take place and the expected return on capital that can be obtained. The study adopted three major methods to measure the economic feasibility of investment: the benefit cost ratio (BCR), the net present value (NPV) and the internal rate of returns (IRR).

4.4.1 Guidelines and assumptions in the investment appraisal

Gittinger (1982) suggested that convenient way of establishing the period of analysis of a project is to use technical life of the major investment item. In jatropha and maize enterprises land and crop improvement is a major investment items as supported by the following guidelines and assumptions:

- i. The costs of jatropha production were generally classified as operating costs and investment costs. Operating costs includes land preparation, plants and planting, fertilizer application, pesticides application, weeding, transport, storage and depreciation. The investment costs include fixed capital.
- ii. Jatropha is harvested from the 2nd year after planting and its useful life period is 10 years. The average seed yield (kg) per tree was 0.0, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5 and 6.0 in the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th and 10th year respectively.
- iii. All assets are depreciated at the same rate. Depreciation was subtracted as cost. It was automatically taken care of in the computation processes, since the cash flow is a combination of the return of capital (which include depreciation) and return paid for the use of capital (Gittinger, 1982). Land was not depreciated. Likewise no deduction was done for interest. Depreciation was estimated using straight line method of estimating depreciation.
- iv. Salvage value for most of items was assumed to have life span less than ten years. Items such as hand hoe and knapsack sprayer were replaced in the sixth year of the project.
- v. Loan and loan repayment were items omitted from the economic analysis since small scale jatropha farmers did not acquire loan for agriculture development.

- vi. Crop prices were valued at average market price of the 2006, 2007 and 2008 price. Jatropha and maize were only crops considered for both sampled farmers. Jatropha: sales price of TZS 120/ kg whereas Maize: sales price of TZS 24 170/ bag. 1 bag of maize is equivalent to 100 kg of maize seeds.
- vii. Hired labour is the most expensive input for the farmers. The payments for hired labour differ depending on the type of operation. Labour is hired on piece-work basis, normally measured in terms of jatropha trees. The most labour demanding operations were weeding, harvesting and transportation. In the study area, the principal source of labour was family labour supplemented by little hired labour.
- viii. Jatropha yield was estimated by number of trees because all interviewed farmers planted jatropha as fence. The survey revealed farmers planted the average of 94 jatropha trees in the 1st year for the rest of the project life.
- ix. Discount rate used was 20% as described in the methodology.
- x. Jatropha yield were estimated as an average of 2 to 6 kg per tree.
- xi. The average maize planted area was 1.5 acres and average yield/ acre was 4 bags (400 kg) which is the same entire period of the project.
- xii. Cost of capital refers to minimum rate of return that the firm must earn on its investments in order to satisfy the expectations of investors who provide funds to the firm.

4.4.2. Results of investment appraisal

An investment appraisal uses current market prices and indicates the return to the resources used. It examined the return to the investment made by sampled farmers. The benefit cost ratio (BCR), the net present value (NPV) and the internal rate of returns (IRR) for 94 trees of jatropha and 1.5 acres of maize were estimated. It is observed in Appendix 2 and 3 after discounting all benefits and costs at 20% for ten years, the BCR for 94 jatropha trees and 1.5 acres of maize were 1.58 and 1.06 respectively. The stream of benefits of jatropha and maize enterprises were greater than the streams of costs due to BCR being greater than one indicating both maize and jatropha enterprises are worthwhile or profitable. Based on this results jatropha enterprise is more desirable or profitable enterprise compared to maize enterprise (i.e. $BCR_{\text{jatropha}} > BCR_{\text{maize}}$). This implies a rational producer will invest in jatropha as compared to maize enterprise.

The positive NPV for 94 jatropha trees and 1.5 acres of maize enterprises were TZS 55 199 and TZS 34 713 respectively when discounted for 10 years at the rate of 20%. This indicates that jatropha enterprise is more profitable or desirable enterprise compared to maize (i.e. $NPV_{\text{jatropha}} > NPV_{\text{maize}}$) although both enterprises returns to investment is more than cost streams. Therefore, a rational producer will invest in jatropha as compared to maize enterprise although both costs for jatropha and maize enterprises are recovered within 10 years.

It is also observed that (Appendix 2 and 3), the IRR for 94 jatropha trees and 1.5 acres of maize enterprise were 58% and 27% respectively when discounted at the rate of 20% in ten years. The present value of inflow for both enterprises matches the

present value of outflow. This indicates the rate of returns of jatropha and maize enterprises are greater than costs of capital. The results support the above description that jatropha is more profitable or desirable enterprise compared to maize enterprise (i.e. IRR for jatropha > IRR for maize). Therefore, investing in jatropha enterprise is economically viable if the true cost of capital is 20%. The summary for economic feasibility of jatropha and maize enterprises is shown in the Table 12.

Table 12: Economic feasibility of investment enterprises

Measures of project worth	Jatropha	Maize
BCR	1.76	1.06
NPV	55 199	34 713
IRR	58 %	27 %

4.4.3 Sensitivity analysis

4.4.3.1 Sensitivity analysis for jatropha enterprise

To test systematically what might happen to the earning capacity of the project, if the opportunity cost of capital of 20% is raised. Table 13 shows the decrease of price of jatropha seeds about 10% will reduce approximately the BCR from 1.76 to 1.58, the NPV reduced from TZS 55 199 to 42 395 and the IRR reduced from 58% to 50%. The increase in production cost of jatropha production by 10% will reduce approximately the BCR from 1.76 to 1.60, the NPV reduced from TZS 55 199 to 47 913 and the IRR reduced from 58% to 51%. This implies that the jatropha enterprise is not sensitive to changes in price of seeds and the production cost. Therefore, jatropha enterprise is profitable even if there is decrease in selling prices and increase in production costs.

Table 13 : Sensitivity analysis for jatropha enterprise

Sensitivity analysis	Base	BCR	NPV	IRR
	0	1.8	55 199	58%
Decrease in selling price	20%	1.6	42 395	50%
Increase in production cost	20%	1.6	47 913	51%

4.4.3.2 Sensitivity analysis for maize enterprise

Table 14 shows the decrease of price of maize seeds about 10% will reduce the BCR from 1.06 to 0.95, the NPV from TZS 34 713 to -25 760 and the IRR reduced from 27% to 15%. Therefore, the maize enterprise is sensitive to changes in selling price and production costs. The negative NPV and BCR less than one from sensitivity analysis indicate that the streams of benefits are less than streams of costs. The IRR of less than opportunity cost of capital indicates that the streams of benefits do not match with the streams of costs, hence there is risk to invest in maize enterprise basing predicted changes of selling price and production costs. Therefore, the maize enterprise is not profitable if there are changes in selling price and production costs in the project period.

Table 14: Sensitivity analysis for maize enterprise

Sensitivity analysis	Base	BCR	NPV	IRR
	0	1.06	34 713	27%
Decrease in selling price	20%	0.95	-25 760	15%
Increase in production cost	20%	0.96	-22 289	16%

4.5. Quantitative Analysis of Factors Influencing Farmer's Adoption

4.5.1 Results from logistic regression

A binary logistic analysis was undertaken to determine quantitatively how the relevant factors interact to influence jatropha farmers in adopting recommended

jatropha cultivation practices. The use of recommended cultivation practices ($Z = 1$) and the non-use of recommended cultivation practices ($Z = 0$) was used as dependent variable and the regressors were age of farmers, education of farmers, land availability and extension services.

After several running of the model, other independent variables were dropped. These factors were dropped for two major reasons. Some factors were dropped off the model because of high correlation with one or more variables, or after depicted a weak relationship with dependent variable. Again, the variables adopted in this model can justify if farmers adopt recommended cultivation practices in order to increase production or otherwise. Some of regressors were insignificant and maintained due to their relevancy in the model. This section below explain each variable used in the model basing on the sign of estimated coefficient value and level of significance.

Age had insignificant relationship with adoption of recommended cultivation practices ($p > 0.05$), the insignificant implies that age has very little influence in either to adopt recommended cultivation practices or reject the recommended cultivation practices. This is so because the age of respondents in the study area did not differ much. Despite, this insignificance the estimated coefficient is positive as was expected. This implies the older farmers the more adoption to recommended cultivation practices. These findings concur with the ones by Gradim and Panell (1999), which assert that age of the farmer is likely to have range of influences on adoption.

The coefficient estimate of education was positive. The sign implies that as people became educated they tend to adopt the use of recommended technologies. The study found that the association between education and adoption of recommended cultivation practices was positive. These findings concur with the one by Machumu (1995) which assert that education make a farmer more receptive to advice from an extension worker or more able to deal with technical recommendations that require certain level of literacy. The variable showed to influence the decision of farmers significantly at $p < 0.05$. Therefore, this is important factor influencing the adoption of jatropha recommended cultivation practices.

The availability of land for crop production, then more people will decide adopts recommended cultivation practices to increase production. The sign of parameter was positive as was expected. This is due the fact that in the study area, the land availability increases farmers' likelihood to adopt recommended cultivation practices in order to increase production. Again, from the analysis the parameter showed significance ($p < 0.05$), means the availability of land is important factor in adopting particular recommended cultivation practices.

The coefficient for extension service is positive. This signifies that extension service influence the farmer's decisions in adopting new cultivation practices, innovations or ideas which will improve the condition of the farmers. It is supported by Mwanga (2002) that access to extension services is crucial in uptake and adoption of improved

technologies. The variable is significant at $p = 0.000$, meaning it is very important factor for farmers for either to adopt recommended cultivation practices.

Table 15: Logistic regression analysis parameter estimation

Variable/ estimate	B	S.E	Df	T-value	Sig
Age of household	0.016	0.032	1	0.499	0.618
Education level	0.310	0.108	1	2.874	0.004*
Land availability	2.574	1.127	1	2.284	0.022*
Extension services availability	4.109	1.116	1	3.681	0.000*
Cox & Snell R square = 32.6%					
Nagelkerke R square = 43.6%					

*= significant at $p < 0.05$

In summary, all coefficients of the variables in the study area were positive as expected. Variables which showed significance ($p < 0.05$) includes education, land availability and extension service whereas one which showed insignificance ($p > 0.05$) was age (Table 15). The Nagelkerke R^2 and Cox & Snell R^2 values provide an indication of the amount of variation in the independent variable explained by the model (from a minimum value of 0 to a maximum of approximately 1). In this study two values are 0.326 and 0.436, suggesting that between 32.6% and 43.6% of variability is explained by this set of variables. These coefficients of determination show relationship between adoption of recommended cultivation practices and independent variables.

4.5.2 Independent Sample t-test results

T-test was used to test difference of household factors between adopters and non-adopters of recommended cultivation practices as shown in Table 16. These household factors are explained below.

a) Age of household

Age is one of the household factors considered to adopters and non-adopters of recommended cultivation practices. The analysis shows that the t-value was -0.477 and also was insignificant at $p < 0.05$ level between adopter and non-adopter of recommended jatropha practices (Table 16). Therefore, it can be concluded that there is no difference in age between the two groups in the adoption of recommended jatropha practices.

b) Level of education

The analysis gives t-value being equal to -2.481. The results also revealed that there is significant difference in the level of education between the adopters and non-adopters of recommended cultivation practices. The two groups differ significantly at $p < 0.05$ level between adopters and non-adopters of recommended jatropha practices (Table 16). Therefore, level of education is one of the important factors to be considered between the two groups.

Table 16: T-test results of household factors

Variable	Adopters	Non-adopters	t	Sig (2-tailed)
	Mean	Mean		
Age of household	44.41	43.73	-0.477	0.635
Level of education	8.18	7.00	-2.481	0.015
Land availability	0.10	0.02	-1.903	0.060
Extension services	0.37	0.02	-5.431	0.000
availability				

c) Land availability

Availability of land for jatropha farming is one of the household factors considered to adopters and non-adopters of recommended cultivation practices. The analysis gives t-value being equal to -1.903. The results also indicate that availability of land for farming not differs significantly at $p < 0.05$ level between adopters and non-adopters of recommended jatropha cultivation practices (Table 16).

d) Extension services availability

Extension service availability is one of the household factors considered to the adopters and non-adopters of recommended cultivation practices. The analysis gives t-value as being equal to -5.431 and also was highly significant at $p < 0.05$ level (Table 16). Therefore, extension services availability is very important factor in the jatropha farming between two groups.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This study objectively investigated prospects and constraints of jatropha production to rural communities in the study area. The investment appraisal was conducted to estimate enterprise worthiness. The investment appraisal of the project was directed towards determining empirically the profitability of the farm investment. The study attempted to investigate household's factors influencing adoption of recommended practices and identified opportunities and challenges in jatropha production.

5.2 Conclusion

Basing on the findings, it can be concluded that jatropha production is more profitable enterprise than other food crops. This indicates that the livelihoods of the rural communities likely to be improved through jatropha production. The jatropha producers are potentially interested in producing jatropha basing on the relative profitability of jatropha compared to other crop such as maize.

Jatropha production is receiving interest by producers in Arumeru for a number of reasons. Jatropha production is considered as source of income, fuel and employments in rural communities. Yet jatropha producers face different challenges affect producer's involvement in the production which includes land availability, food security and government support. The household factors such as age, level of education of household were the important factors that influence adoption of jatropha recommended cultivation practices. The study revealed that there was significant difference on the household factors between the adopters and non-adopters of recommended cultivation practices.

5.3. Recommendations

Basing on the conclusion, recommendations are provided to improve jatropha industry and community's participation in economic development. This proves that if appropriate measures are carried out by the government authorities and other stakeholders, the area under jatropha can be expanded and increase productivity. The main areas that government and other stakeholders can stimulate jatropha sub-sector development to small scale in Tanzania include;

i. Income and employment opportunities

Jatropha sub-sector development programmes must be strengthened to generate income and employment opportunities for small and marginal farmers and other weaker sections of society, particularly those living below international poverty line.

ii. The role of government to promote jatropha production

The Tanzania government needs to consider carefully its role in promoting jatropha oil seeds through development and refining technology for improved productivity, quality, and value addition by assisting capable institutions to take such programs. This means what should be internal activities and what should be carried out by the private sector, NGOs and local government in the jatropha sub-sector development.

iii. Promote applied research and development

It has been observed that the productivity of jatropha is not much economically beneficial to farmers due to lesser productivity and non-availability of recommended cultivation practices packages. It becomes necessary to make countrywide efforts to enhance the productivity and development of specific agronomic packages. In addition, promotion of jatropha planting materials in waste lands through augmentation of superior planting material, production technologies and handling system would enhance jatropha sub-sector development. Therefore, continued applied research and development will be required in local, international academic institutions, private sector and research organizations to collaborate on research and development in jatropha sub-sector development.

iv. Promote awareness raising activities

In order to provide solid grounds for development of jatropha industry in Tanzania, the need of creation of awareness through training, seminar, workshop, publication and publicity on jatropha benefits and opportunities at all levels of production chain is paramount important. Therefore, concerted

efforts for capacity building are required to assist Tanzania government to formulate and implement pro-poor small-scale producers and user's policies, strategies and regulations. Therefore, support for development of local technologies, products, markets and services to meet local energy are essential.

v. National policy frameworks

Government need to lay foundation for pro-poor environmentally sustainable biofuels policy that can achieve energy security. There is a need of clear policy that accelerates jatropha productivity helping to maintain, improve food security and focus more on jatropha technologies in coordination with biofuel users. Therefore, the lack of clear regulations makes investment of jatropha industry difficult and risky in Tanzania as the prospective return on investment and socio-environmental impacts remain largely unclear.

vi. Access to financial services

It is difficult to develop the jatropha industry without incentives to small scale farmers in accessing finance for inputs. Government should empower small-scale jatropha farmer's activities through special fund, grant and assistance with establishment of farmers associations and cooperative enterprises. Special incentives and tax exceptions need to be considered for equipments that rural communities could use to process oil crops to oil and convert it into fuels that could be used to meet local energy needs. Locally accessible micro-financing

services could be sensitized and supported to assist small-scale farmers to get financial support for biofuels business development at the local level.

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APPENDICES

Appendix 1: Farmer's questionnaire

Questionnaire No.....Date of interview.....

Name of respondent.....Interviewer's name.....

Section 1: Farmers characteristics

1.1 Village 1. Ngurdoto 2. King'ori 3. Leguruki 4. Karangai

1.2 Division 1. King'ori 2. Mbuguni

1.3 Gender of respondent.....

1.4 Age of respondent.....

1.5 Marital status 1. Single 2. Married 3. Divorced / separated 4. Widowed

1.6 Farmers level of education 1. No formal education 2. Primary education

3. Secondary education 4. Post-secondary education

1.7. Household size.....

Section 2. Opportunities for jatropha production

2.1 Major source of household income.....

2.2 Major reasons for growing jatropha 1. Income generation

2. Domestic energy security 3. Fences 4. Others (specify).....

2.3 If Yes in (2.2) how the land was obtained 1. Inherited 2. Given by village government 3. Accessed freely 4. Bought

2.4. Do you find difficult to sell jatropha ? 1. Yes 2. No

2.5. To whom you sell your produce 1. Individual private traders 2. Private companies

2.6. What is the source of domestic energy for cooking?

1. Kerosene 2. Fuel wood 3. Charcoal 4. Fuel wood and charcoal

2.7. What is the source of domestic energy for lightning?

1. Kerosene 2. Solar 3. Jatropha oil

2.8 Does energy mentioned in 2.6 satisfy demand for household? 1. Yes 2. No

2.9 Is energy source mentioned in 2.4 easily accessible?

1. Yes 2. No

2.10 How do you travel to jatropha market place?

1. On foot 2. Bicycle 3. Motor vehicle- public transport

4. Motor vehicle-own transport 5. Buyers follow to farmer's field

2.11 How far (km) is the selling point for jatropha market place?.....

2.12. Did Non- Governmental Institution assisted in jatropha farming in your area?

1. Yes 2. No

2.13. If Yes, specify the institution, type of assistance and conditions under which assistance was provided.

Institution	Assistance	Condition
1.		
2.		
3.		

2.14. Did you attend any jatropha field management training? 1. Yes 2. No

2.15. Are the jatropha processing equipments available in your area? 1. Yes 2. No

2.16. Do you know to operate jatropha processing equipments? 1. Yes 2. No

2.17. Changes in output from jatropha for the past three years.

1. Increased 2. Not changed 3. Decreased

2.18. If increased in 3.5 above, the major reasons for the increased output of jatropha.

1. Increased area 2. Increase in price of seeds 3. Prompt payment to farmers

4. Awareness of economic value of jatropha

2.19. Do you belong to any jatropha soap production group / association?

1. Yes 2. No

2.20. Do you use waste land for crop production?

1. Yes 2. No

2.21. Do you use jatropha seed cake as fertilizer in growing crops?

1. Yes 2. No

2.22. Do you use jatropha seed cakes for production of biogas or briquettes as a source of fuel? 1. Yes 2. No

Section 3. Challenges for jatropha production

3.1 Is land available for crop farming in this area? 1. Yes 2. No

3.2 Can you increase the cultivation area of your field? 1. Yes 2. No

3.3 Problems facing supply of jatropha? 1. Non- available improved varieties

2. Shortage of land

3. Access to financial facilities

3.4 What was the biggest means, through which your household get staple food?

1. Own production 2. Purchases 3. Own production and purchases

3.5 Did you divert land or inputs from food crop production to jatropha production?

1. Yes 2. No

3.6 Did you face food shortage for the past two cropping seasons 1. Yes 2. No

3.7 If Yes, what are the main causes of food shortage that farmer's experienced in the past two years?

1. Drought 2. Crop pests and diseases 3. Poor husbandry 4. Low fertility

5. Others (specify).....

3.8. Is there any government support for jatropha production in your area?

1. Yes 2. No

3.9 Do you use recommended agronomic practices such as improving planting materials or fertilizers in your area? 1. Yes 2. No

3.10 Are the improved jatropha cooking stoves available in your area? 1. Yes 2. No

3.11 Are the improved jatropha oil lamps available in your area? 1. Yes 2. No

3.12 Do you have jatropha farming contract with buyers of jatropha seeds?

1. Yes 2. No

Section 4. Household factors

4.1. Is labour for crop production hired or family labour?.....

4.2 Do you face labour shortage? 1. Yes 2.No

4.3 Do you receive extension services 1? Yes 2. No

4.4 How frequently do you receive extension advice?

1. Regular 2. Once per year 3. Twice a year

4.5 Did you receive knowledge from other farmers? 1. Yes 2. No

4.6 Did you transfer knowledge to other jatropha farmers? 1. Yes 2. No

4.7 Does training received help in increasing jatropha production? 1. Yes 2. No

4.8 Major kind of training received?

1. Propagation (planting) 2. Pest and diseases control

3. Oil extraction

4. Drying

5. Others (specify)

.....

4.9 Did you acquire credit facilities? 1. Yes 2. No

4.10 If Yes, what was the purpose of credit?

1. Purchase of crop input 2. To buy livestock 3. Others (specify).....

4.11 If not acquired credit, what were reasons

1. Not needed 2. Financial Institutions were not ready to grant loan

3. Did not want to go into debts 4. Interest was high 5. Did not know how to get credit

6. Others (specify).....

Section 5: Profitability of crop enterprises

5.1 Give the total output sold and the prices of each of the crop grown for 2005/2006 to 2007 /2008 crop seasons.

	Jatropha			Maize		
	2005	2006	2007	2005	2006	2007
Output(kg)						
Acreage						
Price/kg						

5.2. Give amount and unit price of inputs for the past three seasons

JATROPHA						
Year/ seasons	2005		2006		2007	
Inputs	Amount/ha	UP	Amount/ha	UP	Amount	UP
Seeds						
Hand hoes						
Herbicides						
Insecticides						
Others(specify)						
Total						

5.3 Labour for jatropha production

Activities	Amount	Acreage	Days
Maintenance			

Weeding			
Seeding/sowing			
Harvesting			
Others(specify)			

5.4 Give amount and unit price of inputs for the past three seasons

MAIZE						
	2005		2006		2007	
Inputs	Amount/ha	UP	Amount	UP	Amount	UP
Fertilizers						
Seeds						
Hand hoes						
Herbicides						
Insecticides						
Others(specify)						
Total						

Note: UP = UNIT PRICE

5.5 Labour for maize production

Activities	Amount	Acreage	Days
Maintenance			
Weeding			
Seeding/sowing			
Harvesting			
Others(specify)			

5.6 What is the price / acre of land bought or hired for production of jatropha...
(TZS).

5.7 What is the price / acre of land bought or hired for production of jatropha...
(TZS).

Appendix 2: Cash flow-Jatropha production

Year	1	2	3	4	5	6	7	8	9	10
Investment costs										
Fixed capital	3 500					3 500				
Operating costs										
Land preparation	20 000									
Plants and planting	9 400									
Fertilizer application										
Pesticides application										
Weeding	3 000	3 100	3 200	3 300	3 400	3 500	3 600	3 700	3 800	3 900
Harvesting and transport		5 610	7 020	8 430	9 810	11 220	12 630	14 040	15 420	16 830
Depreciation	640	640	640	640	640	640	640	640	640	640
Total costs	33 040	9 350	10 860	12 370	13 850	15 360	16 870	18 380	19 860	21 370
Discount factor (20%)	0.83	0.69	0.58	0.48	0.40	0.33	0.28	0.23	0.19	0.16
Discounted costs	27 423	6 452	6 299	5 938	5 540	5 069	4 724	4 227	3 773	3 419
Sum(C)	72 864									
Revenues		22 440	28 080	33 720	39 360	44 880	50 520	56 160	61 680	67 320
Discounted Revenue		15 484	16 286	16 186	15 744	14 810	14 146	12 917	11 719	10 771
Sum(B)	128 063									
Benefits cost ratio (B/C)	1.757									
Cash Flow	-33 040	13 090	17 220	21 350	25 510	29 520	33 650	37 780	41 820	45 950
Discounted Cash Flow	-27 423	9 032	9 988	10 248	10 204	9 742	9 422	8 689	7 946	7 352
NPV (20%)	55 199									
IRR	58%									
Sensitivity Analysis	Base	BCR	NPV	IRR						
	0	1.76	55 199	58%						
Decrease in selling price	10%	1.58	42 395	50%						
Increase in production cost	10%	1.60	47 913	51%						

Appendix 3: Cash flow- Maize production

Year	1	2	3	4	5	6	7	8	9	10
Investment costs										
Fixed capital	199 500					23 500				
Operating costs										
Land preparation	30 000									
Insecticide application	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600	3 600
Fertilizer application	21 620	21 620	21 620	21 620	21 620	21 620	21 620	21 620	21 620	21 620
Harvesting	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000	3 000
Transport and storage	4 596	4 596	4 596	4 596	4 596	4 596	4 596	4 596	4 596	4 596
Herbicide application	6 200	6 200	6 200	6 200	6 200	6 200	6 200	6 200	6 200	6 200
Planting	6 000	6 000	6 000	6 000	6 000	6 000	6 000	6 000	6 000	6 000
Weeding	15 540	15 540	15 540	15 540	15 540	15 540	15 540	15 540	15 540	15 540
Seeds	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000	24 000
Depreciation	4 600	4 600	4 600	4 600	4 600	4 600	4 600	4 600	4 600	4 600
Total costs	318 656	89 156	89 156	89 156	89 156	112 656	89 156	89 156	89 156	89 156
Discount factor (20%)	0.83	0.69	0.58	0.48	0.40	0.33	0.28	0.23	0.19	0.16
Discounted costs	264 484	61 518	51 710	42 795	35 662	37 176	24 964	20 506	16 940	14 265
Sum(C)	570 021									
Revenues	145 020	145 020	145 020	145 020	145 020	145 020	145 020	145 020	145 020	145 020
Discounted Revenue	120 367	100 064	84 112	69 610	58 008	47 857	40 606	33 355	27 554	23 203
Sum(B)	604 733									
Benefits cost ratio (B/C)	1.06									
Cash Flow	-173 636	55 864	55 864	55 864	55 864	32 364	55 864	55 864	55 864	55 864
Discounted Cash Flow	-144 118	38 546	32 401	26 815	22 346	10 680	15 642	12 849	10 614	8 938
NPV	34 713									
IRR	27%									
Sensitivity Analysis	Base	BCR	NPV	IRR						
	0	1.06	34 713	27%						
Decrease in selling price	10%	0.95	-22 289	16%						
Increase in production cost	10%	0.96	-25 760	15%						

Appendix 4 : Some oil crop as a source of biofuel produced in Tanzania

Oil	% oil content	Favourable climatic condition	Region grown
Jatropha	33 – 60	Tropical & Sub-tropical climates.	Arusha, Bukoba and Kilimanjaro
Sunflower seeds	25 - >85	Tropics, Sub-tropics & Temperate climates.	
Coconut	65		Tanga, Coast
Cottonseeds	18	Tropics, Sub-tropics and Temperate climates.	Tabora, Mwanza, Shinyanga, Mara, Kagera, Tanga, Morogoro, Singida, Lake zone & Coast
Groundnuts	45 - 55	Tropics, Sub-tropics and Temperate climates.	Dodoma
Palm oil	43 - 51	Tropics & Sub-tropics.	Tanga, Dar es Salaam, coast
Soybeans	18 – 48	Tropics, Sub-tropics & Temperate Climates	
Copra	45 - 75	Costal hot temperature	Coastal areas.
Kapok	25	At the Coast and along coastal areas.	Korogwe, Mombo, Tanga, Coast, Morogoro & Shinyanga
Cashew nuts	46 – 47		Lindi, Mtwara, Ruvuma, Dar es salaam, Tanga & Coast
Macadamia Nuts (<i>Macadamia tetraphylla</i>)	60 - 78	Coffee-growing areas of the Tanzania highlands	Kilimanjaro, Bukoba
Eucalyptus	10 - 85	Loam soils, (Moisture climates), Wet Montane climates, Over 2,000m	Arusha, Mbeya & Iringa.
Castor bean (<i>Ricinus communis</i>)	20 –50	Preferring Humus-rich & disturbed ground, (Its drought resistant)	Widely spread all over Tanzania
Moringa Ofeira		Tropical & Sub-tropical climates	Widely distributed all over the country.

Source: GTZ, 2005