Sustainable Energy use in rural areas

Socio-technical analysis of Jatropha in Same district - Tanzania.

Sarah Adelaida Mndeme

July 2008

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Sustainable Energy use in rural areas, Socio-technical analysis of Jatropha in Same district -Tanzania.

Thesis is submitted to the Wageningen University and Research Centre in Partial Fulfillment of the Requirements for the Award of Master of Science Degree in International Development Studies (MID)

By

Sarah Adelaida Mndeme

MSc Thesis International Development Studies

Supervisor:

Dr. Paul Hebinck

Rural Development Department

Wageningen University

ABSTACT

In rural areas biomass is still the main energy source for domestic uses. Depending on biomass fuel for cooking and lighting purposes results in many negative effects which create sociological and ecological problems. This research assessed the available energy sources and services at households and village level in Same district. Research methodologies used in this study are in-depth interviews, open ended questionnaires, literature reviews and physical observations.

The study has shown that the available sources of energy for cooking and lighting include; firewood, charcoal, kerosene, biogas, candles, electricity from hydropower and solar. Relying on this sources of energy results in many problems such as; deforestation, gender, scarcity, health and costs in terms of time and money to the majority of rural population. In order to curb these problems it is urgently required to substitute the utilization of biomass for cooking and lighting purposes. Plant oil is a promising alternative energy source which offers a variety of social, economical and ecological advantages. The usages of oil from plants are many but for this study the concentration was based on jatropha oil. Jatropha oil can be used as source of energy for both cooking and lighting, but for this study the positive results were only on it as source of energy for lighting. Jatropha as source of energy for cooking still need further research. The study concluded that considering the negative effects from the available sources of energy in the research area, jatropha can be part of the solution to the effects.

Key words: *Sustainable energy, Rural areas, Jatropha, Social-technical*

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

LIST OF ACRONYMS, ABBREVIATION AND UNITS

ANT	Actor network Theory
ARI-MONDULI	Alternative Resource Income for Monduli Women
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
HIV/AIDS	Human Immunodefiency Virus/Acquired Immune Deficiency Syndrome
KAKUTE	Kampuni ya Kusambaza Tekinolojia
KIDT	Kilimanjaro Industrial Development Trust
LPG	Liquidified Petroleum Gas
MEM	Ministry of Energy and Minerals
MFP	Multi functional platform
NaOH	Sodium hydroxide
NEP	National Energy Policy
NGOs	Non Governmental Organizations
PRA	Participatory Rural Appraisal
ProBEC	SADC Programme for Biomass Energy Conservation
REA	Rural Energy Agency
REF	Rural Energy fund
RPM	Revolutions per Minute
SIDA	Swedish International Development Agency
SUA	Sokoine University of Agriculture
TANESCO	Tanzania Electric Supply Company Limited
TaTEDO	Tanzania Traditional Energy Development and Environment Organization
TU/e	Eindhoven University of Technology
TV	Television
UDSM	University of Dar es Salaam
UNDP	United National Development Programme
VAT	Value Added Tax
VET	Village Energy Team
WSU	Washington State University

UNITS

Acre	0.4 hectares
C^0	Centigrade degree
g	gram
ha	Hectare
Kg	kilogram
Km^2	kilometre(s) square
m	metre
Mha	Million hectare
mm	millimeter
Tonne	1,000 kg
Tsh/TZS	Tanzanian shilling
US $ /USD	United State Dollar

PREFACE AND ACKNOWLEDGEMENTS

There is nothing better for me than the feeling of having accomplished my thesis. Always an intellectual journey is not a one person show. To this end I would like to take this opportunity to extend my special thanks to a number of people and institutions whose contributions made this work to be successfully.

Firstly, I would like to acknowledge the Anne van den Band Funds (ABF) and Wageningen University who offered me the opportunity to study for an MSc in Wageningen University. I greatly appreciate the financial support which enabled me to successfully complete my study.

Secondly, I am particular indebted to academic supervisor Dr .P. Hebinck of the Rural Development Department for his untiring guidance in the initial planning of the study (proposal writing stage) and valuable constructive criticisms and critical comments during the whole period of the study.

Thirdly, I am most obliged to YES-Africa particular to Harry Kuipers who was the first person to give me advice on how I can apply for study in Wageningen and scholarship opportunity. Moreover he gave me financially support during data collection in Tanzania. During the study period he also gave me some valuable and critical comments in my report. Besides that I also appreciate his kindness of taking me to different places in Netherlands which will remind me of Dutch culture in general. In the same vein, I also thank so much Breman family for making my life in Netherlands easy, I really enjoyed the family atmosphere created by them. I will always remember their act of kindness.

Fourthly, I am also grateful to Janske van Eijck the Diligent manager for her support during data collection in Tanzania. I deeply appreciate the people in the study area without whose cooperation it would be impossible to carry out the study. I genuinely appreciate their willingness and enthusiasm to participate in the research by devoting their time to offer information. Special thanks to SMECAO coordinator Mr. Mmakasa and extension officer Mr. Alphonce without forgetting Mr. Kateri the Caritas director in Diocese of Same for their great support during data collection. Lastly but not the least I would like to thank my fellow Tanzanians in WUR for their friendship, having dinner together each month and support during my stay in The Netherlands. I remember them all with great gratitude.

Finally, I am obliged to mention my special appreciation to my family for the moral support, great patience and continuous encouragement through the study. I love you all.

Wageningen,

July, 2008

CHAPTER ONE: THE RESEARCH ISSUE

1.1 BACKGROUND INFORMATION

The topic of this thesis is rural energy. Energy is hotly debated because global supply is currently mainly based on non-renewable, fossil fuels. The use of fossil fuels has significantly added to the carbon dioxide in the earth's atmosphere. Most scientists agree that this has contributed significantly to the greenhouse effect creating the condition for climate change that threaten life on this planet and causes serious environmental effects and economical problems such as high prices of oil which forces Tanzania to spend a lot of money to import oil from other countries. The value of Tanzania's fuel imports increased from US $ 195.6 million to US $402.0 million in 2005 (Lymo, 2006). This increase is largely attributed by an increase in importation of fuel that forces the country to spend 25%-35% of its foreign earnings (Lymo, 2006).

Politically, the reliance on fossil fuels has been responsible for constant tension and sometimes relying on other country(s) for their energy supplies. Fossil fuel resources are also limited and some analysts have already predicted that the supply will decline few decades to come (Eijck, 2006). Fossil fuels are non-renewable and produce substantial environmental pollution which also adds to existing health hazards. In addition, energy sources have become commodities which limit access for the poor.

The energy question that now emerges is a search for more sustainable sources of energy that are renewable, affordable, accessible and locally available to all people of all kind (that is those with low and high income). Sustainable energy sources like bio-fuels involve the production of own energy which not only makes countries less depended on the importation of crude oil but also generates a range of benefits. These include;

- Agricultural/rural development – Creation of new jobs and income opportunities.
- Improved energy security.
- Creation of new industries.
- Reduction of GHG emissions.
- Reduction of air pollution.

Biofuel have come into the limelight as a solution or part of the solution to the planet's energy and climate crisis as they have a closed carbon cycle and do not contribute to the greenhouse

effect and thus they meet the global energy needs and millennium development goals (MDG).The production of biofuels can be derived from several sources, one of them is oil producing plant/crop called Jatropha.

Jatropha is the plant that originates from Central America and was distributed by the Portuguese sea safers via the Cape Verde Islands to countries in Africa and Asia (Wijgerse, 2007). Jatropha plant is a tree or large shrub, which can reach to a height of 8m.It has 170-175 known species (http://www.worldagroforestrycentre.org), its life span is more than 50 years (YES-Africa 2006; www.fact-fuel.org). It is a drought resistance plant, and is widely cultivated in the tropics and sub-tropics. The plant may provide economic, social and environmental benefits to the communities especially rural poor in developing countries (YES-Africa, 2006). The plant requires large amount of land and agriculture land is often scarce in high-income countries; therefore growing it in a developing country like Tanzania would be more practical because land resources are potentially available with favourable climatic and soil conditions.

Recently some assessment have been done by the Food and Agriculture Organization of the United Nations (FAO) and they found that Tanzania has 55.2 million hectares which is potential area for the rain fed crops production from the total area of 93.8 million hectares(Mha), among these 10.8 million hectares are in use for crop production. This implies that 44.4 million hectares is potentially available for production of food crops and non-food crop production, so these figures suggest that Tanzania has no barrier to bio-energy production.

What is important is the Government to formulate and implement long-term policies, regulations and strategies for its land use to make sure that even the small-holder farmers are in safe place of not being evicted from their land by the multinationals who are driven by large profit only (http://www.tatedo.org). Currently government has formed a National task force under the Ministry of Planning and Empowerment working on policies, strategies and regulations to streamline the development of biofuels in Tanzania.

Biofuel from the jatropha plants has a high potential for the rural population of Tanzania who are poor and without adequate energy services (Eijck, 2006). Production of biofuel could help to stop soil erosion, create additional income for the rural poor and provide a source of energy both locally and internationally and also earn foreign exchange. Initial activities in Tanzania have been directed towards the use of Jatropha plant, which does not require a lot of water and nutrients has a relatively high oil yield and can be produced locally.

1.2 TANZANIA ENERGY OVERVIEW

Tanzania is blessed with abundant energy resources in different forms: biomass, solar energy, wind, coal, natural gas and hydro (Sawe, 2005; Masoud, 2005 and Kaale, 2005). Other energy resources remain unexploited with the exception of biomass (firewood and charcoal) which is considered both as cheap and accessible to the poor majority in rural and urban areas.

Biomass fuels (firewood, charcoal and farm residues) are the dominant energy sources in Tanzania accounting for more than 90% of total energy consumed in the country. About 98% of the total energy is used in the rural household sector (Tanzania, 2007; Masoud, 2005 and Kaale, 2005) and they have significant impact on environmental degradation due to clearing of the forestry without replacement which cause flooding and soil erosion.

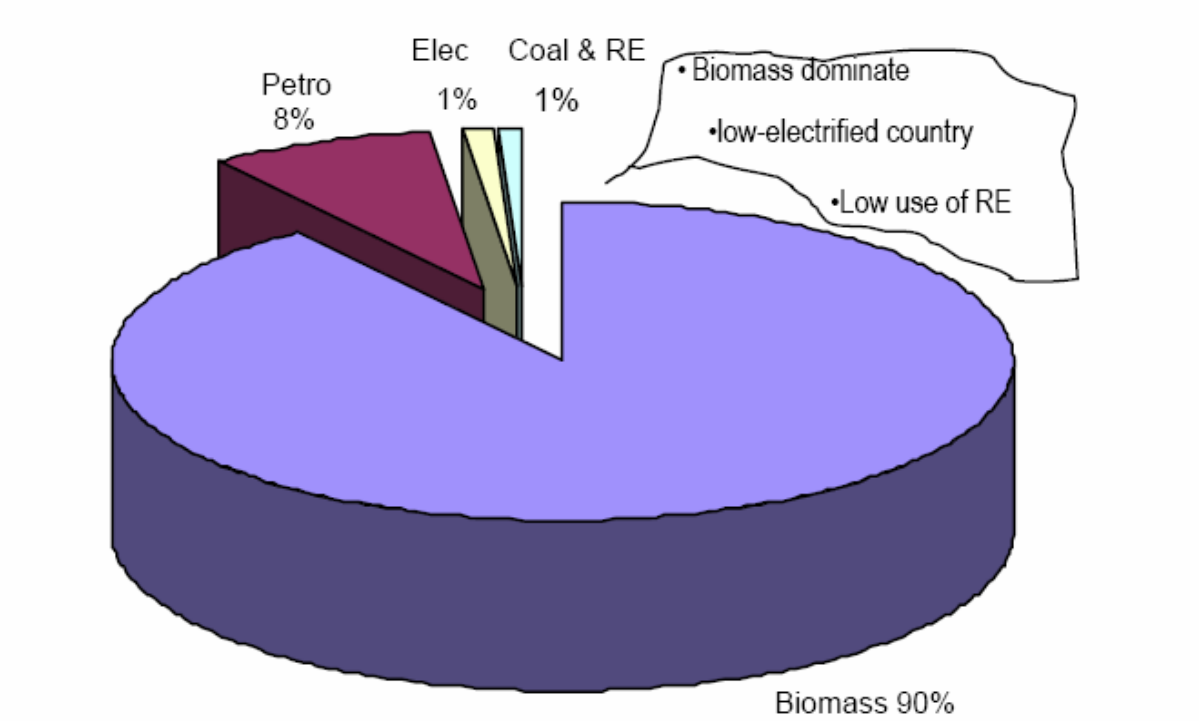
Biomass fuels energy sources are the main sources of energy consumed by the rural household for activities such as cooking, heating, crop drying, fish drying and lighting (Field data, 2007). In rural areas biomass (firewood and charcoal) is the leading source of energy for cooking as compared to urban areas where charcoal, kerosene and electricity are the leading energy sources of energy for cooking. (Field data, 2007).Besides biomass fuels used in Tanzania there are also agriculture waste fuels which are also common in some parts of Tanzania, these agriculture waste fuels include farm residues like maize cobs, coconuts shells and agro-processing wastes like coffee husks, cashew nut husks, rice husks and biogases from sugar factories (Kaale, 2005).

Commercial energy sources includes petroleum which accounts for 8% of the total energy consumed in the country, electricity which account for 1% and other renewable energy sources includes solar, wind, geothermal, hydropower and biogas which account for 1% of the total energy consumed in the country (Kimambo and Mwakabuta, 2005; Masoud, 2005). There is therefore a big gap in Tanzania between the supply and demand of energy, both for domestic and industrial applications[1], so the challenge is to tackle how best to facilitate the availability of an affordable energy supply for households, industrial and commercial activities.

Figure 1 below depicts the consumption pattern of the available sources of energy and their percentages in Tanzania.

[1] Tasea is an International membership organization whose mission is to develop and promote the use of solar energy in Tanzania. It strives to accelerate the development and use of solar energy resources through advocacy, education, research and collaboration among professionals, policy makers and the public.

Figure 1. Consumption patterns of energy sources available in Tanzania



Source: Masoud 2005

The main energy consumption sectors in Tanzania mainly include; household sector, agriculture sector, industry, transport and commercial sector which include; food vendors, hospitals, hotels, restaurants, recreation centers, collages, government institutions, whole sellers and shops. The household sector in Tanzania constitutes the large share of energy consumed in the country as compared with other sectors.

Table 1. Main energy types used by the household sector

Energy types used	Total amount consumed TJ	Share to the total consumption in percent
Biomass	363,840	97.70
Petroleum	7,446	2.00
Electricity	1,335	0.30
Coal	0	0.00
NRSE	0	0.00
Total	**372,421**	100.00

Source: Kaale, 2005

Majority of Tanzania's population (about 75- 80 %) live in the rural areas (Tanzania, 2007). These are areas of primary modes of production, minimal secondary processing, limited

accessibility to market, and poor economic infrastructures (Tanzania Economic Survey, 2006). Agriculture is the main mode of production, major employer to over 80% of the population and major source of income for the rural people and nation as a whole. It accounts for about 50% of the national income and 60% of export earnings (Tanzania, 2007; Kaale, 2005). Other non-farm activities in rural areas include fisheries, small and medium industrial production which includes beer brewing, brick burning, charcoal burning and food vending (Field data, 2007). The combined output of these rural economic activities constitute more than 50 % total output in GDP terms, the rural areas are still largely underdeveloped within increasing poverty situation (Tanzania, 2007).

Per capita commercial energy (electricity and petroleum) consumption is low relative to the per capita biomass energy consumption. More than 90 % of the population in the country does not have access to electricity (Sawe, 1997). About 75- 80% of the populations live in rural areas out of which only 1% is connected to the national electricity grid, leaving a large population without electricity (MEM, 2003). The population that is not served by the grid depends on wood fuels as their main source of energy for cooking and kerosene for lighting. The overwhelming dependence on wood fuels for energy, clearing of land for agriculture and commercial logging are greatly contributing to environmental degradation such as high deforestation, flooding and soil erosion, this implies that there is an urgent need to encourage and promote the supply of affordable, available, accessible and sustainable energy sources in rural areas where the majority of the population live.

It is anticipated that due to lack of affordable alternative sources of energy, this trend is unlikely to change positively in the near future unless there are serious efforts taken both at the national and local levels to facilitate improved and sustainable energy services for the majority of the population.

The government of Tanzania through the Ministry of Energy and Minerals (MEM) with the support of several donors such as UNDP and World Bank has for some years undertaken a number of activities and initiatives aimed at harnessing indigenous energy potential in the country. The recent initiatives by the government, Non- Government Organizations (NGOs) and the private sectors are aimed at improving energy services for people both in rural and urban areas. Some of these initiatives undertaken by the Ministry include the review of the energy policy 2003 that was launched in 1992.The main goal of the national energy policy is to improve the welfare and living standards of Tanzanians, and the national policy objective for the development of the energy sector is: *"To provide input in the development process of the country by establishing a reliable and efficient energy production, procurement,*

*transportation, distribution and end-use system in an environmentally sound manner and with due regard to gender issues"(*NEP,2003*).*

The main elements of the Energy Policy and strategy are to:

- Develop domestic energy resources which are shown to be least cost options.
- Promote economic energy pricing.
- Improve energy reliability, security and enhance energy efficiency.
- Encourage commercialization and private sector participation.
- Reduce forest depletion.
- Develop human resources.

The energy policy with regards to rural energy, Tanzania's National Energy Policy recognizes the importance and contribution of indigenous energy resources, in particular in providing modern energy services in rural areas (Arvidson *et al.*, 2006). With respect to rural energy, the policy stipulates the following development areas were found in the energy policy document of 2003:

- To support research and development into rural energy.
- To promote the application of alternative energy sources, other than wood fuels, in order to reduce deforestation, indoor health hazards and time spent by rural women collecting firewood.
- To promote entrepreneurship and private initiatives in the production and marketing of products and services for rural and renewable energy.
- To ensure continued electrification of rural economic centers and make electricity accessible and affordable to low-income customers.
- To facilitate an increased availability of energy services including grid and non grid electricity in rural areas.
- To establish norms, codes of practice, standards and guidelines for cost effective rural energy supplies.

Moreover establishment of the Rural Energy Agency (REA) and Rural Energy Fund (REF) goes together with the energy policy for the purpose of spreading up availability of modern energy services in rural areas which will ensure socio-economic improvement of the majority of Tanzanians, and the energy Act to establish REA and REF was enacted in June 2005. Also the national task force has been formed under the Ministry of Planning and Empowerment

working on policies, strategies and regulations to streamline the development of bio- fuels in Tanzania.

Tanzania has also implemented World Solar Programme (WSP) 1996–2005 through UNDP, SIDA and World Bank with the main focus on village solar electrification and small Island solar electrification and transforms the market and removes barriers like VAT and officially in July 2005 all taxes on solar energy appliances and small scale wind turbines were removed (Lymo, 2006).

Currently, some energy intensive sectors have begun installing solar systems which utilize locally available resources and they are environmentally beneficial and this has been revealed from the study area where by some households already have started using solar electrification for lighting purposes. Solar energy use has been limited to thermal applications and photovoltaic (PV) applications in the households, health centres, transport and communication sectors in remote areas. The installation of solar energy is centred both in rural areas as well as in urban areas but all these have been centred on household who are well of to install solar energy due to higher investment costs and lack of proper policy incentives to promote solar(Lymo,2006) .

1.3 SCOPE AND LIMITATION OF THE STUDY

The study examined the sources of energy used in the rural areas of Tanzania. Within the selected study area, problems were identified and a detailed analysis of Jatropha technology included. Due to limited time and resources, the study dealt with only few cases that were accessible and formally operating in Tanzania with supplemental information from NGOs and individual Jatropha initiatives.

1.4 STRUCTURE OF THE THESIS

This thesis has seven chapters. CHAPTER ONE is an introductory chapter sketching the relevance of the topic of the study. CHAPTER TWO describes the statement of the problem, conceptual framework and research objective which form the basis for formulating the general and specific research questions. CHAPTER THREE deals with the methodology of the study**.** This chapter presents the description of the study area, research design, data collection methods, data analysis techniques, and problems encountered during data collection, criticisms of the methods used ethical consideration and time schedule of the research.

CHAPTER FOUR provides general overview of Jatropha and its products, review of processes involved for using Jatropha (production chain). The chapter also present a brief note on the different uses of Jatropha and jatropha oil as a substitute or extender for alternative sources of energy such as diesel, paraffin, kerosene, biomass (charcoal and fuel wood). CHAPTER FIVE depicts the jatropha network, actors, roles that they play in that network and the link that they have between each other in the network. Moreover it represents the model which map all actors involved in jatropha network in Tanzania. CHAPTER SIX discuses the finings of the thesis. CHAPTER SEVEN is the concluding chapter and recommendations.

CHAPTER TWO: CONCEPTUAL FRAMEWORK

2.1 RESEARCH ISSUE

The study addresses questions that reflect the social and technical dimensions of energy, particular energy made from jatropha oil. A major concern is the degree to which energy from jatropha is sustainable over a longer period of time. The relevance of this question is that in areas like Same district rural people will not be connected to the national grid to satisfy there demand for energy and thus largely remain to depended on a range of energy sources other than electricity. This thus necessitates comparing jatropha with all other available sources of energy rural people draw from. This enabled a comparative analysis of energy sources. This in turn allowed me to examine the specificities of each source of energy in terms of costs, time, environmental pressure and accessibility.

A major entry point for the exploration of energy issues and questions broadly and jatropha in particular is that, it is important to perceive energy analytically not purely technical neither as purely social, but rather as a socio-technical phenomena. This implies for the analysis including in the analysis the networks that link actors to energy sources and appliances (stoves, sockets, bulbs) and what purposes people use energy for (lightning, cooking, heating). Unpacking Jatropha in this way showed how Jatropha socially is coordinated, regulated and negotiated and technically how and where it is produced, procured and processed. Phrasing this in terms of networks spanning social actors and technologies, would then answer the question whether the jatropha network is a configuration that works.

2.2 CONCEPTUAL RESEARCH FRAMEWORK

A conceptual framework deals with the key concepts and their interrelations used during the study. It is like a map that assists in asking questions, ordering, presenting and interpreting the data. In this way it gives coherence to empirical inquiry.

The conceptual framework applied in this study is based on actor networks. Actor network has been used in this study so as to understand the relation between social actors in the jatropha network and the energy, their sources and the appliances used in Tanzania rural households. Networks are entities in different actors collaborate and exchange information, knowledge and experience as well as interact with objects (i.e. technologies) and institutions or organizations (Caniels and Romijn, 2007).

Actor network is used in this study to elaborate a socio-technical perspective of the energy question. By understanding the connection that is in the network of actors it will be easier to conclude whether the jatropha network in rural Tanzania is a configuration that works or not. The jatropha network in rural Tanzania will be analysed in the three stages; cultivation, production/processing and usage (see chapter five).

2.2.1 DESCRIPTION OF ACTOR-NETWORK THEORY

Actor-network theory also known as enrolment theory or the sociology of translation is the theory that was developed in mid 1980 by Bruno Latour, Michael Callon and John Law. It is distinguished from other network theories in that an actor-network contains not merely people, but objects and organizations. These are collectively referred to as actors, or sometimes actants. *Actants* are defined as any agent collective or individual that can associate or disassociate with other agents in the network (Comber *et al,* 2002). The theory poses to view networks as heterogeneous spanning the social as well as technical parts that are treated inseparable. It rejects the distinctions between nature-society, micro-macro, global-local nature-culture and human and non-human (Hebinck and Verschoor, 2001) it suggests that these aspects should be combined and linked together and brings the outcome.

ANT is an approach for structuring and explaining the links between society and technology. It offers explanations of how technology becomes acceptable and taken up by groups in a society. It suggests how technology is socially, cultural and technically constructed (Monteiro and Hanseth, 1996).In past time technology was an aspect that was treated separately and it was considered as an exogenous factor which develop automatically and cultural neutral (Hebinck and Verschoor, 2001) .But with ANT it suggests that technology is something that has to be developed basing on the situation of the actors or the end- users of that technology. The end-user of the technology shapes it through the process of enrolment. It postulates that technology development is a reflection of society and its different interests and thus it suggest that technology is not neutral artefacts (Hebinck and Verschoor, 2001) but it keeps changing basing on the social construct of the users which automatically shape it. Moreover it suggest that there is no distinction between scientists, technologists and farmers, they are all involved in one way or another in the construction of facts and artefacts of the technology(Hebinck and Verschoor,2001).

The design of a network and the applications of information resources it supports involves decisions on who will use it, how they will use it and what processes will be involved in that

network. The design of the network also defines the rules and roles to be played by users and how they will behave. The set of rules in the network involve both formal and informal rules (Eijck, 2006). Formal rules involve institutional design or the strategies for the sustainable energy supply and informal rules involve rules that have to be followed when designing the project.

Every actor in a network is essentially independent and capable of resistance or accommodation, so there must be some 'glue' that encourages them to be involved in one network, this glue is referred as *translation*. Translation is the process of establishing identities and the conditions of interaction and characterizing representations and at the same time is the process of both social and physical displacement (Ritzer, 2004).

ANT provides a fined-grained approach for analysing the mechanism by which social action shapes technology and technology shapes social action and forms the contents of their actions, this notion is referred as 'script'. The primary focus is on stakeholders (actors) and how they are involved in the shaping of technology. For example, how do jatropha oil as a source of energy is widely socially, technically accepted, shaped in the society and how the network standards are established.

Moreover translation is the process of converting entities making them similar such that one entity may be substituted for another or simply black-boxing or translating network elements into a single block while retaining differences (Latour and Hope, 1999). Following Verschoor (1997), translation is the process that creates a shared space that was absent before the initiation of a project. Basing on Verschoor's idea translation is not simply transfer but creation which results from the shared knowledge and ideas from the network. If the knowledge and ideas in the network are not shared accordingly then this often will lead to redesigning of the network and its relations (Hebinck, 2001).

Each actor in the network whether a person, group, company, machine, nation has its own diverse set of interests, and thus a network's stability will result from the continual translation of interests.

According to Callon (1986 the translation process follows four stages:

- **Problematisation:** an actor analyses a situation, defines the problem and proposes a solution.
- **Interessement:** other actors become interested in the solution proposed in the problematisation stage. They change their affiliation to a certain group in favour of the new actor but it does not mean that it leads to actual enrolment. It achieves enrolment if it is successful (Verschoor, 1997).

- **Enrolment:** the solution is accepted as a new concept. A new network of interests is generated through negotiation and trials and roles are distributed to each actor in the network.
- **Mobilisation:** The new network starts to operate target oriented to implement the solution proposed.

While many approaches to research treat the social and the technical entirely in different ways, actor-network theory proposes instead a socio-technical account in which neither social nor technical positions are privileged but are puzzled together and each achieve significance in relation to others (Tatnall and Davey,2004). ANT deals with the social-technical divide by denying that purely technical or purely social relations are possible, and considers the world to be full of hybrid entities (Latour, 1993), thus ANT is a conceptual frame for exploring collective socio-technical processes, whose spokespersons have paid particular attention to science and technological activity.

Moreover the success of a technology networks and its applications depends not only on its technical excellence but also on its social acceptability, so an understanding of what influences social acceptability may be valuable in the design and management of technology network. Exploring with this concept jatropha as a source of energy in rural areas, both social and technical part has to be combined and well integrated. The technical part of the jatropha as a source of energy involves the whole chain from cultivation to usage and the social part involves the coordination of the chain and the acceptance in the whole process.

2.2.2 POINT OF ENTRY

The application of ANT involves deciding on the point of entry into the analysis basing on the situation at hand and how individuals describe their role and the roles of others. Thus the entry point of ANT in this study is as follows;

Identification of actors

Several social actors involved in the network are identified together with what they do in the network. The jatropha network in Tanzania includes; companies, research institutes, producers and end-users (that is households or families).

A stakeholder is any human or non-human organization unit that can affect as well as be affected by a human or non-human organization unit's policies (Vidgen and McMaster, 1996). Jatropha network in Tanzania involves both human and non-human aspect as it deals with social as well as technical part. Social and technical part goes together.

Investigation of actors

Through interviews each stakeholder is examined basing on reflection, interests, attitudes, relationships, roles, power, influence and involvement in the network process. Looking at interests involves an examination of the stakeholders' rational, organizational and individual interests. *Rational interests* concern their logical interests and the objective view they take in the network, *Organizational interests* concern their political and social interests arising from the organization and *Individual interests* concern personal interests. Due to financial and time constraints for this study not all the actors involved in the network were interviewed.

Analysis of stakeholder interactions

Relationships between each stakeholder/actor in the network are identified. Identification of relationships of actors is described in terms of links and nodes. The nodes in the network are the people and groups while the links show relationships or flows between the nodes.

Building of actor-network model

Building the model on how each stakeholder interact in the processes is important. The model in the network has both strong and weak link connection means that there are strong and weak initiators in the processes, in other words there are important and less important initiators in the network. But in a long run for the sake of feedback in the network both strong and weak initiators are important. For example, the jatropha networks in Tanzania there are stakeholders with strong link such as Kakute and Diligent. These stakeholders have strong link due to the fact that they supply almost all the information on jatropha to other stakeholders/actors inside and outside Tanzania.

2.3 PROBLEM STATEMENT

Grid expansion to remote areas is not expected in the near future and therefore decentralized stand-alone systems are interesting to connect to rural villages. Biofuels especially Jatropha oil can be used in stand alone diesel generators and can therefore make a sustainable solution for rural electrification in near future. However, neither jatropha nor electricity will fully solve the rural energy question, but rather a mix of energy will be required. The compositions of such mix of energies are or will have to be very locally specific.

2.4 OBJECTIVE OF THE STUDY

The broad objective of this study is to assess the quality of life of rural poor by investigating the available sustainable energy sources and services available at the household and village level. The study focuses on Same district as an example of the rural areas, which face the challenges, and problems of energy supply in Tanzania.

2.5 RESEARCH QUESTIONS AND SUB-QUESTIONS

Main research questions

To summarize the main questions: The central research question was two dimensional:

1) How does Jatropha compare with other sources of energy; and

2) Is the Jatropha network a configuration that works?

Sub research questions

There were several specific research questions to address general research questions:

(a) What energy sources that are available in rural areas?
(b) What are the most used energy sources in rural areas?
(c) Can jatropha replace other sources of energy in rural areas?
(d) How is the jatropha network organized in terms of market, land tenure, production and price?

CHAPTER THREE: METHODOLOGY

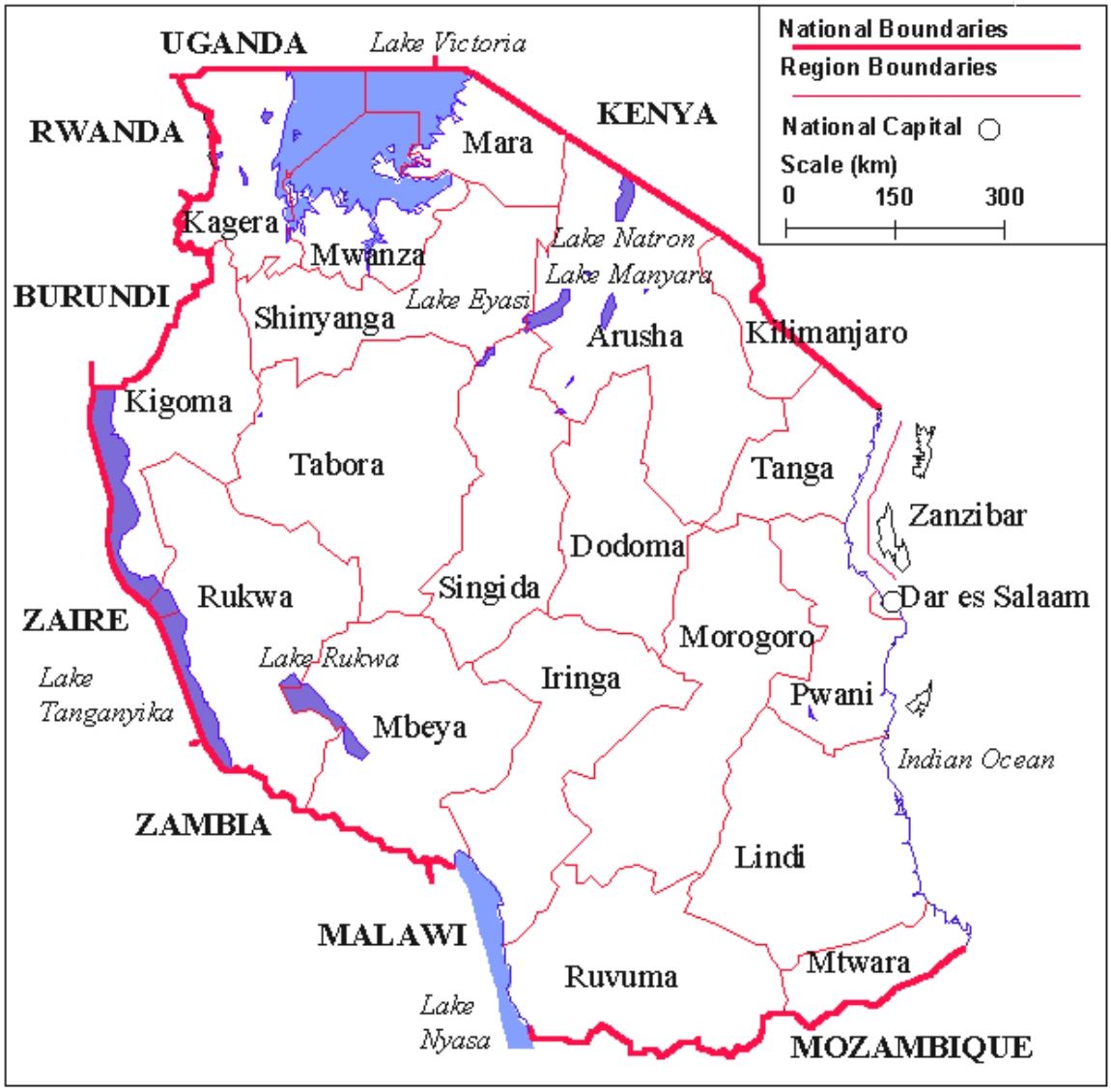
During data collecting from the field, the 'case study' methodology has been used so as to get the primary information. Same district has been used as a case study to investigate the available sources of energy and services in rural Tanzania and acceptance of sustainable source of energy from jatropha oil. Interviews were mainly used as main sources of evidence from the case study. In this study a total number of 30 households were interviewed in three wards (Same mjini, Njoro and Hedaru). Due to long distances from one village to another and time allocation, this study had to be confined to specific villages. The results from this study are based on the selected sample size and this should be considered when analysing them in the results and discussion chapter.

3.1 RESEARCH AREA

The study was conducted in the Republic of Tanzania which is the largest country in East Africa, it lies south of the equator between the great lakes, Victoria, Tanganyika and Nyasa on one hand and the Indian Ocean on the other. It has frontiers with Kenya and Uganda in the north, Rwanda, Burundi and Democratic Republic of Congo in the West and Zambia, Malawi and Mozambique in the south (see figure 2). Tanzania is located in the eastern Africa region between longitudes 29^0 and 41^0 degrees east, latitudes 1^0 and 12^0 degree south (Tanzania,2008) . It has an area of 945,000 km^2 (Tanzania Economic Survey, 2006), which also includes the three major coastal islands of Mafia, Pemba, and Zanzibar, and a coastline that is about 800 km long.

The geography is characterized by plains along the coast, a central plateau, and highlands in the north and south. The northwest of the country encompasses approximately one-half of Lake Victoria the second largest body of freshwater in the world, and the western and southwestern borders about the comparably massive Lake Tanganyika and Lake Nyasa. Elevations range from sea level to the highest point in Africa, the glaciated peak of Kilimanjaro at 5,895 m, the expansive slopes of which constitute one of the unique ecosystems of Africa.

Figure 2. Map of Tanzania showing administrative boundaries



Source. www.Tanzania.go.tz.

Tanzania's precipitation is governed by two rainfall regimes (bimodal and unimodal) which depend on geographical location, altitude, relief and vegetation cover. Bimodal rainfall which comprised of the long rains season between March-May and short rains season between October-December, and this pattern is common for much of the northeastern, northwestern (Lake Victoria basin) and the northern parts of the coastal belt. A unimodal rainfall pattern, with most of the rainfall in December-April, is more typical of most of the southern, central, western, and southeastern parts of the country. The mean annual rainfall varies from 500 millimeters to 2,500 millimeters and above (Shayo, 2006). The dry season can vary from 5-6 months in a year. Temperature also varies in coastal region and off-shore Islands where the

average ranges between 27^0C and 29^0C, the central, Northern and western part temperature ranges between 20^0C and 30^0 C and is experienced to be high in December and March in a year.

According to Population and Housing census of 2002, Tanzania had the population of 34.4 million people with an average growth rate of 2.9 percent per annum. The population projection shows that Tanzania had the population of 37.9 million people by 2006 and is expected to reach to 63.5 million by 2025.Majority of population about 75-80% live in rural areas. Agriculture is the major source of livelihood, income and is the backbone of the nation economy which accounts for 50% of the national GDP, 60% of export earnings and employing 80% of the work force (Shayo, 2006).

Tanzania has about 120 ethnic groups. Sukuma is the largest ethnic group that represents nearly 13% of the population and the remaining groups nearly represent 5% each (African Studies Center). The national language is Kiswahili and English is the official language. It has been estimated that 45% of the population are Christian, 35% Muslim and 20% follow indigenous religion/ traditional (Shayo, 2006). Since the study was carried in Kilimanjaro region below is short description of the region.

3.1.1 KILIMANJARO REGION

Kilimanjaro is one of the 26 regions in Tanzania. The capital of the region is Moshi. Kilimanjaro Region is bordered to the North and East by Kenya, to the South by Tanga region, to the Southwest by Manyara region, and to the West by Arusha region. Administratively the region is divided into 6 districts: Hai, Same, Mwanga, Rombo, Moshi rural and Moshi urban (see figure 3).

According to the 2002 census, Kilimanjaro had a population of 1,381,149, with average annual population growth estimated at 1.6 %. With population projection in 2006 Kilimanjaro region had a population of 1,472,000.

3.1.2 STUDY AREA-SAME DISTRICT

Same district is one of the six districts of the Kilimanjaro region in Tanzania. It is bordered to the north by Mwanga district, to the northeast by Kenya, to the south and southeast by Tanga region and to the west by the Manyara region.

According to the Tanzania National census of 2002, Same district had the population of 212,235 inhabitants. The average population density is 36 people per squire km. Administratively the district is divided into 6 divisions and it has 25wards with the total area of 5,152sq.km which is 39% of total area of Kilimanjaro region making it the largest district in the Kilimanjaro region. The average household size range from 6-10 persons. Topographically the area is divided into three main zones namely; the Upland plateau zone which lies between an attitudes of 1100-2462m above the sea level with temperature which ranges between 15^0C-25^0C, The Middle Plateau zone which lies between 900-1100m above sea level with temperature which varies between 25^0C-30^0C and the lowlands zone which rises from 500-900m above the sea level. The area is dominated by major ethnic group which is composed of Wapare who speaks Kipare as their mother language of communication and Kiswahili being the official language.

The area receives little rainfall of around 400 – 600mm(Yes-Africa,2006;Mziray,2002) annually which is distributed over two seasons; the long rain season that starts from March – May and short rain season that starts from October – December. Lowland areas mainly depend on long rain season and highland areas mainly depend on short rain season.

Majority of people in the study area depends mainly on farming as the main source of living although farming outputs is affected by regular droughts. Crop farming is mainly subsistence and they grow different crops such as maize being the staple crop, cardamorn, cereal crops, potatoes, cocoyams, cassava, fruits (banana, pears, pawpaws, avacados) ginger, little coffee, timber trees (e.g.*gravillea, sedrella, pines* ect) and sugar cane. Besides crops they also grow vegetable such as tomatoes, onions, spinach, lettuce, okra and pepper.

The average farm size is 2.8 acres per household (Field data, 2007). They keep livestock such as indigenous bread of cattle (dairy and beef), goats, pigs, chicken, ducks, rabbits, sheep ,fowls and donkeys which are used for transportation purposes as public transport in some of the villages is difficult and in some cases not available at all.

Major sources of energy in the study area include firewood, charcoal, kerosene, electricity from hydro, candles, biogas and solar. Firewood is the most popular 'traditional' source of energy mainly for cooking. Firewood is used nearly by all households for cooking and in some poorer households for ironing and lighting. Kerosene is the second source which is the most easily available fuel and is popular for cooking and lighting amongst household groups. Electricity is used by few people and they use it mainly for lighting and other small purpose like for refrigerators, charging phones and for watching TV. Biogas was observed to be used by only one station of brother of good shepherd. Solar is also used mainly for lighting purposes

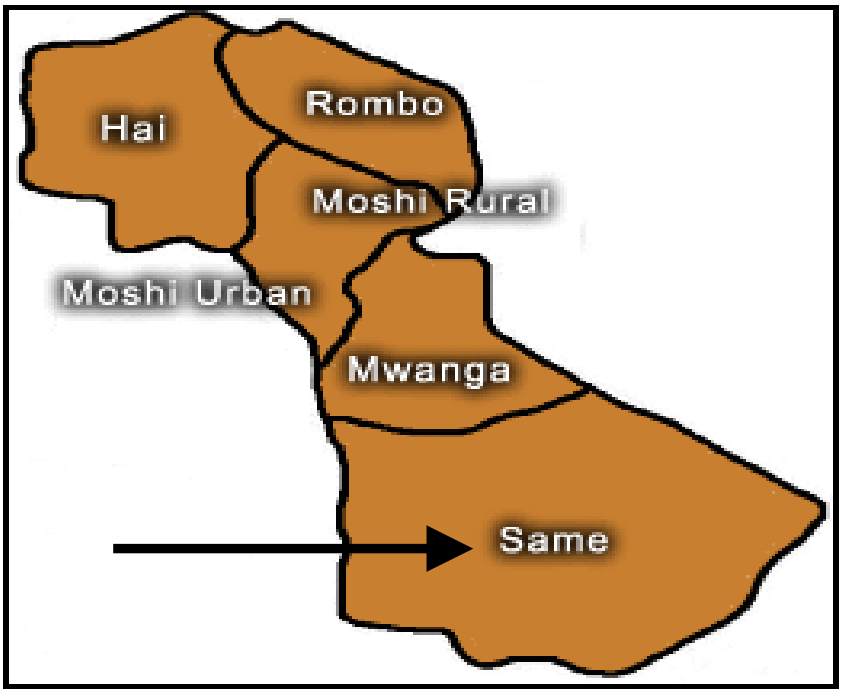
and 25 customers were observed in Hedaru to be using it but they were not involved in the sample size.

However after the introduction of jatropha farmers from these areas are now engaged with the cultivation of jatropha, which is being done in various ways: some in private plots, in institutions (primary schools) and in communal farms. Under these areas jatropha is planted as a fence, independent crop (tree lots), as boundaries, intercropping and as soil erosion prevention (YES-Africa, 2006).

The area was chosen as the study area because of various reasons: One is that is one of the rural area which face the problem of energy sources especially electricity. On top of that is also the area where jatropha has been planted as one of the plant that have great opportunity in providing renewable energy source which is most suitable for rural people who do not expect to have electricity in the near future due to high capital costs, high revenue collection costs, high connection cost due to scattered households and low reliability. Thus the area is therefore chosen as it can provide opportunities to study the available sources of energy in the household, the problems with them and the acceptance of jatropha as the source of renewable energy in the rural areas which can help to curb the rural energy problems.

Figure 3 below is the map of Kilimanjaro region denoting the study area.

Figure 3. Map of Kilimanjaro region showing Same district



Source.www.Tanzania.go.tz.

3.2 RESEARCH STRATEGY/RESEARCH DESIGN

Research strategy/design provides the picture and plan of the methods to be used in the study(Chachage,2003).According to Kothari (2000) research strategy/design provide the blue print of what type of data was collected, what techniques was used and how data were analysed.

In social science research there are several research strategies that are used to address social science research. They include experiments, surveys, case studies, histories and the analysis of archival information. According to Yin 1984 the selection of which strategy to be used by an investigator/researcher depends upon three conditions:

(1) The type of research question being asked.

(2) The control the researcher has over actual behavioural variables or events.

(3) The focus on contemporary as opposed to historical phenomena.

Research has different phases and each phase affects which kind of research strategy to be used. There are explanatory, descriptive and exploratory phases. Each phase differs according to the questions that they try to answer; exploratory research is mainly concerned with answering *"what"* questions. Descriptive research is effective in answering *"who"* and *"where"* questions. Finally, explanatory research is meant to answer *"how"* and *"why"* questions.

The table below summarizes the relevant situations for the five research strategies and each is assessed basing on the above three conditions.

Table 2. Summary of different relevant situations for the five alternative research strategies

		Require control over behavioural events?	Focuses on contemporary events?
Strategy	Form of research question		
Experiments	How, Why	Yes	Yes
Survey	Who, What, Where, How many, How much	No	Yes
Archival analysis	Who, What, Where, How much, How many	Yes	Yes or No
History	How, Why	No	No
Case study	How, Why	No	Yes

Source: Yin, 1984

This study has used the explanatory research phase through the use of face-to- face interviews and observation to answer the *how* and *why* questions. The explanatory research phase used in this study is *case study* which mainly aims at understanding social life and the meanings people attach to it and it does not require the investigator to have control over the variables and is used to accomplish the objectives of the study. This means that researcher study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them.

Case study was best chosen in this study due to the fact that it presents the following characteristics;

(1) Answer "how" and "why" questions.

(2) The investigator has little control over variables.

(3)The focus is on contemporary phenomena with real life context (Yin, 1984; Lindegger, 1999).

Moreover according to Prins 2006, case study approach has the following characteristics;

(1)Deep and holistic knowledge about the cases involved.

(2)Focus on understanding and interpreting the case from an inside perspective.

(3)Observations are done in a natural context.

(4)Utilization of multiple labour intensive methods of data generation.

3.3 DATA COLLECTION

3.3.1 Sampling procedure and sampling size

Experience shows that the household has been the unit of production and consumption in rural areas and also seen as the basic institutions within which resource sharing and exchange among individuals takes place (Nguthi, 2007), hence in this context analytical unit for this study is household. The unit of analysis is the person or objects from which the researcher collects data (Bless *et al*, 1995).

There are several definitions of households offered by different authors. According to (Alila *et al,* 1993) defined household as comprising of a person, or a group of persons generally bound by ties of kinship, who normally reside together under a single roof or several roofs within the same compound and who share the same community life.

However at the field level it became apparent that the criteria for determining household membership had to be adapted. For this study, household is defined as comprising of

members who live together in the same house or in the same compound or in the same homestead, share food from the same common source and are involved in the day-to-day decision making. Additionally for those member who are not involved in the day-to-day decision making but they were involved in making the major decisions such as education of the family members, burial and marriage ceremonies were also included as members of the households.

Non-probability sampling was used, specifically purposive sampling to select the sample basing on the presence of farmers who grow jatropha in that population and women who are believed to have knowledge on the sources of energy used in the household. The reason behind choosing this technique is because in the area under study not all households grow jatropha, as the study was also looking on the perception and acceptance of people on jatropha as the alternative source of renewable energy in rural areas. Also purposive sampling was used because is not possible to map out the entire population.

The list of household who grow jatropha was obtained from YES-Africa project list. The list of the household who grow jatropha helped also to know other household who don't grow jatropha in the study area. Total of 30 households out of the total populations within the villages in the study areas were selected depending on the size of the villages. Within the household women were preferred to be interviewed as it is believed that they know much about the energy source which they use within the household, during the time of interviews in those households where woman were not present or available the adult member of the household was interviewed or the responsible person in the household. Also in some cases the head of the household was also interviewed.

This sample size was selected so as to cope with the researcher's budget and time since a larger sample size could involve more costs in terms of money and time.

3.3.2 Secondary data

Collection of secondary data on various aspects including geography and demographic characteristics, agricultural activities, renewable energy technology was done through visiting the Ministry of energy and minerals, NGOs/company dealing with renewable energies (Kakute, Diligent, TaTEDO, YES-Africa, and Fact Foundation), government central statistics, National website and local government (extension office). The secondary data were collected through a review of published and unpublished literature. The review was also done in books, journal, articles, research reports, annual report, media reports, e-mails, thesis reports both for PhD and

Masters, conference proceedings, newspaper articles and electronic materials. Since the field of study is relatively new especially to the study area, secondary data were used to build the study on existing experiences that were done in other parts.

3.3.3 Primary data

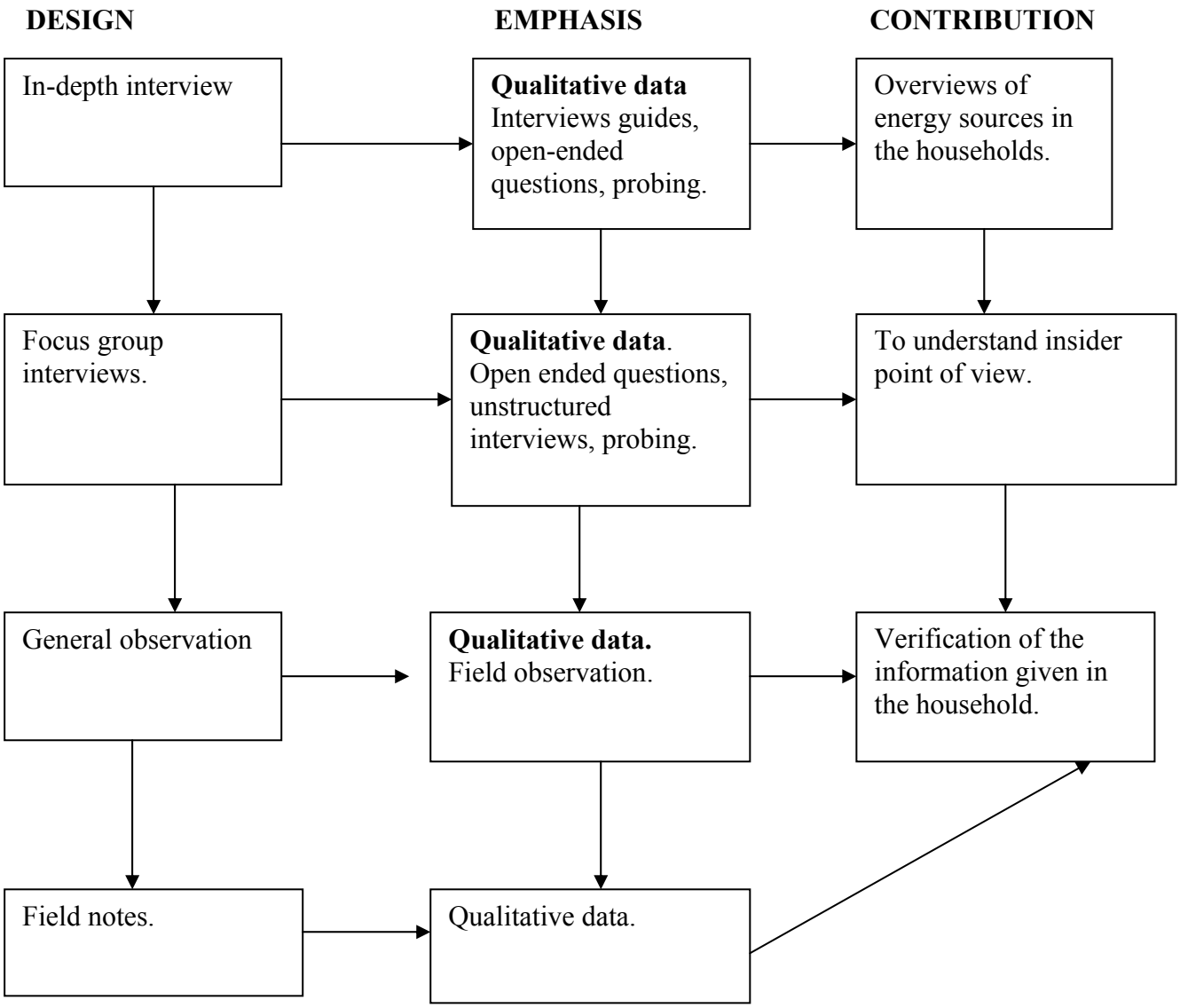
Primary data were collected through the use of an in-depth interview which is the way of conservation using probing techniques to allow lengthier period of questioning and is the predominant mode of data collection in social science research. The interviews targeted the rural household women who in most cases are regarded as the main decision makers in the household regarding what kind of energy source to be used in the household.

During the collection of primary data other interviews apart from households were also done in the area regarding sources of energy available (see appendix 2). Due to the nature of the study it was not possible to rely only in one method, so focus group discussion, field notes and general observation were used as a way to cross-check the responses from interview. These methods are considered as triangulation of methods or mixed method as it is always argued that the best way for data collection is using multiple or mixed methods (Mikkelsen, 1995).

According to Greene et al (1989) suggested five ways of applying mixed method in research strategy as: triangulation, complementarily, development, initiation and expansion. In this study triangulation way was used. Triangulation of methods or mixed method can be defined as the use of multiple methods to get information from the same data or from various data sources for the purpose of improving both internal and external validity and validating or verifying the accuracy of information. The criteria that were used in evaluating the response answers were based on: completeness, clearness, relevance and consistency.

Below is the figure which represents the triangulation of methods used in data collection.

Figure 4. Triangulation of methods used in data collection



Source: Author, 2008

3.3.4 Problems encountered during data collection

- Transport was difficult to some of the areas especially where there was no public transport.
- Some projects are located in very remote areas in such a way that it is difficult to turn in the area for second or third time due to time constraints which in turn hinder more clarification of data.
- Difficult to meet the targeted people in the household.

- Difficult for the respondent to understand some of the questions so much probing was done.
- Difficult to get people for group discussion as targeted.
- Some respondent refused to be interviewed because they don't know the benefits of them being interviewed basing on the assumption that they have been interviewed many times but they don't see the results of them being interviewed. So I hard to put extra effort to explain to the respondents the purpose of the research and give them assurance of them getting the results and recommendation of the study that will help them in the near future.
- The number of days spent collecting data was not sufficient to spend an adequate amount of time with each respondent, which would be required to establish good rapport with the respondent and make sure each question is understood.

3.3.5 Criticisms of the methods used

Primary data

Primary data that were used are of two types; from interviews and observation.

Interviews

They may be biased if the questions are poorly designed/constructed. Interviewee may respond to the questions the way the interviewer wants to hear (Yin, 1994).

Observation

According to Yin, 1994 this method has been described to have several problems:

- Time consuming.
- Bias of the observer.
- Limited to what the observer see i.e. what is going on at that time of observation.
- The observer influences behaviour of the observed. Due to its selectivity a researcher may miss some of the important facts/data.

Secondary data

With this method it may be difficult for the researcher to retrieve the important data due to the fact that the method involves many sources. Access to the data may be blocked and according to Yin, 1994, the reports collected during the study may reflect author's bias.

3.3.6 Ethical consideration

Principle of beneficence

The interview schedule was carried out bearing in mind the need to obtain information from the respondent but also respecting their time. The researcher was aware of the political implications and unwelcome results were handled with great care.

Principle of respect for human dignity

Providing fully information about the purpose of the study protects the right to self-determination and obtaining informed concert for the interview before proceeding.

Principle of justice

Respondents were treated with civility and esteem at all time. Interviews were conducted in privacy and confidentiality and were maintained by carefully storage of personal information details.

3.3.7 Data processing and analysis

Qualitative data analysis is the process of making sense of narrative data. Analysing qualitative data does not entail the use of statistics but it basically involves data reduction, data display, drawing conclusion and verification. In addition, it involves working with data, organising them, tying them into manageable units, synthesising them, searching for patterns, discovering what is important and what is to be learned, and what to tell others (Burden, 2006). The interviews notes were analysed manually by hand and interpreted through the production of descriptive and explanatory accounts.

3.4 TIME SCHEDULE OF THE RESEARCH

I began this study in May 2007 with the title designing and literature review. In June-July 2007 I spent in proposal writing, presentation and submission. August-December 2007 I spent in conducting fieldwork and data collection in Tanzania. In January-March 2008, I worked on data arrangements, processing and initial writings. In April-June 2008 Research writings, submission of first and second draft and presentation .June-July 2008 final draft and submission.

Below is the table for the time schedule for the research.

Table 3. Time schedule for the research

TIME	ACTIVITIES
MAY-JUNE (2007)	Title designing and Literature review
JUNE-JULY (2007)	Writing proposal, presentation and submission
AUGUST-DESEMBER (2007)	Data collection and field work
JANUARY-MARCH (2008)	Data arrangement, processing start writings.
APRIL-JUNE (2008)	Research writings, submission of the first and second draft and presentation
JUNE-JULY (2008)	Final draft and submission

CHAPTER FOUR: JATROPHA AND USAGES

4.1 INTRODUCTION

Jatropha Curcas has the advantage of growing in all types of soil. It can help to reclaim problematic lands and restore eroded areas if planted across the hills and alongside the wind as a windbreak. As it is not a food or forage crop, it plays an important role in deterring cattle and thus protects other valuable food or cash crops. Jatropha seeds can be pressed into bio-oil that can be used to run engines, which in turn drive pumps, food processing machinery, run cars and electricity generators. The bio-oil can also be the basis for soap making and good treatments for hair as traditional shampoos as they have some medicinal qualities. The pressed residue of the seeds is a good fertilizer for agriculture purposes and can be used for biogas production. All the uses of jatropha plant can be presented in one system called jatropha system. Jatropha system promote rural development by contributing/promoting four main aspects which combine to help in assuring a sustainable way of life for village farmers and the land that support them: Renewable energy by becoming self- sufficiency in energy source, erosion control and soil improvement, promotion of women by providing them with employment and additional income generation which is attributed by selling soap, seeds and jatropha oil, poverty reduction through job creation which can help in reducing the urban migration especially for the developing countries(Henning,1998).All the above mentioned aspects are crucially important for all countries which grow jatropha, but particularly for developing countries.

Several aspects of jatropha will be discussed in this chapter; first the description of the plant, varieties, ecology, yield, agronomic information, possible uses of jatropha, other uses of jatropha and the chapter ends with an explanation of viability of jatropha for energy services which includes jatropha oil as a substitute or extender for alternative sources of energy such as diesel, kerosene, biomass (charcoal and fuel wood) which is the focus of the study regarding jatropha oil.

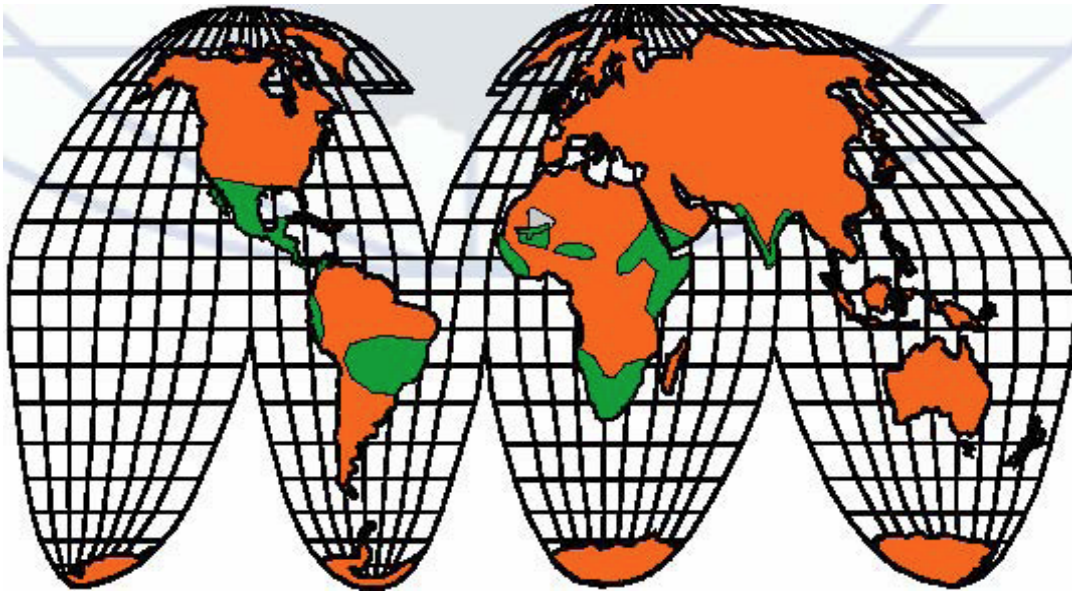
The use of jatropha oil as a substitute/extender of charcoal and firewood have been of great help to improve the health of women and save time that they use in fetching firewood, and this has been documented to be successfully from several countries like Mali, India and Zimbabwe just few to mention.

4.2 DESCRIPTION OF JATROPHA PLANT

Jatropha which refers to as Jatropha Curcas L. is a shrub or a small tree which belongs to the *Euphorbiaceae* family. It originates from Latin- America. From the Caribbean, Jatropha Curcas was probably distributed by Portuguese seafarers via Cape Verde Islands and former Portuguese Guinea and is today found worldwide in arid, semi arid, tropical and sub-tropical countries **(**See figure 5**).** Is a multipurpose plant due to its uses? Is a drought resistance plant that grows to a maximum height of nearly 8m.The root system is comprised of 3-4 lateral roots. The vertical taproot reaches 5m down in the ground (Chachage, 2003; Eijck, 2006). It has the life-span of more than 50 years. The plant starts producing yield from 1-2 year after planting. It produces round fruits with soft brownish skin which have 1.5 -3 cm in diameter with weight of 1.5-3g, the fruit maturation takes 45-50 days (Chachage, 2003;Foidl *et al,* 1996). Is a plant with several common names: Jatropha, physic nut, Barbados nut, purging nut, pig nut, fig nut, purgeernoot and it is sometimes referred to as the biodiesel or diesel tree (Benge, 2006; Eijck, 2006).In Tanzania this plant is known as "Graveyard plant" (mbono kaburi in Swahili), because traditionally the plant was used to mark the graves whenever someone dies and at the same time protect those graves from cows and other animals. The name Jatropha is derived from two Greek words, *jatrós* which means (doctor) and *trophé* (food), which implies medicinal uses (Heller, 1996).

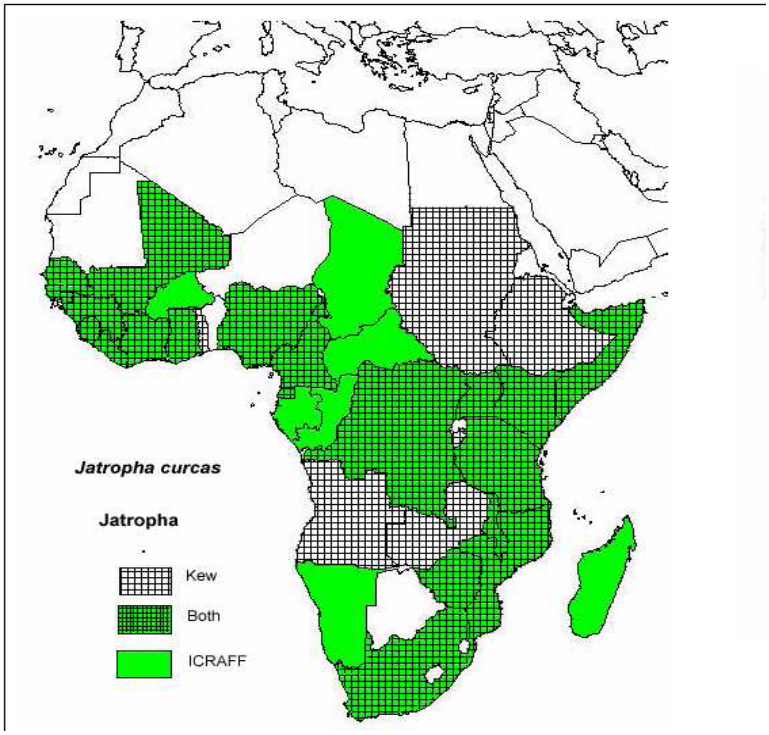
Figure 5 below is the world map and **figure 6** is Africa map. All maps depict the distribution of jatropha. The places that grow jatropha are denoted in green from the maps.

Figure 5. Jatropha distribution worldwide (green)



Source:www.jatrophaworld.org.

Figure 6. Geographical location of Jatropha, according to International Center for Research in Agroforestry (ICRAF) and Royal Botanical Gardens, Kew



Source: Research Group International Programs (IP) (2002)

4.2.1 VARIETIES

The term "Jatropha" is usually used to refer to the species *Jatropha Curcas Linnaeus* and it contains approximately 170-175 know species (www.fact-fuels.org; www.worldagroforestry centre.org; Ejick, 2006 and Wiessenhutter, 2003) .It belongs to the member of *Euphorbiaceae* family. Among these known species some of them are toxic and others are non- toxic. The non-toxic varieties do not contain toxic Phorbol esters and thus is a potential source of oil for human consumption. The seed cake can be a good protein source for humans as well as fodder for livestock and this has been reported from Mexico and Central America (Henning, 2003; Benge, 2006).

4.2.2 ECOLOGY

Jatropha curcas L. is not a weed, it is not self-propagating so it has to be planted (Bailey *et al,* 2007). It grows well in marginal land with more than 600 mm of rainfall per year though the

required condition is between 600mm-1000mm with average temperature of 20^0C and 28^0C (YES-Africa, 2006;Bailey *et al*, 2007), and it withstands long drought periods(www.fact-fuel.org) . With less than 600 mm it cannot grow except in special conditions like in Cape Verde Islands where the rainfall is only 250 mm (Wissenhutter, 2003;Benge, 2006) but the humidity of the air is very high (rain harvesting). It cannot stand frost. It survives in a very light frost, but it loses all leaves and also during drought season the plant sheds most of its leaves in order to reduce water loss (transpiration), the leaves that are shed have organic matter which enhance earth-worm activity in the soil around the root- zone of the plants which improves the fertility of the soil and during winter months form mulch around the base of the plant (www.fact-fuels.org;www.worldagroforestry centre.org; Ejick, 2006 and Wiessenhutter, 2003).

Table 4 below show the Climatic Data of Seed Provenances according to origins.

Table 4. Climatic Data of Seed Provenances

Origins of Provenances	Altitude (m)	Average Temp (°C)	Average Annual Precipitation (mm)
Cape Verde, Fogo	150-1600	19-25	200-1000
Senegal, Santhie Ram	15	28	700
Ghana, Nyankpala	183	28	1080
Benin, Cotonou	7	25	1330
Burkina Faso, Kongoussi	300	-	520
Kenya, Kitui	1020	28	790
Tanzania, Mombo	430	20	670
Burma, Sink Gaing, Mandalay	80	27	825
India, Kangra	580	-	-
India, Kangra	434	11-38	-
India, Poona	556	25	672
Costa Rica, Rio Crande	10	28	2000
Mexico, Veracruz	16	25	1623

Source: Bailey *et al,* 2007; Heller, 1996

4.2.3 AGRONOMIC INFORMATION

Although Jatropha is adapted to low fertility sites and alkaline soils, better yields seem to be obtained on poor quality soils if fertilizers containing small amounts of calcium, magnesium, and sulphur are used (Field data, 2007; YES-Africa, 2006). In the Jatropha Energy System, the processing of the seeds results in such an excellent organic fertilizer, part of which can be returned to the plantations or be used for cash crops. Jatropha can be intercropped with high value crops such as sugar, coconut palm, oil palm, and various fruits, vegetables (red and

green peppers, tomatoes), and export crops such as coffee and cacao (Bailey, *et al,* 2007). The plant not only protects crops from grazing animals, but it also has a phytoprotective action against pests and pathogens providing additional protection to intercropped plants (Field data, 2007).

4.2.4 YIELD

Although Jatropha can grow in semi-arid areas and can survive with a low quantity rain, rain does affect the quantity of annual yield but also genetic variation (seed quality), ecological conditions, propagation, cultivation, harvesting, and oil expulsion methods (Field data, 2007; Eijck and Romijn, 2006). This might explain the differences in opinion about the possible yield of jatropha per hectare but no systematic research seems to have been conducted yet to determine the influence of these factors and their interactions (Caniels and Romijn, 2007).
Researchers claim a yield between 0.4 to12 tonnes per hectares and in some instance 2 tonnes up to 20 tonnes per hectares could be reached (Openshaw, 2000). Jatropha Curcas is still a wild plant which makes yields unpredictable. According to interview, 2007 a yield of 2 tones per hectares in Arusha region is a reasonable guess when space of 3 by 3 meters apart is used. 5 kg of seeds are required to expel 1 liter of "raw oil" (Kakute). Also depending on the soil and climatic conditions, 2-4 tonnes of oil-containing nuts can be harvested annually per hectare when distance of 2.5m between trees is respected (Weggoro, 2008).
One hectare can have trees that vary from 1100-3300 (Peter, 2007). Propagation from cuttings offers good results but it depends on the donor plant and the portion from which the donor plant cuttings were taken, for the establishment of plantations geared towards oil production seedlings from a nursery have higher yields (Field data, 2007). In unkept hedges, Jatropha yields around 4 tonnes of seed per hectare, while under optimal conditions; yields of up to 8 tones can be achieved.
The oil contents of seeds vary according to origin, and this can be observed from the table 5 below.

Table 5. Oil content of jatropha seeds from different countries

Origin	Oil content
Brazil	30.9%
Tanzania	37.8%
Ethiopia	38.8%
India	36.8%
Gambia	32.7%
Nigeria	33.7%

Source: **Peter, 2007**

4.2.5 POSSIBLE USES OF JATROPHA PLANT

Soil stabilization in marginal locations

Jatropha is extremely drought resistant plant. Due to its few demands on the environment the plant is used primarily to stabilize the soil in the marginal sites. It has dense, wide-ranging root structure which protects the soil against erosion and above all it protects the soil from being washed away by rain and it serves as nutrient pump.

Figure 7 below depict how jatropha can be used to stabilize soil in the marginal sites.

Figure 7. **Jatropha planted in marginal sites in the Maasai plains Arusha region**

Source: ***bagani, Reinhard K. Henning, Rothkreuz***

Living fences and enclosing fields

In Africa and mostly in Tanzania the plant is chiefly in most areas planted as a hedge around the gardens, fields and homestead. In Tanzania Jatropha is known for more than 30 years ago

by majority but its utilization was limited. It has been used as living fence for many years by agro-pastoralists (Maasai) in the semi arid areas of northeastern part of Tanzania. This has contributed much to the reduction of conflicts between herders and farmers in the area because they have clear demarcation of their farms. It protects the animals from entering the farmers' farms due to the fact that the plant cannot be browsed by animals and has a long life span. Since Jatropha can be grown on marginal land and around existing gardens and fields, it does not compete for cropland, but complements food crop production.

Figure 8 and 9 below shows how jatropha can be used as living fences and enclosing fields.

Figure 8. **Jatropha planted as hedge around the market place in Arusha -Tanzania**

Source*: http://www.biodieseltechnologiesindia.com and http://www.jatropha.de/*

Figure 9. **Jatropha planted in enclosing fields**

Source: *http://www.jatropha.de/*

Traditional human and animal medicine

Jatropha plant can be used for medicinal purposes as the name Jatropha does apply to (iatros = doctor and trophe = food in Greek). Jatropha has been documented as a traditional plant and the effectiveness of the resulting remedies has been in part scientifically demonstrated. The leaves, stem, seeds and the oil are used as wound disinfectant and as a treatment of skin diseases. Due to the fact that the oils are strong purgative, they effectively induce diarrhea or vomiting and they offer pain relief against rheumatism. Much of this has been observed from the study areas specifically Hedaru where by the soap that were made for promotions by brother of Good Sherphard were all bought mostly by the people who are affected with HIV/AIDS as jatropha soap has anti-fungal properties (Field data, 2007). According to them jatropha soap is better than neem and Aloe Vera soap due to its strongest medicinal properties and they are ready to pay for higher prices. At current they buy one piece of jatropha soap for 500Tsh which is more than the normal soap which they usually buy for 250-350Tsh per bar. Below is the sample of soap which is produced by Kakute in Arusha –Tanzania.

Figure 10 .Jatropha soap produced by KAKUTE

Source: Kakute

Biological pesticides

Because of its insecticides and molluscide effect, the oil can be used as a natural crop pesticide. It has been proved to be successfully in preventing pests in cotton, potato, pulse,

corn, sorghum crops, pulse and tomato (Heller, 1996 and 2007;Solsoloy,1993).Also it has been found to have strong molluscicidal activity and the latex to be strongly inhibitory to watermelon mosaic virus (Benge, 2006). The oil extracts with toxic effects protects plants from various pests. However it is not easily to handle this oil extracts due to its high concentration and strong purgative effects (Axtell and Fairman, 1992).

The toxicity of jatropha has also been reported to cause death of rats which ate raw and cooked seeds died within the duration of 2-3 days, and rats given raw of cooked jatropha oil died within the duration of 6-8 days (Chachage, 2003).It is also reported that when the jatropha seeds are roasted or cooked they cause the rats death in duration of 14-16 days (Liberalino,*et al* 1988).

Soap production

Traditionally soap has been produced from curcas oil in several countries Tanzania being one of them. However the production process is costly and is very difficult to be managed by individuals and if produced by individuals may be of poor quality. High quality soap can only be produced with modern production methods. In addition, sodium hydroxide (NaOH) is required to and at times additional raw materials to improve quality (e.g. tallow, other oils, fragrances). For local production of simple quality household soap the following recipe was tested in Mali.

"1 litre of oil, 1/2 litre of water, 150g of pure NaOH (sodium hydroxide) dissolved in the water. While stirring the oil, the water-NaOH solution is mixed with the oil until a creamy consistence is achieved (like mayonnaise). This is pured into a form where the soap hardens (in tropical countries overnight, in Europe that may take up to a week). After hardening the soap is taken out of the form and may be cut into pieces" (http:// www.jatropha.de/fag.htm.).

India has successfully produced high quality soap by combining hydrogenated Jatropha oil 75% and refined, bleached Jatropha oil 15%; with coconut oil 10% with this mixture soap can be produced with lathering values which is equivalent to regular toilet soap. (Heller, 1996). Jatropha oil for soap production in Tanzania is a successfully business by women group of ARI-Monduli (Alternative Resources of Income for Monduli Women) with the assistance from Kakute in training on hoe to produce soap and extension services. The successfully business of soap production is attributed by providing additional income and employment to women and thus social economical contribution to rural community.

The following economic evaluation of the use of Jatropha for oil and soap production is based on experiences of Kakute in its Jatropha project ARI-Monduli. The economic calculation is

differentiated between seed collection, oil extraction and soap making. It is obvious, that the collection of seeds and its sale gives the least added value. Oil extraction is more profitable than seed collection, but not as good as soap making.

Collection and sale of seeds

"Collection of seeds: (figures from Kakute, 2003)

Collection of seeds: 2 kg in 1 hour

Sale of seeds: 150 TZS per kg

Value added for 1 hour work 300 TZS (0, 29 USD) per hour

Extraction and sale of oil

Oil extraction: (figures from Kakute, 2003) 5 kg of seed for 1 litre of oil is 1.7 hours of work

1.0 hour of work to extract 1 litre of oil

Input: 5 kg of seed 750 TZS (0.71 USD) per litre

1.5 hours of work to extract (1 litre of oil depreciation of ram press 0.02 USD / kg) for 5 kg: 105 TZS (0, 10 USD) per litre

Output:

Sale of 1 litre of oil 2.000 TZS (1, 90 USD)

Value added for 1 hour of work 1.145 TZS (1, 09 USD) per hour

Production and sale of soap

Soap making: (figures from Kakute, 2003)

16 hours work for 252 bars of soap

1 bar sold for 500 TZS

Purchase of 20 litres of oil @ 2.000 TZS = 40.000 TZS

Purchase of 3 kg of Caustic Soda @ 2.000 TZS = 6.000 TZS

Plastic for wrapping soap = 3.000 TZS

10 hours for miscellaneous work (organizing purchase of oil, wrapping the soap, etc)

Input: 20 l oil 40.000 TZS (38, 10 USD)

Plastic 3.000 TZS (2, 86 USD)

Caustic Soda 6.000 TZS (5, 71 USD)

Total input for 26 hours work 49.000 TZS (46, 67 USD)

Output: 252 bars @ 500 TZS 126.000 TZS (120, 00 USD)

Total of revenues 77.000 TZS (73, 33 USD)

Value added for 1 hour of work 2.962 TZS (2, 82 USD)"

Lubricating oil

Jatropha Curcas oil has been proved to be useful as a substitute for lubricating oil diesel motors or engines. But the engine has to be modified before using this oil as diesel. For example in Arusha- Tanzania this has proved to be useful with Diligent Company, all of their cars that they use they use biodiesel from Jatropha.

Fertilizer

The jatropha press cake can be used as organic nitrogen-rich fertilizer that replaces chemical manure. Field trials in Mali examined the effects of various fertilizers; 5t/ha of manure, 5t/ha of Jatropha press cake and 150kg/ha of mineral fertilizer on pearl millet yields. Substantially higher yields were realized from Jatropha press cake 1366 kg versus manure 815 kg and mineral fertilizer 1135 kg (Bailey *et al,* 2007; Heller, 1996*).*

Jatropha nitrogen content ranges from 3.2-4.44 %(www.fact-fuels.org;Heller,1996 and Eijck, 2006).It has high-value of organic fertilizer as compared to chicken manure and cow manure. It can be used in organic agriculture, home gardening and in horticulture, thus reduces pressure on depending on the inorganic fertilizers and reduce risk of environmental contamination on the land. From the study area since production is still low the seedcakes have not been started to be used as fertilizer but that is the future plan. Though it has been reported in many literature that jatropha plant does not require fertilizer, but if it is grown for commercial purposes additional of fertilizer will be important when the land become exhausted (Chachage, 2003; Openshaw, 2000) .

Below is the table that depicts the nutritional analysis of different manure including jatropha.

Table 6. **Nutritional analysis of oil-seed cakes and manures (percentages**)

Property	J.curcas oil cake	Neem oil cake	Cow manure	Chicken manure
Nitrogen	3.2 – 4.44%	5.0%	0.97%	3.04%
Phosphorus	1.4 – 2.09%	1.0%	0.69%	6.27%
Potassium	1.2 – 1.68%	1.5%	1.66%	2.08%

Source: Eijck, 2006

4.2.6 OTHER POSSIBLE USES OF JATROPHA

Jatropha as the support plant

Jatropha can be used to support other climbing plants like vanilla and paper. Vanilla use jatropha for stabilization. In Tanzania jatropha has been used to support vanilla plants in Karagwe - Bukoba. Also in Madagascar it allows the climbing plants to grow well but also to protect them from heavy winds generated by cyclones. Figure 11 below shows how jatropha is used as a support plant for vanilla.

Figure 11. **Jatropha as support plant to vanilla**

Source: **Eijck, 2006**

Jatropha seed cake as source of charcoal

Jatropha seed-cake is the residue left after oil is extracted from the seeds, is widely known as a very valuable form of fertilizer equivalent in fertility as compared to chicken manure. Moreover it can also be used as charcoal or briquette as a source of energy for cooking as when the extraction is due the seedcake contain residues which consists of hulls and some oil seed. The idea of using seedcake as briquettes is still under research because the seedcakes are suspected to contain pollution hazard which is dangerous health wise. In Diligent Tanzania they have tried this experiment of making charcoal from the jatropha seedcake but it has been seen that it produces a lot of smoke that is dangerous for health.

KIDT in collaboration with TaTEDO has been trying to develop the jatropha charcoal stoves but still the technology is not functioning well and there is no data whether there are customers who are using these stoves at the moment.
Figure 12 below is the jatropha charcoal stove developed by KIDT.

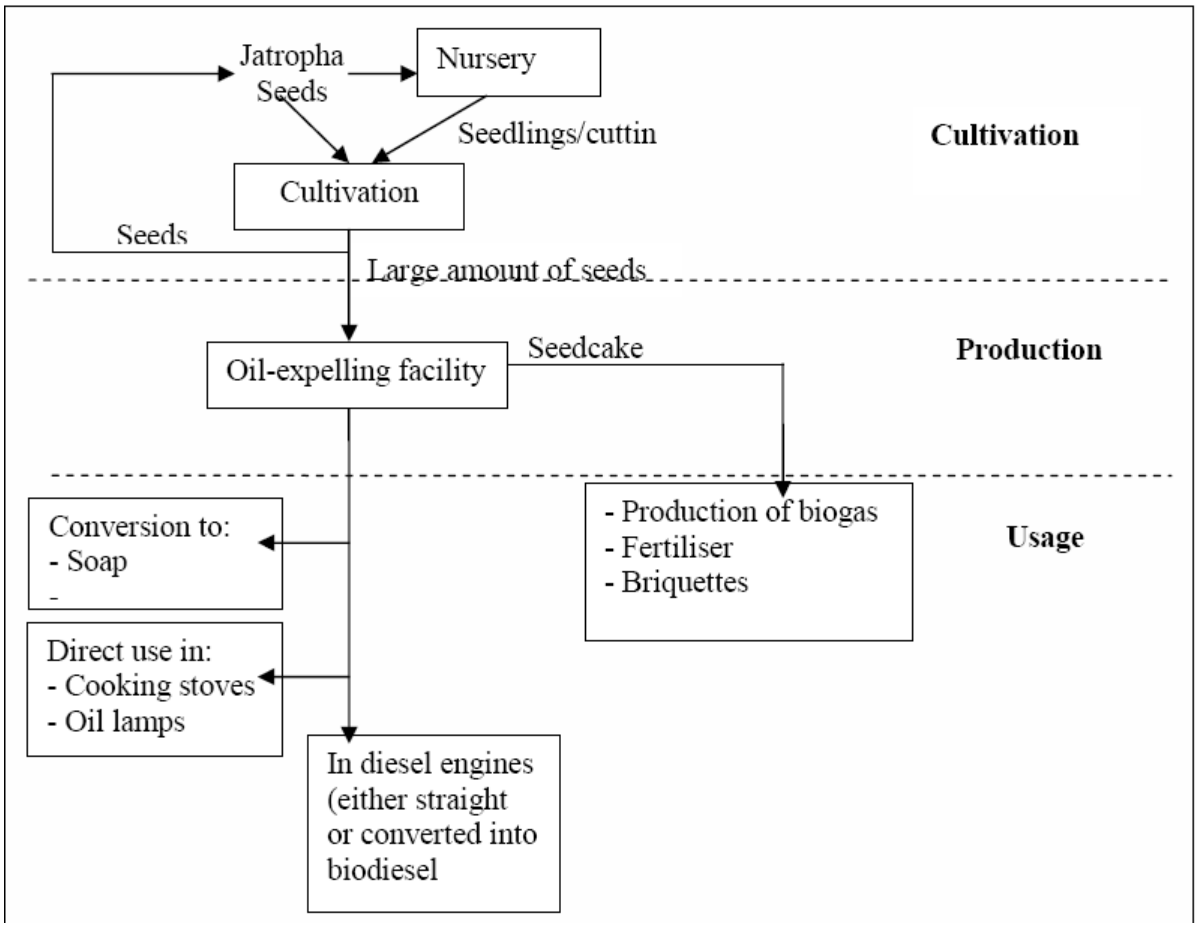
Figure 12. Jatropha charcoal stove

Source: **Eijick, 2006**

Jatropha seed cake as a source of biogas production

Jatropha seed-cake which is the leftover after the extraction of oil together with the leaves can be converted into biogas through fermentation process. The biogas is a methane rich fuel gas and good source of energy for cooking. Kakute in Arusha built the biogas facility to test its properties but the people to whom the biogas facility was built they often use it, they just use it during rain season where it is difficult to find firewood.
However the uses of jatropha plant are many but the above ones are to some extent applicable at the moment and they can be depicted in one figure as below.

Figure 13. Flow diagram of jatropha



Source: **Eijck, 2006; Caniels and Romijn, 2007**

4.3 THE VIABILITY OF JATROPHA FOR ENERGY SERVICES

Due to the lack of empirical data for calculating the economic viability of Jatropha oil for energy service in cooking and lighting, the study reviewed studies that explored the economic analysis of Jatropha oil for energy services in other places where Jatropha activities are taking place. It is assumed that the results from other countries like Mali, Zimbabwe and India also represent many developing countries' situation including Tanzania's situation. From the literature review it is apparent that the economic viability of Jatropha fuel is dependent on the technology used for processing and the capital cost of required equipment (Chachage, 2003).

In Tanzania the only data that are present and practically used is the use of jatropha oil for diesel engine that has been used by the Diligent Tanzania Ltd, jatropha oil to run generator which provide electricity at the households level, soap production by Kakute and to some extent jatropha oil as kerosene and source of biogas.

Diligent Tanzania uses cars which are run by biodisel from jatropha, the extraction of biodisel is also done by the Diligent themselves through collection of seeds from farmers all around the region and extract them. They have several collection stations/points where farmers bring their seeds for selling and buying at weekly markets. In a long run farmers are guaranteed with fixed price and market for 10 years which help in reducing the risk of a price fall.

4.3.1 PRESS TECHNOLOGY

The pressing/extraction of jatropha oil from the seeds can be done hydraulically with ram press or chemically using organic solvent or water (Eijck, 2006). The extraction of jatropha oil chemically cannot be achieved under small-scale basis. In previous time women used stones traditionally to extract Jatropha oil from seeds (see figure 14), and probably in some rural remote areas they still do it today (http://www.Jatropha.de). But this is mostly preferred for small-scale proposition of jatropha oil which can be used for medicinal purposes, but for large scale production is better to use ram press and expellers.
Figure 14 below shows a woman extracting jatropha oil traditionally using stone.

Figure 14. A woman extracting jatropha using stone

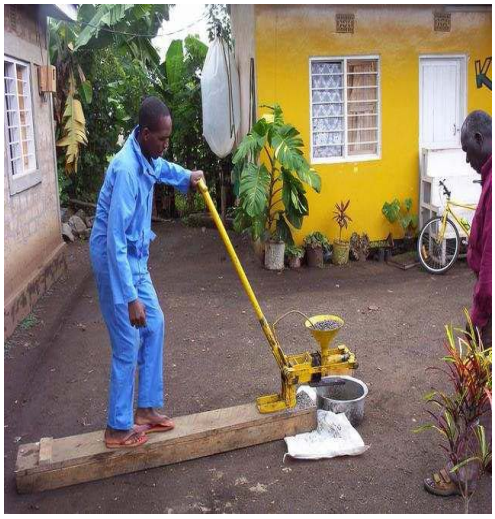
Source. http://www.Jatropha.de.

In Tanzania at current they're using the ram press that its design is cheap, durable, locally maintainable and easy in use to everybody and have been manufactured by the local workshops e.g. vyahumu (see figure 16).

How the ram press is used

A ram press is a small hand press that can be powered by hand. Is operated by one or several operators (See figure 15). In this press, the seeds are poured which applies pressure on the seeds, extracting the oil, which then drips into a container, in the ram chamber the process involves the compressing and decompressing in time and expresses the oil from the seeds and this process is recharged after every cycle. Jatropha seedcake is left after the pressing. The extraction rate of this press is quite low as the seedcake still contains part of the oil. About 5 kg of seed is needed for extraction of 1 litre of oil (Henning, 2004). The capacity of the press is about 1.5 litres per hour. Some study shows that there are other presses that can be run by engine due to its high extraction capacity and due to its high extraction capacity it leaves the seedcake drier as compared to ram press and these presses originate from China and India. At current in Tanzania they use the Sayari oil expeller manufactured by vyahumu trust. This Sayari oil expeller has the capacity of extracting 100kg of seeds/hour and the residual oil content in the press cake is 10 to 12 %(http://www.jatropha.de/news/jcl-news-2001.htm)

Figure 15. Jatropha hand press



Source: Eijck, 2006

Figure 16. Sayari oil expeller

Source: www.jatropha.de/Tanzania/expeller.htm

4.3.2 JATROPHA OIL FOR LIGHTING

Jatropha oil cannot be used directly in the normal lamps using kerosene, the lamps need some modification. The oil lamp has to be short so that the flame is above the liquid surface due to high viscosity and ignition temperature of jatropha oil. Jatropha oil has high viscosity as

compared to traditional oil such as kerosene. In Tanzania the use and design of this lamps has been done by Diligent and TaTEDO but up to the moment their still making some modification, the first design was done by TaTEDO and customers tried to use it but it was not successfully. In Zimbabwe almost in each village the use of jatropha oil for lighting has been successfully as compared to kerosene with the use of the binga lamp.
Below is the explanation of binga lamp.

"The "Binga-Oil-Lamp" is made of a simple glass (jam jar, drinking glass), filled with oil up to 3 -5 cm below the rim. On the oil floats a small cork disc (or a disc of a maize spindle) wrapped in aluminium foil to prevent the cork burning. In a hole in the centre of the disc cotton wick is fixed. The floating wick holder is centred using matchsticks or pins. Thus the flame of the oil lamp is only some 1 or 2 mm above the surface of the oil and the flame gives a quiet and steady light. It seems that the smell of this light also repels mosquitoes" (http://www.gaia-movement.org).
Figure 17 below is the example of jatropha oil lamp that can be used for lighting in rural areas.

Figure 17. **Jatropha wick lamp**

Source: **http://www.jatropha.de/lamps/index.html**

4.3.3 JATROPHA OIL FOR COOKING STOVES

Research shows that the jatropha oil cannot be used to the conversional stoves using kerosene due to its high viscosity, as a result the jatropha oil coking stoves has to be adapted. Some

research has been done by the KIDT in Moshi together with TaTEDO and they have discovered that the oil from jatropha cannot be used directly to the normal conversional stoves using kerosene the oil has to be converted into biodiesel. In Hohenheim University in Germany group of specialists are also developing the special jatropha oil stoves but not readily available at the moment.

In India, Jatropha oil can be used in stoves for cooking purposes. Figure 18 below represent various jatropha oil stoves design in India. The first is pressure stove, which emits oil into burner under air pressure, second is Wick stove, where oil rises to burner by capillary action while third and forth is fed with fuel under gravity force of oil inside the bottle. Villages in India have at least 5 to 10 acres of fallow land that exists in most areas. If people in this villages plant Jatropha on 10 acres of fallow land, they can get at least 2 tons of Jatropha seeds (500 liters of Jatropha oil) after 1 year, 5 tons of Jatropha seeds (1,250 liters of Jatropha oil) after 2 years and 10 tons of Jatropha seeds (2,500 liters of Jatropha oil) every year after 3 years. This can satisfy the needs of liquid fuel for Lighting and Cooking and a village can become self-sufficient in its energy needs.

Moreover in India kerosene is the most common and favourite fuel for cooking food particularly in low-income section of the population. Kerosene consumer constitute a significant majority in the remote towns and villages where LPG is either not available or its regular supply is uncertain. Due to unaffordable prices of LPG by the low-income groups and non-availability of fuel wood and other sources of energy, a large section of Indian population in cities and towns depend upon ratined supply of Kerosene for meeting their domestic needs mainly for cooking. Due to increasing demand and limited supplies of kerosene, one can see long queues for procuring the limited quota of kerosene. The women are the most vulnerable group who have to manage the household with insufficient quota of kerosene, as the increasing demand for cooking fuel is unable to keep pace with the indigenous production of kerosene. Jatropha oil can be used as a direct substitute to kerosene as fuel for cooking while used in the special designed stove with almost matching fuel efficiency.

Much study has been done concerning the use of jatropha oil as kerosene, e.g. from the Department of Mechanical Engineering from Jadavpur University. They have designed the straight jatropha oil-kerosene stoves for burning in the rural areas and this device is called “kupi”. This device has less soot formation as compared to kerosene stoves due to its high oxygen content. Health wise the use of kupi is more advisable as compared to traditional kerosene lamp due to the fact that it reduces the chances of suffocation inside the house. The luminosity during complete combustion, jatropha oil blend is 20% as compared with 80%

from kerosene (http://wbbiotech.nic.in/Background_note.htm.) and thus more safe than kerosene.

Example from India can be taken by other African countries Tanzania being one of them because it faces the problems of energy sources mostly in rural areas. Besides jatropha oil being used for cooking stoves, the cake from Jatropha seed can be used for direct combustion or can be converted into charcoal.

Figure 18. Varieties of jatropha oil cooking stoves used in India.

1 2 3 4

Source: **http://www.svlele.com/book.htm**

4.3.4 JATROPHA OIL FOR ELECTRICITY GENERATION

Major sources of commercial energy in Tanzania include Petroleum, hydropower and coal. The electricity sub-sector contributes about 1% of the total energy consumption in the country. In rural areas very few people have access to electricity due to high costs of electricity and in some areas the grid reference has not reached due to long distance from the main grid. In urban areas and in the large cities most people have access to electricity but power cut-outs are very frequent and customers are forced to use diesel generators to run their business that results to costs of buying diesel. Basing on this assumption jatropha can be the good source to solve all this problems by having the generator being run by jatropha oil instead of diesel. Building this point a case was made in Engaruka and Leguruki village where they use jatropha oil to run generator which in turn provide electricity .Engaruka village was visited physically but Leguruki case was adapted from the literature.

CASE OF ENGARUKA AND LEGURUKI VILLAGE

Engaruka village is situated at the border of Ngorogoro Conservation Area in Monduli district. The inhabitants of this village are rural Maasai .This village is divided in Engaruka

Juu and Engaruka Chini.Engaruka Juu has 6214 inhabitants and Engaruka Chini has 5200 inhabitants. According to village executive officer,Engaruka doesn't seem to cover a lot of poverty; 75% of households in Engaruka earn at least 10000 Tsh per week from selling their farm produce and small businesses.

Leguruki village is located in the slopes of Mt. Meru, in Leguruki Ward, King'ori Division of the Arumeru District in Arusha Region. The village is not far from Kilimanjaro International Airport (KIA).The village is divided in five sub-village sections namely Madukani, Mbaaseny, Songambele, Noseiya and Mlimani. Leguruki is bordered by Arusha National Park forest and four villages namely Nkoasenga, Miririni, Shishitoni and Maruango. Total village area is 2185 ha, of which 1740 ha are suitable for agricultural activities. In 2002, 1537 ha were used for agricultural cultivation and 202 ha were used as pastoral area. They grow coffee, banana trees, beans, jatropha and corn.

Moreover Leguruki and Engaruka village are both located in Arusha region in the North-Western part of Tanzania. Both villages lack electricity from National grid and they don't even expect to be connected in the near future.

Basing on electricity from jatropha these two villages have been successfully in using the MFP and generator connected to it which use jatropha oil. The MFP in these villages were installed by TaTEDO.The criteria that were used by TaTEDO to choose these villages to get the min grid were based on number of habitants (at least 3000), amount of oil seeds produced per year, demand of MFP services, distance from TANESCO grid, acceptance by the local administration, presence of entrepreneurs and others (http://www.tatedo.org).

The generators in this villages are connected to the multifunctional platform min grid (see figure 19) which is being run by both diesel and jatropha oil. During the harvest season they use jatropha oil and during the time when there is deficit of jatropha oil they use diesel. The multifunctional platform in Engaruka has the capacity to generate electricity to 150 people but at the moment it supplies electricity to 23 households and one campsite. The min grid that is located in Leguruki village supplies electricity to 40 houses (25 household and 17 business point like shops, restaurant and butchery).

In Engaruka village the service is provided everyday between 6 pm-12am.The households that are connected are provided with electricity for 2 bulbs of 60W lights each, the campsite has 13 lights, TV, video desk and radio. The villagers have supply to electricity and also they use the generator for dehusking maize, pressing jatropha seeds, charging phones and charging the batteries.

The charges that are used for the connection for each household are as follows;

- Two light points for 3000 Tsh per month and a connection fee of 11100Tsh
- Two light points and a socket, a.k.a. unlimited connection, for 9000 Tsh per month and a connection fee of 21400Tsh.

The charges for connection fee and usage for both limited and unlimited connection was set by TaTEDO and no clear explanation why they decided to charge that amount.

Table 7. Prices charged for the service in Engaruka

SERVICES	**Tsh**
Monthly payment 2 lights	3,000
Monthly payment unlimited	9,000
Connection fee& unlimited connection	11100&21400
De-husking maize	500(for 20kg)
Charging cell phone	300

Source: **Interview, 2007**

Notes: De-husking the maize depends on the kg.

Figure 19. MFP in Engaruka village

Source: Author, 2007

The comparison of the mini-grid electricity with other source of energy such as kerosene in Engaruka village

An interview was done with the customers of the MFP to make the comparison between the available source of energy in the area and the one from jatropha oil. The interview revealed

that, when using kerosene they normally spend 200Tsh per day for lighting; but when using electricity from MFP they spend 3000Tsh per month which means that the cost per day is 100Tsh.

Generally when using kerosene per month they spend from 6000-7000Tsh for lighting and they cannot even recharge their cell phones. From this comparison it shows that the use of mini-grid reference for electricity in lighting is the big solutions to the rural people especially those who don't have electricity and they don't expect to be connected with TANESCO grid in the near future.

Engaruka village is not part of the study area but was used in this study so as to give the overview on the use of jatropha oil for provision of electricity for lighting in rural areas. This area is regarded as the same as the study area due to the fact that they have the same characteristics as the study area. Basing on the fact that in this village have been documented as successfully in the use of jatropha oil for supplying electricity it is believed that other parts of the county especially the rural area can adopt the same technology to help to solve the problem of electricity. In addition they have also extra advantages when using jatropha as a source of energy like charging cellphones, battery, and dehusking maize.

4.3.5 JATROPHA OIL AS EXTENDER FOR DIESEL ENGINE

The history of using Jatropha oil instead of diesel goes back to the Second World War when Madagascar, Cape Verde and Benin used Jatropha oil as a diesel substitute (Chachage, 2003;Foidl,*et al,* 1996).Moreover using jatropha oil as extender for diesel received special attention in 1970 due to oil crisis and limitation of world oil sources(Heller,1996). It is believed that physical and chemical characteristics of Jatropha oil are similar to that of other commonly known bio-oil like sunflower oil which support that it has all the possibilities to be used in diesel engines (Rabe, 2005).

Jatropha oil can be used in diesel engines, either directly but it requires some modifications to the engine in a mixture with diesel fuel or when chemically converted as biodiesel which has about the same properties as normal diesel fuel (Eijck, 2006; Chachage, 2003 and Pramanik, 2003). The reason as to why some modifications are needed is because jatropha oil has higher viscosity as compared to diesel which causes pumping, combusition, excessive engine wear, coking of ingectors on the piston and head of engine and atomisation problems to the engine (Agarwal and Agarwal, 2007).

The most commonly cited engines with regard to the use of Jatropha oil are Lister-style engines, which is a duplicates of the original British 1930's design known as Listeroids and

they are currently mass-produced in India and China, (Bailey *et al*, 2007). Lister engines tend to operate at relatively low speeds, typically between 500-700 RPM and have been successfully used to drive small mills, water pumps and electric generators commonly used in developing countries (WSU, 2002; Bailey *et al,* 2007).

In Tanzania the use of jatropha oil as diesel or biodiesel has been practiced by Diligent and also some research are being done by the University of Dar es Salaam, in co-operation with Eindhoven University of Technology in the Netherlands, to study the effects on the engine when biodiesel is used. According to Tjerk Scheltema in Eijck, 2006 it shows that most of Tanzanians are not ready to pay for their cars to be converted (engines) so the jatropha oil have to be converted to biodiesel.

The physical and chemical properties between jatropha oil and diesel differ (see table 8). Jatropha oil has high viscosity as compared to diesel fuel that is why it poses the problem to be used direct in the engine.

Table 8. **Physical and chemical properties of diesel and jatropha oil**

PROPERTIES	DIESEL	JATROPHA CURCAS OIL
Density (gm/cc), 30˚C	0.836 - 0.850	0.93292
Kinematic viscosity (cSt)	4 – 8	52.76
Cetane No	40 – 55	38.00
Flashpoint, ˚C	45 – 46	210.00
Caloric value, MJ/kg	42 – 46	38.20
Saponification value	-	198.00
Iodine No.	-	94.00

Source: Chachage, 2003

For more understanding of the physical and chemical properties between diesel and jatropha curcas oil the definition of their properties is given in box 1 below.

Box 1. Notes

Box 1. Notes

Density is a measure of mass per unit of volume. The higher the density of a fluid, the higher its mass per volume.

Viscosity is a measure of a fluid's resistance to flow under gravity at a specific temperature. Kinematic means the absolute viscosity of a fluid divided by its density. The higher this figure, the more difficult the flow of the fluid.

Cetane number expresses the ignition quality; the higher this number, the more easily the fuel ignites.

Flash point indicates the temperature at which the vapour-air mixture can just ignite. This temperature should be over 50 degrees for safety reasons. Jatropha oil and Jatropha biodiesel both exceed this temperature.

Calorific value expresses the energy content of the fuel.

Source: Eijck, 2006

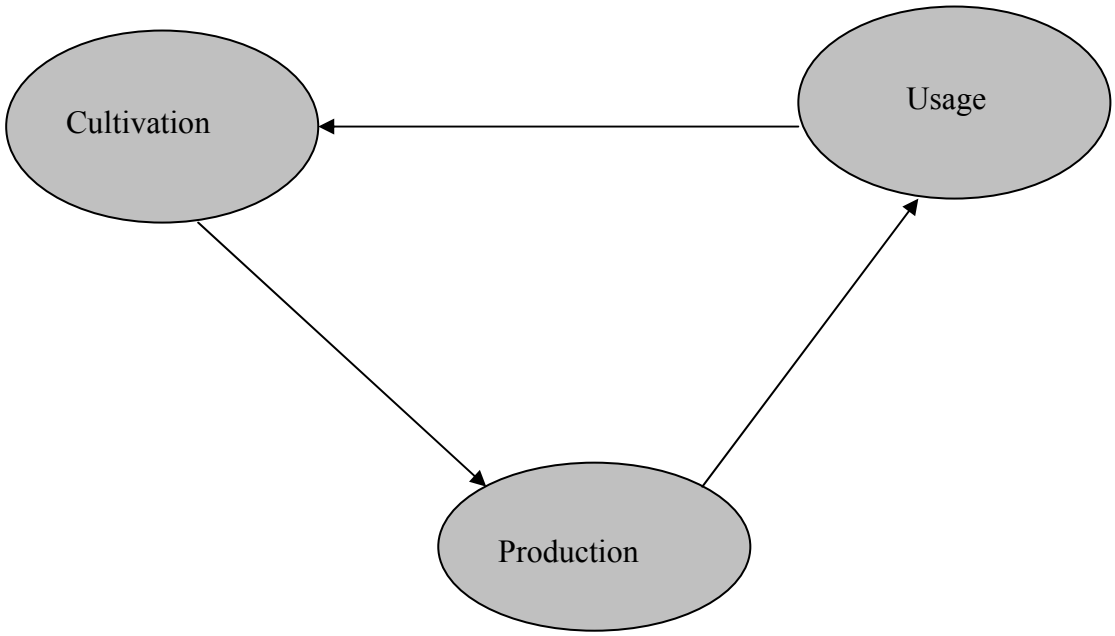
Many experiments are underway World-wide on the properties of Jatropha oil as extender for diesel engine and it seem to point in an encouraging direction but still some technical uncertainties remain, example about long-term effects on engines and opposition against use of biofuels in the existing fuel distribution network(Caniels and Romijn,2007).

CHAPTER FIVE: JATROPHA NETWORK IN TANZANIA

This chapter provides an overview of all actors involved in the jatropha network. The analysis of interactions between the actors aims to show the nature of relations between them The Jatropha network in Tanzania consists of many actors operating in the three stages; cultivation, production and use. In this network other actors operate in more than one stage. During data collection several actors in the network were visited including; Diligent, Kakute, YES-Africa, Brotherhood of Jesus the good sherpherd, Caritas and farmers/villagers..

The network is analysed basing on the successful of each stage because each stage influences the other. These three stages in the jatropha network can not be studied independently of their relation to others but they are jeopardized together (Degene and Forse, 1999). For example, it is not possible to study the three stages and settle for knowing only that cultivation goes with usage but there should be a need to know that all three stage link together and one can not succeed without the other two stages. The link between the three stages is a continuous link and can be depicted as follows:

Figure 20. Continuous link



Source: Author, 2008

These three stages have different actors. A brief description about each actor is given out.

KAKUTE

It is a private company located in Arusha region in the North-Western part of Tanzania. The company is managed by Mr.Livinus Manyanga as the director. The company was established in 1995 and has been engaged in variety of activities in the field of rural technology. The company provide several services including oil-seed processing and renewable energies.Kakute work in collaboration with other NGOs such as TaTEDO in the field of rural energy technology.

Kakute started jatropha activities in 2000 when McKnight Foundation through HPI gave funds to develop the subsector in order to promote rural marginalised women in the region. The fund was provided to ARI-MONDULI women group project and Kakute was used as an implementing agency of the project and they developed the jatropha chain from the scratch. In this project women are involved in several activities including starting nurseries, jatropha plantations, oil-expelling and soap making. In view of jatropha, the project purpose was to help to reduce the problem of bio-diversity and increase the livelihood security of rural women.

DILIGENT

Diligent is a commercial company which is active in the market of biofuels. The company is located in Eindhoven and it was established by Ruud van Eck in 2003 and in 2004 the company started its activities. The mission of Diligent exists from two parts: reduction of CO2 emission and the job creation in developing countries. These two mission goals in the future will lead to a triple P: **P**rofit for the society, **P**rofit for the environment, and **P**rofit for the company itself. Diligent Systems is active in two countries with two biofuel products: ethanol in Colombia and biodiesel in Tanzania. The ethanol in Colombia is produced with a fermentation process from agricultural wastes such as: coffee pulp and fruit production waste. The biodiesel in Tanzania is produced with a chemical process from the seeds of Jatropha plant. Jatropha plant project in Tanzania is a pilot project to demonstrate the feasibility of the commercial production of Jatropha oil and to learn how to manage this production through an out grower network. This out grower network is a network from Multiflower Seed Company, Arushacuttings and Vasso-agro. All these companies are Dutch owned, so they work in collaboration with Diligent. The out growers have special arrangements with the company; they get a fixed price from Diligent for their Jatropha seeds or oil.

YES-AFRICA

YES-Africa is an NGO owned by Dutch. The NGO started jatropha activities in 2005 in Same district. The role of YES-Africa is to share ideas, educate people and facilitate projects with practical support such as provision of plastic polythene tubes and seeds for nurseries. Basing on the fact that the NGO is Dutch owned and the owners are located in Netherlands, they have partner organization in the project areas. The partner organization coordinates all the project activities in the area. The target group include all people in the area who want to participate in the project and who can be reached by the partner organization and local market. Currently people who are involved in the project include; farmers/villagers, schools and Mission parish (brother of Jesus the good shepherd).

BROTHERHOOD OF JESUS THE GOOD SHEPHERD

Brotherhood of Jesus the good shepherd is a Catholic station located in Hedaru.Formarly they stayed in Chanjale in Mwanga district which is close to Same district. This station consists of seven brothers with different qualifications. In Chanjale where they stayed formally, they have a Vocational Training Centre and they train students in different fields including capentry.In this Vocational they have a biogas unit which was contracted under the supervision of Harry Kuijpers from Netherlands. During the time when the biogas unit was contracted, they got new idea from Harry about the potential of jatropha plant which can be used to provide energy as biogas. As a result they decided to start the jatropha plantation in their new compound.

Jatropha activities in their compound started in 2005 with the help of financial support from Harry Kuijpers, Arjan and Mark van den Bosch of YES-Africa. Brothers visited Kakute where they were trained on different techniques on how to start nurseries and oil processing techniques. After the training they started a nursery of 1000 seeds, after the seeds were grown they replanted 500 jatropha seedlings. At the time when the station was visited, they had a first harvest, but very few products.

Moreover, all seven brothers are involved in jatropha project but one is the overall in charge of the jatropha activities. He attends several training in Kakute for the development of the project. The time when the station was visited, they hard already gained knowledge on how to press the jatropha seeds and how to make soap. Knowledge which they gained in Kakute on how to make soap they have already used it to make soap and they sold the soap to different people. Their future plan is to have more jatropha plantation so that they can harvest enough

products. The knowledge which they have they disseminates to all farmers who are interested with jatropha in the area. They disseminate the knowledge through church preaching and by action in their own station.

CARITAS- SAME

Caritas is a catholic organization that combats poverty, social exclusion, intolerance and discrimination. Caritas enables people to participate completely in the improvement of their own conditions and livelihood. They promote cooperation, in which the local autonomy is the key to develop an effective cooperation.

In regards to jatropha, Caritas-Same is the partner organization with YES-Africa. Most of YES-Africa project activities in Same are coordinated by Caritas-Same. They have different programme activities like food for work. They use this programme also to initiate the jatropha activities. In 2005 when jatropha activities were initiated in the area it was also the time when the programme food for work was in progress. At this time farmers were given knowledge about jatropha (the potential of the plant, how to plant it, how to manage it, and how to press the seeds).

However Caritas-Same is the knowledge provider on jatropha issues but they are also grower of jatropha.Caritas coordinator, Mr.Kateri is the in charge of all jatropha activities. He has his own jatropha farm which he uses it as demonstration farm to other farmers. He is a good entrepreneur especially with the potentials of jatropha.In the near future he want to have more production and own a MFP connected to generator and supply electricity to households who can not have access to the national electricity in the area.

FARMERS/VILLAGERS

Majority of farmers depends on farming as the main source of living. Crop farming is mainly subsistence and they grow different crops such as maize being the staple crop, cardamorn, cereal crops, potatoes, cocoyams, cassava, fruits (banana, pears, pawpaws, avacados) ginger, little coffee, timber trees (e.g.*gravillea, sedrella, pines* ect) and sugar cane. Besides crops they also grow vegetable such as tomatoes, onions, spinach, lettuce, okra and pepper.

In Tanzania jatropha plant is not a new plant, farmers know it for more that 30 years ago, what is new is the potentials of the plant. In previous years, farmers new it as a graveyard plant. In the study are the potentiality of jatropha plant were introduced by YES-Africa project in 2005.In this year farmers started planting jatropha as a commercial plant.

Farmers plant jatropha in various ways; some in private plots, in institutions (primary schools) and in communal farms. Under these areas, jatropha is planted as a fence, independent crop (tree lots), as boundaries, intercropping and as soil erosion prevention.

However, in the study area not all farmers are engaging with the activities of planting jatropha, this is because, when the project was introduced in the area those farmers who showed interests are the ones who now grow it. But at the time of data collection more farmers are now interested and plan to plant jatropha as a commercial plant.

VYAHUMU TRUST

Is a company which was developed by FACT a Germany company in 1999.In Tanzania, the company is located in Morogoro region but also in other parts of the country including Iringa,Dodoma,Singida and Arusha region. The company is involved in manufacturing of presses especially the Sayari oil-expeller (see figure 16).These kind of presses can press a variety of seeds including jatropha seeds and sunflower seeds.

The company is also involved in selling the presses, spare parts and expert in setting the press to customers who buys them. In their compound they have press where farmers press their seeds for fee. The seeds that are pressed are of different varieties; seeds for consumption and those which can not be consumed. Seeds that are for consumption include; sunflower and groundnuts. Seeds which can not be consumed include; neem, jatropha and castor. The running of the press is done through the use of both electricity and diesel and this determine the price of pressing. Pressing 1kg cost 60-90Tsh depending on the type of seeds. Like sunflower seeds cost 60Tsh per 1kg because is easier to press and thus it does not consume much electricity. The press has the capacity of pressing about 75-100 kg of seeds/hour or 17-24 litres of oil/hour.

The company main aim is to improve the economic returns of farmers by supporting individuals and groups to establish and operate oil-expelling services, also they don't aim at making big profit, but aim at meeting farmer needs (http://www.jatropha.de/tanzania/vyahumu/vyahumu.htm).

RESEARCH INSTITUTES

Currently three research institutes are active actors in the jatropha chain. These institutes include; SUA, UDSM and TU/e.UDSM and TU/e work in collaboration with Diligent in various researches concerning the technical aspects of jatropha like the function of engine.

A brief explanation about each institute is given below;

SUA

Is an agricultural University which was inaugurated in 1984. The University is currently made up of four campuses and one constituent college. The campuses are: the Main Campus and Solomon Mahlangu Campus in Morogoro; the Olmotonyi Campus in Arusha, and the Mazumbai Campus in Lushoto. The constituent college is the Moshi University College of Cooperative and Business Studies (MUCCoBS) located in Moshi. The University offers Bachelors in various fields, also postgraduate training leading to the award of Master of Science and PhD in the respective fields of Agriculture.

The Main Campus has a total land area of 3,350 ha, of which about 2,300 ha are reserved for the University farm. In this farm, part of it is reserved for cultivation of jatropha.

UDSM

This University was inaugurated in 1970 as a results of the decision which came out from the from the University of East Africa that this Universities should be splited into three Universities; University of Dar es Salaam(Tanzania),Makerere University(Uganda) and University of Nairobi(Kenya).

The University is involved on various activities on the uses of jatropha oil as source of renewable source of energy. The University have different departments but department of energy in the faculty of Mechanical Engineering is the key actor on developing the efficiency cooking stove which use jatropha seedcake as a source of bigas.Also the faculty of chemical and Processing Engineering is doing research to find out ways of converting jatropha oil into biodisel and UDSM Institute of Production Innovation is developing different types of jatropha oil cooking stoves. The UDSM work in collaboration with Kakute Diligent and TU/e.With regard to jatropha cultivation, the university has the plan to plant 10,000 hectares. The production which will come out will be processed and usage as oil to replace kerosene and also as biodisel which is their main target.

TU/e

Is a technical University which was inaugurated in 1956.The University have several programmes in the level of Bachelor, Masters and PhD. Activities and research regarding Jatropha is concentrating in the faculties of mechanical engineering (technology for bio fuel production and combustion and press technology), TDO Center for sustainability and the department of Technology Management, Technology and Policy, the latter is involved in analysis of management and policies. Regarding Jatropha, the University has been an

important promoter and much involved with the spin off in organizations like FACT foundation, Diligent as well as exchanges with UDSM. The TU/e is mainly focussing on high tech solutions, so it has no program for jatropha as such, but in the recent years TU/e has been enabling research by supporting and supervising students and providing knowledge and researchers to institutes like UDSM, FACT foundation and Diligent.
After a short description of actors, the part that follows explains the three stages of jatropha chain. Actors involved in each stage is given out and the roles that they play in the stage.

CULTIVATION

Cultivation is the first stage in the jatropha chain/experiment. Actors involved in this stage can generate income out of selling the seeds/seedlings to other groups. Selling of seeds to generate income start from the second year after planting when they have first harvest. Planting of jatropha is done in several ways, as seeds, seedlings and cuttings either in small scale or in large scale. In small scale it can be planted as fence along the farmers plot or in homestead and in large scale it can be done through intercropping or without intercropping. Under cultivation the following are the actors who are involved and what they do.

KAKUTE

Kakute provides technical assistance to farmers who grow jatropha.Assistance is done by field officers by visiting farmers and explaining to them the procedures needed to set out the nursery, raising the seeds and planting the seedlings. At the same time Kakute act as a trader in buying the seeds from the farmers and sell them to other groups.

DILIGENT

Diligent play the role of stimulating farmers and villagers to grow more jatropha by providing assurance to them for the fixed price for the seeds for more than ten years. For those interested farmers and villagers at the beginning Diligent provided them with free seeds and also involved in setting different seminars to make farmers more aware on jatropha and they still do it.

YES-AFRICA

Yes-Africa is the key player in the study area, for the cultivation of jatropha it has provided free materials like polythene tubes, seeds, hand press and seminars for the first start to those

farmers and villagers who were interested. At present they are in the process of planting more that million jatropha seedling in the study area.

BROTHERHOOD OF JESUS THE GOOD SHEPHERD

They provides seeds/seedlings to villagers and farmers, provides seminars on how to raise nursery and cultivation of jatropha.Besides provision of services themselves are also growing jatropha.They have 1.25 ha of jatropha,sometimes they use this plot as demo plot to motivate more villagers and farmers to grow jatropha in their farms in Hedaru.

CARITAS- SAME

Caritas works in collaboration with Yes-Africa in the study area to provide education and seminars on jatropha plantation to villagers and farmers. They provide seeds/seedlings to farmers and themselves are also growers of jatropha.

FARMERS/VILLAGERS

Farmers are the main cultivators of jatropha in the study are and in other areas as well. They receive knowledge from the expertise (Kakute, Diligent, Yes-Africa, Brotherhood of Jesus the good shepherd and Caritas).For those farmers who are more motivated they share the knowledge with other farmers in their area, so the knowledge is easily disseminated among themselves.

PRODUCTION

The second stage in the jatropha chain/experiment is obtaining oil from the seeds. Different actors are involved in the extraction of oil from the jatropha seeds. The extraction of oil is done through using different kinds of press; there is hand press (manual) and mechanical press. All these presses have different capacity of extraction as explained in chapter 4 and more in the appendix 5. At current the actors are using ram press and screw press as shown in chapter 3 and are more active in Arusha region under Kakute and Diligent.

Under this stage the following are the actors involved and what they do;

KAKUTE

As in the cultivation stage, Kakute play a major role in providing technical assistance and provision of equipment (ram presses) to farmers and villagers linked with it. The equipments are owned by groups but also individually. In Engaruka village the women group own the

press and they use it in extraction of oil which they use in soap making and some of the oil they sell which is used as kerosene for wick lamp in the village. Also in Mto wa Mbu the women group also own the press and this group is managed by Kakute.

DILIGENT

Diligent is in the processes of establishing more facilities in the future for the production of jatropha.At the moment they are extracting jatropha oil and they do several experiments to test the oil. Also they provide the maintenance for the presses especially the large ones. Maintenance of the equipments is done in collaboration with several researchers from Eindhoven University of Technology.

VYAHUMU TRUST

In collaboration with Kakute and Diligent, vyahumu provide the oil expelling facility to farmers in a reasonable price, they are both the provider and manufactures of the equipments. They also have the subcontractors to build the oil expeller ones the customer buys the equipment.

FARMERS/VILLAGERS AND WOMEN GROUPS

They provide labour for pressing the oil, buyer of oil pressing equipments and buyers of oil.

RESEARCH INSTITUTES

In this stage several research institutes are active actors including Sokoine University of Agriculture (SUA), University of Dar es Salaam (UDSM) Faculty of Engineering and Eindhoven University of Technology (TU/e).At current they are involved in different experiments regarding the performance of oil and the function of different equipment. These research institutes they do their work in collaboration with Diligent Tanzania.

USE/USAGE

Jatropha as a multipurpose plant has many uses or application as it was seen in chapter three. Basing on this assumption then even the actors involved are also many.

Actors involved in this stage are as follows;

RESEARCH INSTITUTES

UDSM is involved in the research on the biodisel, the performance of the biodiesel in engines. During the time when the Institute was visited they were not through yet with the research.TU/e is involved with the research on jatropha oil and they do this in collaboration with Diligent Tanzania as the initiator.

USERS

Users of jatropha products are farmers/villagers, women's group, car owners, owners of the gasoline stations. In resent the use of jatropha oil as diesel is not yet practiced in large scale only Diligent Tanzania is using jatropha oil as biodisel to run their cars. Also Yes-Africa in December 2007 they derived the track from South Africa all along to Tanzania and this track used jatropha oil as diesel. The main purpose of this track was to motivate people in Tanzania to see that jatropha is a valuable plant which has many uses besides as a source of energy for cooking which is the scope of this research. The track was one of the practical example to motivate farmers and thus make them to plant more jatropha.

Farmers/villagers and women group in this stage have many use with the jatropha products and they are producers, buyers and users of the products. They use jatropha oil in soap making, as extender of kerosene for lighting and in generators to generate electricity for lighting to those areas where there is no electricity. They can use jatropha seedcake as charcoal and biogas mainly for cooking purpose which can reduce the trouble for fetching firewood which is the big issue to women and children especially in rural areas because they spend a lot of time in fetching firewood and thus fail to do other developmental activities.

The use of jatropha oil as diesel or as extender for kerosene need special attention, for example the oil can not be used direct in diesel engine the engine need some modification, the initiator for this in Tanzania is Diligent and UDSM. The use of jatropha oil as kerosene for cooking need special stove and also special lamps, so to make all this possible this activities are done in collaboration with Kakute who provide the technical assistance to the users and the equipments to be used like lamps.

The use of jatropha seedcake as charcoal for cooking also needs the special stove. Making of these stoves have been done by KIDT in Moshi in collaboration with TaTEDO but still not successfully and no customers are known to use this stoves yet. The use of jatropha seedcake as biogas has been done by Kakute to test the properties and several farmers have been installed with the biogas facility but the adoption is very low because they rare use it only in rain season where fetching for firewood is difficult. Moreover recent study has been done on

seedcake as a source of briquettes and it resulted that, the jatropha seedcake is not easy to press into a briquette. If briquetted straight it smokes badly, so most likely it will have to be carbonised first. In the carbonisation process a lot of material is lost and it takes a lot of time. Then a binder would have to be sought and a briquette press is needed. This can be a normal briquette press, because now it's just a matter of pressing carbon briquettes. So there is no need for Ecofys to design a new briquette press. Besides this, if a briquette press would be designed it would be difficult to sell. Since at currently jatropha projects are in small scale basis there is less production of seedcake and the market is small.

Finally selling briquettes also seems to be difficult, which means that people might not even find it very attractive to produce briquettes. They would also need a course to learn how to make good quality briquettes. All of this means that producing and selling briquette presses for jatropha is very unlikely to be profitable. Because the real problem is that there needs to be some overall system in which these kind of tools might be useful.

After the introduction of actors involved in the jatropha network, what they do, how they collaborate, the next step is mapping the model. The links between actors have to be mapped in order to be able to elucidate the networks and structures (Comber *et al,* 2002).As stated from above that network is described in terms of nodes and links, the nodes in the network are the people and groups while the links show relationships or flows between the nodes.

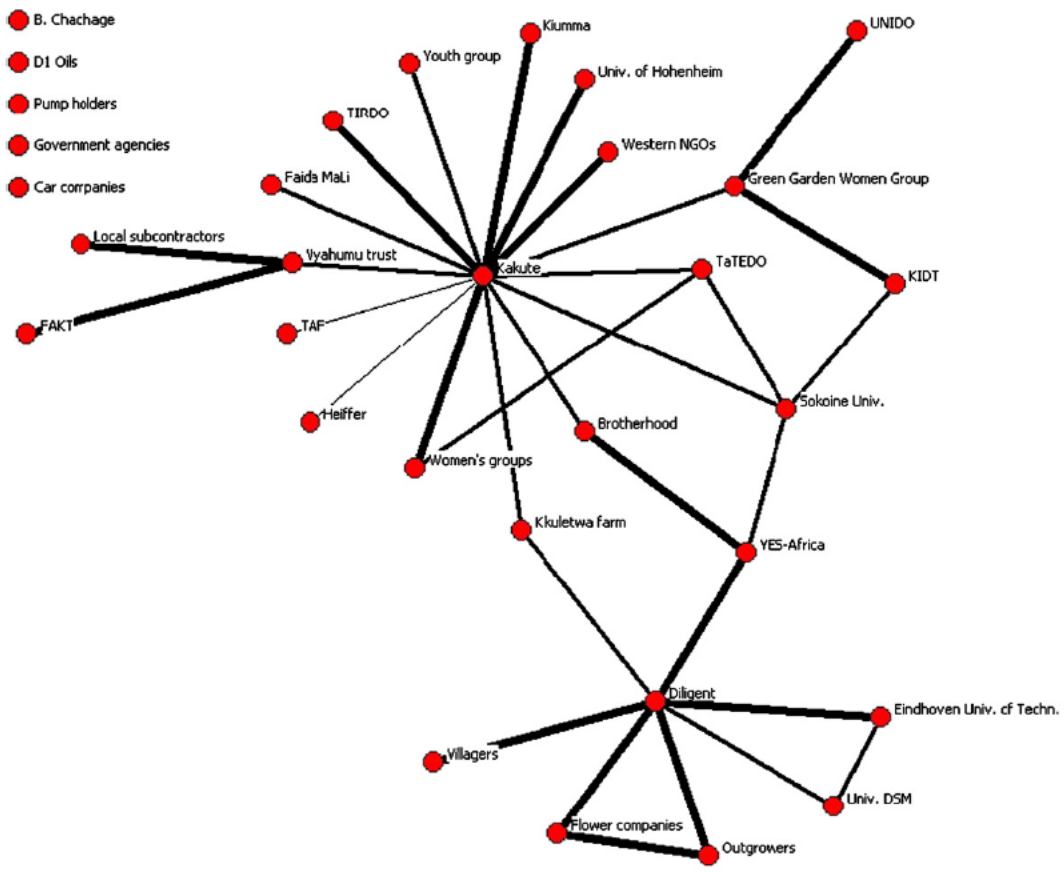
However understanding of the network need to have the location of actors in the network that means finding the centrality of the nodes. Knowing the centrality is the good measures that gives the insight into the various roles and groupings in a network, who are the connectors, leaders, bridges, isolates, where are the clusters and who is in them, who is in the core of the network, and who is on the periphery.

From figure 5.2 below, the centrality on the nodes falls under Kakute and Diligent. They are the leading source of jatropha production in Tanzania.

Moreover, the relationships of actors in this chain are of two kinds: strong and weak relationship. Strong relationship from the model means actors who have co-operation in terms of providing knowledge to other actors. Weak relationship involves those actors who have few links with other actors. Explaining this concept from the model below, Kakute and Diligent are the actors who have strong relationship because they have many direct links with other actors and thus they are the key actors in the chain. Also this can be depicted from three stages of jatropha chain. Diligent and Kakute play role in all three stages (cultivation, production and usage).Actors with weak relationship involves YES-Africa, Sokoine University and University of Dar es Salaam. These actors have weak relationship because

they have few links with other actors. Also at the moment they don't provide much knowledge to other actors**.**

Figure 21. **Jatropha chain of actors**



Source: Caniels and Romijn, 2007

CHAPTER SIX: RESULTS AND DISCUSSION

6.1 RESULTS

This chapter present the qualitative results from the interviews and discussion after. In order to fulfil the objective of the study which is to assess the quality of life of rural poor by investigating the available energy sources and services available at the household and village level. The interviews focused on the household as a unit of analysis. The questions were asked to investigate the available sources of energy which based on two parts; energy use background (section 6.1.1) and energy trends within the household (section 6.1.2). The interview also focused on the issues of jatropha oil as a source of energy in rural areas by exploring the acceptance and perception of villagers which at the end will help to tell whether is the source of energy that will cater the existing energy problems in rural areas. The interviews on jatropha in total looked jatropha issues basing on cultural (acceptance and perception), marketing and institutional aspects which also fall under the three stages of the jatropha network (section 6.1.3).The interview questions are in line with the questions (general and specific) formulated in chapter two.

The reason as to why the researcher did an interviews to investigate the available sources of energy is because prior to introduction/introducing new energy technology to the area it is important first to investigate the available source of energy and consumption patterns, costs of traditional energy sources, share of households income devoted on fuel to meet their energy needs, issues of land (where do they cultivate the jatropha), the land where they plant jatropha is it their own land? Answers to these questions will then help to come out with the results that at the end will suggest that the introduction of new technology is far better than what is present or not. Also ANT perspective about the production chain will go in line with the results from the interviews in concluding about the technology.

6.1.1 RESULTS ON ENERGY USE BACKGROUND

Source of energy in the households and how they are used

For lighting

The interview revealed that the major sources of energy for lighting include kerosene, candles electricity from hydropower and solar. Among these sources of energy for lighting, kerosene is the leading source and observed to be used by most of the majority. Kerosene is the most easily available fuel and is popular for lighting amongst all household group interviewed.

Devices generally used are, kerosene lamps, candles, wick lamps and hurricane lamps. The lights produced from these devices is very low, it suffices only for seeing things inside the house and prevent people from bumping into each other. Electricity was also revealed to be used by few people and mainly for lighting and other small purpose like for refrigerators, charging phones and for watching TV. Moreover solar PV was also revealed to be used as a source of energy for lighting. From the study area (Hedaru village), a total of 25 customers were observed using solar PV mainly for lighting, this was the results from an interview which was done with the seller of solar shop. The response from the solar shop concerning their customers, they revealed that their customers like the service more than the services from electricity.

For cooking

The interview revealed that the major sources of energy for cooking include firewood, charcoal, kerosene and biogas. Among these sources of energy for cooking, firewood is the leading source due to the fact that all the households interviewed use it as their main source of energy for cooking. Firewood is the most popular 'traditional' source of energy mainly for cooking. It is used nearly by all households interviewed for cooking, heating water for body hygiene, as a means of heating the house during cool seasons and in other households is used for ironing. Charcoal was also observed to be used among the households interviewed as second source of energy for cooking.

Though some studies comments that kerosene is mainly used for lighting in rural areas, but in the study area few household were found using it as supplements of biomass (firewood and charcoal) for small purposes like cooking tea during the morning when the children prepare to go to school and for cooking snacks. One of the respondent revealed that she always prefair to use kerosene in the morning to make sure that her children don't get late to school, she said that using charcoal or firewood in the morning take much time to get stated that is why she prefair kerosene which is more easier to get stated.

The reason as to why kerosene was found to be used by few household interviewed is because in rural areas kerosene is very costly due to poor infrastructures which hinder the transportation of the fuel. Biogas was also observed to be used but in one place/station for brother of good shepherd in Hedaru. Despite the fact that some households interviewed were found to have access to electricity but they don't use it as energy source for cooking due to the fact that it is very expensive.

Generally firewood is the major source of energy in rural areas and is considered as important substance that compliments the acquisition of food in the provision of adequate nutrition

(Biran *et al,*2004).One of the respondent revealed that firewood is the traditional source of energy, they inherited it from their fore parents so it is impossible to omit it completely, but she said that, though firewood is our traditional source of energy mainly for cooking but we are flexible to change to other source but we will not leave firewood completely, we will use it as supplement.

Ranking the energy source for cooking in the study area, firewood is the leading source followed by charcoal and then kerosene. None of the households in the study area was found using electricity for cooking even when it was available. Also ranking sources of energy for lighting in the study area, kerosene is the leading source as it can be depicted from the tables below

The two tables (9 and 10) below depict the number of respondent to each energy source.

Table 9. Sources of energy for cooking

Source of energy	Firewood	Charcoal	Kerosene	Electricity	Biogas
Number of respondents using the source for cooking	30	12	7	-	1
Total	30	12	7		1

Source: Author, 2008

Table 10. Sources of energy for lighting

Source of energy	Kerosene	Electricity	Candles
Number of respondents using the source for lighting	25	5	3
Total	25	5	3

Source: Author, 2008

Problems with the energy sources and how is solved in the study area

The interview revealed that the devices that are used for lighting includes kerosene lamps, candles, wick lamps and hurricane lamps. The efficiency of these devices is very low and gives poor lighting which causes major indoor air pollution. As proper ventilation in rural households is not a concern, the smoke generated by kerosene lamps remains inside and inhaled.Rooms are badly ventilated and without chimneys, which leads to a buildup of

indoors smoke. Furthermore, health is severely affected by the use of fuel wood and kerosene for cooking and lighting.

Generally house construction in rural areas in Tanzania consists of multiple-use construction; where by the same rooms are used for cooking, sleeping and working. Energy accessibility and quality directly affect women and children especially girls between 5-10 years on wards. Women are the primary gatherers and users of traditional fuels who are most severely affected by fuel shortages and environmental degradation and hence soil erosion which is quite severe in Tanzania.

Moreover women and children are particularly affected because cooking is confined to indoor settings, to which they are exposed for extended period of time. Women and children are the major collectors and gathers of firewood. Collecting firewood consumes a lot of time which in turn hinders them to engage in other development activities, and for children they loose their time for attaining education. Some studies have also documented that traditional biomass (firewood and charcoal) energy use has direct negative impacts on women and children, who are the most vulnerable group in terms of biomass energy scarcity and adverse indoor air pollution (Kerekezi, 2004) and thus entrench gender disparities as the time spent on collecting traditional fuels could be spent on other productive activities and education.

Moreover with kerosene sometimes they don't have money most of the time to buy it since they depend on their livestock and crops to get money, so sometimes if they haven't sold any crops or livestock they don't have money to buy kerosene. Basing on these they are forced to close everything before it gets dark and in some days to sleep early due to absence of light. One respondent revealed that is real very hard to sleep before it gets dark. In Tanzania normally evening darkness start at 19:00 hrs most of the households go to sleep between 22:00-0:00 hours, so for her she finds that sleeping before that time is very hard, but she said that because I don't have any other alternative I have to muddle through with it.

Generally the use of these 'traditional' sources of energy creates many problems. Several renewable energy options are available to avoid the problems related to the use of these traditional energy sources, jatropha being among of them as it is used as a source of energy for both lighting and cooking, does not produce any smoke and is cost effective to rural people in terms of time and money. To support jatropha as source of energy which is effective to solve the problems that rural people have with their energy source have been much revealed from different countries like Zimbabwe, Ghana Mali and India which their rural situation are the same like Tanzania's rural situation. These countries have been documented to be successful for using jatropha oil as a source of energy in rural areas for both cooking and

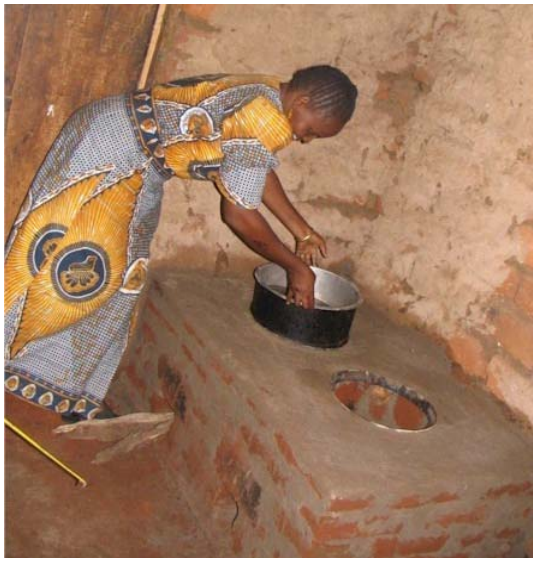
lighting and to some extent for pumping water for domestic purposes and these have been explained much in chapter four. In addition, the use of jatropha oil as source of energy has been documented to improve women's health and save their time as compared to when using firewood because jatropha source of energy reduce safety and security risks of traveling long distances for firewood collection and improve the living conditions in households due to its cleaner air.However switching from traditional energy source (firewood and charcoal) to sustainable source of energy like the one from jatropha contributes to economic, social, environmental and health benefits.

In the study area most of the households interviewed they tend to solve energy problems associated with traditional source (firewood and charcoal) by adopting the modern stoves which were introduced by SMECAO (see figure 22) which uses few firewood as compared to the normal traditional three stones and thus reduce pressure on forest destruction (deforestation).The efficiency of modern stoves is 50% as compared to traditional three stone stove.

The stoves which were introduced by SMECAO the contraction of these stoves requires stones and mud which serves as binder and few bricks which are used to construct the chimney. It has two opening for firewood and two spaces for cooking pots (see figure 22). These stoves reduce the amount of indoor smoke in the cooking area since they have chimney and in additional they provide the households with faster cooking time compared to traditional three stones.

The traditional three stones are made out of three stones; it has one or two and sometimes three spaces for putting fuelwood (see figure 23). The traditional stove is used for cooking and also for warming the house. Construction materials for these stoves (improved and traditional) can be obtained locally, but not all people can afford to have the improved firewood stoves because in order to have it constructed you must have cement and bricks which has to be bought. One of the respondent concluded that, she like to have one improved firewood stove because she missed the first face which SMECAO constructed the stoves for free but now she can not afford to buy the cement and the bricks. Literature document that adoption of modern wood-fuel stoves is supposed to be household initiative, but basing on rural households this initiative should not be their own responsibility they need support from different NGOs and companies who are expert on the technology .

Figure 22. Improved firewood stove.



Source: Author, 2007

Figure 23. Traditional three stone stove.

Source: Author, 2007

These results suggest that increased use of improved stoves and adoption of energy source from jatropha in the study area will help to reduce the energy problems and associated results from them like environmental destruction which is caused by forest destruction. Also it will keep women in the position of involving themselves in development activities.

Time used to cook the food

The interview revealed that the major food in rural areas is grain and legume (makande) which consume long time in cooking. About 3 hours is spent in cooking makande but this is not always the case to all households interviewed as the styles for cooking makande differ. Some women put the pot for makande from morning till during lunch time, when the pot is on the stove they engage themselves with other activities around the house. One of the respondent concluded that she normally put her pot in the morning with little firewood and when the pot is on the stove she does her other activities around the house.

Most of the respondents use their stove daily for cooking, which is about 2-3 times per day, but commonly thrice a day (breakfast, lunch and dinner). On the average, about 2.5 hours is spent in cooking meals per day excluding breakfast which spend less time.

Source of income

The interview revealed that source of income in rural areas includes selling of food crops which is the main source of income earnings followed by sale of cash crops and business

income. The remaining income earning activities includes sale of livestock and livestock products, wages and salaries in cash for the white colour jobs (government, companies and NGOs), cash remittances, and sale of forest products.

The relation of the source of income with the study is that, source of income determine/influence the source of energy to be used within the households. This is because among the households interviewed some were found to have very low income which forces them to rely on firewood as their major energy source for cooking and lighting.

Source of stoves used

Most of the stoves used by the households interviewed they purchase them from stores/local distributors. However for those using fuelwood, they are using three stone which they assembled it at home and also the improved fire stoves which were introduced in the area by SMECAO.The respondents using charcoal and kerosene stove purchase their stove from manufacturer within town/village. This is so because some people in their area are locally making/producing these stoves from scrap materials.

Responsible person in the household for the source of energy and decision on the energy kind to be used in the household

Collection of firewood is mostly done by mother and children but in few households interviewed is done by everybody in the house. Buying of kerosene from the retailer shops most of time is done by children and if is to buy it from the gasoline station is done by any person in the household excluding children. The interview revealed that in Njoro village when it comes to the issue of collecting charcoal from the distance it became men's work/task. Decision on how much to spend for the source of energy in the households interviewed varied, some they do in collaboration (wife and husband) and in some households mother is the one to decide, the husband only collaborate in terms of giving money to be spent. But all these is attributed by depending on what they have (income).On these issue of decision one of the respondent concluded that her husband give her money monthly, she has to decide by herself how much to spend on kerosene and charcoal as firewood is for free.

Moreover for those households that have electricity, the interview reveled that the husband/farther in the house is mostly responsible to make sure that the monthly bills are being paid accordingly because if they are not paid then they will have fain.

However the interview revealed that decision on what kind of energy to be used within the household is based on low operating cost, availability, convenience, seasonality and what

kind of food to be cooked. From the study area as stated early the most available source of energy include firewood, charcoal, kerosene and biogas especially for cooking and kerosene, candles electricity from hydropower and solar for lighting.Basing on the low operating costs, availability convenience, seasonality and type of the food to be cooked, firewood is the leading source for cooking followed by kerosene as source of energy for lighting.

Some respondents indicated that during rainy season they sometimes use charcoal because is difficult to find dry wood. It is easy to store charcoal in the house during the rainy season and the energy content of charcoal is higher than that of fuelwood. Generally decision is based on what they have at hand.

Source of the energy

The study revealed that most of the households interviewed collect firewood in the area where they own either in the backyard or farm/woodlot within and beyond 1km- 2 km but this is much attributed by physical locations of the households because other go beyond 3-6 km from their village boundaries.This has been much revealed in many documents where they say women walk up to four kilometres everyday to collect the days supply of fuel for their households (http://www.tatedo.org) .Only a small percentage of the respondents collect firewood in the area that they do not own which includes woodlands surrounding the village (mapori) and forest reserves.

Collection of firewood is done mostly on a daily basis and sometimes also weekly and monthly basis. On daily and weekly basis that period of one week they spend 2-4 hrs per day for gathering firewood, where by on monthly basis is done after every 3-4 mouths, and the firewood that they collect to use in that period of 3-4 mouth they spend one week to gather the firewood. Transportation of firewood from the source to the house is done manually through carrying the backload of firewood on the head.

Charcoal on the other hand is usually being bought from the farmers who make it themselves, from middleman either wholesaler or wholesaler-retailer, or from the forest since the seller make it themselves out of the wood they get from the forest.

Kerosene can be bought on gasoline stations and sometimes on retail stores. For kerosene, it can be bought per Litre on Gasoline stations, and also in smaller quantities in retail stores. For those retail shops, they get it from gasoline stations around town.

Attitude towards the kind of energy used in the households

The study revealed that the households attitude towards such kinds of energy that they use, first they like it because is the only alternative that they have but they also revealed that if they can have other alternative which is at their pace they can use it. Basing on this fact it is possible that when jatropha will be ready to be used as a source of energy in their village for cooking and lighting their in the position to adopt it.

Price of the energy source and stoves

Price of fuel depends on the quantity or unit being sold. Kerosene is mostly sold per Litre in Gasoline stations, but can be bought on smaller amount on retail shops. Price of the fuel is mostly based upon the price from the source. The higher the market price and the price from the source, the higher the price of the fuel being sold by the dealers to customers.

At current one litre of kerosene fuel is sold at 1350Tsh at the gasoline station. At the retail shops the price differ, is at 1400-1600Tsh per litre. This price differences is based on the distance of the village from the gasoline station, if the village is far from the gasoline station the price is higher due to transportation costs.

Charcoal prices vary with selling sites. Also different selling points have different prices based on accessibility and means of transport used from the source which ranges from 7000-10000Tsh per sack. In these selling points, charcoal is being sold per sack, per cane of different sizes or per bag (plastic bag).

Price of the kind of the stoves also depends on the size of the stove. However the price of stoves used vary in price, for charcoal stoves the price ranges from 3500-20, 000 depending on the size, for kerosene stoves it depends on the design, brand and number of the burner. Most of the respondent interviewed using kerosene stoves they use the single burner which cost 4500-5000Tsh.

Life time of the stoves

The interview reveled that how long a stove lasts depends on several factors, two of which are the materials used and how the owner use or take care of the unit. Average lifetime of charcoal stove is 1.5 years, for kerosene stove is 3-4 years. The relation of life time of the stove and the study is to know how long the stoves last which will help to know how long the stoves using jatropha press cake will last.

Plans to change to alternative source of energy

Most of the respondents are not satisfied with their current cooking and lighting technology due to time consuming and cost-wise. With the dissatisfaction of the respondents, all of them are willing to purchase a new cooking and lighting technology like electricity for lighting if their economic situation will change or if the village can be electrified.

Moreover they are also willing to purchase jatropha source if is going to be, efficient, available and if its costs will not exceed what their using now. The study revealed that the households are willing to spend 10,000Tsh per month for jatropha source of energy for both cooking and lighting.

Energy expenditure within the households.

The study revealed that among the households interviewed they spend 1-2 litres of kerosene for lighting per month and these are those household which use kerosene for lighting only, for those households that use kerosene for cooking as supplement source they spend 3-5 litres per month. One litre of kerosene costs 1400-1600Tsh at the retailer shops and 1350Tsh at the gasoline station, so basing on these the households spend 2800-3200Tsh per month for lighting only. For firewood they spend 1-3 bundles per week and most of these depend on the number of population within the households(person who eats meal in the house on the daily basis), which means if the number of members in the house is large then they spend more because they have to cook much food. One bundle of firewood is estimated to be about $3/4m^2$-$1m^2$ though it was difficult to get the estimate of pieces they collect and use per day, week and per month . The firewood they get them for free, the cost is just in term of time spend for gathering. For those households that use charcoal as supplement source of energy for cooking, the study revealed that they spend 1-2 sacks per month and one sack cost 7000Tsh - 9000Tsh.These sacks has the weighs about 25-30 kg.These prices per sack are cheap as compared to urban areas where it costs 10,000Tsh-15,000Tsh per sack.

Appliances owned

The interview revealed that the households that have access to electricity are the ones who own refrigerator/freezer, radio, TV/video and cell phones which they plug in for electricity, for those households that does not have access to electricity they own appliance like radio but it does not use electricity, they use battery. Also they own cell phones which they charge them

in places where electricity is available. The payments are made per cellphone.The price to charge cell phone differ with places, it ranges from 300-500 Tsh.

6.1.2 RESULTS ON ENERGY USE TREND WITHIN THE HOUSEHOLDS

The study revealed that most of the households interviewed use the same source of energy for cooking and lighting (firewood, charcoal, kerosene and electricity) that they were using in previous time (five years ago).Moreover considering their future plan on what kind of energy source they will use, most of them are planning to use source of energy that is cost-effective in terms of time and money. Basing in that sense if jatropha is going to be initiated in their villages and its costs will not exceed on what their using now it will then be their preferred source of energy both for cooking and for lighting. Also in the Njoro village most in the highland part where there is no access of electricity, they indicated that they plan to use electricity if their economic situation will improve in the future or if their village will be electrified but they plan to use it only for lighting and not for cooking, so they still need another source of energy for cooking which favour them in terms of time and money.

The organization on what kind of energy source to be used for both cooking and lighting is done by themselves (households) though sometimes they are given knowledge from different NGOs like SMECAO which introduces in the villages the special stoves which consume little firewood as compared to traditional three stone stoves.

6.1.3 RESULTS ON ENERGY FROM JATROPHA

Several interviews were conducted by the researcher from NGO/company dealing with jatropha out of study area and from households engaging in jatropha activities in the study area (For interview questions see appendixes 1 and 2). From the study area the use of jatropha as a source of energy for cooking and lighting have not been used, so in order to substantiate the researcher did interviews from other area(Arusha region) where they have started using jatropha oil as a source of energy for lighting and few for cooking using biogas .The study and the results from the area will help the researcher at the end to come out with the conclusion that the technology is possible or not possible basing on the situation/condition of the area which is the same as the study area. Also to suggest if the technology if far better than what is present in the area.

Jatropha production/cultivation

From the study area, production of jatropha is done in private farms (by smaller farmers), communal plots and in instructions (Government Primary Schools). Jatropha is planted in small plots (as tree lots) and some near home steady and in the farms as fencing and border making between one farm and another farm.

Heller (1996) suggested that selection of methods for planting jatropha vary depending on labour, costs and desired type of plantation and thus the style of planting differs from place to place. In the institutions they planted along the footpath and the space that they use is 40cm between one tree and the other. In private farms (as tree lots), the space between one tree to the other is (m2 x 2m) that means the space between one tree to the other is 2m and between one line to another line 2m.As boundaries/fencing around farmer farms and around their homestead, Jatropha are planted with the space of 40 in between .As intercropping the space between is (m5 x m5) and the remaining space in between is used to plant other crops such as maize or beans (See figure 24). As soil erosion preventer the space between is 40-50cm as shown in chapter four figure 7.

Production from the study area is still low because they don't harvest much seed at current but their target is to have more production in the time to come in order to solve the electricity problems in their area by having their MFP being run with jatropha oil. Therefore these suggest that farmers are willing to cultivate more jatropha. From the actor perspective it indicate that the network is expanding in cultivation stage because more farmers are willing to cultivate jatropha.At the southern part of Tanzania farmers are uprooting other crops that are not benefial and their now planting jatropha but is not clear what kind of crops that they are uprooting. The reason that triggers them to become motivated is because they have seen the benefits of jatropha plant as a multipurpose plant. Cultivation in the jatropha chain is the first stage and is the most important stage that influences other stages (processing and usage), so if is successfully it suggests that even other stages will finally be successfully. From the study area the processing and usage is still low and in other places is absent but because the major stage is successfully then other stages are going to be successfully as it will complement and benefit from each other as actor network suggest that every stage should be jeopardized together and they should not be separated.

Figure 24. **Jatropha intercropping**

Source: **Eijck, 2006**

Jatropha market

Jatropha market is still low and difficult because there is no fixed price. In the study area they have harvested only ones since they planted and this is yearly. The present market in the study area is for seeds that mean farmers sell seeds to other farmers and these farmers are small scale farmers. But an interview was done with the YES-Africa project coordinator concerning the market aspect in the study area, and the results that he gave is that the market is going to be official immediately this year and their going to buy all the seeds from the farmers, they will have different collection points where farmers are going to bring their seeds for sell and their planning to pay higher price as compared to the present price in order to motivate farmers to see the value of planting jatropha.

The reason as to why the project has decided to have the collection point is because at the moment collection of seeds is not a serious work farmers think that this work can be done by children only, so to say is not taken as a serious work.

However at the moment SMECAO buy seeds from the farmers in the price of 200Tsh but this price is not the actual price that will be used in the future time, may be it will be higher or lower than this but it will depend on the consumption. This issue pose the risk to farmers because if the price will be lower in future years than what is now (currently) there is

possibility of leaving farmers with less profit and they will not be motivated to plant more jatropha.

The market arrangement differ in places because in other parts they have clear market, like in Arusha farmers are assured with the market for more that ten years by Diligent and Kakute. Market in this area is growing at an increasing rate. The assurance of market to farmers is like an incentive to them and thus motivates them to increase the production. Moreover on other study that was done in 2003 on issues of jatropha as a source of energy for road transport documented that the market for jatropha products is both local and international due to the fact that the oil is going to be transported to UK where the market for biodiesel is already established. The interest on biofuels is not only in UK but at the moment is a worldwide interest which in turn stimulates the jatropha cultivators due to market assurance. In Tanzania the market for biodiesel is still low due to lack of awareness and for those who are aware they don't show any interest to change their cars to fit with the use of biodiesel, thus lot of awareness creation is needed to make people interested.

Jatropha organization

The organization of the jatropha planting is done by project coordinators. The project coordinators use groups in some parts of the study area (Hedaru) because it works better with groups than individual. Also these groups they use them for other developmental activities in the area. These groups they use them for different activities but they don't pay them because most of these activities are initiative activities and they think that if they pay they in the future they will cause much trouble to them because they will need to be paid in any activities which they will be doing even if is for their benefits.

From the study area pressing of jatropha is going to be done manually as the project planned at the initial stage. Other parts of the study area they don't have any education on how to press jatropha seeds but the SMECAO coordinator said the education is going to be provided to farmers on how to press using hand press and they hope that is going to work. SMECAO will also initiate farmers by doing training on how to use jatropha oil as kerosene and other economics of jatropha. The extraction should be or will be done through machines (hand press). SMECAO think of having the demonstration machines in the area to motivate farmers and other entrepreneurs who can install their own machine later.

Institutions required for jatropha electricity production

According to Diligent manager, for jatropha electricity production to work there should be:

- The unit of operation which deals with implementation through building the reliable source for jatropha seeds, though jatropha in Tanzania is well known for long time like 30 years ago but there should be reliable source of seeds which will provide more dedication to jatropha plantation.
- Availability of land where jatropha can be planted
- Organizing, giving training and monitoring of activities.
- Network which include all actors in the chain starting from cultivation, production and usage and start up money for rural people to buy the equipments like MFP mini grid.

Network theory argues that these institutions combine and integrate both the technical and social part as energy is neither purely social nor purely technical but social-technical.
However, currently TaTEDO provide the MFP mini grid but as a subsidy and there are criteria that the village has to meet. As stated in chapter four, these criteria are based on number of habitants (at least 3000), amount of oil seeds produced per year, demand of MFP services, distance from TANESCO grid, acceptance by the local administration, presence of entrepreneurs and others. After the village meet all these criteria then TaTEDO is in the position to install the mini grid. In addition the acceptance from people is also important because it will help for the survive of MFP services.
Piloting of MFP mini grid aims at increasing access to modern energy services and facilitates rural enterprises development and is one of the TaTEDO project in rural areas where there is problems to the access of electricity. Training on how to use the multi-platform is hosted by TaTEDO where by the responsible people are trained on the installation processes, operation and maintenances of the MFP and training on business and marketing skills which comes out after the trial period of running the MFP is successfully. So to say TaTEDO bring in knowledge, technology and capital awareness where as villagers provide infrastructure, land and houses, commit time and other locally available resources which are useful for running the MFP. After training from TaTEDO, the management responsibility is left to the village Energy Team (VET).The Village energy team is selected by villagers themselves and they are the potential link to TaTEDO by providing the progress of MFP functions and other necessary information. The main work of VET is running the MFP, collecting connection/services fees and ensuring platform maintenance. VET manages their work/activities by handling meetings every month. As started in chapter four already these have been successfully in three

places/villages; Engaruka, Leguruki in Arusha region and one in Mbezi juu in Dar es salaam region. The MFP located in Dar es Salaam, TaTEDO use it as demonstration to people in the area to get them motivated in the production of jatropha.

As started in chapter four, Engaruka village was visited by the researcher. The mini-grid (MFP) in this village has been constructed to supply electricity to 150 customers for household use and in business centres but at current it has 24 customers, the range of services will be extended to further improve the livelihood of Engaruka village people. The major consumer of the MFP electricity is the campsite owner which has more than 10 lights, video desk, TV set and radio. Other customers are provided electricity for 2 (60W) lights only. Before the installation of MFP villagers were asked to sign the connection contract to register as either for limited or unlimited connection and 23 villagers registered for limited connection and one villager registered for unlimited connection (campsite). Already villagers can dehusk maize and press their jatropha seeds at the MFP. The MFP generator operates during the evening starting from18:50-00:00A.M.

Management/running the MFP in Engaruka village encounters some problems such as; customers payment delay. According to VET revealed that they plan to solve this problem through disconnecting the customers from the services. Disconnecting the customer from the services has not happened in their case but that is how they have planed to solve this problem. In their case the delay of the payment has happened but when they make some follow ups the customers do pay. Also problem of shortage of jatropha seeds to be extracted for use which most occur during off harvest season. Tackling this problem, they are forced to use diesel which is not their target and is costs twice as much compared with jatropha oil as one litres of diesel has the ability to run the MFP for one hour while when it is jatropha oil one litre has the ability to run the MFP for 1.30-2 hrs.

Moreover at the moment they have few customers for electricity connection, thus they make little profit but it was not clear how much profit that they make and no statistical data to show, but they hope in the near future when they will have enough customers they will make more profit.

According to the interview that the researcher did with the TaTEDO staff in Dar es Salaam concerning the issues of MFP, she said that installation of MFP does not only include getting the technical part right but it also involve the whole process of learning about the social process of adapting the technology which go in line with the actor network that, it does not only include the technical or social part only but all are jeopardized together. The process of getting the MFP in place in Engaruka village was done through Participatory Rural Appraisal

(PRA) to ensure technical feasibility, social acceptance and economical viability of the technology.

Benefits of MFP

MFP system has been appreciated by the villagers although it has been used for short time. It has provided them with electricity (for lighting, watching TV, charging cell phone), maize dehusking and jatropha seed pressing which the oil they use it in other purposes like for lighting instead of kerosene which is the big threat in rural area due to the fact that it is very expensive and the price change drastically due to poor infrastructure systems which hamper fuel transportation. Also the villagers are interested with the use of jatropha oil in small lamps as jatropha oil has good smell when burning as compared to kerosene.

In Engaruka village, most of the villagers own cell phones, before the installation of the MFP they used to travel to Mto wa Mbu for charging their cell phones something which costs them more that 5000Tsh for the bus fair and 300 for charging the cell phone but now the service is at their disposal. They have experienced a big impact in their lives particularly women who are suspect to the energy problems. At the moment the MFP in Engaruka is used for three things: to provide electricity for lighting, to de-husk maize and pressing the jatropha oil. But in other parts like in Mali the MFP is used to provide electricity for water pumping, workshop tools and a compressor for inflating tires. So these can also be the extension of services to Engaruka village and other parts of Tanzania where this technology is going to be initiated.

Generally MFP can provide energy services for variety of economic and social purposes and can help to reduce both time and energy required to complete daily tasks especially for women and children. Some African countries that have been successfully in running MFP with jatropha oil include; Ghana, Zambia, Mozambique and Tanzania.

6.2 DISCUSSION OF THE RESULTS

The study focused on three parts; energy use background, energy use trend within the households and energy from jatropha. Each part had specific questions which were used for interviews to fulfil the objective of the study. The discussion from the results follows.

6.2.1 ENERGY USE BACKGROUND

The study revealed that the major source for lighting include kerosene, electricity from hydropower and solar. Among these sources, kerosene is the leading source these have also

been revealed from the literature review that kerosene is the major source of energy in rural area for the most of majority. This was reported from the survey which was done in the southern part of Tanzania (Songea and Mtwara) where it was found that kerosene is used by 95.2% and 87.1% respectively. From these figures it suggests that kerosene is the leading source of energy in rural areas.

Electricity was found to be used by few people due to the fact that it is expensive and in other villages is not available due to high capital costs, high connection cost due to scattered households and low reliability.

Solar power was also found to be used by few households and is due to some number of barriers; still new technology from the area, high initial costs, associated duties and taxes and it needs more technical expertise. However on other parts of Tanzania like Mwanza region Solar has been documented to be used by majority of population and is mainly used for telecommunication, lighting, refrigeration, water pumping and powering electrical equipments at individual residents and health centers in rural dispensaries (Masoud, 2005).The annual average solar radiation level in Tanzania range between 4.2-5kwh/m^2 per day (Masoud, 2005). But still is not a convenience solution due to the fact that most of the solar equipments are imported from abroad.

Moreover the study revealed that the major sources of energy for cooking include firewood, charcoal, kerosene and biogas. Among these sources of energy for cooking, firewood is the leading source and used by the most of majority interviewed followed by charcoal which is used as substitute source and in other households is used seasonally especially during rain season when it is difficult to gather firewood. Cooking operations include boiling, frying/roasting and simmering. Besides cooking, in the study area they also use firewood for bricks burning and in other parts of the country they use firewood for village industries, including tobacco curing, lime and cement making, fish smoking, baking, local beer brewing, tea drying and village metal works, and relatively small amounts of fuelwood are being used for large scale industrial activities.

The survey which was done by ProBEC in Southern part of Tanzania(Songea and Mtwara) concluded that firewood is the leading source of energy for cooking and accounted for 97% and 99.2%respectively.These figures suggest that firewood is the leading source of energy in most of rural areas in Tanzania and in Africa in particular (Kerekezi, 2004).

Relying on non-commercial (firewood and charcoal) as the source of energy for cooking has resulted to many problems; environmental destruction (deforestation), gender, scarcity, health and time expended. Environmental destruction and scarcity are caused by continuous cutting

down of trees without replacement which results to soil erosion. Firewood scarcity have occurred for long time in human history and thus in not a new aspect. The heavy reliance on fuelwood as the principle source of energy in most African countries, in combination with expanding human populations, has led to large-scale localized depletion of wood resources, but literature document that the societies have managed to solve this problem by switching to other sources of energy. From the study area this has also been revealed but is not switching to other source of energy but the same source but used in a sustainable way. Gender and time spent aspects emanate as a result that women and children mostly girls were observed to be the major collectors and gathers of firewood, they loose most of their time on this activity due to long distances that they take in searching, harvesting, transporting firewood and thus it hinder them to cook for children three times a day even if the food is available (Mongela, 1991) and also to engage in other developmental and income generating activities, and for children from attaining education and thus it has a serious implications in their welfare. Health problems are caused by air pollution produced by firewood in the kitchen areas as most of them are badly ventilated without chimney and women and children spend much time sitting in the kitchen when waiting the food to get ready.

Moreover as started from the problem statement that only 1% of rural people have access to electricity(connected to national grid electricity) and is mainly used for lighting it shows that majority of the population rely on kerosene and candles for lighting which has jeopardized many opportunities which results to poor life conditions in most of rural areas. As it was revealed from the results that most rural population have poor income which drags them to use traditional source of energy. Respondent reveled that they are interested to use electricity as their source of energy for lighting if their economic situation will allow or if their villages will be electrified, but due to some costs that electricity have it is documented that it will be very difficult for rural poor to cope with it and it is suspected that it might increase stress on rural people expenditure and make them more poor.

However, in general all the above problems suggest that the level of Tanzanians access to modern energy services is very low and this is a challenge that calls for an urgent solution to curb them. The solution to these problems should be sustainable and renewable in nature, affordable, accessible, socially acceptable, environmental friendly and locally available to the intended end user and hence availability of household energy. Following this line will help to boost up the country economy as rural people will have access to sustainable and improved energy source and will reduce the rural- urban migration rate to seek what is not available in rural areas.

6.2.2 ENERGY USE TREND WITHIN THE HOUSEHOLDS

Considering the results from the respondents on their future plan on what kind of energy source that they are going to use, they have opted the energy source that is cost-effective in terms of time and money. Jatropha as a source of energy has been accepted by the respondents. Basing on experience from other places that have used jatropha oil as a source of energy and comparing with the study area it suggests that is good source to rural people. Besides jatropha being used as a source of energy it has many other applications to rural population.

Electricity is also is one of the options that Njoro village respondents have opted. Part of this village is very remote from the national electricity grid and is not clear when the grid will reach them. Also basing on the cost-effective aspect, electricity does not much. Income situation of rural people is very poor, they mainly depend on farming as their main source of income, paying electricity bills each month is a problem to them, thus it is believed that instead of helping the rural population, is increasing more stress to them and eventually can making them more poor.

Making the comparison between the renewable and non-renewable source of energy that are present in the study area and considering the cost-effective aspect, jatropha overshadow other sources and thus is good option to be used and these will be much revealed in the conclusion part.

6.3 ENERGY FROM JATROPHA

Jatropha oil as a source of energy for lighting and cooking in the study are has not been used, but in other parts of Tanzania it has been used as it has been revealed in chapter four in Engaruka and Leguruki case and part of the results. Jatropha oil as source of energy has been used by several developing countries such as Ghana, Zambia, Mozambique to mention just a few. In these countries the use of jatropha oil has been documented to be successfully at small-scale basis and mainly for rural population.

For jatropha electricity production to work smoothly, several aspects are well required

- An association of some sort that secures supply of relevant varieties of jatropha seeds.
- Availability of land where jatropha can be planted.
- Organizing, giving training and monitoring of activities.

- Network which include all actors in the chain starting from cultivation, production and usage. Areas such as seed multiplication, processing of oil and overseeing distribution of electricity within the villages are key.
- Start up money for rural people to buy the equipments like MFP mini grid.

However assessing these aspects with the situation from the study area and other parts of Tanzania my data and analysis indicates positive outcomes. Many companies and NGOs (Diligent, Kakute and YES-Africa) are active engaging with jatropha production guaranteeing reliable sources of jatropha seeds, at least in place where they operate. Chapter I has indicated that land availability in Tanzania is not a real big issue. Jatropha can be intercropped, planted as protective hedges around the home stead and as border in farms. Land for jatropha cultivation is assured in such a way the competition for land for food is not an issue. Organizing, giving training and monitoring of activities is also facilitated by the above mentioned company and NGOs in the areas where they operate. In addition in the study area there are other NGOs such as SMECAO and Caritas which work in collaboration with YES-Africa in giving training and monitoring of jatropha activities.

A national energy policy have been operationalized by establishing REA and REF (see Chapter I), which mandate is implement on-going planned project and programmes initiatives, facilitate modern energy projects, promote modern rural energy services and provide technical assistance to developers (Uisso and Mwihava,2005).Basing on this then rural people are in the position to get start up money for jatropha projects and buying of equipments like MFP which can be used to run electricity to rural people who are not expecting to be connected to national electricity grid and those who are unable to pay the month electricity bill.

The market for jatropha products in the study area is still limited because production is also low and certainly below the potential. YES –Africa project is planning to increase the production and improve the market which will ultimately motivate farmers. In the Arusha region, the market for jatropha products is very lucrative and farmers are assured of a market for over 10 years. The demand for jatropha as biodiesel is high in other developed countries which would imply a potential international market. Tanzania has not reached the position to exploit that market. Following this line of argument, Eijck (2006) argues that such market opportunities exist but opinions on the dynamics and future of world market vary. Some observers think that jatropha oil product should be exported, while others feel that it should remain a local product for use in the region. A realistic estimation is that given the poor state

of the infrastructure in rural areas, the production and consumption will only occur at the local level. Jatropha generated electricity will for a long time be only profitable at the local level.

6.4 CONCLUSION

Prior to the introduction of new energy technologies to the area it is important first to investigate the available source of energy, compare the costs of 'traditional' energy sources, the problems of the available sources, share of households income devoted on fuel to meet their energy needs. Issues of land, such as where to cultivate the jatropha), on what land (private or state land) are important to consider.

The study has shown that the major sources of energy for lighting are kerosene, candles, electricity from hydropower and solar sources. The major sources of energy for cooking include firewood, charcoal, kerosene and biogas. Costs for these sources are based on time (labour) and money. A focus on the monetary costs is important as four energy sources (firewood, charcoal and kerosene and electricity) are accessed in one or the other way through money and thus financial transactions. Firewood is largely obtained for 'free' and the only cost is in terms of time used for gathering. Only marginally, people buy firewood. Charcoal costs 7,000-9,000 Tsh and the household interviewed spends 1-2 sacks per month which gives a total of 7,000-16,000 Tsh per mouth. Kerosene costs 1350Tsh at the gasoline station and 1400-1600Tsh at the retailer shops. Most households interviewed spend 2800-3200Tsh per month for kerosene. The portion households spent on energy depends on their cash income and what is cooked in the house. Social status but also a culture of food appears as important factors shaping the nature and use of energy in the rural areas. The latter was unfortunately not investigated.

Problems associated with these energy sources include; environmental (deforestation), gender, scarcity, health and costs in terms of money and time.

The trend of switching to other source of energy gained much acceptance from all households interviewed and the option was on the source of energy that is cost-effective in terms of money and time.

To assess the source of energy that is cost -effective, a comparison is made on the available sources of energy with regards to labour, employment income generation social analysis and access. These aspects were selected to make the comparison because they have relation with the conceptual framework especially in the social –technical aspect.

Table 9. Comparative analysis of sources of energy

	Firewood	charcoal	Kerosene	Electricity	Jatropha
Labour use to collect or produce	Time spend in collection	Time spend in making	Little labour	Little labour	Requires extensive labour from production
Employment opportunity	Little to no (structural) employment: petty trade	Petty trade opportunities	Petty trade opportunities	At the national level: skilled labour	Provide employment in various stages
Gender	women	man	men	men	men
Social network analysis	Loose network	Loose network	Loose network	Dense network: coordination required	Dense network: coordination required
Access	Open access	Money	Money	Money	Land and money
Competition between sources of energy	Competes with charcoal	Competes with fuelwood	No direct competition	No direct competition	No direct competition

Source: Author, 2008

From table 9 above more clarification of labour and social network analysis aspects is given; less labour means organization to get the source of energy consume less labour in terms of time used. A 'loose' network means little coordination between limited numbers of people is involved in obtaining the source. Loose also captures that the processing is usually limited to one locality and involves one stage processing; the potentiality for generating employment and income is in this way rather limited in scope. The production and collection of fuelwood usually is coordinated at the household level and engagement with the forest and involves gendered activities as part of household chores for women. Charcoal is in many cases a men's job and very often ran as a local business by a local businessman. Charcoal competes with the sue of the forest with those households relaying (partly) on fuelwood. A dense network on the

other hand emanates from the fact that the coordination and the actors involved to get the source of energy into usage involve different stages. For example, for jatropha to be used as a source of energy it has to pass different stages (cultivation, production and usage). In all these stages a coordination of actors involved has to take place.

However after the assessment of all factors concerning sources of energy in the study area, the comparative analysis indicates many have negative effects to the end users. The negative effects that these sources of energy have to the end users in general include social, economic as well as environmental. The social effects emanate from the fact that women and children spend much of their time in gathering firewood. Economic effect results from the costs that the households incur in buying the source of energy, and in this case is mainly on kerosene, electricity. Environmental effects emanate from the fact that households harvest forests to get firewood without replacement which results to soil erosion. Solving all this problems households need a source of energy which can meet their energy needs in a sustainable manner.

Jatropha has been introduced as the solution for the above problems. Assessment of jatropha has been on both as source of energy for both cooking and lighting .Jatropha as a source of energy for cooking has little success; alternatives for cooking such as biogas has only few users. Jatropha for lighting looks positive, from a social/institutional and technical point of view, Jatropha energy technology is thus part of a sustainable solution for the rural energy question: it is a renewable source of energy, is affordable, accessible, socially acceptable, environmental friendly and above all locally produced, processed and made available.

Moreover, Jatropha based energy can never be the sole energy source. Rural Tanzania will for a long time be relying on a mixture of sources of energy. The mixture of energy will for technical and social reasons be locally specific and thus variable.

CHAPTER SEVEN: CONCLUSION AND RECCOMEDATIONS

This chapter is divided into three sections. The first section discusses the general conclusion of the study, section two discusses the recommendation of the study, and finally the last section proposes the way forward of the study.

7.1 GENERAL CONCLUSIONS

Only10% of Tanzania population has access to electricity and in rural area this is merely 1%. Inadequate access to electricity in rural areas is caused by many factors but generally is lack of money and distance of villages from the national grid. Rural people rely on 'traditional source of energy (firewood and charcoal) for cooking and in some instance for lighting. Kerosene is the major source of energy for lighting and is used by majority of the population especially in rural areas. Relying on traditional source of energy pose many problems: gender, especially to rural women who are more responsible persons for energy source in the households. Environment destruction due to continuous harvesting of forest without replacement. The use of traditional source of energy (firewood) cause health problem basing on the fact that the same room is used for cooking, sleeping and working. Traditional sources of energy pose costs in terms of time and money. Firewood in the study area does not incur monetary cost but largely the labour time that women spend in collecting. They travel long distance of about 2-3 kilometers to collect firewood, which often conflicts with the many household chores that they have to do. Kerosene is a commercial energy, is costly, and involves time in the sense of walking to the market. Beside, prices are fluctuating which is partly the result for the poor infrastructure.

The energy question is thus constituted by monetary costs, environmental costs, labour time of women in particular, distance to and from the grid and the markets. Solutions call for a sustainable approach which is hinging on an increasing use of renewable energy, affordability, accessibility, social and cultural acceptability, environmental friendly and locally available. Jatropha is part of the many components of the rural energy mix and because of the work of Ngo-like companies such as Diligent and Kakute has been positioned in the rural area as an accepted and relevant source of energy.

Moreover besides jatropha being source of energy it promotes several aspects as started in chapter one:

- Renewable energy by becoming self- sufficiency in energy source, enhance energy security and reduce country expenditure on imported fossil energy thereby freeing up resources for other uses.
- Soil erosion control and improvement which diversify agriculture production raise rural incomes and improve quality of life.
- Promotion of women by providing them with employment and additional income generation which is attributed by selling soap, seeds and jatropha oil.
- Poverty reduction through job creation which can help in reducing the urban migration especially for the developing countries.

7.2 RECOMMENDATIONS

Jatropha as source of energy involves a range of social-technical aspects. Taking into account the above conclusions, some recommendations can still be made to increase the chances of the success of the technology. The recommendations that are made are mainly based on; awareness raising which combine policy aspects and market aspects, jatropha varieties, social-coordination which make issues of inclusion and exclusion visible.

Raising awareness

Jatropha as source of energy is a new technology, and involves several ministries such as Ministry of agriculture as jatropha is a plant, Ministry of energy and natural resources and Ministry of Energy and Minerals. These ministries should corporate together to develop policies that address the development of new technologies to enhance jatropha and its products. At the moment many foreign investors are eager to invest in jatropha and monopolization of powerful investors should be prevented. Preventing monopolization of jatropha activities will help to put small scale farmers in a better, strategic position in the jatropha network.

Moreover, the market of jatropha products like oil as kerosene to be used for lighting to substitute kerosene in Tanzania is not realized yet. More awareness raising to make people more interested in using jatropha oil as new clean fuel is required. Awareness raising can be done through different means of communication: developing demonstration sites in every area where jatropha is being planted and to advertise jatropha in national exhibitions (nanenane) and trade fairs (Sabasaba) through demonstrating the Jatropha, how it is grown and how it is processed which will help to disseminate the information to the wider community.

Jatropha varieties

The Jatropha plant has more than 175 varieties; each variety realises different yield levels depending on ecological conditions and cultivation methods. Jatropha can survive in dry and in unfertile lands, Tanzania has areas that are dry and unfertile. These areas should be explored to develop scenarios for how to expand jatropha in a meaningful way. Variety selection for poor and dry areas is a necessary dimension of scenario development. Intercropping and jatropha as hedges demarcating fields should be part of the scenario explorations.

Social-coordination

Jatropha as source of energy involves both social and technical aspects. For jatropha technology to work, the network requires coordination. Provision of electricity from the Multi Functional Platform to these sites is now managed by using fixed price for those people who have limited connection and unlimited connection. It is worthwhile to investigate the possibilities of installing electricity meters (prepaid) instead of using fixed prices; this will enable because the monitoring electricity consumption all the times. Using meters (prepaid) will help the rural poor and will stimulate them to use efficiency lights. Moreover, the customers will be paying for usage and it will help to control those people who have the inclination of finding the way of taping the electricity illegally as is always the case in the developing countries.

Collection of payments should be managed by Village Energy Team (VET) using consumption managements schemes and they have to take responsibility to make sure that all the customers follow this rule. It is necessary to use scheme due to the fact that most rural dwellers are farmers and their incomes are low and keep on fluctuating all over the year and thus payments scheme should be flexible to allow them to accumulate more income. The VET should be member of the community/village because is believed that they have strong ties to the community and thus are less likely to leave the village.

Experiences elsewhere have shown that the management of group payments system is a good and sometimes even the best option. Since the year consists of twelve months, the group should have twelve people and each member in the group pays ones in a year in different months and every member is responsible to each other to make sure that every member in the group pays. This system can be called informal payment group and it has been proved to be successful in many remote areas in the developing countries (Bailey *et al,* 2007). Using these

system will help to reduce pressure to people and it will help to prevent inclusion and exclusion aspects.

7.3 THE WAY FORWARD

Although useful information was obtained through this study, there are many aspects that need to be improved for more clarification and feasibility of the technology. The following areas were identified for further research.

The scope of jatropha plant in this study based on jatropha as source of energy for both cooking and lighting, the results that were revealed from the study have positive results in one side, jatropha as source of energy for lighting in form of electricity. Jatropha as source of energy for cooking need further development.

Moreover at current the price of jatropha cook stove costs 20,000Tsh which in one way or another bring barrier to rural people who don't have enough income. This call for further research for the production of cook stove which will be affordable for the poor small-scale farmers and other rural households.

However jatropha to be used as source of energy for lighting extraction process has to be carried out, the on going world of science and technology there are different ram presses which are manufactured, so the differences and their optimization of their outputs need further research so that the users can get clear information on the differences and optimization in order to make good informed decisions. Also during jatropha extraction process the seedcake residues that are left are good source of charcoal or briquettes for cooking but need further research because the seedcake are suspected to contain pollution hazard which is dangerous health wise.

REFERENCES

Agarwal,D. and Agarwal,A.K. (2007).Performance and emissions characteristics of jatropha oil (preheated and blends) in a direct injection compression ignition engine. Volume 27:pp2314-2323.

Alila, P.O., Kinyanjui, K., and Wanjohi, G. 1993. Rural landlessness in Kenya: dynamics, problems and policies. IDS Occasional Paper No. 57. Nairobi: Institute for Development Studies, University of Nairobi.

Arvidson, A and Nordstrom, M. (2006). Energy sector policy overview paper. Stockholm Environment Institute.

Axtell and Fairman (1992). Minor Oil Crops, *FAO Agricultural Services Bulletin* No 94.

Bailey, P.N., Chotimongkol, O. and Isono, S. (2007). Demand Analysis and Optimization of Renewable Energy: Sustainable Rural Electrification of Mbanayili, Ghana.Master Thesis.

Biran,A.,Abbot,J. and Mace,R.(2004).Families and Firewood: A comparative Analysis of the Costs and Benefits of Children in Firewood Collection and use in two rural communities. Human Ecology,vol.32 No.1.

Bless, C. and C. Higson-Smith. (1995). *Fundamentals of social research methods: an African perspective*. 2nd Ed. Cape Town: Juta and Co.

Burden, F.J. (2006) .The development of an organizational redesign model: A South African case study. PhD Thesis Johannesburg University.

Callon, M. (1986) Some Elements of Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay. In: J.Law (ed) *Power, Action and Belief: A New Sociology of Knowledge?* Sociological Review Monograph 32 London.

Caniels, M.C.J. and Romijn, H.A (2007), "Actor networks in Strategic Niche Management: Insights from social network theory, Journal of Futures". Volume 10 p 1016.

Chachage, B. (2003) 'Jatropha oil as a renewable fuel for road transport. Policy implications for technology transfer in Tanzania', Masters Thesis, International Institute for Industrial Environmental Economics, Sweden.

Degenne, A. and Forse, M. (1999).*Introducing Social Networks.* Sage Publication Ltd.

Eijck, J.A.J van **(**2006) 'Transition towards Jatropha biofuels in Tanzania? An analysis with Strategic Niche Management', MSc thesis, Eindhoven University of Technology, Eindhoven.

Eijck, J.A.J van and Romijn,H, (2006). Prospects for Biofuels in Developing Countries: An analysis for Tanzania with Strategic Niche Management.

Foidl, N., Foidl, M. Sanchez, M. Mittelbach &. Hackel, S. (1996). Jatropha Curcas L. As a Source for the Production of Biofuel in Nicaragua. *Bioresource Technology,* **58**: pp.77 – 82.

Greco,D. and Rademakers,L.(2006).The jatropha Energy System: An Integrated approach to decentralized and sustainable energy production at the village level,p.4.

Greene, J. C., V. J. Caracelli and W. D., Graham (1989), Towards a conceptual framework for mixed-method evaluation designs, *Educational Evaluation and Policy Analysis* **11**(3):pp. 255-274.

Gwang'ombe F.R. (2004)**,** *Status of biomass co-generation in Tanzania;* paper presented at Tanzania National Seminar on Renewable Energy Technologies, Peacock Hotel.

Hebinck, P. and G. Verschoor (eds.), 2001, *Resonances and Dissonances in Development. Actors, networks and cultural repertoires*. Assen: Van Gorcum, pp. 119-139. ISBN: 90 232 3784 6.

Heller, J. (1996), *Physic nut Jatropha Curcas L. Promoting the conservation and use of Underutilized and neglected crops*. Gatersleben: Institute of Plant Genetics and Crop Plant Research, and Rome: International Plant Genetic Resources Institute. http://www.ipgri.cgiar.org/publications/pdf/161.pdf.

Heller, J. (1996). Physic nut. *Jatropha curcas* L. Promoting the conservation and use of underutilized and neglected crops. 1. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome.

Henning, K.R (1998). Use of Jatropha Curcas L. (JCL): A household perspective and its contribution to rural employment creation. Experience of the Jatropha Project in Mali, West Africa, 1987-1997. *Regional workshop on the Potential of Jatropha Curcas in Rural Development and Environment Protection: A workshop sponsored by the Rockefeller Foundation and Scientific & Industrial Research & Development Centre*, 13 – 15 May 1998, Harare, Zimbabwe.

Henning, R.K, (2003). Integrated Rural Development by Utilization of Jatropha Curcus L. (JCL) raw material and as renewable energy.

Henning, Reinhard K., The Jatropha website http://www.jatropha.org, 1997 – 2004.

Holmes, C.M. **(**2007), Cultural Variation, Decision Making and Local Institutions: An Examination of Fuelwood use in Western Tanzania: Society &Natural Resources 18:1.61-73.University of California.

Kaale, B.K, (2005). Baseline Study on Biomass Energy Conservation in Tanzania. SADC Programme for Biomass Energy Conservation (ProBEC).

Kasenga, G.R. (1997), Fuel and energy abstracts, volume38, Number 4 pp 247-247.

Kimambo, C.Z.M., Mwakabuta, N., 2005**.** Transformation of Rural PV Market in Tanzania. Consultancy reports on study of pricing structure of energy services and products. Ministry of Energy and Minerals and United Nations Development Programme.

Kothari, C.R. (2000). *Research Methodology: methods and techniques*: New Delhi: Wishwa Prakashan.

Latour, B. (1993). *We have never been modern*. Hemel Hempstead, Harvester

Liberalino, *et al*. (1988). Seeds: Chemical analysis and toxicity. In Gubitz, G.M., M.

Lymo, B.M, **(**2006), Energy and Sustainable Development in Tanzania.*Helio International.*
Mikkelsen, B. (1995). *Methods for development work and research: a guide for practitioners.* New Delhi: Sage Publication.

Ministry of energy and Minerals of Tanzania (2003) 'The National Energy Policy Document' February 2003.

Ministry of Minerals and Energy of Tanzania**,** (MEM 2004/2005), Speech by the Minister of Energy and Minerals, Daniel M. Yona, presenting to the National Assembly the estimate of expenditures of the Ministry of Energy and Minerals for the financial year 2004/05: Dar es Salaam, Tanzania, Ministry of Energy and Minerals.

Ministry of Minerals and Energy of Tanzania, (MEM 2005), Speech by the Minister of Energy and Minerals, Daniel M. Yona, presenting to the National Assembly the estimate of expenditures of the Ministry of Energy and Minerals for the financial year 2005/06: Dar es Salaam, Tanzania, Ministry of Energy and Minerals.

Mittelbach., & M. Trabi. (1999). Exploitation of the tropical oil seed plant Jatropha curcas L. *Bioresource Technology,* **67:**pp 73 – 82.

Mongela, G. I., 1991, 'Women and energy', in M.J. Mwandosya and M.L. Luhanga, eds., *Proceedings of the seminar on the national energy policy for Tanzania 10-14 September 1990, Arusha*, Stockholm Environment Institute.

Monteiro, E. and Hanseth, O. (1996). Social shaping of information infrastructure: on being specific about the technology. In Orlikowski, W; Walsham, G; Jones, M.R and De-Gross, J (Eds) *Information Technology and Changes in Organisational Work*. Chapman and Hall, London.

Mwihava, N.and Mbise, H.A. (2003). Status of Power Sub sector Reforms and Promotion of Renewable Energy and Energy efficiency Partnerships. ©2004 AFREPREN/FWD, NORAD /Sida.

Nguthi, F.N. **(**2007), Adoption of agricultural Innovations by smallholder farmers in the context of HIV/AIDS: *A case of the Tissue cultured Banana in Kenya*. PhD Thesis, Wageningen University.

Openshaw, K. (2000). A review of Jatropha Curcas: an oil plant of unfulfilled promise, *Biomass and Bioenergy* **19:**pp1-15.

Peter, B. (2007), Screw-pressing of Jatropha seeds for fuelling purposes in less developed countries. Master Thesis. Eindhoven University of Technology.

Pramanik, K. (2003). Properties and Use of Jatropha curcas oil and diesel blends in compression ignition engine. *Renewable Energy* **28**: pp 239-248.

Rabe, E.L.M (2005).Jatropha oil in compression Ignition Engines; Effects on the engine, environment and Tanzania as supplying country. Master Thesis, Eindhoven University of Technology.

Research group international programs (IP) (2002), An industry and market study on six plant products in South Africa, Jatropha or Physic Nut. Washington State University. Available at http://oregonstate.edu/international/outreach/rlc/resources/Jatropha.pdf.Accessed 5/02/2008.

Sawe, E.N (1997), Household energy in Tanzania: Issues. Options and Initiatives.TaTEDO, Dar-es-salaam.

Sawe, E.N. **(**2005), Rural energy and stoves Development in Tanzania: Experience, Barriers and Strategies: TaTEDO, Dar-es-salaam.

Shayo, C.M. (2006), Adaptation Planning and implementation: Agriculture and Food Security. Vice President's Office Dar es Salaam Tanzania.

Solsoloy, A.D., (1993). Insecticidal action of the formulated product and aqueous extract from physic nut, In_Gubitz, G.M., M. Mittelbach., & M. Trabi. (1999). Exploitation of the tropical oil seed plant Jatropha curcas L. *Bioresource Technology,* **67**: 73 – 82.

Tatnall, A. and Davey. (2004).An Actor Network Approach to Informing Clients through Portals. Victoria University and RMIT University, Melbourne Australia.

Uisso, J.and Mwihava, N. (2005).Tanzania National Energy Policy: Focus on Renewable Energy and Poverty Reduction, Partners for Africa Policy Dialogue Conference, Dar es Salaam, Tanzania.

United Nations (2007).Small-Scale Production and use of Liquid Biofuels in Sub-Saharan Africa: Persepectives for Sustainable Development. New York.

Verschoor, G. (1997).Tacos, Tiendas and Mezcal: An actor-network perspective on small-scale entreneurial projects in Western Mexico. PhD Thesis Wageningen University.

Vidgen, R and McMaster (1996) Black-boxes, non-human stakeholders and the translation of IT through mediation. In Orlikowski, W; Walsham, G; Jones, M.R and De-Gross, J (Eds) *Information Technology and Changes in Organizational Work*. Chapman and Hall, London.

Washington State University (2002). "An Industry and Market Study on Six Plant Products in Southern Africa: Jatropha or Physic Nut." US Agency for International Development.
Weggoro, N.C (2008). EAC Regional Strategy for scaling-up access to modern energy and biofuel in East Africa.

Yin, Robert K. **(**1984) Case study research: Design and methods. Beverley Hills: Sage publications.

Yin, Robert.K. 1994. *Case Study Research: Design and Methods*. Sage Publications, Inc.

Internet pages.

- *(http://www.gaia-movement.org.(Accessed 17 February 2008).*
- Centre of Excellence for Jatropha Biodiesel Promotion. http://www.jatrophabiodiesel.org/.(Accessed June 2007).
- Energy challenges in Tanzania. http://esi-Africa.com/archive/esi2-2006/pdf/64.pdf (Accessed June 2007).
- Energy for rural Africa. http://www.in went.org/E+Z/content/archive-eng/03-2007/inw-art 2.html (Accessed June 2007).
- http:// www.jatropha.de/fag.htm. Accessed 10 March 2008).
- http://en.wikipedia.org/wiki/Conceptual_framework. (Accessed 27 May 2008).
- http://wbbiotech.nic.in/Background_note.htm(Accessed 17 February 2008).
- http://www.africa.upenn.edu/NEH/tethnic.htm.African.African Studies Center (Accessed 17 March 2008).
- http://www.cotswold.gov.uk/nqcontent.cfm?a_id=1484(Accessed 17 March 2008).
- http://www.fao.org/inpho/vlibrary/x0043e/X0043E00.htm#Contents. (Accessed 10 March 2008).
- http://www.isf.lilik.it/files/jatropha/jes.pdf. (Accessed June 2007).
- http://www.jatropha.de. (Accessed 10 March 2008).
- http://www.jatropha.de/lamps/index.html (Accessed 17 February 2008).
- http://www.jatropha.de/news/jcl-news-2001.htm.(Accessed 8 February 2008)
- http://www.jsdnp.org.jm/susEnergy.htm (Accessed 17 March 2008).
- http://www.svlele.com/book.htm. (Accessed 8 March 2008)
- http://www.tatedo.org (Accessed 27 May 2008)
- http://www.world agro forestry center.org (Accessed 8 February 2008).
- Tanzania government site; www.Tanzania.go.tz. (Accessed June 2007).

- Wikipedia http://en.wikipedia.org/wiki/Actor_network_theory(Accessed 22 February 2008).
- www.fact-fuel.org (Accessed 5 February 2008).

Unpublished documents.

Mndeme, S.A. (2006). Yes-Africa Progress report on Jatropha.

Mziray, S.J. (2002).Food security and nutrition improvement project. Semi annual progress report January-June .Diocese of Same-Tanzania.

Wijgerse, I. (2007). Jatropha for rural electrification in Tanzania; A case of Engaruka.

APPENDICES

APPENDIX 1: Households interview

TITTLE: SUSTAINABLE ENERGY USE IN RURAL AREAS
SOCIO-TECHNICAL ANALYSIS OF JATROPHA IN SAME DISTRICT - TANZANIA

Dear Respondent
Good morning/afternoon. I am MSc student from Wageningen University in The Netherlands. I would like to thank you for agreeing to meet with me today. All the questions I shall be asking relate to my research for my MSc. degree course and any answers or replies made will be kept confidential. No names will be revealed and on the interview form itself, a number known only to me will identify you.

My research attempt to:
Assess the quality of life of rural poor by investigating the available sustainable energy sources and services available at the household and village level. The study focuses on Same district as an example of the rural areas, which face the challenges, and problems of energy supply in Tanzania.

1. Energy use background in general at the household level
How energy is used within the household?
How do you obtain it?
Where do you get such kind of energy?
Who is responsible?
How much do you spend for energy within the household per day/mouth?
How much time you spend to get such kind of energy?
Sources of income (where do you get income)?
Costs of the stove used.
Time used for the kind of stove used.
Life time of the stove.
Appliances owned by the respondent
Collection of fuels (who gets it or collect it)

Who make decision on the kind of energy to be used within the household?

How do you decide what source of energy to use?

What is your attitude towards such kind of energy that they use?

Which problem do you have with energy source that you use?

How do you intend to solve such problems?

How do you make your living with energy source that you're using?

How much firewood do you collect per day/week/month?

How many bundles of firewood do you collect per day/week month?

How much firewood do you use for cooking one meal?

How far do you have to go to collect firewood?

How long do you spend in collecting firewood?

How many times per day/week/mouth do you collect firewood?

How long do you spend to cook a meal when using firewood?

2. Energy use trend in the household.

What energy sources that you were using in previous time?

What energy sources that you're using now?

What energy sources that you plan to use in the future time?

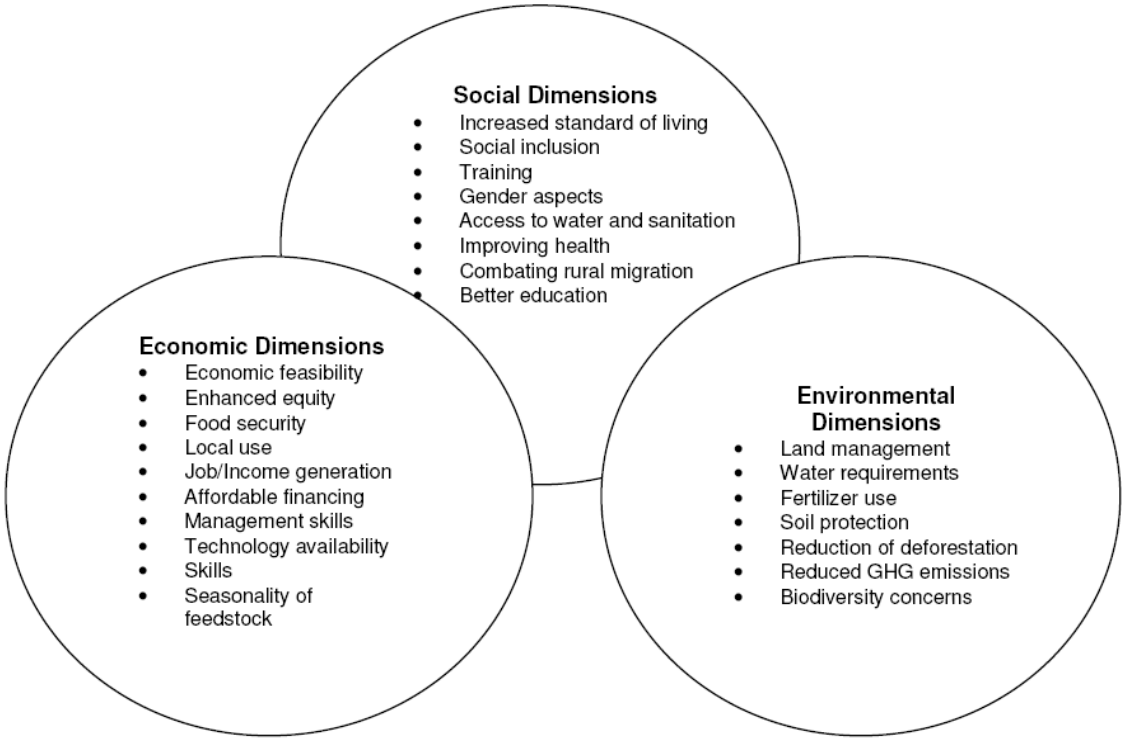
How do you organize for your energy sources?

- Is it through government
- Other outside bodies.
- Themselves.

3. Energy from jatropha. (Interview in Diligent).

1. How can jatropha be organized in terms of consumption, production, market, supply, land tenure and price?
2. Can it be produced enough in terms of quantities?
3. How does jatropha production, processing into biodisel and the transformation into electricity for use in villages fit the existing forms of organisation in the villages?
4. What institutions you think would electricity production from jatropha require?
5. Will there be a mismatch between what is required and what is present at the village or household level?

APPENDIX 2: Criteria for sustainable small scale production and use of liquid biofuels



Source: **United Nations, 2007**

Applications of the above criteria are site and situation specific and the priorities of which criteria may vary by region, country and province. Placing these criteria with the Tanzania situation of liquid biofuels they do apply.

APPENDIX 3: Estimated production cost of jatropha oil in Haubi village, Tanzania

SEEDS PRODUCTION COST (€/ha)		
	Installation	Annual
Nursery	275 €	55 €
Leasing the land		3,75 €
Clearing		38 €
Organic Fertilizer		180 €
Planting		19 €
Pruning		38 €
Harvesting		475 €
Management		250 €
TOT cost per ha		1059 €
Cost of 1 kg of seeds		**0,18 €**
COST OF BASIC POWER SYSTEM		
	Installation	Annual
Cost of Seeds		2091 €
Expeller	3000 €	467 €
Filter machine	150 €	50 €
Engine	2500 €	250 €
Extraction		100 €
Conventional Diesel		145 €
Extra costs	200 €	80 €
TOT.	**5850 €**	**3183 €**
COST OF JATROPHA OIL		
Income from Seedcake		280 €
Income from Residuals		30 €
Cost of Jatr. Oil (€/l)		**0,70 €**
Diesel cost in Haubi (l)		0,95 €
Savings for Milling		**1009 €**

Source: Del Greco and Rademakers 2006, The Jatropha Energy System: An integrated approach to decentralized and sustainable energy production at the village level, p. 4.

The estimated production of jatropha oil in Haubi village is an example which was made after the village had been seen to suffer from electricity problem to run the dispensary. The quickest solution was thought out and they came to discover that if they install MFP being run

by jatropha oil could help to curb the problem. The MFP also consists of milling machine and it has proved to be successfully. This case can be the same as the one in Engaruka.

APPENDIX 4: Small scale presses that are used in a variety of micro-scale jatropha oil projects

Bielenberg/Ram Press 	A ram press is a small hand-press. Moving the bar up and down operates a piston which applies pressure on the seeds, extracting the oil, which then drips into a container. About 5 kg of seed is needed for 1 litre of oil. The capacity is about 1.5 litres per hour. The ram press has the advantages of being of simple and economic construction, easy to maintain and operate and being operated by a single person. The two most common, mid-sized models range in price between USD 100-280.
Sayari/ Sundhara Oil Expeller 	The Sayari (former Sundhara) oil expeller can be powered by a diesel engine or an electric motor. It can extract 1 litre of oil from 3kg of seeds and the extraction rate is circa 20 litres per hour. It presses almost any hard seeds with more than 25% oil content. The price is about USD 3,200 for the one operated by the electric motor and about USD 3,400 for the one with the diesel engine.
Mafuta Mali (Swaili term for Oil Wealth) press 	The oil wealth press is a manual press for local, small-scale production and represents a more efficient version of the Bielenberg Ram Press. The extraction efficiency is considered better than any other manual press with about 12 kg seeds per hour. It is easy to use and durable, and its price is around USD 250.
Täby Press 	The Täby Press is a screw press manufactured in Sweden. Various models are available for cold-pressing rapeseed, linseed, flaxseed, sunflower seed, sesame seed, peanut, groundnuts, mustard seed, poppy seed, cotton seed, jojoba, etc. Various models are available with different capacities (from 6 kg seeds per hour producing circa 2 litres of oil to 90 kg seeds per hour producing circa 25 litres of oil. Prices vary from about USD 1,200 to USD 14,000.

Source: United Nations, 2007

From chapter four sample of presses was given out but in this appendix more presses are given out for more overview of them. These presses can be used in small-scale jatropha oil projects in Tanzania.