Transition towards Jatropha Biofuels in Tanzania?

An analysis with Strategic Niche Management

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Preface

This thesis is written for the fulfillment of the Master Innovation Sciences, Technology and Policy for Developing Economies at the Eindhoven University of Technology. For this thesis I conducted a field study of three months in Tanzania, from March till June 2005.

Writing a thesis in a developing country is always a guarantee for the occurrence of extra 'harsh' experiences and unexpected events. Power shutdowns, language-problems, malfunctioning equipment, huge numbers of insects, time schedules that are always violated, and so on. I have experienced it all but I have to say I did it with the greatest enthusiasm. I was able to see and talk to numerous people in Tanzania, sometimes in very remote areas, which provided me with great experiences 'off the beaten track'. I'm very grateful that I was able to experience this.

I never really got pessimistic about my research, not in the least because there were so many people who always provided me with support and enthusiastic cooperation. From this place I would like to thank all of you. Especially Henny Romijn who has provided excellent supervision with great enthusiasm and always somehow found the time to discuss interesting new findings and obstacles. It was really a pleasure. I would also especially like to thank prof. Kees Daey Ouwens who was the initiator of my research and has provided valuable feedback and an extensive and interesting network. Furthermore I would like to thank everybody who has had part in this research:

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* Albert Mshanga, field officer at Kakute who also introduced me to several womengroups and shared a lot of knowledge with me,

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* Brotherhood of Jesus the Good Sheperd, especially father Moses, who were so kind to let me stay at their residence for a couple of days and invite me to a celebration at the archbishop's place in Moshi,

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Peter Burland
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Mr. E.N. Sawe, director of TaTEDO
Mr. S. Kijazi, agri-business officer from Faida MaLi
Mrs. F. Coutinho, managing director of FINCA
Mr. D. Makundi, senior R&D officer at TIRDO
Mr. F. Heimbach from the Kiumma project
Mr. A. Manyanga, director of Kakute and Ms. Edith, manager at Kakute
Mr. S. Solomon, assistant village head at Engaruka
The women from the Monduli women group
Mr. F. A. Elise, manager at KIDT

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Mr. N. Mwhihava, assistant commissioner Renewable Energy at the Ministry of Energy and Minerals
Mrs. J. P. Uisso, senior Research Officer at the Ministry of Energy and Minerals

And last but not least all friends, family and colleagues who supported me during my stay in Tanzania and/or who stayed with me on the campus.

As Strategic Niche Management emphasises learning processes on all levels, I cannot conclude anything else than this: I have learnt a lot! On different levels and in different processes. After completing this research I remain positive about the potential of biofuels in developing economies, and sincerely hope that a strong 'healthy' biofuel sector will flourish in Tanzania, creating not only numerous benefits for local people but also for the environment as a whole.

I would like to thank Amin Kassam for editing the manuscript for language.

I hope you will enjoy reading this thesis.
Janske van Eijck,
Tilburg, March 2006

Summary

The global energy supply is currently based mainly on fossil fuels. The use of fossil fuels has added significantly to the carbon dioxide in the earth's atmosphere and most scientists agree that this has contributed significantly to the greenhouse effect, creating the conditions for climatic changes that threaten life on this planet. Politically, the reliance on fossil fuels has been responsible for constant tensions – and sometimes war – between countries that have plentiful supplies and those that rely on other countries for their energy supplies. Also, fossil fuel resources are limited and some analysts are already predicting that the supply will decline within a few decades. All this creates an urgent need for more sustainable sources of energy. Biofuels are one option, as they have a closed carbon-cycle and do not contribute to the greenhouse effect. The biomass which is necessary for the production of biofuels can be derived from several sources, one of which is oil-producing crops. Because such crops require large amounts of land and agricultural land is often scarce in high- income countries, growing them in developing countries would be more practical. Moreover, such crops could provide economic and environmental benefits to the developing countries concerned.

Currently, Eindhoven University of Technology is exploring the potential of biofuels in Tanzania, where the population is mostly rural, very poor and without adequate energy services. 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. Thus, it could also earn foreign exchange.

Current initial activities in Tanzania have been directed towards the use of *Jatropha curcas* L., an indigenous plant which does not require a lot of water and nutrients and has a relatively high oil yield. However, so far it is not clear how a transition based on Jatropha could be realised, or what factors influence the process. Therefore, the main research question posed in this research is:

> *What is the status of the transition process towards Jatropha biofuels in Tanzania, and how can the process be improved?*

Strategic Nice Management (SNM) was adopted as the principal method for this research. Since it was designed specifically to investigate the experimental introduction of new sustainable technologies through societal experiments, it could be expected to be a suitable research instrument for a multidisciplinary study about the prospects for a transition towards Jatropha biofuels in Tanzania; for documenting the initial activities and processes in that direction; and for taking stock of the important stimulating and constraining factors in that process.

The use of SNM in this research is innovative and experimental, in that the method has never been used to analyse transitions in developing countries. It was developed for the study of transitions in high-income countries, and so far it has only been applied there. This research is based on substantial fieldwork in Tanzania during March-June 2005. Field data were gathered through interviews with the actors involved in activities based on, or with, Jatropha. Literature was used as a secondary source of information.

SNM views transition as a gradual learning process driven by several experiments executed by the new technology's stakeholders in a protected space called a 'niche'. The processes in the niche take place in, and interact with, a broader context which is composed of a so-called 'landscape' and a 'regime'. This multi-level perspective – landscape, regime, and niche – is used to analyse whether

developments at those levels have a positive or negative influence on a transition. Developments at the macro or 'landscape' level are external to the developments in the regime and niches but they do influence them. Regimes are described as the dominant or 'normal' way of doing things. The room for new developments within regimes is increased by a high level of uncertainty and tensions between the technological configuration, the actors and the set of rules (that is, a decrease in 'alignment'), reduced resistance from the dominant regime against a certain niche development (that is, an increase in 'permeability') and an increase in the perception that problems are no longer solvable with the current regime (that is, a change in 'vision'). Finally, three processes are important at the niche level: network formation and stabilisation, learning processes, and dynamics of expectations (voicing and shaping). A high quality of niche processes is indicated by a wide and interconnected actor network, many learning processes on several subjects (technology, user acceptance, system, and so forth) and expectations that are stabilising and becoming more specific. It is also important that the niche processes give rise to a technology that is financially feasible.

The current activities in Tanzania focus on the use of the plant *Jatropha curcas* L (referred to in this thesis as Jatropha). This plant was found to have the following properties: It is easy to establish and is drought resistant. The plant is not browsed by animals, therefore it is traditionally used as a hedge. It can live for up to 50 years and can produce seeds from one to three times a year. The seeds can be pressed to obtain oil. Seedcake is left after pressing. The seed yield is highly variable (from 0.1 to 20 t/ha/y), depending on a range of factors. The seeds contain about 30% oil.

There are many applications for Jatropha. Using the concept of the production chain, these different applications can be subdivided into three stages, namely: cultivation, production (pressing) and usage. Pressing is currently done with hand presses or screw presses. The oil can be used in diesel engines, either directly (requiring 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). Jatropha oil can also be used in oil lamps, cooking stoves, and as basis for soap-making. The seedcake has several uses, two of which are in biogas production and as fertiliser.

The main results of the analysis of the landscape, regime and niche dynamics are as follows. Most developments at the landscape level influence the transition positively. Renewable energy and biofuels are gaining interest worldwide. A global market for biofuels is being created. Currently the share of biofuels in the total renewable energy supply is still quite low. The Tanzanian government stimulates some renewable energy technologies but its position on biofuels is unclear. Tanzania has enough land to be self supportive in biofuel. Tanzania's infrastructure is poor but that does not have to be a barrier to local production and use of Jatropha biofuel. However, export might be more difficult.
Four regimes were found to be relevant to the transition: the *agricultural regime* (cultivation of Jatropha), the *vegetable oil regime* (production of Jatropha oil), the *energy regime* (use of Jatropha biofuel) and the *financial regime* (financing all niches). For all regimes, the cultural aspect is the same, people seem to be reluctant to risk trying something new. They prefer to see an innovation in use before trying it themselves.

The agricultural regime has practices that are close to the cultivation of Jatropha. Problems have been recognised in this regime and farmers are looking for new crops to increase their income. This regime seems to be open for a transition towards Jatropha biofuel. Current practice in the vegetable oil regime consists of local facilities where industrial or edible seed oils are produced. Farmers use these facilities to have small quantities of their crops pressed at a time. However, Jatropha oil is poisonous, so there is a reluctance to use the existing pressing equipment to produce it. The energy regime is quite complex. There are different applications (fuel for diesel engines, electricity generation, lighting and cooking) and sources (fuelwood, kerosene and diesel fuel, among others). There are currently problems in this regime, which vary from health issues to limited availability of energy. User preferences are important in this regime. Consumers are price-sensitive, and they are choosy with respect to their cooking regime. This limits the prospects for Jatropha as a source of lighting and cooking fuel. Using Jatropha oil in a mixture with normal diesel fuel seems to have better prospects. It requires the least modification to engines, so it is most likely to be facilitated by the current regime. Also, there would probably be little resistance to using Jatropha biofuel to generate electricity. Finally, in the financial regime, a new development which facilitates provision of microcredit has a positive influence on the transition.

The analysis of the dynamics within the different niches showed that the processes in the first step of the production chain, cultivation, have particularly proceeded well. In the other niches, the major problems are lack of sufficient learning processes and expectations that are still wide and diverse.

The main conclusion is that the transition toward Jatropha biofuel in Tanzania is still in a very early phase.

Recommendations are made for several levels:

- The government should facilitate protection of the niches and should supervise the system of cultivating Jatropha (avoiding mono-culture plantations).
- Production chain management should be undertaken by organisations like NGOs or universities, should focus on stimulating all niches with sufficient network dynamics (many different types of actors and interconnections) and dissemination of the learning processes to all actors involved.
- Finally at the niche level, niche management should focus on the main niche processes, actor network, learning processes and levelling of expectations. Local niche champions who could lead this process may, for example, include local entrepreneurial farmers or foreign lead firms. The thesis makes some specific recommendations on cultivation, production and biofuel use.
- The main methodological recommendations include integrating the literature on SNM with other literature on technological development in developing countries, and conducting more research on the interrelationships between the niches.

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Definitions - Abbreviations

Biofuel	Fuel derived from biomass (pure Jatropha oil as well as biodiesel).
Biogas	A methane-rich fuel gas produced through anaerobic digestion of suitable biomass feedstocks.
Biodiesel	A biofuel produced through transesterification, a process in which organically derived oils are combined with alcohol (ethanol or methanol) in the presence of a catalyst to form ethyl or methyl esters.
CDM	Clean Development Mechanism, one of three flexible mechanisms of the Kyoto Protocol to the UN Framework Convention on Climate Change. Industrialised countries can invest in renewable energy technologies in developing countries to meet the Greenhouse gas emission reduction targets.
Jatr. biodiesel	Biodiesel derived from Jatropha oil.
Jatropha oil	In this thesis, it is the unmodified oil derived from cold-pressed Jatropha seeds.
BCR	Benefit Cost Ratio; sum of the discounted cash *out*flows divided by the sum of the discounted cash *in*flows. The BCR should be larger than 1.
IRR	Internal Rate of Return; the discount rate that would make the *NPV* of the project equal to zero. The basic investment rule based on the *IRR* (which is not sufficient) is "accept the project if the *IRR* is greater than the discount rate; reject it if the *IRR* is less than the discount rate."
NPV	Net Present Value; sum of all expected discounted cash flows. A positive NPV amount is a necessary (but not sufficient) condition for a profitable project.
PBP	Pay Back Period; the number of years it takes before the sum of the undiscounted cash flows from the project becomes positive.
CO	Carbon monoxide
CO_2	Carbon dioxide
HC	Hydrocarbon
NO	Nitric oxide
NO_2	Nitrogen dioxide
Faida MaLi	Faida Market Linkage
FINCA	Foundation for International Community Assistance
KIDT	Kilimanjaro Industrial Development Trust
KIUMMA	Kituo cha Elimu na Maendeleo Matamanga
NGO	Non Governmental Organisation
TAF	Tanzania Association of Foresters
TaTEDO	Tanzania Traditional Energy Development and Environment Organisation
TIRDO	Tanzania Industrial Research and Development Organisation
TU/e	Eindhoven University of Technology
UNIDO	United Nations Industrial Development Organisation
USDM	University of Dar es Salaam, Tanzania
WHO	World Health Organisation

Units

TZS	Tanzanian Shilling, 1€ is about 1400 TZS, 1 USD is about 1100 TZS (exchange rate in May 2005).
USD	American Dollar, 1 USD is about € 0.78 (exchange rate in May 2005).
Acre	0.4 hectares
Gr.	Gram
Ha	Hectare
Kg	kilogram
l	litre(s)
MT	Metric ton (1,000 kg.)
Ppm	Parts per million
Tonne	1,000 kg.
y	year

1 Introduction

This chapter starts by presenting some background information on the research problem and some of the characteristics of Tanzania. It goes on to set out the research aim and research questions as well as the limitations of the research. Then, after describing the research method (the research model will be described in Chapter 2) it outlines the structure of the thesis.

1.1 Research problem

The global energy supply is currently based mainly on fossil fuels. This causes serious environmental and other problems. Emissions from burning fossil fuels are adding to changes such as global warming (the greenhouse effect) and ozone depletion, which are expected to have significant long-term effects on the climate globally. Also, the geographical location of the fossil fuels creates a tension between countries that are rich in them (oil exporting countries, for example) and those that are not. Another problem is created by the finite nature of fossil fuel resources. Estimates of the extent of, for example, oil reserves vary but most analysts agree that within a period of several decades to over 100 years the oil reserves will be depleted. It is anticipated that the demand for fuels will continue to rise in the future, due to increased population and increased demand from rapidly growing economies such as China and India. This clearly indicates that other, more sustainable energy sources are necessary.[1]

Biofuel is one form of sustainable energy. Biofuels are derived from biomass. They can be used as substitutes for fossil fuels, in cars or generators, for example. In contrast to fossil fuels, burning of biofuels is CO_2 neutral, since the emitted CO_2 was acquired by the plant from the atmosphere through photosynthesis fairly recently. Therefore, it will not contribute to the greenhouse effect. The biomass which is needed for the production of biofuels can be derived from several sources (for example, waste). One option is to use crops.

All agricultural crops can yield oil, some more than others. When they are specially cultivated for their fuel value, they are called 'energy crops'. Table 1 compares the oil yield of several crops. The yield always depends on conditions such as climate, nutrients, and so on. Rapeseed oil is the biofuel mostly used in Europe at the moment.

Crop	Litres oil/ha
Corn (maize)	172
Cashew-nut	176
Cotton seed	325
Euphorbia	524
Sunflower	952
Rapeseed	1190
Castor beans	1413
Jatropha	1892
Oil palm	5950

Table 1: Oil yield of several crops in ascending order

Source: http://journeytoforever.org/biodiesel_yield.html accessed October 2005.

1 These problems have been identified by many authors; for example, Meadows et al. (2004).

The oil can be obtained by using very simple technology, mechanical extraction. Biofuels can be used for several purposes, including as a substitute for diesel fuel. This is not new – -for example, when Rudolf Diesel demonstrated his engine at the World Exhibition in Paris in 1900 he used peanut oil as a fuel.

A transition towards biofuels from oil-producing crops is considered to be desirable and could solve some of the problems associated with energy supply. However, since a lot of land is required it is difficult to cultivate these crops in adequate quantities in industrialised countries. Developing countries often have a lot of available land and could profit environmentally as well as economically by producing and using biofuels. A couple of years ago I studied a biofuel system in India. Eindhoven University of Technology is currently studying the potential of biofuels in Tanzania. Research that has been carried out by several students, for example by Rabé (2004), has concluded that biofuels can have economic, environmental and social benefits. However, it is not yet clear how such a transition could be realised in Tanzania, or what influences this process. Furthermore, what are the limitations and possibilities? What would the impact of the cultivation of biofuels be on the local people? Some characteristics of Tanzania are described in the next section to place the research in context.

1.2 Research context

Tanzania is one of the poorest countries in the world; it is ranked 226 on a GDP per capita list of 232 countries in declining order.[3] The country is situated in Eastern Africa (Figure 1).

Figure 1: Location of Tanzania in Africa

It has a population of about 35.5 million,[2] of which 36% lives below the poverty line.[3] GDP/capita in 2004 was USD 700. A large share of the population, over 77%, lives in rural areas.[4] These areas are also the poorest, with 39% of the rural population living below the poverty line,[5] in comparison with 18% in Da -es Salaam and 26% in other urban areas.[6] Agriculture is a very important sector for Tanzania, providing about half of the GDP and employing over 80% of the workforce.[3] Nationally, 97% of the energy consumption is derived from biomass, mainly fuelwood. Using fuelwood for energy creates serious problems such as soil erosion, deforestation and health problems related to thick smoke in the houses. These figures indicate that the rural population in Tanzania constitutes a major part of the country's total population, but that they are also very poor and lack adequate energy services.

Biofuels could be a very good solution to alleviate the environmental, poverty and health issues in Tanzania. Producing and using biofuels can help to stop soil erosion, provide an energy source and create an additional income. The production process can also create jobs, as it involves site preparation, planting, harvesting, transport, preparation, selling and other activities. The process also strengthens the local economy by recycling income in the community.

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2 July 2005 est. Worldfactbook, http://www.cia.gov/cia/publications/factbook/geos/tz.html
3 2002 est. Worldfactbook, http://www.cia.gov/cia/publications/factbook/geos/tz.html
4 Data from October 2004, Tanzania National Profile Data in Brief, National Bureau of Statistics Tanzania.
5 A 'basic needs' poverty line is used here, which includes 2,200 calories a day and allows for basic non-food consumption (Household Budget Survey).
6 Data from 2000, Household Budget Survey, 2000/01, National Bureau of Statistics, Tanzania.

In Tanzania most attention is currently being paid to an indigenous plant called *Jatropha curcas* L. (referred to in this thesis as Jatropha). The great advantage of Jatropha is that, in addition to yielding a relatively large oil yield, it does not require a lot of water and nutrients. It can grow in very poor soils, thereby reclaiming land (and preventing soil erosion). Another advantage is that the seeds are poisonous; therefore the plants can be used as a hedge to keep animals at bay (this is a traditional use of Jatropha) and the oil does not compete with food products. The plant has several uses, which will be explained in Chapter 3.

Chachage (2003) identifies the current activities in Tanzania based on Jatropha oil as soap-making on a limited scale and use in oil lamps. So, while most reports on biofuel are upbeat about its potential, Jatropha oil does not seem to have been developed to its full potential in Tanzania so far.

In principle, a transition towards biofuels which includes the complete production chain would be beneficial for Tanzania, especially when it is based on Jatropha with its many advantages. However, the activities with Jatropha have not been particularly successful. According to Raven (2005b), this pattern often occurs with respect to innovations with (potentially) improved environmental characteristics. Even innovations that have very promising characteristics can fail to be commercially successful because the competition from incumbent fossil-fuel based technologies is too powerful. Raven used a method called "Strategic Niche Management" (SNM) which has been designed to investigate the experimental introduction of sustainable technologies through societal experiments before exposing them to market-based competition. Several factors are taken into account; for example, the social, institutional and economic structure surrounding the technology.

On the face of it, SNM seems to be suitable for analysing the prospects of a transition towards Jatropha biofuels in Tanzania, since the technology is locally so novel that it will require substantial experimentation in order to be commercially viable and applicable on a larger scale. Up to now, however, SNM has only been used to study transition processes in industrialised countries. It has never been used to analyse experiments in developing countries.

1.3 Research aim

The aim of this study is to obtain insight into the current transition process in Tanzania towards Jatropha biofuels, by using Strategic Niche Management as the research instrument. The main research issues include:

- the opportunities for such a transition,
- the factors influencing that process, including existing technological and socio-economic, cultural, political and institutional conditions (that is, the existing "regime" and "landscape" in SNM-terminology)
- possible ways to stimulate the process.

There are many possible application-domains ("niches") for Jatropha. For example, in addition to diesel fuel, Jatropha can be used to make soap and as lamp oil; its by-products can be used as fertiliser and raw material for biogas. Therefore, a study of the transition should focus on the quality of the experimentation processes within these different niches, and one has to ask whether all these processes actually add to the transition process.

According to SNM, the transition process can be stimulated by inducing more experimentation. SNM tacitly assumes that all experimentation is (equally) beneficial. However, in the context of a poor developing country like Tanzania, "stimulation" has to take social equity considerations into account. Certain transition processes may be more beneficial for local people than others because they provide possibilities for their participation in the process. In this thesis, "stimulation" will take these wider socio-economic issues into account.

1.4 Research questions

The main research question is:

> *What is the status of the transition process towards Jatropha biofuels in Tanzania and how can the process be improved?*

There are also several sub-questions:

- Question 1: *What are the main processes that are important for a transition?*
- Question 2: *What are the different niches or application domains for Jatropha in Tanzania?*
- Question 3: *What is the influence of the related regimes and landscape on the transition process?*
- Question 4: *What lessons can be learned from the analysis of Jatropha experiments in Tanzania, using the SNM-method?*
- Question 5: *What recommendations can be made to improve the transition process?*

1.5 Limitations of the research

This research was conducted to fulfil the requirements of an MSc degree. Inevitably, that created time and financial constraints which affected the extent and depth of the research. The following are the main limitations.

Geographical boundaries are hard to set for this research as the landscape level contains global influences. However, only experiments which are executed by actors in Tanzania will be analysed.

There are many sources for biofuels and there are also many ways in which biofuels can be produced. In this report only biofuels derived from Jatropha will be analysed. And only the technologies that are actually used in Tanzania will be taken into account. Other processes to produce biofuels, such as Fischer-Tropsch, will not be addressed (although they are also viable options). Mechanical extraction is the simplest technology, so this report focuses on pure Jatropha oil (obtained by cold pressing), a mixture of Jatropha oil with diesel fuel and a conversion to biodiesel by adding methanol (methyl ester). Jatropha biofuels can only serve as diesel substitutes, not as, for example, a substitute for the fuel in gasoline engines.

Only the processes that are important to the transition process will be analysed. Furthermore, the transition to Jatropha is considered to be desirable. This is taken as a fundamental assumption in this research, in keeping with the SNM method. The desirability of the transition is not in question here.

1.6 Research Method

The method used in this research is Strategic Niche Management (SNM). SNM utilises a multi-level perspective to study transitions. This will be explained in detail in Chapter 2. Using the SNM methodology, the transition to Jatropha biofuels in Tanzania will be analysed on three levels: landscape, regime and niche levels. The main focus is on lessons learnt from experiments. The research will be exploratory in nature.

Experiments on Jatropha carried out in Tanzania, and interactions with actors involved in Jatropha activities, will provide the input for the analysis at niche level. In the Jatropha chain, the activities (processes and applications) are the “niches” used for analysis in this thesis. Experiments which were executed in the same niche will be grouped together for the purpose of the analysis. The quality of the niche processes will be analysed and the potential influence of the niche on the transition explained. The related regime and landscape processes will also be analysed to determine whether they have a positive influence on the transition process or not. An overall conclusion will be presented for each of the three levels, as many of the actors operate in more than one niche. The research framework is summarised in Figure 2.

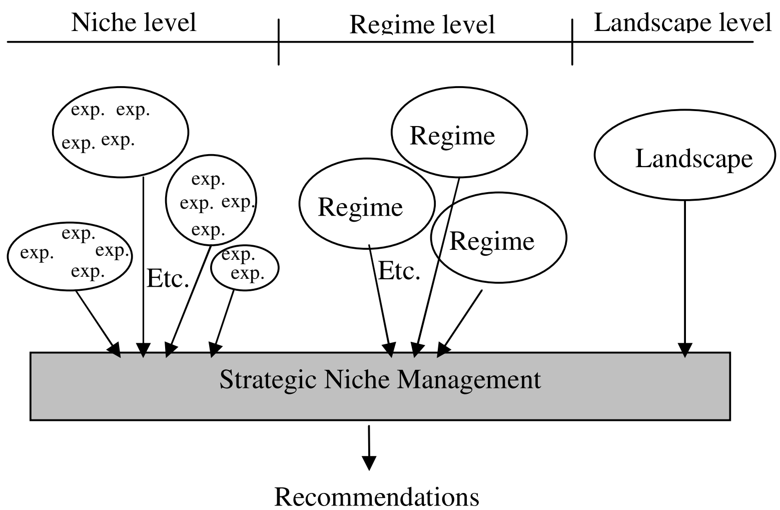

Figure 2: Research framework

A study of the relevant concepts in the literature was the starting point for this research. The data were derived from various information sources: reports on projects and reports on the techniques for the Jatropha niches, among others. The data necessary for the niche-level analysis were collected during a three-month stay in Tanzania from March to June 2005. Field visits to several experiments and interviews with several actors in the Jatropha chain have provided the data. Several questions were asked to the actors In an open interview setting (see 0 for the list of questions). Other data sources included e-mail contacts, data on websites and seminars. The data necessary for analysis at the regime level were also derived from the interviews, and were complemented with information from statistical data, reports (from organisations in Tanzania as well as libraries), books and websites. The data for analysis at the landscape level were mainly derived from reports and websites.

1.7 Structure of the thesis

Chapter 2 explains the Strategic Niche Management method, with the landscape, regime and niche levels being described separately. Chapter 3 describes the properties and applications of Jatropha and gives some technical details on its applications in Tanzania. Chapter 4 presents the data analysis. Again, the three levels are analysed separately, starting with the landscape level. Then follows the regime analysis, covering four regimes. The third part of the analysis consists of an analysis of the experiments at niche level. The analysis at this level is subdivided into the different niches, following the Jatropha production chain. Chapter 5 presents the conclusions and recommendations. The appendices contain literature on Jatropha yield, the information derived from the field visits and interviews, contact addresses, and the questions that were asked to most of the actors.

2 Strategic Niche Management

The method used in this report to analyse the transition is called Strategic Niche Management (SNM). This method is grounded in evolutionary economics and was first propounded in literature on innovation diffusion theory in 1999 (Ieromonachou et al., 2004). In these theories technological development is seen as a process of variation and selection. Variation because several technologies and products are generated, and selection because of the process where the variation is reduced until the most viable of the options has become the dominant one. The generation of new technologies and products is not random, the developers are using guidelines (heuristics) to solve problems and are therefore steering the process. The selection is done in an environment where several factors play a role, for example the market, institutional factors (government, political structure) and social factors (for example, public opinion). The interaction between variation and selection leads to technological trajectories; that is, cumulative developments in a specific direction, see Figure 3 (Geels and Kemp, 2000).

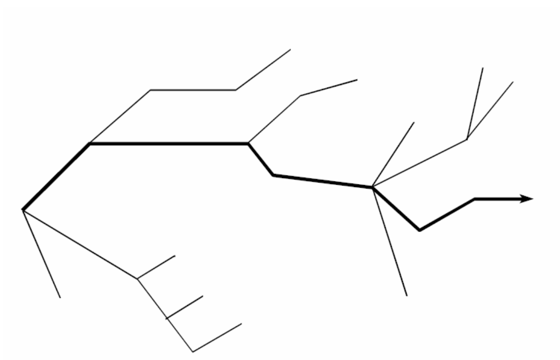

Figure 3: Technological development as process of variation and selection
Source: Schot (1991) in Geels and Kemp (2000).

SNM focuses on the trajectories and socio-technical dynamics that bring about change. The concept of a 'regime' is used to understand the structure of technological development. A regime can be described as a set of 'rules' that structures actors' behaviour and guides them into specific directions (Raven, 2005a). The concept is explained in more detail in section 2.2. Successful adoption of a new technology implies a regime change or the establishment of a new regime. So SNM views technology in a broad and sociological sense. The focus is on learning its various aspects by performing several experiments: 'Learning by doing'. 'Experiments' can be defined as *"unique socio-technical laboratories for learning about the problems, shortcomings and barriers a new technology faces"* (Hoogma, 2000).

Strategic Niche Management can be defined as:

> *"The creation, development and controlled break-down of test-beds (experiments, demonstration projects) for promising new technologies and concepts with the aim of learning about the desirability (for example in terms of sustainable development) and enhancing the rate of diffusion of the new technology"* (Weber et al., 1999).

The purpose of SNM is '*to learn more about the technical and economical feasibility and environmental gains of different technological options, that is to learn more about the social desirability of the options'; and 'to stimulate the further development of these technologies, to achieve cost efficiencies in mass production, to promote the development of complementary technologies and skills and to stimulate changes in social organisation that are important to the wider diffusion of the new technology'* (Hoogma et al., 2002).

It is important to have appropriate levels of niche protection. With too little protection there is no learning process and with too much protection there is a risk of creating an expensive failure. New technological options can only become competitive when exposed to increasingly demanding economic and regulatory environments. The goal is to successfully introduce the new concept and, after a period of niche protection (which usually includes financial and organisational support) expose it to real-world conditions where it should be able to survive. Once the protected space has performed its function, SNM demands the dismantling of the protecting factors, so the new technology can be tested in real-world conditions (Ieromonachou et al., 2004). Even when projects have turned out to be a failure SNM can still drawn lessons from the dynamics of, for example, network processes.

The transition process towards adoption of a new technology can be analysed on three different levels through a multi-level perspective (Figure 4). First is the micro level, which includes the niches, the second level includes the regimes and finally the macro level is the landscape. This perspective emphasises that the success of a technology does not only depend on the processes within the niche, but it is also influenced by developments at regime and landscape levels. Successful niche processes can be reinforced by changes at regime and landscape levels; together, they determine whether a regime shift will occur (Kemp et al, 2001 in Geels, 2002)

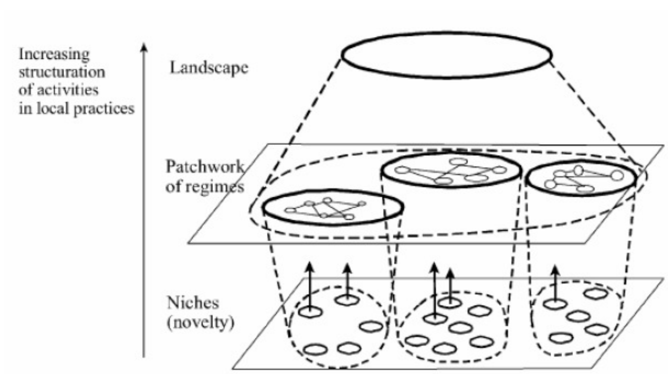

Figure 4: Multi level perspective

Source: Geels (2004)

The three levels will be explained in more detail in the following sections.

2.1 Landscape

The landscape is at the macro level. Developments in the landscape level are external to developments in the regime and niches but they do influence them. Factors at this level include material aspects such as infrastructure; highways and power lines, and non-material aspects such as culture, lifestyle, prices and wages

(Geels and Kemp, 2000). Most processes at this level, such as industrialisation, develop slowly. However, sudden or unexpected (often 'global') events also belong to this level when they can influence the regimes and niches. Some examples of these are wars, disasters like the accident leading to release of radioactivity at Chernobyl, and the oil crisis of 1973. The development of a technology slowly 'moves' through the landscape (see Figure 5). The landscape determines whether a certain technology path faces barriers or not.

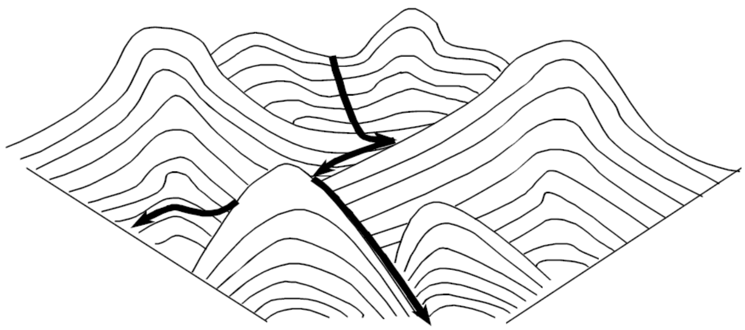

Figure 5: The macro landscape channels micro and meso developments

Source: Sahal (1985) in Geels and Kemp (2000).

According to Geels and Kemp (2000), the following elements are often important at the landscape-level:

- Material infrastructure
- Political culture (broad political coalitions)
- Social values, lifestyles ('common sense')
- Macro-economic aspects (for example, the oil price, recession or economic growth)
- Pervasive technologies (for example; ICT, electricity, steam engines)
- Demographic developments (for example, emigration)
- Natural surroundings (for example, environmental problems, raw material supply)

The outcome of a landscape analysis should provide information on whether the developments at this level have a positive or negative influence on the transition process.

2.2 Regimes

The concept of 'technical regimes' has been used to explain processes which occur within the process of variation and selection. Traditionally it was used in a rather narrow technological sense, for example by Nelson and Winter (1977) and Dosi (1982). However, it was necessary to broaden this definition to include the selection environment as well; therefore, the concept of a 'socio-technical regime' was introduced (Geels and Kemp, 2000)· This thesis uses the term 'regime' to denote this concept. Regimes could be described as:

> *"the dominant social, technical and economic forces that support the technology and its physical and non-physical infrastructure"* (Lane, 2002).

An example of this is the fossil-fuel-based regime that currently dominates energy production and use.

Changes in regimes normally occur gradually. Regime change (transition) takes place in different ways due to niche developments, substitution and accumulation/transformation. In substitution (Figure 6) the 'new' technology has to compete with the 'old' technology to obtain more market share and in the end the old regime is replaced by a new regime. In accumulation/transformation (Figure 7) the existing system is adapted instead of being replaced. New elements are added to the system, which leads to adaptations and new learning processes.

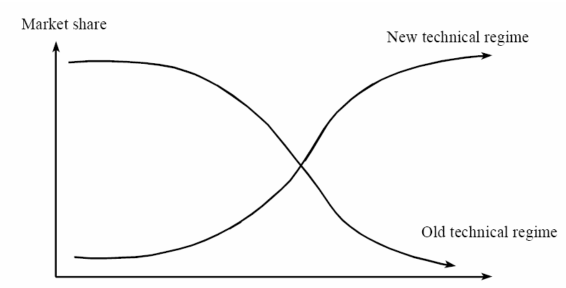

Figure 6: Transition by substitution
Source: Geels and Kemp (2000)

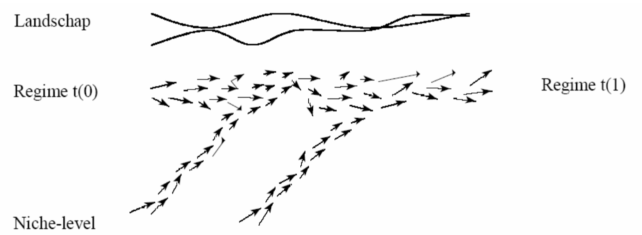

Figure 7: Accumulation/transformation as transition route
Source: Geels and Kemp (2000)

According to Raven (2005a) the main factors in a regime are technological configuration, the actors and the set of rules.

Technological configuration can be described by analysing the technology and infrastructure. Important issues can be, for example, the rise of new technologies as well as optimising of existing technologies. The *actors* are important because their role in the regime can change, with some actors becoming more important and others less important. For example, companies that are active in distribution can become more important than production companies. The role of users of the technologies can also change; for example, they can become more active within the regime. The set of rules consists of formal and informal rules. Formal rules are, for example, the institutional design or strategies for sustainable energy. Informal rules are more intangible, for example, the rules engineers have to observe when designing a project.

The process that combines these factors is '*alignment*'; a regime is more aligned when all three factors are in line. According to Raven, the introduction of new technologies is more difficult when the alignment is higher. This is because there is less room for different views and circumstances. **Tensions between the factors** and a **high level of uncertainty** are an indication of a low alignment within a regime.

Two other processes that are important within a regime are *permeability* and *visions*. Permeability describes the process outside the current regime. How much room is available for new technologies? Energy from biomass, for example, takes place outside current structures but within, for example, the waste regime and agricultural regime. The dominant regime typically exerts a certain resistance against a certain niche development; that is, its permeability is limited.

The *vision* of the problems within the current regime is also important. What are the problems within the regime and do actors think the current regime can provide a solution to those problems? A vision that is shared by many actors will create more room for niche development than a vision that is shared by only a couple of actors.

So the regime describes the 'normal way of doing things, 'and according to Raven (2005a) the room for niches within a regime, and thus for a transition, is increased by a decrease of alignment (high level of uncertainty and tensions between the technological configuration, the actors and the set of rules), an increase of permeability (reduced resistance from the dominant regime against a certain niche development) and an increase in the vision that problems are no longer solvable with the current regime. A transition is facilitated by a regime that is open to new developments in niches.

2.3 Niches

The final level of analysis is the niche level. New technologies often have a low performance in the beginning of their development; therefore it is hard to compete in the market. They need to be protected for their development to be stimulated. In
Figure 8, protection is necessary between T(1) and T(2). These protected spaces for new technologies are called 'niches' (Geels and Kemp, 2000).

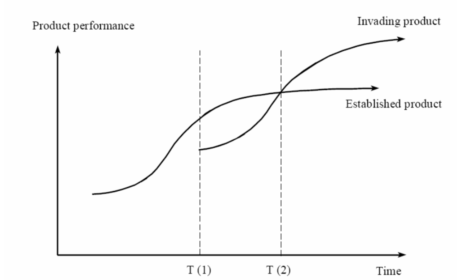

Figure 8: Competition between an established and invading product

Source: Utterback (1994) in Geels and Kemp (2000)

Niches facilitate a variety of further innovations and by doing so create a new development path. Experiences with a new technology in the niche help to gain user acceptance, change established views (both on the supply and demand sides), benefit from feedback from users, achieve scale advantages and can promote the development of complementary assets (Kemp et al., 1999).
A niche can be defined as:

> *"a loosely defined set of formal and informal rules for new technological practice, explored in societal experiments and protected by a relatively small network of industries, users, researchers, policy makers and other involved actors"* (Raven, 2005b).

Several factors are important in determining whether a technology is still in a 'niche-phase'. First, the technology should be surrounded by a **protected environment**; for example, financially through subsidies or organisationally through technical or other assistance. According to Raven (2005b) **market share** and **stability** are also important factors. Both are relatively low in a niche; market share is low because few people have adopted the technology yet, and stability is low because the 'rules' of the technology (for example, on the production side) are not yet clear.

There are two kinds of niches: a *technological* and *market*. When some kind of protection (subsidies or other preferential treatment such as special services offered at a low price) is provided to the technology by certain actors, because they expect the technology to have 'market potential,' about it is a technological niche. In a market niche, the protection is derived from the specific problems or demands of the market. For example, the mining and aerospace sectors require specific performance from the equipment.

Several processes take place within the niche itself. The three main processes, as identified by Raven (2005a and b) are:

- Network formation and stabilisation.
- Learning processes (as regards technology, user preferences, infrastructure, and so on).
- Formation and stabilisation of expectations (voicing and shaping of expectations).

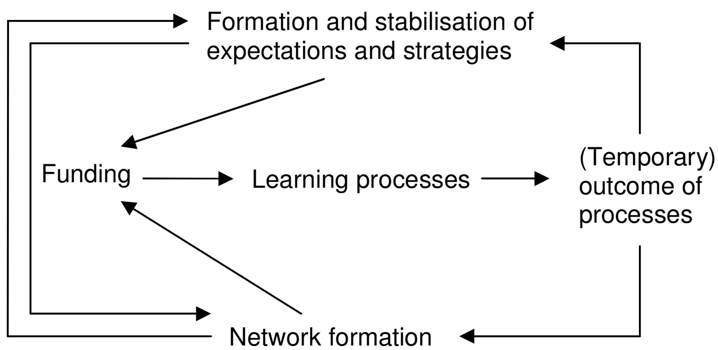

Figure 9: Linkages between internal niche processes
Source: Geels and Kemp (2000)

These processes influence each other (see Figure 9). Expectations can change due to a different composition of the network, but they can also change due to the outcome of learning processes. When a certain new technology performs well in the experiments, and the users are satisfied, the expectations around the technology will rise and become stronger. This will facilitate the expansion of the actor network. Because of these higher expectations and the expanded network, more money will become available for further learning processes. Eventually a new stable socio-technical regime will appear. The expansion of the actor network is important because participation in the niche from a wide set of actors is needed if the lessons are to be effective, according to Hoogma et al. (2002).

It is also possible that expectations are unfulfilled or that there has been movement in the surroundings. This will cause destabilisation of the niche and prevent the formation of a new regime (Geels and Kemp, 2000).
The quality of niche processes is increased by:

- Widening the actor network and increasing the connections within the network
- Wide and qualitative learning (single, double loop learning)
- Increasing the quality, robustness and specification of expectations

When the niche processes proceed well, they will ultimately culminate in a change of the regime. This process visualised in Figure 10.

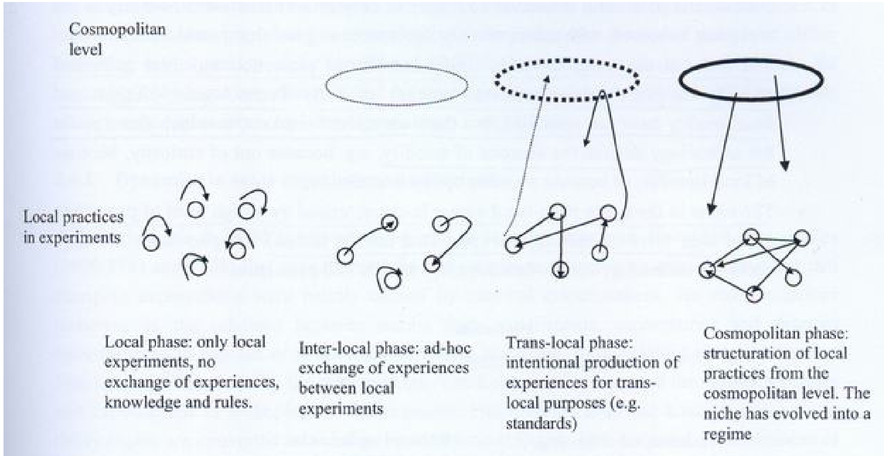

Figure 10: Emerging level of niches in relation to local practices in experiments
Source: Raven (2005b)

With regard to processes *between* niches, the niche can also serve as a stepping-stone for the diffusion of an innovation. When the technology is developed within a certain niche, the technology can be used for other applications, other niches, as well. Electricity, for example, was first used in telegraphy (1830s), after which it was adopted for lighting (1870s) and then used as a power source for engines (1980s) (Geels and Kemp, 2000).

Figure 11 summarises all three levels. On each level there are developments that are important for the diffusion of the new technology. The technology originates at niche level. When successful, it will slowly induce a regime-change and finally a landscape change. The arrows in Figure 11 are very much simplified; in reality, there are different processes on each level with sometimes a positive and sometimes a negative effect on the development of the new technology.

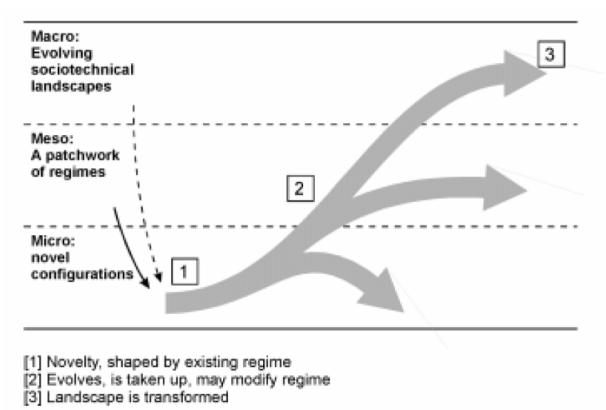

Figure 11: Origin and diffusion of a new technology
Source: Rip and Kemp (1996) in Geels and Kemp (2000)

3 Jatropha

Several aspects of the Jatropha plant need to be discussed in this chapter. First, the properties of the plant are explained by describing the history, botanical properties, yield and potential pests. Then, the chapter describes the possible uses of Jatropha. It ends with a technical description of the applications in Tanzania.

3.1 Properties

The genus *Jatropha* contains approximately 170 known species and is a member of the Euphorbiaceae family. Jatropha is derived from the Greek *jatrós* (doctor) and *trophé* (food), which implies medicinal uses (Heller, 1996). *Jatropha curcas* Linnaeus is the species that is referred to as Jatropha in this report. This species is commonly known as 'physic nut' in English and as 'purgeernoot' in Dutch.

History

Jatropha has been used a lot in history. For example, Jatropha oil exports contributed 60% to the agricultural exports of Cape Verde in the nineteenth century, and 5 to 15% of the total reforested area in 1989 and 1990 were planted with Jatropha, mainly for erosion control purposes (Heller, 1996). There are also reports on the use of Jatropha oil as a diesel substitute in Mali during the Second World War, but after this the potential of the plant seems to have been forgotten.

The plant was originally found in Central America but now grows in several regions across the world. Figure 12 shows the spread of the plant in Africa,. where it is believed to have been brought by Portuguese seafarers (Heller, 1996).

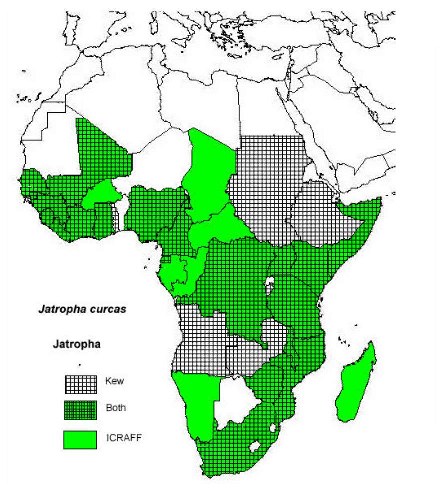

Figure 12: Geographical location of Jatropha, according to International Center for Research in Agroforestry (ICRAF) and Royal Botanical Gardens, Kew
Source: Research Group International Programs (IP) (2002).

Botanical description

Jatropha curcas L. (referred to as Jatropha in this thesis) is a large shrub, or small tree. The genus *Jatropha* contains approximately 170 known species. Jatropha is easy to establish, even in soil which is quite infertile, and is drought resistant. The root system of Jatropha plants (seedlings) consists of three to four lateral roots and a vertical taproot which reaches 5m into the soil. Reports mention that cuttings do not develop a taproot (Heller, 1996). Jatropha tolerates a minimum annual rainfall of 250 mm (observed in Cape Verde – Research Group IP, 2002) and a maximum annual rainfall of 3000 mm. The minimum depends on the humidity, the higher the humidity the less the minimum rainfall Jatropha can tolerate. Jatropha can be found from sea level to an altitude of 1800m. The tree grows to a maximum height of nearly 8 m and can live for up to 50 years (Chachage, 2003).

Provided the nutrient level is sufficient, plant growth is a function of water availability, especially in the tropics (Openshaw, 2000). When water is available Jatropha growth is rapid and a thick hedge can be formed nine months after planting. The plant produces a round fruit, with two seeds (kernels) inside. The seeds are inedible. Fruit production varies; it can start four to five months after planting or up to three to four years after planting. Flowering is associated with the rainy season, both at the beginning and end in many locations, so the plant can flower one to three times a year according to Jones and Miller (1993). Fruits mature two to four months after flowering and turn yellow when they are mature (ibid.). Harvesting takes place during the dry season, normally a quiet period for agricultural labour. The seeds contain about 30 to 40% oil. The oil is pale yellow to brown in colour. The oil contains a toxic substance, curcasin, which is a strong purgative (Chachage, 2003). The seedcake which is left after pressing is relatively rich in nitrogen. This implies that Jatropha requires a nitrogen-rich soil for good seed production. This is because Jatropha is not a nitrogen-fixing plant (Openshaw, 2000).

Yield
The yield from the plant varies substantially. Openshaw (2000) mentions a variation in seed production in the literature, from 0.4 to over 12 tonnes/ha/y. The number of plants per hectare varies from 1100 to 3300. In addition, two tables in Heller (1996) and Jones and Miller (1993) summarise several Jatropha yields in the literature (see 0). They report an even larger variation in seed yield, from 0.1 t/ha/y to 15 t/ha/y. The mean of these two tables is 4.8 t/ha/y (the median is slightly lower, 3 t/ha/y). At the project sites in Tanzania (see 0) the expected or reported seed yields are higher and vary from 5 to 25 t/ha/y (2kg/plant/y to 10 kg/plant/y).

Pests
“Jatropha cultivation has no known major disease or insect pests,” which is one of the reasons the plant is so popular according to Jones and Miller (1993). Heller (1996) mentions several insects, although he also mentions that pests and diseases do not cause severe problems. According to him, seedlings are susceptible to competition from weeds during their early development. Therefore weed control, either mechanical or with herbicides, is required during the establishment phase. Millipedes can cause total loss of young seedlings. Jatropha is probably also a host for cassava viruses that can be transmitted, so the plant should not be used to fence in cassava fields. Termites can also damage Jatropha plants.

Grimm (1999) identifies the insects that can cause damage to Jatropha. He describes three insects, two species of fruit-feeding true bugs and one flower-feeding true bug: *Pachaycoris klugij Burmeister*, *Leptoglossus zonatus* and *Hypselonotus intermedius*. Other pests, according to Grimm and Maes (1997), include the stem borer *Lagocheirus undatus* (Voet) (Coleoptera: Cerambycidae), grasshoppers, leaf-eating beetles and caterpillars as well as leaf-hoppers.

3.2 Applications

Jatropha is a multi-purpose plant, with many possible applications. In Tanzania the plant is known under the Swahili name Mbono Kaburi (graveyard tree). This is because it was traditionally planted on graves, probably because Jatropha cuttings can establish in any season and so the plant can be used to mark a grave whenever someone dies.[7] In another Tanzanian language, Harya (spoken near Lake Victoria), Jatropha is called Mwitankoba or 'thunder killer tree'. Every house was traditionally supposed to have at least one Jatropha tree near it to prevent the house from being destroyed during a a thunder storm.[8] Another traditional use for Jatropha is medicinal. The milky sap that bleeds from the leaves when they are broken is used, for example, to heal skin cuts.[9] A project in the Philippines found that the signs of Tinea pedis ("athlete's foot") and ringworm disappeared after the application of Jatropha ointment (Aesotope, 2004). Jatropha is also planted as a hedge (living fence) by farmers all over the world around homesteads, gardens and fields, because it is not browsed by animals (Henning, 2004). The seeds, too, are useful: they can be pressed to obtain oil, leaving a seedcake relatively rich in nitrogen (see section 3.3). While the seed oil can be used for soap production, as insecticide or for medicinal purposes, the seedcake can be used as fertiliser, animal fodder (after detoxification) or to produce biogas (the seed shells and branches can be used for this purpose as well) (Heller, 1996). The Jatropha plant itself has insecticidal properties.

Several processes are necessary to produce Jatropha oil and use it in diesel engines (either directly or converted into biodiesel). These processes are listed in Figure 13. They are divided into three separate stages (a) Cultivation: the Jatropha is grown and the seeds are harvested; (b) Production: the Jatropha seeds are expelled and Jatropha oil and seedcake are produced; and (c) Usage: the Jatropha biofuel (pure Jatropha oil or converted into biodiesel) is used in diesel engines. In this stage also, the seedcake is used to produce biogas production for cooking, as fertiliser or pressed into briquettes for cooking fuel. Other applications that are being explored in Tanzania are expanded use of Jatropha oil for soap-making, use of the oil in oil lamps, and use of the oil in cooking stoves.

[7] Interview with Tanzanian Association of Foresters, Moshi, May 2005. See 0.
[8] Ibid.
[9] Ibid.

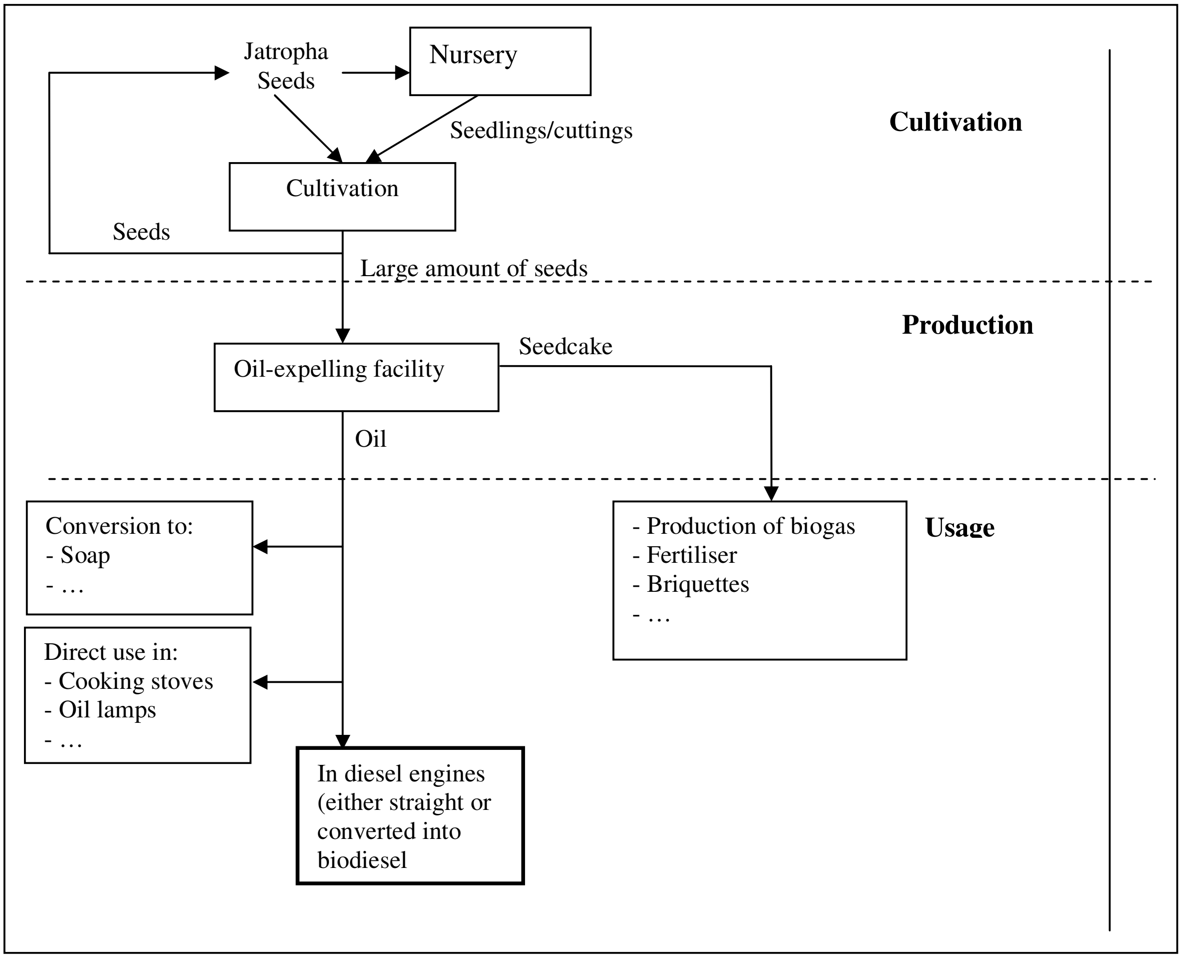

Figure 13: Jatropha production chain

The applications listed in the figure are not exhaustive; more applications are possible, as the dots indicate. For a transition towards biofuels the use of Jatropha biofuel in diesel engines is the final stage.

3.3 Technical description of application domains in Tanzania

Only the Tanzanian applications from which technical data was available will be described in this thesis. These are, extraction of the oil, usage of the oil in diesel engines, usage of the oilseed cake for biogas production (for cooking purposes) and as fertiliser. Also the use of Jatropha oil for soap making, in oil lamps and in cooking stoves will be described.

3.3.1 Extraction of the oil

A variety of equipment is available to obtain oil from the seeds. The oil can be extracted mechanically with a press (ram, hydraulic or screw) or chemically with organic solvents or water (Foidl et al., 1997). In Tanzania currently, the oil is obtained only mechanically with a ram press or a screw press.

A ram press is a small hand-press (Figure 14. In this press, the seeds are poured in through the funnel and by moving the bar up and down operates a piston

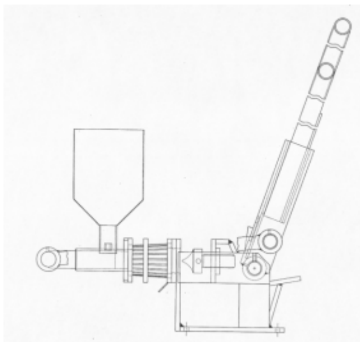

Figure 14: Ram-press

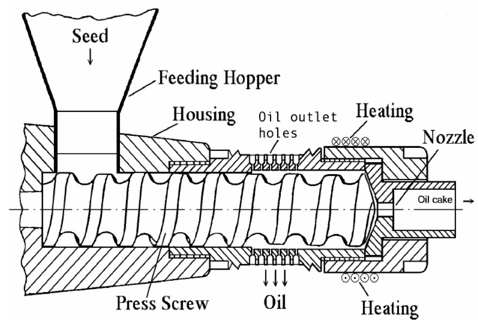

Figure 15: Screw press (hole cylinder)

which applies pressure on the seeds, extracting the oil, which then drips into a container. 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 1 litre of oil (Henning, 2004). The capacity is about 1.5 litres per hour. There are also larger expellers, screw presses, which are run by an engine (Figure 15. The extraction rate of this press is higher; because more oil is extracted from the seeds, the cake residue is much dryer. The screw turns continuously, transporting the seeds from one side of the press to the other while squeezing out the oil. The capacity is higher than that of the ram press. For example, the Sayari oil expeller (Figure), which is used in Tanzania, has a capacity of about 20 l/hour (60 kg/hour) and can extract 1 litre of oil from 3 kg of seeds. There are also larger screw expellers, for example Chinese expellers which can extract about 50 l/hour (150 kg/hour). After the oil is expelled it is filtered by letting it stand for a while or pouring it through a cloth.

Storage of the raw material is important for continuous operation, as the Jatropha seeds are available seasonally. Two options are bulk storage and bag-storage. The storehouses should be well ventilated in order to prevent self-ignition. The location plays an important role, as it has a considerable impact on transport and storage costs. Raw material transport costs are often higher than oil and cake transport as the volume weight of the seeds is higher. If the oil cake can find local use a location in the rural area might be advantageous. However, an export industry might be better located in urban areas with easy access to harbours, railway stations or truck stops. The oil-seeds should be weighed and registered when entering the facility and a sample should be taken to control the quality. A number of skilled workers are necessary for such a facility, so training is also important (UNIDO, 1983).

3.3.2 Use in diesel engines

When Jatropha oil is used as fuel, it can be utilised directly, in a blend or modified into biodiesel.

Direct use

The viscosity ('thickness') of Jatropha oil is much higher than that of diesel fuel (see Table 2). This is the main problem of using Jatropha oil in an engine. A number of Jatropha oil properties are compared with those of diesel oil in the table. When Jatropha oil is used directly in a diesel engine, some modifications are usually necessary, although Heller (1996) says that the filtered oil can be used directly in many suitable engines such as Deutz, Hatz, IFA, Elsbett, DMS, Farymann and Lister-type (India). Some experiments have shown that only changing the nozzles and fuel lines is enough for the engine to work properly, for example in India. Other tests with vegetable oils have shown that the overall functioning of the motor is affected and caused premature wear. Long-term testing demonstrated the following problems, according to a report by TIRDO (no date):

- obstruction of feeder filters and injector nozzles
- deposition of carbon and gum on injector nozzles, valves, pistons and cylinder components
- shortened durability of lubricating oil
- difficulty in cold weather starts
- weak combustion efficiency during idle

Appropriate engine modifications can overcome these problems. There are several options; for example, use of a dual fuel tank system, or preheating of the fuel to improve the flow of the oil. With a dual fuel tank system the engine is started with normal diesel fuel and switched over to the tank with Jatropha oil when the engine is warm. Before the engine is stopped, a switch back to diesel is necessary. There are also 'one-tank' systems, where the switch to diesel fuel is not necessary. The German company Elsbett, for example, sells 'adaptation-kits' for about €500 to €1700.[10]

Blended diesel

According to Pramanik (2002) Jatropha oil can be blended with diesel fuel – in a blend containing about 40-50% Jatropha oil – without any adaptations to the engine or preheating of the blend. A report by Forson et al. (2004) conclude that even a –blend with 97.4% diesel and 2.6% Jatropha oil has the highest cetane number and an even better engine performance than 100% diesel fuel, suggesting that Jatropha oil can be used as an ignition-accelerator additive for diesel fuel.

Conversion into biodiesel

Jatropha oil can also be converted into biodiesel (also known as methyl ester), which has a lower viscosity and has properties comparable to those of normal diesel fuel (see Table 2. The engine not have to be adapted, although some reports mention that biodiesel affects fuel hoses, so replacing rubber hoses with synthetic hoses might be necessary. Obtaining biodiesel requires a chemical modification of the Jatropha oil. The oil is mixed with methanol and caustic soda and then left to stand. Glycerin settles to the bottom of the tank, leaving the methyl ester, or biodiesel, at the top. Methanol is highly flammable and toxic so this requires special equipment. Also, it is very important to monitor the quality of the fuel, so a laboratory setting is necessary. The glycerin can be used for several purposes (for example, to make a high-quality soap) or it can be refined and used in a range of products (for example, cosmetics, toothpaste, embalming fluids, cough medicine, and so forth). (Research Group IP, 2002).

[10] www.elsbett.com, accessed November 2005.

Properties	Diesel	Jatropha oil	Jatropha biodiesel
Density (gm/cc), 30°C	0.84-0.85	0.90-0.93	0.88
Kinematic Viscosity (cSt), 30°	4-8	50-53	5.7-8
Cetane No.	40-55	38-51	50
Flash point, °C	45-80	110-240	170
Calorific value, MJ/kg	42-46	38-42	38
Sulphur (%)	1.0-1.2	0.13	0
Carbon residue (%)	0.1	0.64	0.5

Table 2: Properties of diesel oil, Jatropha oil and Jatropha biodiesel

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 .
The *Cetane* number expresses the ignition quality; the higher this number, the more easily the fuel ignites.
The *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.
The *Calorific value* expresses the energy content of the fuel; the higher it is, the better. For both the sulphur and carbon residue counts, the lower the values, the better.

Sources: Pramanik (2002), Prof. E. Schrimpff, FH Weihenstephan, Germany (www.jatropha.de) and Kumar et al. (2003).

Exhaust emissions from Jatropha biodiesel are comparable to the ones from diesel fuel. Kumar et al. (2003) found that CO (carbon monoxide) and HC (hydrocarbon) emissions are slightly higher with Jatropha oil and Jatropha biodiesel as compared with normal diesel, while NO (nitric oxide) is slightly lower. HC emission for diesel is 100 ppm, compared with 110 ppm for Jatropha biodiesel and 130 for Jatropha oil. In most other research on biofuel emissions, these figures are reversed, often showing lower emissions of CO and HC for biofuels as compared with normal diesel, and a slightly higher NO emission.[11]

3.3.3 Seed-cake for biogas production

Biogas can be generated from cattle dung and animal wastes, and from some crop residues. The seedcake which is left after Jatropha oil has been extracted can be used for this purpose.

The cake is converted by a process of anaerobic digestion (bacterial action in a tank without air). The Jatropha cake is placed in a digester where bacteria ferment the organic material. There should be a continuous supply of organic material (Jatropha cake) and water. The gas, comprising methane (50-70%) and carbon dioxide, is stored in a gasholder. There are different designs for a biogas facility to hold the gas; a floating dome (a moving gasholder keeps the biogas under pressure with its own weight as well as additional weights), a fixed dome (gas is collected under a fixed top which pushes the liquid slurry into an expansion chamber; gravity secures the pressure) or a bag type gasholder (gas is

[11] For example, at the Central Pollution Control Board, Govt. of India, http://cpcb.nic.in/ch30902.htm

collected in plastic bag, which is kept under pressure by squeezing the bag with a weight).

Staubmann et al. (1997) found that the biogas yield from Jatropha seedcake can be very high, with 1 kg seedcake residue (organic dry material) yielding 446 l of biogas. The theoretical total yield of gas as calculated from different substrate components would be 649 l/kg organic dry material. The nut shells from the seeds are only slightly degradable and can give about 37 l biogas/kg dry weight. About 80% of the substrate can be converted in four days, 90% within seven days (Staubmann et al. 1997).

3.3.4 Seed-cake as fertiliser

Jatropha cake has good fertiliser qualities, as Table 3 shows.

Property	*J. curcas* **oil cake**	Neem **oilcake**	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

Table 3: Nutritional analysis of oil-seedcakes and manure (percentages)

Sources: Wiemer and Altes (1989), Delgado Montoya and Paredo Tejeda (1989), 'Wealth of India 1959' in Research Group IP (2002).

In addition to the above applications, which are related to use in diesel engines (including byproducts thereof) there are some other applications for the Jatropha oil, as listed below.

3.3.5 Jatropha oil in soap-making

The process of soap-making is quite simple. The ingredients are: 1 litre of oil, 0.5 litre of water and 150 g of pure NaOH (sodium hydroxide) dissolved in the water. The oil is stirred while the water-NaOH solution is mixed in until a creamy consistency is achieved. This is poured into a form, where the soap hardens (in tropical countries overnight, in Europe up to a week). After it is hard, the soap is taken out of the form and can be cut into pieces.[12] Projects in the Philippines and other places have found the soap made from Jatropha oil to be excellent. It is a detergent soap and is also used for the elimination of scabies, Tinea pedis, acne and pimples (Aesotope, 2004).

3.3.6 Jatropha oil in lamps

Jatropha oil cannot be used directly in conventional lamps. Its viscosity (between 50 and 53 10^{-6} m^2/s, see Table 2) is much higher than that of the traditionally used kerosene (2.2 10^{-6} m^2/s). The ignition temperature is also higher (340 °C[13] vs 50-55 °C). So, Jatropha oil will not burn easily and could clog up all the tubes and nozzles in a conventional lamp (Research Group IP, 2002). This problem can be overcome by using a low-intensity lamp with a wick which has been developed in Germany.[13] The oil lamp requires a very short wick so that the flame is very close to the oil surface. It is also possible to have kerosene both to start the stove and to clean it just before it is turned off.

[12] http://www.jatropha.de/faq.htmm , accessed November 2005.
[13] www.jatropha.de, accessed December 2005.

3.3.7 Jatropha oil in cooking stoves

A conventional cooking stove (using kerosene) does not function with the high-viscosity Jatropha oil. The tubes and nozzles would clog up (Research Group IP, 2002). A Jatropha/kerosene mixture and/or an adapted stove are necessary. Research shows that a petroleum-Jatropha oil mixture used in a slightly modified kerosene stove within a room with a volume of 20 m³ produces a very high level of emissions (see Table . The report does not mention the proportion of Jatropha oil in the mixture.

	CO (mg/m^3)	NO_2 (mg/m^3)	Formaldehydes (g/m^3)	Suspended particles (mg/m^3)
Jatropha mixture	114	45	400	2.4
Open wood (concentration depends on position in room)	32-102	0.145-0.220	145-182	4.3

Table 4: Emissions from aJatropha/petroleum mixture in stove within a room with a volume of 20m^3 compared with an open wood fire in a kitchen comparable in size

Sources: Kollar (1993), Kandpal and Maheshwari (1995), Kandpal et al. (1994) in Mühlbauer et al. (1998).

While emissions of CO, formaldehyde, and suspended particulate matter are within the same range using the plant oil cooker and the open wood fire, respectively, emission of NO_2 (nitrogen dioxide) is very much higher with the plant oil burner. All these levels are far beyond the safe limits set by the WHO. The safe limits are 10 mg/m³ for CO and 60 m g/m³ for NO_2, respectively. Since cooking often takes place in poorly ventilated kitchens in developing countries, the plant oil cooker requires considerable improvement regarding emissions in order to lower the risk of health problems (Mühlbauer et al., 1998).

4 Analysis of Jatropha Biofuel Transition in Tanzania

After a short introduction to the main sources of data for the analysis and the most important actors in the field, this chapter analyses the landscape, followed by the regimes and the niches. Each section ends with a conclusion. Finally, there is a niche analysis followed by a brief summary.

4.1 Short introduction to the experiments

In order to obtain a good overview of the Jatropha-related activities in Tanzania, as many experiments as possible with Jatropha were identified. In total, 16 experiments were visited, one experiment (Kiumma) was analysed through e-mail contact, seven organisations were visited (of which three were actively executing projects), and two companies and two individuals were visited. Data on these projects, organisations and companies are given in 0. Most experiments were situated in the Arusha and Kilimanjaro region (see Figure. Other actors or projects which were analysed were situated in Morogoro, Dar es Salaam and in Tunduru in the south;. All actors were asked to identify barriers and state what lessons they had learnt and what expectations they had (see 0 for the list of questions).

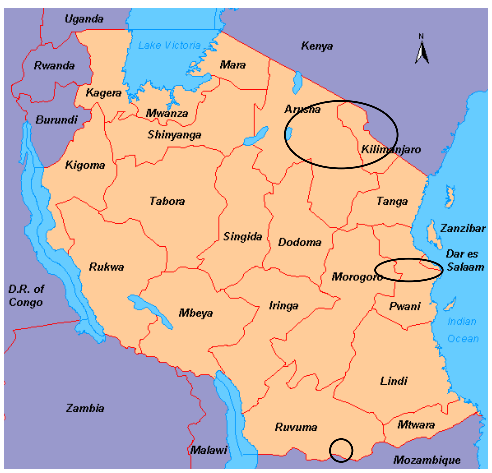

Figure 16: Location of experiments in Tanzania

The most important actor in the Jatropha field in Tanzania is *Kakute*. This is a private company (but working like an NGO), established in 1995. Its activities include several rural technologies, of which the Jatropha activities are currently the most important. The company is funded by several NGOs and organisations. It is a source of Jatropha information and is approached by individuals in Tanzania (for example, when someone wants to set up a Jatropha nursery) as well as from abroad (some have even visited Kakute from abroad for information).

Another important actor is *Diligent*, a Dutch company based in Eindhoven, the Netherlands, and Arusha, Tanzania. It has been active since 2003 and wants to become a large supplier of Jatropha oil in the European biofuel market for and/or in the Tanzanian market).

4.2 Landscape analysis

Several developments at the macro level influence the transition towards Jatropha biofuels in Tanzania.

Rise of oil price

The oil price has increased sharply during the last years and is expected to remain high or even rise further in the near future. This is due to the growing worldwide demand for oil, modest increase in economically exploitable oil resources, geopolitical instability and hurricanes, among other factors.[14] In 2003 the price per barrel of the benchmark Brent crude was under USD 25 while in 2005 it was over USD 60 per barrel. It is expected to average USD 64 per barrel in 2006.[14] Worldwide, people are now beginning to understand that they are dependent on oil, and that a rise in the oil price can be damaging to all economies. This is strengthening the movement towards sustainable energy sources.

Dependence on oil exporting countries

The dependence on countries in the (unstable) Middle East is considered to be a risk. Therefore, domestic (national) sources of energy are important for sustained economic development.

Increased environmental awareness

Due to the two reasons explained above, among others, policies to promote renewables have mushroomed worldwide over the past few years. At least 43 countries, including 10 developing ones, now have some type of renewable energy promotion policy (Renewable Energy Policy Network, 2005). There is increased environmental awareness and the Kyoto Protocol to the UN Framework Convention on Climate Change, which has been ratified by 165 countries,[15] is an example of this. The Kyoto negotiations started in 1997 and the Protocol effectively came into force in February 2005. The countries that have ratified this protocol have committed themselves to reducing their emissions of six greenhouse gases[16] with an average collective reduction of 5.2% compared with the situation in 1990. Each country has its own target, but emission trading between the countries is allowed. This means that countries which do not yet meet the limits can buy credits from countries that have limits above their production. The Clean Development Mechanism (CDM) is one of these instruments.

At a seminar on renewable energy in Dar es Salaam in September 2005, UNIDO's representative in Tanzania, Mr Felix Ugbor, said that "the timing of the seminar was appropriate because the rest of the world is warming up to the idea of renewable energy and Tanzania does not want to be left behind."[17] This confirms that in Tanzania, too, there is an increased environmental awareness.

Increasing global interest in biofuels

Although biofuels account for only a small part of the worldwide renewable energy contribution (see Figure) more and more attention is being directed towards them. The worldwide production of biofuels (bio-ethanol and biodiesel) exceeded 33 billion litres in 2004, of which 31 billion litres per year was ethanol and 2.2 billions litres biodiesel. This was 3% of the worldwide gasoline consumption of 1,200 billion litres. Furthermore, about 900,000 people worldwide

[14] http://www.eia.doe.gov/emeu/steo/pub/contents.html, accessed March 2006.

[15] As of Feb. 2006, http://en.wikipedia.org/wiki/Kyoto_Protocol, accessed January 2006.

[16] Carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, and chlorofluorocarbons (CFCs).

[17] http://www.bcstimes.com/dailytimes/printable.php?category=1&newsID=975, accessed February 2006.

are active in this sector. The biodiesel-sector grew by 25% per annum between 2000 and 2004. The production of biofuels is highest in Germany, with 50% growth in 2004. France and Italy come second and third (Renewable Energy Policy Network, 2005). The European Union is particularly active in promoting biofuels and its members have agreed on guidelines to promote them. The goal is to have biofuels comprise 2% of the total fuel supply in 2006 (in terms of energy content). The share is intended to be 5.75% in 2010.[18] The European Union is promoting biofuels in order to reduce dependence on oil imports, because of rising oil prices, and in order to reduce greenhouse gases. Biofuels can also be a means to protect agricultural jobs and will increase Europe's technological leadership in these sectors. While biofuels are attracting increasing interest, many other sources of renewable energy are being stimulated as well.

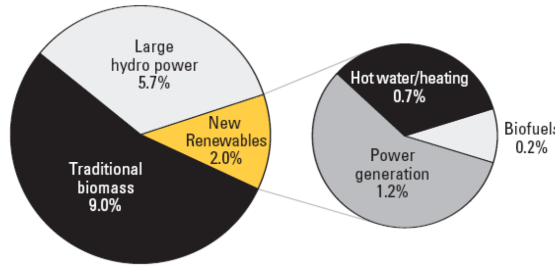

Figure 17: Share of renewable energy in global primary energy, 2004
Source: Renewable Energy Policy Network (2005).

Renewed interest in agriculture
The World bank and other organisations view agricultural development as being very important for achieving the Millennium Development Goals,[19] especially for developing or low-income countries (World Bank, 2006). Cultivating Jatropha in a developing country fits in with this perspective.

Tanzania's low GDP
Another global factor is Tanzania's GDP, which is low even in comparison with that of many developing countries. Related to this is the scarcity of foreign exchange. GDP is currently USD 26.62 billion (2005 est.) for a population of almost 37 million. GDP/capita is USD 700. In Tanzania, 36% of the population live below the poverty line (2002 est.).[20] Growing Jatropha could contribute substantially towards relieving the country's foreign exchange constraint, while at the same time boosting growth.

Tanzania imports all its diesel fuel. If Jatropha oil were to be used as a substitute for that diesel, the country would save an enormous amount of foreign exchange. For example, the import of over 465 million litres of diesel (gas oils) imported in 2002 (see Table) had a value of over TZS 465 billion (USD 423 million) at a pump price of TZS 1000 (USD 0.90). This was 4.7% of the GDP for that year (USD 8927.1 million), a heavy burden on the balance of payments. To produce 465 million litres of Jatropha oil, the country would need: 69,750 ha to 139,500 ha of land (with an assumed Jatropha yield of 10-20 tonnes/ha). The total surface area of Tanzania is about (900.000 km^2) or 90 million hectares, Of which 94.4%[21] (85 million ha) is not arable or under permanent crops. Only 0.08 to 0.16 % would have to be covered with Jatropha in order to make Tanzania self sufficient in diesel. Even partial substitution would yield big savings in foreign exchange.

[18] Guideline 2003/30/EG
[19] In the year 2000 the member states of the United Nations adopted the Millennium Declaration, which includes eight Millennium Development Goals to motivate the international community and provide an accountability mechanism for actions taken to enable human development.
[20] http://www.cia.gov/cia/publications/factbook/geos/tz.html, accessed January 2006.
[21] 2001 est. http://www.cia.gov/cia/publications/factbook/geos/tz.html

Poor infrastructure in Tanzania
The infrastructure in Tanzania is very poor. The roads are hardly sufficient for lorries, especially in very remote areas. The infrastructure for electricity is also very poor, most electricity being generated in the south of Tanzania (through hydro power) and the power lines being reliable. This results in regular power shutdowns. Jatropha biofuel can be produced in remote areas, creating an energy source which is not dependent on the current infrastructure. On the other hand, when Jatropha seed or biofuel is exported to other countries, the infrastructure is more important.

The perspective of the government of Tanzania with regard to renewable energies is described in the following section.

4.2.1 Role of the Government

The government of Tanzania is currently involved in setting up rural energy agencies. These agencies would facilitate the access of the rural population to modern energy services by providing capital subsidies to qualifying projects on the basis of established criteria.[22]

The objectives of the National Energy Policies say nothing about oil-bearing seeds or biodiesel. However, one of the objectives is "to promote development and utilisation of appropriate new and renewable sources of energy."[23] Jatropha biofuels could be viewed as an appropriate new and renewable source of energy.

The government of Tanzania is aware that an appropriate instrument for policy implementation is necessary in order to "undertake the development and efficient use of indigenous energy resources."[23] It is in the process of setting up a Rural Energy Agency (REA) which will serve as the responsible institution for rural energy development. REA will facilitate development of projects which will ultimately be owned and implemented by the private sector, NGOs and community-based organisations. A Rural Energy Fund (REF) will be established as well to provide capital subsidies in order to reduce the risk to project developers.
The Rural Energy Act of 2005 was passed by the Parliament in April 2005 to allow the establishment of REA/REF. Currently the Ministry is waiting for the President to endorse the Act and for it to be gazetted. The expectation is that REA/REF will be operational during the 2005/06 financial year, which started in July 2005. The budget has already been submitted to the Treasury.[24]

Although the government seems to be active, there is still a serious problem with corruption, which surfaced during several interviews conducted for this research. For example, Mr Malcolm, who wanted to start a large-scale Jatropha plantation for the international company D1 oils, was unable to do so because certain politicians wanted a large sum of money for long-term use of the land. Politicians were a problem, too, for Mr. Burland, who owns a large scale farm near Moshi where he also has a Jatropha plantation. He would be able to provide employment for hundreds of people if the government was willing to invest in his farm, but, according to Mr. Burland, certain politicians seem to be more interested in personal gain. Mr. Fons Nijenhuis, who is involved with Diligent in Tanzania, explained that it is very important to work with someone who knows

[22] E-mail contact with Mr N. Mwihava, Assistant Commissioner Renewable Energy, Ministry of Energy and Minerals, Tanzania.
[23] Government Policy on Rural Energy Development, document written by Mrs Justina P. Uisso, Senior Research Officer, Ministry of Energy and Minerals.
[24] E-mail contact with Mrs Justina P. Uisso, Senior Research Officer, Ministry of Energy and Minerals.

his way around at the government level. So far, the government seems to be more a barrier than an important facilitator.

4.2.2 Conclusion

The situation is quite good for a transition to biofuels. At the landscape level, renewable energy, including biofuels, is receiving considerable attention worldwide. The share of biofuels in the renewable energy market is currently very small, but an increasing number of countries are committing themselves to achieving a certain share of biofuels in their total fuel supply. This is creating a global market for biofuels, which has very positive implications for a transition in Tanzania. Tanzania could export biofuels to other countries, which is a stimulation for the cultivation of Jatropha. Agricultural development in developing countries is also a worldwide concern. The government of Tanzania is aware of environmental issues, but its position on biofuels is unclear. So far the government has been a barrier rather than a facilitator, especially when investors do not know the right people. Tanzania has enough land to be easily self supportive in fuel (at the current rate of consumption, 0.08 to 0.16% of uncultivated land covered with Jatropha would be sufficient) and could thereby save foreign exchange. Also the poor infrastructure does not have to be a barrier for a transition to biofuels, as even in very remote areas the fuel can be produced locally. However, for export purposes the poor infrastructure might be a barrier.

4.3 Regime analysis

A regime could be described as the dominant or normal way of doing things. A regime can provide room for new developments, or it can make it very hard to induce changes. Several regimes are important for the transition to Jatropha biofuel: the Agricultural regime (for the cultivation of Jatropha), the Vegetable Oils regime (production of Jatropha oil), the Energy regime (use, not only in engines but also for electricity, cooking and lighting) and finally the Financial regime (to finance Jatropha activities in each niche). These regimes are analysed in order to determine the room that the regime provides for new developments. If a regime provides considerable room, the transition towards Jatropha biofuels is facilitated by the regime.

Some cultural attitudes, about which information was derived from the interviews, are important in each regime. To quote from the respondents statements:

- People have an attitude like not trying anything new before other people in your neighbourhood have tried it. (Diligent)
- The Chagga people think they already know all there is to know and are very reserved in trying out new things. You cannot push them too hard, they slowly have to get used to it. (Fons Nijenhuis)
- The main barrier is a cultural one, according to Mr. Burland. People in the Kilimanjaro region are from the Chagga tribe and seem to lack any incentive whatsoever.
- TAF offered 2000 Jatropha seedlings free in three villages, for use as support for vanilla plants. Only a few villagers accepted the offer. (TAF)

This indicates that the cultural attitude is quite reserved, and changes will not be accepted easily. However, as activities prove to be profitable, more and more people will probably be convinced.

4.3.1 Agricultural regime

Agriculture is a very important sector for Tanzania, providing about half the GDP (GDP/capita in 2004 was USD 700) and employs over 80% of the workforce.[25] Most of it is subsistence agriculture, the harvest being meant for own consumption. The technology used is often very simple, either manual labour or animal labour. Most of the rural people are very poor, as observed earlier. This indicates that there are currently problems in the regime.

Remarks from the interviews:

- Most land in the region around Moshi (Kilimanjaro), and also in other parts of the country, is owned by co-operatives. These co-operatives consist of large groups which, for example, all help one day to harvest or to weed. According to Fons Nijenhuis, all members have to agree before a certain new crop, for example Jatropha, is adopted.
- In the Masaai tribe, land is owned by men, not by women. However, agricultural labour is often done by women, so there is a conflict. Women will be reluctant to plant Jatropha because they are not in charge. (A. Mshang)
- Traditionally, Jatropha is used to mark a grave or for its medicinal properties (TAF and T. Scheltema). Therefore, the species is known, which facilitates the adoption process although a 'graveyard' tree has negative connotations for some people (TAF). It is new for people to use it as a cash crop.
- In high-altitude areas like Monduli (1700m) it is very common to buy trees from a nursery. Plants will not establish easily at this altitude and, therefore, people often buy trees from a nursery, according to a women's group in Monduli.
- The price of coffee (which is traditionally grown in the Moshi region) has fallen dramatically on the world market; therefore people are looking for new crops. (TAF)
- In the Monduli region, many trees were chopped down during a tsetse fly infestation because people believed that the flies, which transmit a parasite that causes sleeping sickness, were hiding in the trees. (A. Mshanga)
- In the region around Moshi, sisal is often used to fence off land. While Jatropha cuttings are maturing, sisal could be planted to keep cows away from the Jatropha saplings. (Green Garden Women Group)
- Sisal is also often used as a fence and the leaves are then sold to rope-making factories.
- Euphorbia is also used as a fence. This, too, is a poisonous plant like Jatropha, but it does not need pruning. (A. Mshanga)
- Nurseries are already established for a variety of trees and plants. You see them in villages as well as in cities.
- Farmers around Dar es Salaam were very enthusiastic about planting Jatropha and selling the seeds to Diligent. Their main crop until now has been cashew, but the price of cashew-nuts has fallen and they are looking for another crop to plant.

From these remarks it appears that growing Jatropha is not radically different from current practice. People are used to planting a fence around their land and selling crops for processing into various products (for example, selling sisal leaves to rope-making factories). Even more importantly, farmers are looking for new crops because the prices of their current crops have fallen drastically. This last factor indicates that there is a vision in which problems in the current regime are

[25] 2002 est. http://www.cia.gov/cia/publications/factbook/geos/tz.html

recognised and that actors are open to 'new' solutions like, for example, planting Jatropha.

The major crops cultivated in Tanzania are maize, sorghum, millet, rice, wheat, pulses (mainly beans), cassava, potatoes, sweet potatoes, bananas and plantains. The main export crops are: coffee, cotton, cashew-nuts, tobacco, sisal, pyrethrum, tea, cloves, horticultural crops, oil-seeds, spices and flowers.[26] Most of the prices of these export crops have fallen considerably. Farmers are willing to try new crops to regain their income. Table compares the yield and income from some of the main crops (food and cash) in Tanzania and Jatropha. It is assumed is that the yield for Jatropha is between 4-8 kg/plant/year with about 2500 plants per hectare, and that the seeds can be sold for TZS 80/kg. Most Jatropha fields were in the Arusha region; the prices and yields for other crops are listed for that region only where data was available.

Crop	Average yield (kg/hectare)	Average price (TZS)	Average revenue for one hectare (TZS)
Maize (region Arusha)	1220 ('94/01)	136.70 (TZS/kg) (July'98-June'99)	166,774 (≈ €119)[*]
Wheat	1344 ('94/01)	220 (TZS/kg) ('98)	295,680 (≈ € 211)
Sweet potatoes (Arusha region)	2085 ('94/01)	100 TZS/kg (97/98)	208,500 (≈ € 150)
Banana	2585 (1994-2001)	300 TZS/kg (97/98)	775,500 (≈ € 554)
Cassava	2219 (2431 for all regions, 94-01)	125 TZS/kg (97/98)	277,375 (≈ € 198)
Cashew-nuts	Total production 2001-2002: 122 *1000 tonnes	375 TZS/kg ('93/'00)	
Sisal	Total production: 23.5 *1000 tonnes for 2001-2002.		
Jatropha (seeds)	10,000-20,000	80 TZS/kg	800,000-1,600,000 (≈€571 - € 1,143)

Table 5: Yield, prices and revenue for crops in Tanzania

Notes:
[*] TZS 1400 = € 1 (May 2005)

Sources: Basic data, agricultural sector, Tanzania Ministry of Agriculture and Food security. http://www.agriculture.go.tz/MAFS-Services/Statistics.htm (chapter 1 and chapter 2) and http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/004/w9479e/w9479e00.htm

Table 5 indicates that using Jatropha as a cash crop (selling the seeds) is very profitable, and the revenues are higher than for the traditional crops. The main difference between cultivating Jatropha and other food or cash crops is that Jatropha does not have to be replanted every season (it can live up for to over 50 years) and can be harvested only after one to two years. This requires more long-term thinking, unlike for crops that need to be replanted each season. When a system of intercropping is used, farmers can still keep planting other crops.

[26] http://www.tanzania.go.tz/agriculture.html, accessed November 2005.

Jatropha can be grown on uncultivated land, which means that it not compete with food crops. Of the total surface area of Tanzania (900,000 km^2), 4.53% is arable land and 1.08% is used for permanent crops. This indicates that a large of amount of land is not yet cultivated.

In most cases, food crops are sold in the market – this is true of 59% of rural households in Tanzania. The majority of the holdings (31%) sell their produce to private business persons. An agricultural survey conducted in 1997/8 (National Bureau of Statistics, 2000) found that 29% of the holdings faced several marketing problems: low prices, poor roads, transport difficulties, lack of a market and no grain bags.

It is not (yet) normal practice to sell Jatropha seeds in a market. The seeds are collected by either Kakute or Diligent. This is comparable to the current system of private business persons buying agricultural produce from farmers. When the quantity of Jatropha seeds becomes much larger, collecting the seeds might be more difficult. So a system for trading the Jatropha seeds could be expanded in the future. Poor roads, transport, lack of a market and lack of grain bags are also important factors to take into account for Jatropha trading.

Overall, the agricultural regime seems to provide enough room for new developments. Problems in the current way of doing things are recognised (farmers are looking for new crops) and the differences between the current way of doing things and starting to cultivate Jatropha seem to be minimal. However, there are certain risks associated with the long-term nature of the investment required for Jatropha cultivation (less flexibility than with seasonally planted crops). Several systems – such as, for example, intercropping – could reduce this risk. The transition towards biofuels in Tanzania, in which the first stage – cultivation – is very important, does not seem to be held back by the agricultural regime. Because the cultural attitude is quite reserved it will take some time (and a couple of good, profitable examples) before the farmers are convinced of the value of this relatively new crop. This is the lesson from the free seedlings given by TAF. While not all villagers accepted them, some farmers became very enthusiastic when Diligent told them how much they could sell the seeds for. This indicates that at least a portion of the farmers are willing to try this 'new crop' and their success could motivate others.

4.3.2 Vegetable oil regime

There is some overlap with the agricultural regime here, but in addition to being grown and harvested, an oil-seed crop also has to be processed to obtain vegetable oil. Therefore this is a separate regime.

Lesson from the interviews

- Because it is poisonous, it is hard to find people who want to press the seeds. It's better to tell them the seeds are not for human consumption than to tell them they are poisonous because they get scared. (Diligent)

The ISIC classification (revision 2) has a separate number for Vegetable and animal oils and fats (3115). The annual Survey of Industrial Production (2003) mentions that in Tanzania there were 31 establishments in this industry in 1996 and 32 in 1999. The number of employees grew marginally from 2626 in 1996 to 2938 in 1999. So there is very limited growth in this industry.

The 'traditional' oil-seed sector can be divided into two sections; industrial and edible oil-seeds. An example of an industrial oil-seed is the castor-oil seed. Examples of edible oil-seeds are sunflower, groundnut (also known as peanut), sesame, coconut, cottonseed and soya bean. These seeds have shown irregular production trends, mainly due to low producer prices and the collapse of domestic export and marketing systems.[27]

The main crops used for oil production in 1997/98 are listed in Table . Groundnuts and cashew-nuts were the principal oil crops, with 41% and 32% of the area under oil crops being covered by them respectively.

Type of oil crop	Planted area (ha)
Groundnuts	202,343
Cashew-nuts	157,505
Sunflower	80,676
Coconuts	33,435
Simsim	20,794
Other	4,125
Total	498,878

Table 6: Distribution of planted area by oil crop

Source: National Bureau of Statistics (2000: 20)

It is not unusual in Tanzania for an oil facility to be owned by a co-operative. Farmers take their seeds there and have them pressed for a fee. This is the case at the Vyahumu Trust in Morogoro, (see sub-section 4.4.2). So the current practice is not very different from what is required for the production of Jatropha oil. However, there is a substantial barrier within this regime for Jatropha because Jatropha is poisonous. Few processing firms are willing to use their equipment to press both edible seeds as well as a poisonous seed. Therefore, room for new developments within this regime seems to be quite low. For a transition towards biofuels in Tanzania, it might be necessary to develop new oil-expelling facilities that are specifically dedicated to pressing Jatropha seeds.

4.3.3 Energy regime

The most important source of energy in Tanzania is biomass, especially for people in rural areas. Some biomass is converted into charcoal and sold in commercial markets. Of the total energy consumption in Tanzania, 93% is derived from biomass. This mainly consists of fuelwood and charcoal, a smaller percentage is derived from agricultural and forestry waste and dung. Fewer than 8% of households in Tanzania are connected to the electricity grid. Energy purposes vary from fuelling engines, cooking and heating to lighting.

Table shows the projected consumption of various fuels in Tanzania is given. The demand for energy is expected to rise in the future so the potential for biofuels is quite high.

[27] http://www.agriculture.go.tz/Agr-Industry/Crops-grown-tz.htm#Pyrethrum, accessed December 2005.

Fuel Type	1990	2000	2010	2020
Oil products	729.4	1028.3	1655.7	2707.5
Coal	82.26	134.0	206.0	317.0
Wood fuel*	9000.00	11862.0	16420.0	22,729.6
Natural gas**	00	153.0	226.4	226.4

Table 7: Projected consumption of various fuels, in '000 MT

Notes:
*Units in tonnes of oil equivalent
** Units in millions of cubic metres

Source: Meena and Mwandosya (1996)

The use of these 'traditional' sources of energy creates many problems. The use of wood fuel causes deforestation and hence soil erosion. Both are quite severe in Tanzania: the deforestation rate in 2001 was 250,000 hectares per annum.[28] Furthermore, health is severely affected by the use of fuelwood and kerosene for cooking and lighting. Rooms are often badly ventilated and without chimneys, which leads to a buildup of smoke indoors.

Several renewable energy options are available to avoid the problems related to the use of these traditional energy sources (see Table 8.

Energy Services	Renewable Energy Applications	Conventional Alternatives
Cooking (homes, commercial stoves and ovens)	• biomass direct combustion (fuel wood, crop wastes, forest wastes, dung, charcoal, and other forms) • biogas from household-scale digester • solar cookers	LPG, kerosene
Lighting and other small electric needs (homes, schools, street lighting, telecom, hand tools, vaccine storage)	• hydropower (pico-scale, micro-scale, small-scale) • biogas from household-scale digester • small-scale biomass gasifier with gas engine • village-scale mini-grids and solar/wind hybrid systems • solar home systems	candles, kerosene, batteries, central battery recharging, diesel generators
Process motive power (small industry)	• small hydro with electric motor • biomass power generation and electric motor • biomass gasification with gas engine	diesel engines and generators
Water pumping (agriculture and drinking)	• mechanical wind pumps • solar PV pumps	diesel pumps
Heating and cooling (crop drying and other agricultural processing, hot water)	• biomass direct combustion • biogas from small- and medium-scale digesters • solar crop dryers • solar water heaters • ice making for food preservation	LPG, kerosene, diesel generators

Table 8: Common existing applications of renewable energy in rural (off-grid) areas
Source: Renewable Energy Policy Network (2005)

The main projects that are promoted, according to the Tanzania Country Assessment of 2001, are biogas production for cooking, improved technologies (cooking stoves and kilns), solar thermal applications for water heating and cooking, and solar and wind technologies. The Tanzanian government has, for example, decided to reduce the tax on solar panels. However the Country Assessment also states that very few attempts have been made to utilise wind and solar energy. The main problems are:
- a poor payment record
- low awareness and lack of confidence in renewable energy technologies
- high investment requirements in relation to the low purchasing power of the target groups

[28] http://www.areed.org/country/tanzania/tanzania.pdf accessed February 2006.

- weak institutional framework and infrastructure for effective promotion and support
- lack of financing mechanisms to provide credit to potential users.

A biofuel like Jatropha oil could be used for all the energy services listed in Figure 18. The different applications within the energy regime will be analysed separately. These are: use in diesel engines, for electricity, lighting and cooking. Electricity can be used for all the other applications but is treated separately because the infrastructure is very different from that of the others.

Diesel engines

Diesel fuel is used for transport (in cars and trucks), in agricultural equipment such tractors, and in diesel generators. Most rural people do not own vehicles, nor do they have agricultural equipment requiring fuel. They often rely on public transport such as dalla-dalla's (taxi-vans) or on private persons who do own vehicles. Also, trucks in Tanzania use diesel fuel, which has to be transported a long distance from the harbours. In big cities like Dar es Salaam, there is high demand for fuels because of the volume of traffic.

- The price of diesel fuel in Dar es Salaam rose to TZS 1090 and TZS 1100 per litre in August 2005. (Rik Luiten)

Currently diesel fuel and gasoline are used as transportation fuel. All fuels are imported. Table lists Tanzania's diesel oils imports between 1998 and 2002.

year	Distillate fuels: Gas Oils (GO) (l)	Distillate fuels: Diesel Oils (IDO, Industrial diesel oils) (l)	Light oils and preparations: motor spirit (Regular)	Light oils and preparations: motor spirit (Premium)	Medium oils and preparations: illuminating kerosene (l)
1998	317,633,113	60,192,929	3,769,763	118,952,760	122,535,993
1999	519,627,730	21,552,735	999,679	156,104,969	141,441,143
2000	513,682,796	27,488,877	31,202	179,412,478	138,216,276
2001	423,294,177	29,137,233	10	137,484,979	126,652,542
2002	465,177,996	14,870,931	128,117	148,100,158	154,702,808

Table 9: Import of petroleum products by Tanzania, 1998-2002

Source: TRA

Diesel engines would have to be modified to run on Jatropha oil (for example, installation of a two-tank system or a change of nozzles – see section 3.3). Since vehicle manufacturers do not provide vehicles with such modifications, there would be an additional cost for vehicle owners, leading to considerable resistance as people in Tanzania are quite poor. Another barrier to the transition is that technical knowledge is required to make the modifications.

When Jatropha oil is converted into biodiesel before being used, vehicles require almost no modification (only the fuel hose need to be resistant to biodiesel). The University of Dar es Salaam, in co-operation with Eindhoven University of Technology, the Netherlands, is starting a research project to study the effects on the engine when biodiesel is used. Jatropha oil could also be mixed with normal diesel fuel and sold at gasoline stations; people would not even know they were driving on biodiesel. Resistance against this new development could therefore be anticipated to be low were a mixture to be used.

Electricity
Petroleum, hydropower and coal are the major sources of commercial energy in Tanzania. The electricity sub-sector contributes about 0.6 per cent of total energy consumption (Tanzania Country Assesment). Two thirds of Tanzania's installed capacity is hydro powered. Rural areas often have no electricity. Even in the larger cities, power shutdowns are very frequent and consumers have to use diesel generators as a backup source. The room for niches in this regime is quite large, as villagers are often interested only in how much electricity they can get and what equipment they can connect to it; how the electricity is generated – from solar panels, biodiesel or another source – is not an issue. Also, electricity is often generated for more than one household, so the maintenance of the equipment can be shared. This increases the likelihood of of the equipment having a long lifespan. However, equipment maintenance requires some technical skills.

Lighting
The fuel in oil lamps is mostly kerosene. Other sources of lighting are candles, torchwood, batteries, solar electricity, and grid electricity. However for more than 90% of low-income households, kerosene is the light source of choice; in rural areas, this figure is almost 100%.[29] There is a fairly well-established distribution network. Kerosene is imported by private oil companies, and sold at gasoline stations. This facilitates its use by low-income urban and rural households.[30]. A rural family spends about TZS 3000 per month on kerosene.

The price of kerosene keeps rising: it was TZS 426 per litre in 2002, TZS 505 in 2003[31] and TZS 850-980 in 2005.[32] All kerosene in Tanzania is imported and the quantity keeps rising as well. In 1998 Tanzania imported 122,535,993 litres of kerosene; in 2002 this figure had risen to 154,702,808 litres (see Table. This would seem to indicate a large potential market, with additional savings in foreign exchange, if Jatropha oil were to be used for lighting.

Jatropha oil can be used in diesel generators to generate electricity, which can then be used for lighting. It is also possible to use Jatropha oil directly in oil lamps. However, the oil can only be used in lamps especially made for it. The Jatropha oil lamp costs TZS 1700, and Jatropha oil TZS 2000/l; this is higher than the price of kerosene. People are habituated to using kerosene whereas Jatropha oil is not only a new fuel, it also involves using a different type of lamp. The price of Jatropha oil is very important in deciding whether the room for new developments in lighting is high or low. At the current price of TZS 2000/l, people are unlikely to be enthusiastic about a transition to Jatropha biofuel.

Cooking
The dominant energy source for cooking is fuelwood. In the year 2000, households in sub-Saharan Africa consumed nearly 470 million tonnes of wood fuels in the form of wood and charcoal. This is far more than on any other continent. For 94% of the rural households (41% of urban) in sub-Saharan countries, wood or crop residues are the primary source of energy. Charcoal is the primary source for 4% of rural households (34% of urban), and kerosene for 2% of rural households (13% of urban) (Renewable Energy Policy Network, 2005). Table shows the average monthly consumption of various types of energy

[29] http://www.hedon.info/goto.php/TanzaniaCountrySynthesis, accessed July 2005. This information is based on KAALE and HIFAB (1998), who conducted a rural energy study.
[30] Ibid.
[31] http://www.tanzania.go.tz/economicsurveyf.html, accessed July 2005. Development in different sectors of the economy.
[32] Price in Dar es Salaam on 28-7-2005 (at different gasoline stations).

in Mwanga district, along the highway between Dar es Salaam and Arusha. The figures were derived from interviews in the district by Harry Kuipers.

Energy source	Consumption hh/month
Fuel wood (kg)	230
Charcoal (kg)	25
Kerosene (liter)	5
Electricity (kWh)	n.a.

Table 10: Average monthly energy consumption per household (hh), Mwanga District

Source: Kuipers (2004)

Jatropha seedcake can be used to produce biogas for cooking. In addition, Jatropha oil can be used directly in modified cooking stoves.

Several relevant remarks emerged from the interviews:

- The price of charcoal is TZS 3000 for a bag which can last two weeks; however, the majority in this village use fuelwood, which is collected free. (women's group, Engaruka)
- Charcoal, kerosene and wood fuel are used instead of Jatropha oil in cooking stoves. (Green Garden)
- Although biogas (Jatropha) was available to the Monduli women's group, they were cooking with firewood. When asked why they did not use the biogas stove, they said they only use this during the rainy season when firewood is not easy to find. However, the technical properties of the biogas installation were not very good. (Monduli)
- A charcoal stove costs TZS 15,000. Another alternative energy source for cooking is briquettes made from sawdust. There is a small factory at KIDT in Moshi, which currently sells these briquettes only to schools that were provided with a briquette stove earlier. (KIDT)
- A Jatropha cooking stove costs TZS 12,000-20,000. (Green Garden, KIDT)
- A (Jatropha) biogas cooker costs TZS 10,000. (Monduli)

Several NGOs are actively spreading more efficient cooking stoves. TaTEDO, for example, has provided several households with improved cooking stoves. And Kakute is providing several groups with a biogas system. However, from an interview with a women's group it appears they are not used with enthusiasm. This indicates there are some alternative energy sources available for cooking purposes.

Some (health) problems are recognised by this regime, but they are mainly recognised by NGOs, not by the local people. Especially from the remarks in the interview it appears that the dominant cooking regime is quite strong. People are not satisfied with a system which increases the cooking-time, even if their health would be improved. So a new fuel should meet their demands precisely.

Overall, the current energy regime faces many problems, ranging from lack of availability to health issues. Many sources are used for the different purposes in this regime; they vary from wood fuel to kerosene and solar panels. There does not seem to be a very strong dominant energy regime; as many (rural) people lack energy sources, fuelwood is used most often, mainly for cooking. There is room for new developments as the many initiatives by NGOs for improved stoves show, but the users do not seem to be willing to compromise on their demands for a fast and cheap fuel. Using Jatropha oil in a mixture with normal diesel fuel requires the least modification to the engines, so this option is most likely to be facilitated by the current regime. Also, the use of Jatropha biofuel to generate electricity will probably arouse little resistance. For cooking purposes, the room for new developments seems to be quite low.

4.3.4 Financial regime

Households in the rural areas do not have much money; they spend less than half of what a household in the city Dar es Salaam spends (see Table. Any additional income is welcome, and every extra cost, for example, for cooking fuel, will not be accepted easily.

Measure	Dar es Salaam	Other urban areas	Rural areas	Mainland Tanzania
Mean expenditure per capita	21,949	14,377	8,538	10,120
Median expenditure per capita	16,349	11,561	6,860	7,523
Mean expenditure per household	117,893	78,079	52,649	59,935

Table 11: Average consumption expenditure levels in 2000/01 (28 days, TZS, nominal prices)

Source: Household Budget survey 2000, http://www.tanzania.go.tz/hbs/HomePage_HBS.html, accessed December 2005.

In rural areas the interest the loans is often quite high and loans are not given easily. However, several new systems have been developed and small microcredit loans are given to, frequently rural, people who often have a very high repayment rate. For example, in one system a group receives a loan and all members are responsible for the repayment. In another system, each member of a group contributes a small amount per week to a group savings fund; once a week in turn, one of the members receives the amount that all the members have saved. Usually the amounts are quite low, but the members can use the money, for example, to pay school fees. According to Mrs. Coutinho, the director of FINCA, a microcredit organisation (see 0) the cost of going from a rural area to the bank regularly to repay the loan in instalments is very high. Therefore, it is difficult for rural people to get a loan. Furthermore, she said, most women in Tanzania are shy and afraid to enter the premises of a microcredit organisation or a bank. When a microcredit is obtained from FINCA, (its focus is mainly on rural areas and women) the loan size varies between USD 500 and USD 5000, depending on the scale of the business and the collateral. The average repayment time is 12 to 18 months. For a USD 500 credit, for example, a refrigerator and a TV could serve as collateral. A business plan is required for a loan, but FINCA can send a research team to help with this. Kakute has a link with a microcredit facility, which has given some farmers in Engaruka loans of TZS 50,000- 100,000 or TZS 500,000.

Last year (2005) was declared 'the international year of microcredit;[33] this indicates a change in the regime towards more awareness and initiatives to provide these credits. Overall, there is a tension in this regime towards rural people who hardly obtain any loans. But new developments towards microcredit and the support of rural people shows that the regime could facilitate a transition towards biofuels.

[33] http://www.yearofmicrocredit.org/, accessed February 2006.

4.3.5 Conclusion

The culture of Tanzanian people creates barriers because they seem to be somewhat sceptical about new technologies.

The agricultural regime in Tanzania seems to be open to a transition towards biofuels. The current regime is not very different from the cultivation of Jatropha, although Jatropha could require more long-term investments than other (cash) crops. Problems are recognised in this regime, as farmers are already looking for new crops in view of poor revenues from existing ones. However, some farmers will probably wait to see the results of cultivation of Jatropha on other farms.

The vegetable oils regime shows that people are already used to oil-expelling facilities. However, Jatropha oil is poisonous and this could be a barrier to the use of existing facilities.

The dominant regime for energy is quite complex. In rural areas, the energy sources are mostly wood (fuelwood or charcoal). Energy purposes vary from using fuel in engines to electrification, lighting and cooking. Switching to Jatropha biodiesel or a mixture of Jatropha oil and diesel fuel would seem to have potential. These fuels do not require extensive engine modifications, so they would be more in line with the current regime than using Jatropha oil in its pure form. Electricity (which can be generated with Jatropha biofuel) is often not yet available in most Tanzanian villages, but electricity could be used for lighting as well as cooking and would raise the standard of living. Kerosene is used mostly as a source of lighting. Its comparatively low price does not encourage the use of Jatropha oil as a substitute. Finally, changing cooking habits seems to be quite difficult.

There are already many alternatives in this regime. There is room for a transition, but user preferences are very important.

In the current financial regime, it is quite difficult for rural people to obtain a loan (for example, to purchase an oil press). But there are organisations, like FINCA or NGOs, from which it is possible for rural people to acquire a (small) loan. The room in this regime for new developments seems to be increasing. When microcredits are more easily accessible to rural people, there will be a positive influence on the transition.

4.4 Niche analysis

Several niches will be analysed. At the end, an actor network overview will be given for all the niches together as there is some overlap between them (see Figure 26: Actor network of Jatropha projects inTanzania, according to information given by actors. Each niche offers potential for actors to start activities. The niches analysed in this section are derived from the interviews and communications during the fieldwork in Tanzania (see 0 for a detailed description of each experiment or interview).

The Jatropha production chain consists of three separate stages: cultivation, production and usage (as was illustrated in Figure 13. Experiments in the second and third stage, production and usage, need the input of the previous stage. Some experiments contain more than one step of the Jatropha chain. Soap-making activities can, for example, also consist of growing the Jatropha and expelling the oil. Related lessons from these experiments are placed in their separate niche.

For this thesis, only the niches that were related to actors and activities in Tanzania were analysed. The niches are:

Cultivation

- Jatropha cultivation (additional income is acquired by selling seeds or seedlings/cuttings)

Production

- Jatropha oil production (in an oil-expelling facility)

Use

- Jatropha oil used as substitute for diesel fuel
- Jatropha cake used in a biogas facility
- Jatropha cake used as fertiliser
- Jatropha cake pressed into briquettes (no data)

Other applications for Jatropha oil

- Jatropha oil used as basis for soap-making
- Jatropha oil used in oil lamps
- Jatropha oil used in cooking stoves
- Jatropha plants used as support for vanilla plants(no data)

The three main niche processes, as explained in Chapter 2, are: network formation and stabilisation (actor network composition and network dynamics); learning processes; and formation and voicing and shaping of expectations (dynamics of expectations). These three processes will be described for each niche. Each niche will also be given a short introduction, an economic analysis to determine the financial feasibility, and a conclusion.

4.4.1 Cultivation

Farmers can create extra income by selling Jatropha seeds or seedlings. Jatropha seeds can be harvested about two years after planting. The Jatropha plant can be harvested twice a year when nourished properly (with water and nutrients). There are several ways in which Jatropha can be planted; for example, on a small scale as a fence along the farmer's plot or on a larger scale in a plantation setting with or without intercropping. It is also possible to pick seeds from Jatropha growing 'wild' or to sell small Jatropha seedlings from a nursery. All these methods are practised in Tanzania.

Introduction

Currently Kakute and Diligent are paying farmers for seeds, and both are encouraging farmers to grow more Jatropha. Diligent, however, is stimulating the farmers on a much larger scale. The data in this application-domain are collected from about nine different experiments. They are: Kikuletwa Farm – data from Peter Burland in TPC (near Moshi, this farm has Jatropha and Aloë Vera); the Brotherhood of Jesus the Good Shepherd in Hedaru (they grow Jatropha on a small scale and intend to use the oil as a diesel substitute); and farmer Ismael Manang near Arusha, who is going to deliver seeds to Diligent. Several farmers and villagers around Arusha, Dar es Salaam and Selela/Engaruka are also going to deliver seeds to Diligent. Furthermore, data were obtained from a women's group in Monduli, who sell seedlings from a nursery (the members also use biogas made from Jatropha) and individuals like Bukaza Chachage (who wrote a thesis on Jatropha oil in Tanzania), Doherty Malcolm (who was about to start a large-scale plantation for D1 oils two years ago), Mr. Sawe (director of TaTEDO), the director of Kakute and finally field officers of Kakute.

Network formation and stabilisation

Actors

- Kakute (supervision, management, seed trader)
- Diligent (supervision, seminar training, seed trader)
- Seed/seedling suppliers (Peter Burland, Brotherhood of Jesus the Good Shepherd, Ismael Manang, farmers around Arusha and Dar es Salaam, women's groups in Monduli and Engaruka, villagers in Selela, more farmers in future)
- Research institute; Sokoine University of Agriculture
- Other interested parties: Harry Kuijpers, Mark van den Bosch, Malcolm, Bukaza Chachage, NGOs like TaTEDO, Faida MaLi, etc.

The women's groups are involved through Kakute, Peter Burland from Kikuletwa Farm has acted as an individual and farmer Ismael Manang and several other farmers and villagers have been encouraged to grow Jatropha by Diligent. Harry Kuijpers and Mark van den Bosch came into contact with Diligent as well (through connections at the TU/e with Kees Daey Ouwens) and have started to encourage Brotherhood of Jesus the Good Shepherd. Kakute also provides technical assistance: two field officers are visiting the groups and explaining how, for example, they can set up a nursery. They also act as traders, buying oil or seeds from one women's group and selling them to another group. Diligent is stimulating farmers and villagers to grow Jatropha by guaranteeing them a fixed price for the seeds. It has provided interested villagers and farmers with free seeds and is also organising seminars to make farmers and villagers aware of the guaranteed price for Jatropha seeds sold to Diligent.

Dynamics
The number of actors in this part of the chain is increasing. More and more farmers are planting Jatropha. Large players like Diligent are also growing. One group of farmers even came all the way from Dar es Salaam to talk with Diligent about planting Jatropha. Several NGOs are involved due to connections with Kakute; in addition, other NGOs are focusing more on biofuels while the possibility of using them as an alternative fuel continues to gain interest worldwide. TaTEDO, for example, wants to create a strong network/Jatropha sector, according to the director, Mr. Sawe. People or organisations that are interested in Jatropha in other countries also come to Kakute for information on how Jatropha should be managed. Kakute, in turn, collects this information from women's groups or individual farmers like Peter Burland. So far little research institutes are involved in studying Jatropha in Tanzania. There are reports that a research project is starting at Sokoine University of Agriculture in Morogoro.

Economic analysis

<u>Picking seeds</u>
About 2 kg of seeds can be picked in one hour; this equals a revenue of TZS 160/hour. A seed picker working eight hours a day would earn TZS 1280/day, which is quite reasonable (a rural worker earns about TZS 10,000 a month, according to Henning, 2004).

<u>Planting Jatropha</u>
Detailed calculations on each project are given in 0. Table summarises the economic analysis of five running projects. All of the projects are making a profit from Jatropha, albeit in a protected environment. The first three projects in the table, Kikuletwa Farm, the Brotherhood and farmer Ismael Manang, have started either large or small plantations of Jatropha and their object is to make a profit by selling the seeds. The other two projects in the table do not have plantations; the villagers of Engaruka simply pick seeds from Jatropha growing wild and from planted Jatropha fences. In Monduli, the women's group sells Jatropha seedlings which its members grow in a nursery.

The calculations are made with an assumed yield of 4 to 8 kg of seeds per tree per year[34] and 2500 trees per hectare (about 1000 per acre). This yields about 10 to 20 tonnes per hectare. The assumptions for Kikuletwa Farm and farmer Ismael Manang are slightly different; the *reported* yield at Kikuletwa Farm (the farm is already productive) is 4-5 kg/plant/harvest, which results in a yield of 8-10 kg per plant/year. So this yield (20-25 tonnes per hectare) is used for Kikuletwa Farm. Farmer Ismael Manang has planted 1225 trees per acre instead of 1000, so a yield of 11-23 tonnes per hectare is used for him.

The price for which seeds can be sold varies with the buyer. So far only Kakute and Diligent have showed interest in buying the seeds from individuals, farmers and/or groups. While Kakute is working like an NGO and is supported and sponsored by several funds and organisations, the price Kakute pays is higher than that paid by the commercial company Diligent. Kakute is currently paying about TZS 150/kg for Jatropha seeds and Diligent is paying TZS 80/kg.

Farmer Ismael Manang is going to supply seeds to Diligent; therefore, he will sell them for TZS 80/kg, the same price paid to Engaruka villagers and Kikuletwa Farm. The Brotherhood has not yet decided to whom it will sell the seeds and therefore both prices are used in the calculations (low estimate with low yield and low selling price, high estimate with high yield and high selling price). The seedlings in Monduli are sold for TZS 50-00/pc.

Other assumptions:

- Constant prices
- Real discount rate (r): 9.8%, calculated by using inflation (p) of 4.4% and the average interest rate (i) on medium- and long-term loans in 2003, which was 14.6%[35], in the formula: r=(1+i)/(1+p)-1.
- Project running time: 5 years
- Yield of seeds for plantation (Kikuletwa, Brotherhood and Ismael Manang): harvest starting after 2 years, in 3rd year yield of 50%, in 4th year 75%, 5th year 100%. So there is no income from Jatropha in the first two years.
- Decision positive when: NPV>0, IRR>real discount rate (9.8), BCR>1

All figures are quite positive, only the low estimate for the Brotherhood does not have positive figures. Kikuletwa Farm and Ismael Manang, particularly, earn a very high profit. However, for various reasons, there are some differences between the figures for the projects.

A large difference between the projects is the scale; Mr. Burland's Kikuletwa Farm is working with 200 hectares (494 acres), Mr. Manang is working with 80 acres, while the Brotherhood is so far working with only one to three acres. This creates large differences in the cash inflow after the plants start producing. The larger the surface covered with Jatropha, the more the cash inflow.

[34] Diligent's estimate is a minimum of 2kg/year per plant. Kakute's experience is a yield of up to 6 kg/year per plant and Mr. Burland's experience is 8-10 kg/year per plant. The calculations here are made on the basis of an output of 4-8 kg/year to limit the range.

[35] http://www.tanzania.go.tz/economicsurvey1/2003/part1/financeinstitutions.htm, accessed August 2005.

Project	Kikuletwa	Brotherhood	Ismael Manang	Engaruka Village[36]	Monduli
Size of plantation	200 ha (494 acres[37])	1 acre (3 acres after 2 years)	80 acre (33 ha)	300 bags/season, 60 kg per bag (2-4 acres)	10,000 seedlings
Investment costs for first 2 years	22,000,000 ($20,000)	1,577,500 (≈$1,430)	1,878,500 (≈$1,700)		
Forecast of cash inflow/year after 5 years	318,850,000 to 398,850,000 ($289,864 to $362,591)	At max: 184,000 to 2,824,000 ($167 to $2,567) If they don't expand to 3 acres: ($ -415 to $ 385)	31,346,800 to 62,706,800 ($28,497 to $57,006)	2,880,000 ($ 2,618)	500,000 to 1,000,000 ($455 to $909)
NPV	511,000,745 to 644,660,146 ($464,546 to $586,055)	-2,405,343 to 878,294 (-$2,187 to $798)	50,486,760 to 102,881,245 ($45,897 to $93,528)	12,054,828 ($10,959)	1,592,852 to 3,185,704 ($1,448 to $2,896)
IRR	315% to 359%	## to 26%	262% to 384%	-	-
BCR	22 to 28	from 0.3 to 1.3	27 to 55	- (96 when 30,000 costs each year for bags)	-
PBP	between 2 and 3 years	>15 to 4/5 years (∞ to 7/8 years at 1 acre)	between 2 and 3 years	0	0

Table 12: Economic analysis of several projects. Prices in TZS where not specified as USD ($)[38]

Other differences in the table are due to the necessity or otherwise of investments. Establishing a plantation entails investment and costs and the plants take some time to mature. However, the Engaruka villagers, for example, do not need to invest money to grow Jatropha. Jatropha is indigenous in the region, so they can pick seeds from the wild plants and grow more Jatropha along their fields. If the villagers used their cultivated land for Jatropha plantations, there would be the costs of ploughing, weeding, harvesting, and so on (higher opportunity costs).

Another difference is the way the Jatropha plantation is managed. Kikuletwa Farm uses a system with intercropping, therefore there are no labour costs for weeding and irrigation. The Brotherhood has hired one person who is in charge of the Jatropha full-time. The drive to the area where the Jatropha is grown requires

[36] Data derived from expectation of village ward in Engaruka (see Engaruka women's group in Appendix II)
[37] 2.4 acres = 1 hectare
[38] USD 1 $ = TZS 1100

diesel fuel. Farmer Ismael Manang was able to provide a detailed list of the expenses for his Jatropha plantation (see Table 13).

Expenses per acre first year	TZS
* Pegs (sticks) 140 pieces (cost is for labour, pegs are made from wood)	1000
* Paint (for the pegs) ½ litre	450
* Painting of pegs, labour charge	1000
* Seed sowing	1000
* Seeds 35x35=1225 (2 per hole) x2=2450 no charges yet	
* Diesel for tractor 6,5 litres to dig trenches	6500
* Survey team: 1 supervisor + 4 people 3200+1000 TZS	4200
* Weeding 3 times a year (2 times spot-weeding, once complete weeding) 4000 TZS for complete weeding, 2500 for spot-weedingx2=5000	9000
* Equipment: brush (1000,-), tape measure (6000,-), hammer (5000,-), sisal rope (2500,-), Panga (machete to clear the area) (3000,-), total: 17,600 for 80 acres, per acre:	220
Total per acre	23,370
Total 80 acre	1,869,600
Expenses for 2nd year	
Weeding	9000
Expenses for 3rd year to η year	
Weeding	9000
Picking seeds	4500
Total	13,500

Table 13: Jatropha expenses of Ismael Manang

None of the projects required a loan for starting the activities. Those who undertook the projects either already had a business from which they could obtain the money, or they were sponsored by a third party. This means they all were able to survive the first two years during which a Jatropha plantation does not provide an income. Some small farmers who want to start a Jatropha plantation would, of course, need a loan and the economic analysis would than be not as positive, depending on the size of the loan.

The Monduli women's group had already established a nursery for several species of trees and plants. Jatropha only had to be added, therefore their investment costs were very low. Also, the members do not depend only on Jatropha for their income since they still sell other seedlings. The Jatropha income should be seen as additional revenue. The same applies to the villagers of Engaruka; they are still carrying on their own business, but pick the seeds to add to their income.

To summarise, the differences between the projects are: the price obtained for seeds, the scale of the plantations, the investment and maintenance costs, and the predicted yield of Jatropha seeds.

Sensitivity analysis

Even if the calculations for Kikuletwa Farm are made with the same estimates for the yield as the other projects (4-8 kg in stead of 8-10 kg/plant/year) all economic parameters are still very good. The NPV ranges from 243,681,943 (USD 221,529) to 511,000,745 (USD 464,546), the IRR ranges from 204% to 315%, and the BCR ranges from 11 to 22.

The Brotherhood breaks even: 2.4 acres (2400 plants). If calculations are made with a selling price of TZS 80 in the high estimate (instead of TZS 150) the PBP is slightly longer, five to six years, the IRR is -18% and the BCR ranges from 0.3 to 0.7 (it should be more than 1). The cash inflow at maximum (this is after six years, when all three acres are fully established), will be USD 1,040 annually. So the Brotherhood will still make a profit by selling the seeds for TZS 80; but the economic parameters will, of course, be much lower.

Ismael Manang was able to provide the most detailed and complete picture of all the costs on his farm. A sensitivity analysis for his farm is summarised in Table.

	Yield 1 kg/plant/yr	Cash outflows doubled	Price for seeds halved
NPV	11 million TZS (about $10,000)	48.5-100 million TZS (about $44,000-91,000)	24-54 million TZS ($22,000-46,000)
IRR	112%	175-262%	175-262%
BCR	7	14-27	14-27

Table 14 Sensitivity analysis for Ismael Manang

When the yield is changed to a very low estimate of 1kg/plant/year, the results are still positive. After five years he would still make a profit of at least USD 7,115 a year (USD 4,901 if discounted). When the yield is lowered to 0.15 kg/plant/year the BCR is 1 (and the IRR is 11%). When the cash outflows are doubled, the results are still positive. The low-yield estimate has a BCR of 1 (and IRR of 10%) when the cash outflows are 27 times as high. When the price for the seeds (TZS 80/kg) is halved to TZS 40/kg only the NPV changes in relation to the double cash flows. At a price of TZS 3/kg, the low-yield estimate has a BCR of 1 (IRR 11%).

Learning processes

Cultivation of Jatropha

- The ground should not contain left-over roots from other crops. If it does and ploughing is not done properly, the Jatropha will choke. So it is important to plough the land properly. (Malcolm)
- Cuttings establish faster than seedlings (Burland). However, some reports say that the roots of cuttings will not establish properly in the long term. Also, Mr. Malcolm mentioned that the roots of Jatropha cuttings will not grow as deep as the roots of seedlings. In the end, cuttings will thus not help to stop soil erosion. (Malcolm)
- A mixture of cow dung and soil seems to work fine in the seedling nursery. Kakute taught this to the Brotherhood and the Jatropha grew well, although not all seeds germinated.
- Mr. Ismael Manang also mentioned that 30% of the seeds did not germinate on his plot. He thought it was due to the fact that the seeds had not been sorted. Normally, seeds for sowing must be sorted.
- Jon-Erik from TAF planted some Jatropha seeds just after the rainy season (thus at the start of the dry season) as a test. He did not water some of the saplings. The saplings that received no water did not survive, the ones that were given a small amount of water did survive (about 80-90% of them). At Kikuletwa Farm, plants that were watered copiously grew very fast and with a high yield. Plants that received less water (for example, at the end of a row) grew much slower. When Jatropha was planted and left for 18 months without water, it did not grow, even after being watered (although this could also be due to salt in the soil).Fons Nijenhuis also said that availability of water is important. At a teacher training college in Monduli, however, plants that did not receive water survived, although

they were relatively small. So it seems that water is not absolutely necessary but it increases yield.

- After 6-8 months, the seedlings in the nursery should be replanted to their permanent spot. If this is done later, the taproot will be destroyed and the plant will not establish properly. This was learned after plants that had been replanted after a longer time remained very small (although this could also be caused by marginal soil or the fact that those plants were also given fertiliser) (Fons Nijenhuis). This was in contrast to a lesson learned in Monduli. There, the taproots of the Jatropha seedlings were cut because they were growing too deep into the soil. The women's group thought that cutting the taproot would harden the plant and perhaps stimulate the growth of lateral roots from the main root. According to the women's group, the plants treated in this way establish properly. Tjerk Scheltema bought some of the seedlings to check if that was true, and indeed they seemed to establish properly.
- Jatropha planted in marginal soil does not establish properly. However, some were planted on a slope and the cold temperature at night and in the early morning could also have had an effect (the area is influenced by the nearby Mount Kilimanjaro). (Fons Nijenhuis)
- Jon-Erik (TAF) planted some Jatropha in his garden as well. It seems that in some places it grows well and in others it does not. Plants as close as 2 metres to each other planted at the same time can vary widely in size. The reason for this is not known.
- If Jatropha is grown without fertiliser the yield will decrease over the years. (Malcolm)

System

- A small tight fence of Jatropha cuttings is necessary in a plantation to prevent Masaai cows from damaging small saplings, according to Albert Mshanga. The Green Garden Women Group also mentioned this; cows destroyed all the plants in their 5- acre plot, which had no fence and was not guarded.
- According to Mr. Malcolm, it is important to keep in mind that large-scale plantations can damage the environment. When a Canadian firm planted 100,000 ha with wheat, it caused desertification of the entire area.
- Intercropping is a useful way of getting villagers to look after Jatropha well. This is practised at Kikuletwa Farm (see Figure 19).

Managing Jatropha

- Weeding is not really necessary. The Jatropha field at the teacher training college in Monduli was not weeded and the plants survived; however, they were relatively small. Mr. Ismael Manang mentioned an important reason for weeding: when there are weeds in the field during the dry season, Masaai herders will come to the field to graze their cattle. Spot-weeding (only removing weeds in the direct neighbourhood of the Jatropha) can suffice in the beginning. So weeding could be important for larger plots.
- Jatropha does not like shade. (TAF)
- When passing by Engaruka village, it could be seen that some of the Jatropha plants had been pruned. It was the wrong season to do this as the plants could be harvested in a month's time. When the village ward was asked why the plants had been pruned, he said there was no incentive to increase production since Kakute had limited resources for purchasing seeds. However, he said he would immediately start telling the villagers not to prune the Jatropha at that time.
- In Engaruka, termites damaged the stem of a Jatropha tree (see Figure 18). In a group of about five Jatropha trees (>30yrs old) only one stem was affected. It is not clear which termites did this.

Figure 18: Insect damage on Jatropha stem at Engaruka

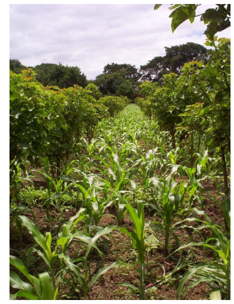

Figure 19: Intercropping with Jatropha at Kikuletwa Farm

Seed production

- The figures in Table showed that planting on a large scale generates more income, but it is also important to keep the investment and maintenance costs (weeding, irrigating, and so forth) low, for example by using intercropping (Kikuletwa) or using the Jatropha as a fence (Engaruka).
- One farmer had already picked a bagful of Jatropha seeds to sell to Kakute. Even while the Kakute field officer was present, the farmer was (in the end) willing to sell the seeds to Diligent for TZS 80/kg. He said the seeds would be sold to whoever came first to buy them (in other words, the farmer needed the money). Tjerk paid the higher Kakute price to create goodwill, but next time he will pay TZS 80.
- There is a chance that people will start to ask for a higher price for the seeds. This happened with farmers around Arusha National Park.
- Local people are positive about the potential of Jatropha. (around Dar es Salaam, Engaruka, etc.)
- The difference in the price the farmers received from Kakute and the lower price Diligent is paying might be a problem. At first the villagers think they are getting paid too little; however, when it is explained that Kakute can only buy a limited amount of seeds and Diligent will buy any amount, whether it is 1 kg or 10,000 kg, and for a guaranteed price, they agree.

User preferences

- People often ask for a seminar to have new technologies or crops explained; for example, such a request was made by the women in Monduli as well as a farmers' group near Arusha National Park.
- Land is often owned by cooperatives and it can be used for Jatropha only if all members agree. (Fons Nijenhuis)
- You have to show up regularly and keep promises, otherwise the people will not trust you any more (around Arusha National Park).

Acceptance

- Kakute did not return to pay for the collected seeds; therefore the farmers in some regions are a bit reserved or even sceptical. It is important to gain trust by making long-term agreements and returning on a regular basis.
- TAF has offered villagers free samples of Jatropha seeds, but not all villagers accepted the seeds. Only the villagers who were willing to try something new did so. The Jatropha was promoted as support for vanilla plants. It will probably take some time to get the local people to understand the profits that can be earned from Jatropha.
- According to Mr. Albert Mshanga, Masaai woman form a special group and are more difficult to persuade to grow Jatropha. This is because they do

not own the land (it is owned by men). With mixed tribes, this cultural problem is much less.
- The Swahili name for Jatropha, Mbono Kaburi (graveyard tree) is causing some scepticism because it is used in graveyards and people have associations with that. It is used to mark graves, probably because Jatropha can establish in any season, so when a person dies Jatropha cuttings are planted on the grave
- *Jatropha curcas* is an indigenous plant. This is very helpful for the adoption process: what TAF/Kakute is telling people (to plant Jatropha) is not completely new for them, so they are less sceptical. (TAF)
- Farmers around Dar es Salaam: were very enthusiastic about planting Jatropha and selling the seeds to Diligent. Their main crop until now was cashew-nuts but the price for this crop has fallen and they were looking for another crop.

Dynamics of expectations

Expectations about cultivating Jatropha

- Planting Jatropha will provide a lot of possibilities: fencing, nursery, cuttings; it will help to stop erosion. (T. Scheltema)
- Jatropha can grow in very dry areas. This can be seen throughout the country, so it would be a waste to use valuable irrigated land for Jatropha; that land is better used for food crops (T. Scheltema). (Note from author: however, the yield can be significantly higher if irrigated.)
- Many things will have to be learnt in the future: Is fertiliser necessary? Is pruning necessary? Is irrigation necessary? (I. Manang). Bukaza Chachage has also mentioned the necessity of these kind of lessons; therefore he is planning to set up several plots at his home-town (near Iringa) to experiment.
- The expectation is that irrigation is not necessary. The rains were good this year, so they already received a lot of water. (I. Manang)
- A lot more research has to be done on several aspects (such as growing/cultivation) of Jatropha (and Moringe). The ecosystem is fragile and unstable, there can be huge effects which work up all the way through the food-chain. The influence of Jatropha plantations has to be researched first. They should set up test plots to measure, for example, how deep the roots of cuttings and seedlings actually go, the amount of fertiliser (nitrate) that works best, and so on. When it goes wrong, the reputation of Jatropha will be destroyed. (D. Malcolm)
- Perhaps at a later stage also involve the Government, who can profit because of less soil erosion and could perhaps provide women with subsidies for this.(T. Scheltema)

Expectations about seed production and selling for cash

- When Mr. Burland started he did not think much money would be generated by it (a barrel of oil was then USD 30) but now with oil prices of nearly USD 50 per barrel it is getting much more interesting.
- Most farmers will not transfer to Jatropha completely; to survive the two years without a harvest they have to keep up other income-earning activities.
- At first the idea (with Ruud van Eck from Diligent) was to plant 10,000 ha with Jatropha themselves, but at a later stage they agreed it was better to invest in knowledge instead of in capacity. So now they leave the planting to their outgrowers with whom they were working already. When farmers ask for more money Diligent will just have to wait and eventually the farmer will sell for 80 or 85 shillings anyway. (Hans Baart)
- The Jatropha can only be harvested after one or two years; the farmer does not have the money to wait for a harvest that long (Manang). There are costs involved, such as ploughing, etc.

- The village heads and farmer were very enthusiastic and are willing to plant a lot of Jatropha. The farmer has already started planting eight acres because he thinks it will be very profitable. (Selela)
- The villagers and village heads seemed to be really enthusiastic about the idea of selling Jatropha seeds to Diligent. They really think they can make a lot of money. Because the rains were not so good last year they now want to plant Jatropha instead of maize and beans. This indicates they have a great trust in the future of Jatropha. (Engaruka)
- Farmers around Dar es Salaam have high expectations and will start planting soon.
- Their expectation regarding Jatropha is that in 3-5 years' time a lot of Jatropha will be planted mostly by private persons. (TaTEDO)
- Originally the Green Garden Women Group wanted to plant five acres with Jatropha and two acres with Aloe Vera. Money is the problem at this moment. If they received some support in the form of money they would try to plant the five acres with Jatropha again, this time with a fence.
- Jatropha storage is important. According to Mr. Malcolm, the high humidity in Tanzania could cause the seeds to germinate. A normal silo could become too warm.

  <u>On yield:</u>
- Tjerk Scheltema expects a yield of 2 kg a plant.
- Kakute is planting 2x3 m and we are 2x2, so 1600 trees/hectare for Kakute and 2700 trees/hectare for Diligent.
- Suppose 30 acres, 1000 trees per acre, yield of 2 kg/tree, will yield 60 tonnes of seeds, which will give the farmer TZS 4,800,000. Oil content is 30% so 20000 litres of oil. The farmer can grow 30 acres of Jatropha, he will give the seeds to us and will get some diesel in return. (Tjerk)
- Predicted yield is reported at 1500 kg/acre but this seems to be on the positive side. (Fons Nijenhuis)

Barriers

- The amount of information that is still lacking on growing Jatropha. Several people are waiting for this information or are now trying to get the information themselves. Information like: how much water is needed, how many nutrients, when and what is the best height for pruning, etc.
- Options like intercropping or pre-financing could overcome the problem of lack of money to wait very long for a harvest. When Jatropha is grown as a fence or on a small scale, this problem is smaller.
- The government of Tanzania is not very supportive, so far they have only showed interest when they can make some money as well.
- Logistics in the field as well as transport to other places is expensive and time-consuming.
- Multiple actors: Kakute was already active in this area; he does not want a clash of interests with this organisation so he hopes they can work together on the promotion and let the farmers decide to whom they are selling their seeds, Diligent will tell them Kakute will pay more but will not be able to buy everything. (T. Scheltema)

Conclusion

At this point the **actor network** is expanding rather quickly. More and more farmers seem to be willing to participate and are starting to plant Jatropha, expecting to make a considerable profit. This is happening mainly because they are able to sell their seeds now to Diligent, which is guaranteeing them a fixed price for a longer period, thereby reducing their risk (of a dramatic fall in the prices they get for their crops). Also, because the prices of other crops (cashew-nuts, coffee) have fallen considerably, the farmers were looking for new crops.

The network is quite diverse with many actors., Only research institutes had not really been involved so far, but one is involved now.

From the **economic analysis** it appears to be very profitable for the farmers to plant Jatropha, although it is important to pay attention to the scale, investment costs and maintenance costs.

There are many **learning processes** in this part of the chain, mostly with regard to how Jatropha should be grown and managed, but also regarding user acceptance. There are also learning processes of a higher order, for example Mr. Manang who says in his expectations that many more things (like amount of water needed, etc.) will have to be learnt. So, although already there are many learning processes, many more lessons are necessary on the cultivation of Jatropha.

Expectations from several actors are high and positive, and in some cases even rising (like those of Mr. Burland who did not think much of the project in the beginning, or Diligent who, when they started, thought the yield would be much lower). However, the period of experience is too short to be stable or to allow very specific conclusions. According to Mr. Burland, a 'good name' can be destroyed quickly when a project fails, which happened with Moringe. The larger companies that are involved in processing the seeds into biodiesel (Diligent, D1 oils) also expect to make a considerable profit. Their expectations are based on the forecast of a large market for biofuels. If this market (for Jatropha oil) turns out to be not as big or profitable as anticipated, the price the farmers get for their seeds will drop drastically. So there is still a risk involved for the farmers. Especially if they were to completely change over to Jatropha without any other activities, they would become totally dependent on the price of Jatropha seeds and wouldl be much more vulnerable if their Jatropha crop was damaged, for example by a plant disease. Therefore, changing completely to Jatropha might not be a good idea, although this is true of all crops. (The risk is especially when *food* crops are changed for Jatropha.)

The barriers to Jatropha as a cash crop mainly have to do with lack of information on growing Jatropha and the cultural attitude towards risk. Tanzanians are not very willing to take risks, so an initiator (either local or western) is necessary. All barriers seem to be surmountable though.

So the processes all seem to be quite positive for this part of the chain; rising expectations, increasing actor network and many learning processes – although not stabilised yet, so further lessons are necessary.

4.4.2 Production

The next step in the Jatropha chain is to obtain the oil from the seeds. Although so far most of the groups that are involved in processing the oil, for example into soap, are also expelling their own oil. This could also be a separate facility. Two presses are used currently, the difference between these presses (the ram press and screw press) was explained in section 3.3..

Introduction

Only mechanical extraction methods are used In Tanzania. Kakute has a number of ram presses in store (see Figure, and is selling them to the' groups associated with it. A women's group in Engaruka owns one; it sells Jatropha oil in addition to making soap from the oil. A women's group in Mto wa Mbu, which is also managed by Kakute, uses the same type of expeller (this group was not visited). The Green Garden Women Group in Moshi also makes soap and has a ram-press.

The Sayari Oil Expeller (see Figure, is designed by a German company, manufactured by the Vyahumu Trust in Morogoro and assembled by subcontractors. It can press a large variety of seeds, and clients can choose whether they want their machine to run on diesel fuel or electricity. The Vyahumu Trust has a factory in Morogoro, where one expeller is available for farmers to have oil extracted from their seeds for a fee. Clients can also buy an expeller. Recently Kakute installed a screw press from China, with a capacity of 20 bags x 60 kg/day, 8 hours a day (150 kg/hour). Diligent is planning to set up an oil-expelling facility near Moshi or Arusha.

Figure 20: Ram-press

Figure 21: Sayari oil expeller

Network formation and stabilisation

Actors

- Kakute (technical assistance, provider of equipment)
- Vyahumu Trust (manufacturer of oil expeller, provider of oil-expelling facility)
- FAKT (German company, subsidised Vyahumu)
- Subcontractors in Tanzania (to build the Sayari expeller)
- Other oil press suppliers (China)
- Women's groups (buyers of oil-pressing equipment, providers of labour for pressing)
- Villagers (oil buyers)
- Diligent (wants to set up one or more facilities in the near future)
- Eindhoven University of Technology (research institute)

Dynamics

Equipment can be supplied by several manufacturers; for example, Kakute has bought a press in China. When women's groups that own a ram-press want to have a press with a larger capacity, they turn to Kakute. This indicates that Kakute plays an important role as a connector or 'platform', but also that not all actors in the network are interconnected. Maintenance is required for larger presses; this indicates opportunities for technical services as well as for spare-part suppliers. Diligent has links with several researchers at Eindhoven University of Technology which are, or going to be, directed to optimising Jatropha oil extraction (and performance of the oil and equipment).

Thus, although all the activities are only in a starting phase, the diversity of actors is quite good, with many different type of actors. At least the potential for the dynamics is very good.

Economic analysis

There are two options for making an oil-expelling facility financially feasible. Firstly, seeds can be brought in by seed pickers and pressed for a fee. Secondly, the owners of the facility can press seeds (which have been bought or picked) and sell the oil.

The Vyahumu Trust in Morogoro charges the following fees for extracting oil from seeds:

- TZS 60/kg for sunflower seeds
- TZS 90/kg for all other seeds

Sunflower seeds are less hard than other seeds, therefore less electricity or diesel is used.
The cost of having one litre of oil expelled from Jatropha seeds is: 3 kg of seeds for 1 litre: 3*90= TZS 270.The oil can be sold for at least TZS 700 (diesel fuel is about TZS 1100 and kerosene TZS 750). Thus, the profit (without taking into account any additional production costs) is 430 TZS/l.

The second option is practised in Engaruka, where the oil is expelled and sold to villagers for TZS 2000/l. The seeds from which the oil is extracted are obtained by picking or buying. Table lists the parameters for an oil expelling facility, both the ram-press and the Sayari expeller at Vyahumu Trust.

Inputs	Parameters
Seed picking	2 kg per hour (3-5kg/l)*
Seeds	TZS 80/kg
Ram press	
Investment cost	275,000 (lifetime 5 years)
Labour for pressing: ram.	1.5 litres/hour** (5kg/l oil)
Sayari expeller	
Investment cost	3,500,000 (lifetime 6 years)
Diesel consumption	1-1.5 litre/hour
Labour for pressing: Sayari	20 l/hour, (3kg/l oil)
Maintenance costs	280,000 after 20 tonnes, 270,000 after 140 tonnes of seeds***
Filtering	2 l/hour
Revenue from oil sale	TZS 2000/l

Table 15: Parameters of oil-expelling facility

Notes:

* Henning (2004). Data on Tanzania derived from Kakute's 2003 data.

** The ram-press can extract 2 litres/ hour, according to A. Mshanga. Henning (2004) and informants in Kakute give the extraction capacity as 1 litre/hour, so the calculations are made on the basis of the average: 1.5 litres/hour.

*** www.jatropha.de. Economics of the ELCT/FAKT project, accessed December 2005.

The lifetime of the ram-press is five years, the lifetime of the larger expeller is a bit higher. A manufacturing employee said it is safe to take five years for planning purposes, but a person at Vyahumu Trust said the machines manufactured six years ago are still working very well and the lifetime could be as much as 10 years. Currently the by-product, seed-cake, is of no value; if a market could be found for this product, the profit would be higher. Kakute is currently working on a biogas system in which the Jatropha seed-cake could be used. Another option would be to sell the seed-cake to farmers as fertiliser.

Table compares the economic aspects of the two presses. The following assumptions are made in the calculations:

- Constant prices
- Real discount rate (r): 9.8%, calculated by using inflation (p) of 4.4% and the average interest rate (i) on medium- and long-term loans in 2003, which was 14.6%[39], in the formula: r=(1+i)/(1+p)-1.
- Project running time: 5 years, investments are made in year 0, production in years 1-4.
- Hours in action: 8 hours a day, 50% of the days in a year; this adds up to 1460 hours annually at maximum output
- All necessary seeds are available and bought for TZS 80/kg, all produced oil is sold (for 2000 TZS/l), the diesel price is 1100 TZS/l.[40]
- Decision positive when: NPV>0, IRR>real discount rate (9.8), BCR>1

	Ram	Sayari
Non-financial cash flow from 1st year	TZS 3,504,000	TZS 48,531,000
Labour annually (hours)	2555	14600
Oil produced (litres)	2,190	29,200
NPV	10,887,708 TZS ($9,898)	151,105,413 TZS ($137,369)
IRR	1274%	1387%
BCR	3.86	3.98
PBP	2 years	2 years
Liquidity	Good	Good

Table 16: Economic analysis for two presses

The analysis shows that the economic parameters are very good. However, some of the assumptions are perhaps too positive. In reality, the supply of seeds might not be sufficient for the Sayari press and it is also not very likely that all the oil would be sold.

Sensitivity analysis

Assume that the oil is not sold for TZS 2000/l but for TZS 1000/l, which is more likely to attract new consumers. For both presses, all parameters are still good (see Table.

	Lower oil price		50% of output		Both	
	Ram	Sayari	Ram	Sayari	Ram	Sayari
NPV	positive	positive	Positive	Positive	Positive	positive
IRR	477%	552%	637%	675%	237%	257%
BCR	1.93	1.99	3.59	3.34	1.79	1.67
PBP	2 years	2 years	2 years	2 years	2 years	2 years

Table 17: Sensitivity analysis for ram-press and Sayari oil expeller

If the oil is sold for TZS 2000/l but only 50% of the maximum output is realised (due to, for example, 50% shortfall in seed supply) the parameters are also

[39] http://www.tanzania.go.tz/economicsurvey1/2003/part1/financeinstitutions.htm, accessed August 2005.

[40] Price at pump in Dar es Salaam, July 2005.

positive for both presses: almost 1100 litres of oil for the ram press and 14,600 litres for the Sayari press, which is still a large quantity. When both the price of the oil and the supply of the seeds are lower, the parameters for both presses are still positive; however, they are, of course, much lower.

To break even with the ram-press, at least 165 litres of oil should be sold (at TZS 2000/l); this would recover the investment costs for press and seeds. The break-even point for the Sayari press is about 2000 litres.

For all assumptions, the liquidity is good, with enough profit being made in the first year to recover the investment costs plus 14% interest.

Conclusion: The choice of press depends on how much oil can be sold, the quantity of seeds available and the amount of time available to make the decision as to which machine to buy. Both options can be very profitable.

Learning processes

System

- It is taking a lot of time to achieve large-scale production of Jatropha seeds, so there might not be enough supply for a big expelling unit.
- Transportation is very expensive, with a lorry load from Dar es Salaam to Kilimanjaro region costing USD 1000, according to Mr. Burland. Mr. Scheltema, too, thinks transportation is going to be the big problem, with a factory needing tonnes of seeds a day.
- Be careful how you set up the system. Everyone is seeking a personal optimum; if the driver gets his money, he will not consider it his responsibility to obtain a higher price. (Malcolm)

User acceptance

- The village ward was not happy with the low capacity of the ram-press; he wants to have bigger (electrical) equipment for the expelling process (Engaruka).
- Few people are prepared to press Jatropha seeds because they are poisonous. (Diligent)

Technology

- The quality of the seeds is very important; if the seeds are not fresh, they will yield less oil, but if you use fresh seeds the yield is quite high. Drying and maturity are important. (Vyahumu)
- Most people are very satisfied with the Sayari machine; if the machine breaks down, it is usually because it was used improperly. (Vyahumu)
- The hulls of Jatropha seeds are quite hard, but pressing in the Sayari oil expeller went very well; cone adjustment is necessary (see 3.10 for test results).
- The quality of the equipment might be a problem. In very remote areas it can take a long time before spare parts arrive. (Diligent)
- According to Malcolm, an expeller designed for sunflower seeds will never give a good yield on Jatropha seeds because the pressure exerted by a sunflower seed expeller is much lower. This implies that a machine should be built especially for Jatropha; this could be a problem when the market is not big enough. However, special adjustments, such as another cone, might also work.

Dynamics of expectations

- Mobile expellers could be used; for example, they could be placed on a lorry which could visit farms twice a year to press seeds on the spot. (Burland)

- At a later stage, the seed-cake which is left after pressing could be used in flower-pots; currently, coconut fibre imported from Thailand/Sri Lanka is used for this purpose. (Scheltema)
- High profits can be made by exporting the oil to the Netherlands; if this was not the case, they would not have thought about it. (Fons Nijenhuis)
- Perhaps small expellers could be installed in several villages and the oil refined in one place. (Scheltema, Diligent)

Barriers

- Transport
- Diligent (and others) lack knowledge with regard to processing the Jatropha seeds into diesel oil, and the marketing aspects of the oil. Knowledge of emissions, CDM, and so on is insufficient. Further research is necessary.
- Lack of training: the ram-press is a very simple technology but the Sayari expeller requires a certain amount of maintenance. This requires technological skills.
- The investment costs of a large expeller are quite high, a loan might be necessary.
- Supply of Jatropha seeds is seasonal, so storage is necessary.

Conclusion

This is a rather unclear part of the Jatropha chain. The **network** formation is quite good, with a large variety of actors. A research institute, equipment producers and users are involved. The network is quite dynamic and many actors are connected to each other; however, most contacts run through Kakute. Supply of equipment and maintenance creates chances for other sectors and actors to be involved as well. The **economic analysis** is promising, but actual data on quantities of oil sold is lacking. The ram-press requires a lot of labour, but only 165 litres of oil has to be sold for the investment cost to be recovered. In the case of the larger Sayari expeller, at least 2000 litres has to be sold because, its investment cost is quite high. However, for both presses, the facility could be profitable. Once a value for the by-product seed-cake is established (for example, sale as fertiliser) the profitability of such a facility could be even higher. There are few **learning processes** as yet: some technical lessons regarding the presses and the quality of the seeds, and some regarding user acceptance. However, there are no learning processes yet on the infrastructure, how best to set up such a facility or, for example, on storage of seeds. This may be a temporary gap, because, with a research institute involved, it is likely that more (technical) lessons will be learnt in the near future. An important aspect is that **expectations** vary widely. It is not clear to everybody in what direction the Jatropha chain will evolve: Will small expelling units be installed or will there be a big one in a central place? Will the technology be will it be hand-presses or larger expellers? Currently, the groups are mostly working with a ram-press, but at least one of the groups (Engaruka) is not satisfied with its capacity. And the seed production is not yet enough to start a large facility. The investment costs of a large expeller are also quite high. Some aspects, such as transport, reliable and efficient equipment and financial support, are seen to be important barriers.

The women's group in Engaruka is selling the oil (presumably for use in oil lamps), for the rather high price of TZS 2000/l, while the normal diesel price is about TZS 1000/l. This indicates that there is a market for the oil.

The supply of seeds is not yet guaranteed and the market is not yet developed; this makes it difficult to invest in an oil expelling facility for Jatropha seeds only. The machine manufactured by the Vyahumu Trust can press more than one variety of seeds and could be a way to overcome some of the problems.

4.4.3 Use in diesel engines

Jatropha oil can be used directly in a diesel engine, blended with diesel or converted into biodiesel (as explained in section 3.3).
Diesel fuel is currently used in rural areas mainly as fuel for tractors and in generators for main or back-up electricity supply. Jatropha oil can serve as a substitute for this diesel. In urban areas, too, Jatropha oil can be used in diesel engines; for example in electricity generators and cars. A third application for use in diesel engines, would be to export the oil (or biodiesel), for example to Europe.

Introduction

Jatropha oil is not yet used as diesel fuel in Tanzania. However, Diligent (and probably D1 oils although it is unclear whether the company is active in Tanzania) is directing its efforts towards this application of Jatropha oil. Diligent wants to set up a factory in Moshi to produce Jatropha oil and/or Jatropha biodiesel, and research is being conducted on the properties of Jatropha oil as fuel in engines. The University of Dar es Salaam (USDM) is also going to conduct research in cooperation with Eindhoven University of Technology (the Netherlands), mainly into the exhaust emissions from Jatropha biodiesel. Research on biodiesel from coconuts is already being done at USDM. The university also demonsrates a vehicle run on biodiesel at exhibitions. In the south of Tanzania, the Kiumma project, involving Germans, is setting up a Jatropha plantation with the purpose of using Jatropha oil in an electricity generator as the main power supply for a small hospital.

Network formation and stabilisation

Actors

- Kiumma project members
- University of Dar es Salaam (USDM) (research on biodiesel)
- Eindhoven University of Technology (TU/e) (research on Jatropha oil)
- Diligent (initiator, will become producer of Jatropha oil and/or biodiesel)
- D1 oils (three years ago they wanted to set up a large factory, but failed; the field officer from Kakute mentioned they might be active again in Tanzania)

Dynamics

The network mainly consists of researchers, and actors intending to start activities (Kiumma and Diligent). No users are involved yet, while user acceptance for this application is very important. Diligent is going to set up a factory in Moshi. They will probably have the oil expelled at several places and than collect it for refining in Moshi. There is no certainty yet about distribution; for example, it is unclear whether petrol stations will be willing to sell Jatropha oil or whether oil companies will be willing to blend their diesel with it. The linkages between the different research institutes seem to be quite good, and worldwide much more research is being carried out on Jatropha. So, much more expansion of the actor network and dynamics is possible for this application.

Economic analysis

It is not possible to make an economic analysis with the current data. No Jatropha oil is available as diesel fuel yet. The Jatropha oil sold in Engaruka is priced at TZS 2000/l, diesel fuel at petrol stations in Dar es Salaam is priced at about TZS 1100/l (June 2005). Jatropha oil probably should not exceed this price by too much.

Learning processes

- To test Jatropha oil as diesel fuel, the Vyahumu Trust (manufacturer of Sayari oil expeller) tried it in their own machine and it worked well.
- Production of Jatropha seeds on a large scale is taking a lot of time (Diligent).
- Modifying the engine of a car costs about TZS 600,000: Elsbett, a two2-tank system with a preheater (A. Mshanga).
- A German in Arusha has converted his car; he uses sunflower oil in his engine (A. Mshanga).

Dynamics of expectations

Use for domestic purposes in remote areas

- In the south of Tanzania, the Kiumma project is going to plant Jatropha and use the oil in a diesel generator. The expectation is that they can be self-sufficient in Jatropha-based diesel fuel.

Use for domestic purposes

- Tanzanians will not pay to convert their cars, so the oil will have to be converted (Tjerk Scheltema).
- Mr. Makundi, from TIRDO, has high expectations of biofuels. The main reason for this is the rise in oil prices.
- Tjerk Scheltema thinks it is much better to modify the oil in Tanzania so that the local people can profit from the technology and buy fuel for their cars etc. This is in contrast with Hans Baart's view that the oil should be exported and modified in the Netherlands.

Use for export

- Rapeseed oil is currently pushed by European governments as a source of biodiesel, which they are required to produce by European Union guidelines. It is only successful because the governments are putting money into it. If the governments stop doing this, rapeseed oil will become too expensive. Jatropha oil from Tanzania should be able to compete with rapeseed oil (Scheltema).
- There will always be demand for diesel. The modified oil is better (Hans Baart).
- Big money can be made by exporting the oil to the Netherlands. If this was not the case, they would not have thought about it (Fons Nijenhuis).
- The oil will be used by people who want to have a 'green' image. It is not for people who just want to have the cheapest fuel (Diligent).
- Knowledge is lacking about the processing of Jatropha seeds to obtain oil, the marketing aspects of the oil, emissions, CDM, etc. Further research is necessary (Diligent).

Conclusion

For this application, there are mainly just expectations by actors and no actual lessons from experiments. There are different options for oil use: who could use the oil, could it be used domestically, in remote areas or cities, or for export purposes. The **network** of actors is quite limited, although at least two research organisations are involved. The network is not really expanding (yet), perhaps it will do so when tests results are positive and are publicised. Diligent, the USDM and the Kiumma project members are the only actors pushing this application in Tanzania. There are no **learning processes** yet on the user side. The only technical learning processes so far are the experiments carried out by Diligent in Eindhoven. Worldwide, many more experiments are being carried out on the properties of Jatropha oil; they seem to be positive, especially about the converted oil. However, so far there are still some technical lessons to be learnt, for example about long-term effects. The **economic analysis** remains unclear. Diesel prices are about TZS 1100/l at the pump in cities. The general

expectations are very positive, but cannot yet been be more specific due to the lack of learning processes. Many things remain unclear; for example, whether the oil should be converted into biodiesel or not.

4.4.4 Uses of the seed-cake

Jatropha seed-cake, which is the residue left after oil is extracted from the seeds, is currently only a by-product and has no value. When an application is found that has very good properties for users and the quality of the niche-processes is good, the Jatropha seed-cake could gain value. This would strengthen the production stage and have a positive influence on the transition to biofuel.

Use of seed-cake for biogas production

In a microbiological process, Jatropha seed-cake and/or leaves can be converted into biogas (a methane-rich fuel gas produced through anaerobic digestion of suitable biomass feedstocks) which, for example, is an energy source for cooking. See section 3.3 for a technical description of the process of biogas generation from seed-cake.

Introduction

A biogas facility was built at Kakute, Arusha, to test the properties. Kakute has also provided a women's group in Monduli with a biogas facility. (The group also has a nursery with Jatropha and other trees.) Earlier, the group was provided with an efficient cooking stove by TaTEDO, so it has had links with other NGOs for some time. The plastic bag in Figure is where the biogas is stored. The plastic tube leads the gas to the biogas cooker. The women's group uses cow dung from its own cows as well as Jatropha seed-cake as source of biomass. The group was enthusiastic about the properties of Jatropha because the seed-cake generates more biogas the same amount of cow dung does. However, the members did not seem to be so enthusiastic about the biogas system itself, since they were cooking with firewood even though biogas was available. When asked why they did not use the biogas cooker they said they only used it during the rainy season when firewood was difficult to find. This indicates that they prefer to cook with firewood. When the biogas cooker was demonstrated, the pressure of the gas in the cooker seemed quite low, extending cooking time which may be why the group members prefer firewood. Yet, when asked if they would be prepared to pay for a biomass source such as Jatropha seed-cake, they said they would be prepared to buy it. In Engaruka, Kakute is going to install a biogas system as well. The sludge which is left after the process could serve as fertiliser.

Figure 22: Biogas storage and cooker, Engaruka

Network formation and stabilisation

Actors

- Kakute (providing technical assistance, equipment)
- Women's group, Monduli (users)
- TaTEDO (familiar with this group)
- In future: women's group, Engaruka

Dynamics

This application is applied in Tanzania to a very limited degree. Kakute started with just one group, to learn about the technology and the users. No research organisation seems to be involved, so the network for the biogas application seems to be quite limited. Also, the feedback from the users does not seem to be resulting in an adapted design.

Economic analysis

The costs of installing a biogas system are unknown.
The price of a Biogas cooker (not including the system) is TZS 10,000 (Monduli).

Learning processes

- Although biogas was available to the women, they were cooking with firewood. The extended cooking time because of low gas pressure probably plays a role.
- The women said they would even be willing to pay for Jatropha seed-cake as it produces much more biogas than cow dung (Monduli).
- The biogas facility, as constructed in Monduli, was of very poor quality.
- The users of this application (the women's groups) are reluctant to share their learning experiences; only after repeated questioning did they (half) admit that they prefer to cook with fuelwood. This lesson did not seem to have reached Kakute, which is installing more facilities (feedback loop is lacking).

Dynamics of expectations

- Kakute is going to install a biogas facility in Engauka, so it expects this technology to be beneficial to the villagers.

Conclusion

The **actor network** seems to be quite limited and the dynamic processes are not optimal. The users seemed to be very enthusiastic about the properties of Jatropha seed-cake as source for their biogas facility. However, the technology is not developed enough to satisfy the users. Many **learning processes** regarding the technical properties are necessary. Kakute should evaluate its experiments and install feedback loops. Kakute has positive **expectations** of this technology, but in view of the actual performance so far it is not clear what the expectations are based on.

Use of seed-cake as fertiliser

Several people mentioned that Jatropha seed-cake is a good fertiliser. However, Jatropha cake was not available in large quantities, so it was not being sold (yet). The agricultural nutritional values of Jatropha cake were outlined earlier in this study, in section 3.3.

Figure 23: Jatropha seed-cake

In Engaruka, a large amount of Jatropha cake is left after the seeds have been processed with the ram-press (see Figure 23). The women's group indicated that the cake was not being sold, and that one farmer was using it as fertiliser on his

land. When the supply increased, the cake could probably be sold instead of being given away free.
Diligent plans to use Jatropha cake as fertiliser for its Jatropha plants, as reports mention that Jatropha plants need fertiliser to remain productive over the long term.

Conclusion

This application has not been practised or tested yet. Potential actors are farmers who want to use the cake as fertiliser, and all facilities where Jatropha seeds are pressed and Jatropha cake produced. Worldwide research has been done on the properties of Jatropha fertiliser, but so far it has not been tested in Tanzania. There are no learning processes yet and the expectations are slightly positive.

Use of seed-cake as briquettes

When the Jatropha seeds are pressed, not all the oil is extracted. So the cake residue consists of the hulls and some oil. When this cake is pressed into briquettes, it can be used as for a fuel in wood stoves. This is practised in Engaruka, but information about the experience is lacking.

4.4.5 Other applications for Jatropha oil

Besides being used as fuel in diesel engines, Jatropha oil can also be used in soap-making, oil lamps and cooking stoves. This has two implications for its use as biofuel. On the one hand, these applications can strengthen the transition to biofuels because, when the niche-processes are good, user acceptance of Jatropha (oil) increases. On the other hand, they can also have a negative influence on the transition to biofuels if one of these applications is very successful and the price of Jatropha oil rises as a result.

Jatropha oil in soap-making

Jatropha oil can be used to make soap. There are different options for obtaining it for the process: the oil can be bought, or expelled from seeds which are either bought or picked. The process of soap-making was explained earlier, in section 3.3.

Introduction

Kakute has a soap factory in Arusha, where the managers help women's groups to make soap from Jatropha oil. Kakute also supplies the ingredients. The women's groups can take the soap home where they sell it (often informally) to villagers. Kakute also sells Jatropha soap in nicely packaged 30 or 90 gr. tablets. The soap that is sold by the women's groups is not packaged in this way. The market for the soap seems to be quite small: most of the soap sold by Kakute is bought by (international) visitors, while the women's group in Engaruka sells about 20 tablets a month. Users of the soap are really enthusiastic, especially about its medicinal properties. People are willing to pay TZS 500, which is more than for normal soap (TZS 250-350). The women's groups cannot make a living out of their soap activities yet (they need more capacity in terms of the quantity of seeds, pressing equipment and market for the soap).

Network formation and stabilisation

Actors

- Women's group, Engaruka (producers and users of the soap)
- Green Garden Women Group, Moshi (producers and users of the soap)
- Kakute (equipment supplier, technical knowledge, soap trading, etc.)

- Villagers, Engaruka (soap buyers)
- Small shops where the soap is sold (e.g. gift shop at Kinderoko hotel, Moshi)

Several important actors or institutions seem to be missing. For example, micro-credit organisations could be involved, to pre-finance the soap–making process. Research institutes are also lacking; the properties of the soap should be tested. Finally an (export) marketing organisation could try to increase the Jatropha soap market.

Dynamics

There are many interactions between the actors, but the network is not really expanding. All women's groups were taught to make the soap at the Kakute soap factory in Arusha. Kakute is selling the soap on its premises in Arusha, the women's groups also sell the soap but more informally. The Green Garden Women Group indicated that they would like to make the soap on their own premises but they lack the equipment and do not know where they can buy it. So Kakute's suppliers of equipment (and raw materials such as caustic soda) are not being shared.

Economic analysis

Jatropha oil, which is used for the soap-making process, can be obtained in several ways. It can be bought from oil expellers; this is currently being done in Engaruka, where the oil is bought for TZS 2000/litre. It is also possible to collect Jatropha seeds and press the oil in a ram-press (hand-press), and finally the seeds can be bought and then pressed. Table lists the expenses of the soap-making process when the oil is bought.

Soap-making expenses	Unit	Labour - TZS
Seeds (95 kg)*	TZS 80 /kg	7,600
Labour for soap making	Hours	16 hours
Labour for various jobs (wrapping, organising etc.)*	Hours	10 hours
Oil (19 litres)	TZS 2000 /l	38,000
Caustic soda	5000/65 pcs	18,500
Water	0.75 l/1 l oil	
Wrapping (polythene)	3000/65 pcs	11,000
Rent for space	8 sq. feet TZS 1000/day	2,000
Revenue (240 pcs)	TZS 500 /pcs	120,000

Table 18: Yearly cost of soap-making, 20 tablets per month

Notes: * to yield 19 litres of oil annually; about 5 kg is needed per litre.
pcs = pieces (tablets) of soap.

Sources: (for seed quantity, labour and water): R. Henning (2004). Tanzania data derived from Kakute statistics for 2003.

In Engaruka, the women's group sells about 20 tablets of soap a month, so the assumed yearly quantity is 240 tablets. Table presents the economic analysis for soap-making in Engaruka, for comparison purposes. It includes the option of pressing the seeds. The calculations are made in constant prices, with 9.8% as real interest rate (see earlier calculations). The project life time is five years, the output is generated from the beginning because no large equipment is necessary. See 3.7.4 for more detailed calculations.

	Oil bought for soap-making	Including pressing, own seeds	Including pressing, seeds bought
Yearly expenses	69,500	306,500 (31,500 for η^{th} year)	314,100 (39,100 for η^{th} year)
Non-financial cash flow in 5th year	50,500	88,500	80,900
Yearly labour	26 hours	97 hours	49 hours
Value added per hour (profit/labour)	1,950	912	1,650
NPV	211,378 (USD 192)	95,435 (USD 87)	63,623 (USD 58)
IRR		32%	24%
BCR	1.73	1.23	1.15
PBP	0	3-4 years	3-4 years

Table 19: Comparison of three options in soap-making at Engaruka (TZS)

Currently a rural worker earns about TZS 10,000 a month (Henning, 2004). So the amount workers can earn through soap-making is quite good; but the profitability is just about reasonable, due to the small quantity sold. Were the maximum capacity of the ram-press (2,190 litres per year) to be used for soap-making and all the soap sold, the NPV would be USD 35,583 and the BCR would be 3.47 (1.62 when the same quantity of oil is bought).

So the profit on the soap is quite good, but due to the small quantity sold the economic analysis does not show much profit. The market needs to be increased.

Conclusion

- The economic analysis for soap-making is positive.
- However, the market is currently too small; with 20 tablets being sold per month, the additional income is very low. It is important to find ways of increasing the market.
- With sales of 240 tablets, it is more profitable to buy oil instead of buying a press. However, were the maximum capacity of the press to be used and all the soap sold, having a press would be the best option.
- The Jatropha seed-cake which is left after the seeds are pressed can be used as fertiliser. Currently there is insufficient seed-cake to sell as fertiliser to farmers, but when production increases the women's group will probably sell the seed-cake (or the biogas sludge). So the by-products could create revenue additional to that obtained from soap sales.
- The ram-press accounts for the largest share of the cost. If this press was subsidised, the profits from soap-making could be substantial (BCR of 3.81).

Learning processes

User preferences

- The Jatropha soap is a very good medicinal soap. It is used for the body as well as the face. It has anti-fungal properties. Mama Leema (from Green Garden Women Group) uses it a lot. According to her, Jatropha soap is better than Neem soap and Aloë Vera soap.
- The price of other types of soap in this village is TZS 250-350; however, because of the medicinal properties people are willing to pay a higher price for this soap (Engaruka).

- Neem soap and Aloë vera soap are similar to Jatropha soap, but Jatropha soap has the strongest medicinal properties. Normal soap is sold for about TZS 250 in Moshi; the Jatropha soap is sold for twice that, but people are willing to pay that price. Neem soap and Aloë vera soap are sold for the same price as Jatropha soap (Green Garden Women Group).

System

- One of the outlet points for the Jatropha soap is the small gift shop at Kinderoko Hotel in Moshi. There, they sell a large bar of Neem soap or Jatropha soap for TZS 1500. According to the shop assistant, few pieces of soap are sold; this could be because the wrapping of the Jatropha soap is of much lower quality than that of the other soaps. Marketing seems to be important.

Dynamics of expectations

- In Tanzania you will not get a good price for the 'funny' soap made from Jatropha, but in Europe you can get a good price for such soap (Tjerk Scheltema).
- Jatropha soap is not suitable for export due to low quality; however, for local usage it is fine (Peter Burland).
- If they had the money and proper equipment for soap-making, they would want to make the soap in Moshi, but until then they will keep going to Kakute in Arusha. The Jatropha soap is a really good product, according to Mama Leema (Green Garden Women Group).

Barriers

- Capacity and market.

Conclusion

The **actor network** has increased, mainly because of Kakute, which is pushing the women's groups and attracting interested persons by selling the soap. However, some important actors are missing and the dynamics are not optimal. The women's groups do not really know how they can expand. The **economic analysis** shows that the women's groups do make a profit, but it is very low. This is due to market (demand) constraints. The **learning process** has developed rather well in terms of technical problems, with all the groups being able to make the soap. However, the learning process should also include other factors, such as marketing. Capacity is a problem; for example, in Engaruka the women's group would like a bigger press, while in Moshi the women would like facilities to make the soap themselves. Also, research on the properties of the soap is lacking. The **expectations** for the soap-making business vary widely. Users of the soap (the women's groups) seem to be very enthusiastic about the properties of the soap, and they would be willing to make and sell more of it. Kakute is also enthusiastic, but others have different opinions about the soap (Burland, Scheltema).
Overall, it is a profitable business, but there is a very small market. Expectations are very diverse, but the calculations for the soap-making process seem to show promise.

Jatropha oil in oil lamps

Jatropha oil can also be used for illumination by burning it in oil lamps. The technical details of this were given earlier, in section 3.3.

Introduction

Currently Kakute produces oil lamps of a very simple design in which Jatropha oil can be used and sells them to villagers in its project areas. Kakute has also trained a group of young people to produce oil lamps. Some women's groups – for example, the women's group in Engaruka – are selling Jatropha oil to villagers for use in lamps. In Selela village, the village ward said he had bought Jatropha oil to use in his lamp. The University of Hohenheim in Germany has done research on Jatropha oil lamps.[41]

Network formation and stabilisation

Actors

- Kakute (initiator of the project, producer of oil lamps, supervision, training)
- Women's group, Engaruka (pressing the seeds, selling the oil)
- Buyers of the oil and oil lamps (e.g. Selela villagers)
- Research institutes (the University of Hohenheim in Germany)

Dynamics

The actor network is still relatively small. One actor group was trained in making oil lamps but did not do anything with the knowledge; it is not active in the network anymore. Kakute did not train other groups after this failure. It is unclear how many users there are and whether they are happy with the oil lamp. The village ward in Engaruka said he was.

Economic analysis

The women's group in Engaruka (Arusha district) is selling the oil to villagers in Selela (about 10 km from Engaruka). The villagers are willing to pay as much as TZS 2000 per litre of oil. Special lamps for Jatropha oil are produced by Kakute and can be bought for TZS 1700 (€1.21).[42]

The lamps produced by Kakute are made from small, used, Africafe (instant coffee) tins. The factory currently produces only on demand (about 1000 lamps/year).

Learning processes

Technical

- The oil lamps made from Africafe cans work reasonably well. The Kakute factory is still producing lamps.
- At the Hohenheim University in Germany, research is being done on wick burners for Jatropha oil.

System

- In Engaruka, Kakute trained young people to make oil lamps, but the trainees did not do anything with the knowledge.
- The oil press currently used by most women's groups has a capacity of 1.5 litres/hour. This is too low for large-scale production and the groups want a larger press.
- In Selela, villagers are willing to pay even TZS 2000 per litre of oil.

Dynamics of expectations

No expectations were shared by the actors.

The number of oil lamps sold by Kakute is still relatively low. It is unclear why this is so; perhaps the reason is inadequate supply of Jatropha oil, too high a price level for the Jatropha oil lamp, or users' lack of faith in the functionality of the lamp.

When large quantities of Jatropha oil are available, the opportunities for local people will be: setting up oil lamp factories, saving money by using Jatropha oil instead of kerosene (if the price of Jatropha oil is lower than that of kerosene).

[41] According to the website www.Jatropha.org

[42] €1 = TZS 1400 (May 2005)

Conclusion

Network formation has not developed very well. Some young people were trained but did not do anything with the knowledge. Kakute is the only producer of the Jatropha oil lamps and there do not seem to be many buyers. However, it has a capacity of about 1000 lamps/year, an indication that there is a market and the lamps probably work well. Information on users of the Jatropha lamp is lacking, although Jatropha oil from Engaruka is sold to villagers in Selela for use in oil lamps. **Learning processes:** some lessons have been learnt on the technical aspects and the system. **Expectations** are very unclear, although the application of using the oil in a lamp seems to work technically and people are willing to use it for that purpose.

Jatropha oil in cooking stoves

Jatropha oil can be used as fuel in a specially designed cooking stove. A normal cooking stove cannot be used, as the viscosity of the oil is too high.

Introduction

KIDT (a technical school where, among other things, a charcoal stove has been further developed) has tried to design a Jatropha cooking stove (see Figure) at the request of the Green Garden Women Group, which is sponsored by UNDP. TaTEDO, an NGO, was also involved. The prototype Jatropha cooking stove is still not functioning properly. KIDT did not have enough Jatropha oil to test it adequately. None of those using the stove is enthusiastic about it. TIRDO, a research institute in Arusha, is now doing research on the Jatropha cooking stove. The problems with using the stove are that the oil is poisonous and the emissions exhausted while using the stove could possibly be dangerous to the health of users. The emissions of another stove, which uses a mixture of Jatropha and kerosene, were listed earlier, in section 3.3. The emissions from that stove as well as those from an open wood fire were found to be higher than WHO safety limits.

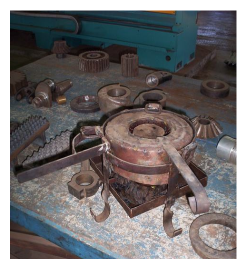

Figure 24: Jatropha cooking stove at KIDT

Network formation and stabilisation

Actors

- Green Garden Women Group (selling the stove, asked KIDT to further develop the stove)
- Kakute (funding)
- KIDT (R&D, producer of the stove)
- TIRDO (research institute)
- TaTedo (NGO)
- UNIDO (sponsor of the women's group)

Dynamics

In the process of developing the stove, the network has expanded properly; even a user (women's) group was involved in the development phase. The stove has been tested (though inadequately) and research is being done before it is produced on a large scale, which is very positive. However, the feedback from the research (with potential negative results) has not been spread among the actors. And during the development phase KIDT did not have enough oil to test the stove, indicating that the network was not properly connected between the actors.

Economic analysis

So far two cooking stoves have been sold by the Green Garden Women Group, for TZS 12,000 each (according to Mama Leema). According to KIDT, the final

Jatropha cooking stove will cost about TZS 20,000. Jatropha oil is available at TZS 2000/l.

Learning processes

Users

- Mama Leema is not using the Jatropha cooking stove herself, she is afraid that the smoke might cause health problems. She also does not know anybody who is using the cooking stove at the moment, although two have been sold so far (one in West-Kili and one in Uhuru).

Technical

- The viscosity of Jatropha oil is too high for a cooking stove (KIDT).
- There was a lack of Jatropha oil for further testing; larger quantities of Jatropha oil should be made available (KIDT).

Dynamics of expectations

According to Mr. Frank A. Elise of KIDT, the viscosity of the pure Jatropha oil is too high to enable it to burn well in stoves. The oil is like raw natural oil. It would be better to modify it into biodiesel.

Barriers

Users are not happy, the prototype stove does not inspire faith, it is potentially dangerous to health.

Conclusion

There seem to be too many barriers to using Jatropha oil in this way. The technology is not functioning properly and the users are not happy In fact, the emissions might even be dangerous. The **network** for the development of the stove was quite large and very diverse, many different actors were involved. However, it seems that the actors are not actively involved any more and the network was not properly connected. **Learning processes** for this application were very good in the beginning; the stove was tested and researched with various actors involved. However, the knowledge was not shared in the end. **Expectations** have not stabilised yet, but are already very negative.

4.4.6 Other uses for the Jatropha plant

A demonstration site was visited where Jatropha was being used as a support for vanilla plants (see Figure 25). There were four Jatropha plants, two of which were quite big and with vanilla vines entwined around them; but the other two were very small, with a large vanilla vine around them. It is not clear whether the vanilla was responsible for the plants being smaller than normal.

Figure 25: Jatropha as vanilla support

Brief summary of the niche analysis:

1. **Cultivation**

Extra income is earned by selling seeds from 'wild' Jatropha or from Jatropha planted as a hedge or in a plantation. The seeds can be sold to Kakute or Diligent. In the cultivation phase, the actor network is expanding quickly and it is becoming more diverse with the involvement of research institutes. Several learning processes have already occurred but have not yet been synthesized or shared among all the actors. The economic analysis is very good, although attention has to be paid to the costs of managing the Jatropha. Finally, the expectations vary.

2. **Production (oil expelling)**

The niche processes here are less positive than for cultivation. The actor network is quite diverse, but so far most contacts are linked through Kakute. There is potential for more dynamics when spare parts suppliers or maintenance service companies become involved. The economic analysis shows a large difference in the size (and profits) of the two presses. Unfortunately, actual data on the quantity of oil that can be sold is lacking. When the seed-cake gains monetary value, this application will have better profitability. The learning processes are mainly technical and some are on user acceptance. There are no lessons on the infrastructure or storage. The expectations vary widely, from small pressing units in several places to one big pressing unit in a central place. Also, expectations on capacity vary, with some user groups wanting a press with larger capacity although it is not clear whether the market is ready for that. Transport, and unreliability and inefficiency of equipment are seen as barriers. Equipment suitable for processing a variety of seeds could overcome the problem of limited supply of Jatropha seeds.

3. **Jatropha oil as diesel fuel**

The fuel can be used domestically, in remote areas or cities, or it can be exported. The actor network is quite limited; so far only Diligent, UDSM and the Kiumma project are putting efforts into this application. No Jatropha oil is actually used by consumers as a diesel substitute yet. Some technical learning processes have occurred, with experiments by Diligent at TU/e. There are no lessons on user acceptance so far. The economic analysis is unclear, expectations are positive but not stabilised yet (e.g. conversion to biodiesel or not).

4. **Jatropha seed-cake for biogas production**

The women's group in Monduli is enthusiastic about the properties of Jatropha (a given amount of gas production requires less Jatropha cake than cow dung), but not so enthusiastic about the biogas system itself (cooking with woodfuel is faster). Technical learning processes are necessary; so far the lessons are without a feedback loop. Kakute is going to install a biogas system in Engaruka as well.

5. **Jatropha seed-cake as fertiliser**

Several people have mentioned that Jatropha is a good fertiliser. However, so far Jatropha seed-cake is not available in large quantities so no price is charged for the cake. The possibility exists of charging a small price for Jatropha cake in future.

6. **Jatropha seed-cake pressed into briquettes**

This is done In Engaruka, but no details are available.

7. **Jatropha oil in soap-making**

Jatropha oil is used with some other ingredients to make soap. The users are very happy, but the market is very small. Training and equipment are only provided by Kakute. The actor network lacks some important groups of actors and the dynamics are not very good, either (everything runs through Kakute). The economic analysis shows promise but women's groups cannot make a living from soap sales due to market constraints. The learning process should include marketing. Expectations still vary widely.

8. **Jatropha oil in lamps**

The women's group in Engaruka sells the oil to villagers, for example in Selela. Villagers are even willing to pay as much as TZS 2000 per litre of oil. Kakute has a small oil lamp factory.

9. **Jatropha oil in cooking stoves**

Actor composition is very good, with many different types of actors. Connections between the actors are very poor. There is no sharing of lessons, and no continuation of development, due to shortage of oil. The Jatropha cooking stove prototype is still not functioning properly. Nobody is using the stove with enthusiasm so far. There is even a possibility of emissions being unhealthy.

10. **Jatropha as support for vanilla plants**

Too little information was available to be able to draw aany conclusions about this niche.

4.4.7 Conclusion niche analysis

The main niche processes are: network composition and dynamics, economic feasibility, learning processes and dynamics of expectations.
Cultivation of Jatropha is very important as this is the first step in the chain. The niche processes for this stage are quite good. More learning processes are expected in the future. The big push in number of actors is mostly due to Diligent and Kakute.
The second step in the chain is the production phase. Diligent is setting up a facility and Kakute owns a large expeller and sells hand-presses to women's groups. Learning processes on technology (equipment), storage and infrastructure are necessary. Most contacts run through Kakute so far.
The final step in the chain is use. So far Jatropha oil has not been used as a diesel substitute; therefore many, different experiments will have to be carried out to create several learning processes. Technical lessons as well as user acceptance lessons are necessary. There is a division in expectations between actors who think the oil can best be exported and actors who think the oil should be used domestically. Neither use rules out the other.

Not only can the Jatropha oil be used as a diesel substitute, but the seed-cake which is left after the oil has been expelled can also be used for certain applications. A good application for the seed-cake would strengthen a transition towards biofuels; after all, if the seed-cake has a value, the production stage is more profitable. So far, the applications have been explored very marginally. A biogas production facility has been installed, but there does not seem to be a learning feedback-loop, as Kakute is installing exactly the same facility somewhere else while the current facility is hardly being used. Further development of this application is desirable, as the users are enthusiastic. Using the seed-cake as fertiliser is a good application in theory, since the agricultural nutritional value is high. Farmers seem to be willing to use it on their land. The actor network should be increased, and more experiments need to be carried out to create learning processes. The application of pressing the seed-cake into briquettes for cooking purposes should also be explored further. No learning processes have occurred for this application yet.

Finally, there are other applications for the Jatropha oil that present a dual possibility: they could strengthen the transition towards biofuels or have a negative influence. Strengthening of the transition would occur if the niche processes were good, which would create user acceptance, and stabilised expectations would create trust in Jatropha oil. The transition to biofuels would be weakened if the applications for Jatropha oil were so successful that the price of

Jatropha oil rose to a level much higher than that of diesel. One application with this dual possibility is soap-making, which is quite a profitable business, with enthusiastic actors. Women's groups that are producing the soap want to expand their business. Even with a Jatropha oil price of TZS 2000/l, this business is profitable. If the oil price were to fall (more towards the current diesel price of TZS 1100/l) profitability would increase, so this is a very good application for Jatropha oil. Another use of the oil, in lamps, is practised already. Although a large actor group of young people were involved in the beginning, they are not part of the network anymore. Using Jatropha oil in a cooking stove has started off with high-quality niche processes. However, the expectations of the actors are very negative and the research institutes that are involved report some negative technical lessons.

Figure gives an overview of all actors in the Jatropha experiments in Tanzania. The more the number and types of actors, the better the network composition. Dynamics in the network are visualised by the connections between the actors; more connections indicate a better network. Three actors have abandoned the network: Faida MaLi (who only supported Kakute in the beginning), a youth group that was trained to produce oil lamps, and Mr. D. Malcolm, who wanted to start a large-scale Jatropha/Moringe plantation for D1 oils three years ago. Other actors have remained in the network, which is expanding rather quickly with new farmers who want to start cultivating Jatropha. Also, research institutes are about to start their research (UDSM and Sokoine University have not started yet). The network is expected to expand further when research results become available.

Overall, the actor network already has really good properties and many different types of actors are involved. Kakute and Diligent could be seen as two platforms which enable other actors to be involved.
The different types of actors include:
Research institutes: TU/e, USDM, KIDT, TIRDO, Sokoine University
Producers: farmers, brotherhood, outgrowers, Peter Burland, Kiumma
Users: women's groups, villagers
Connectors/platforms: Diligent, Kakute, Harry and Mark
Fund-raisers/providers: TAF, TaTEDO, Heiffer, FAKT, UNIDO
Faida MaLi, the youth group and D. Malcolm were actors that were involved in the beginning but are not any more.

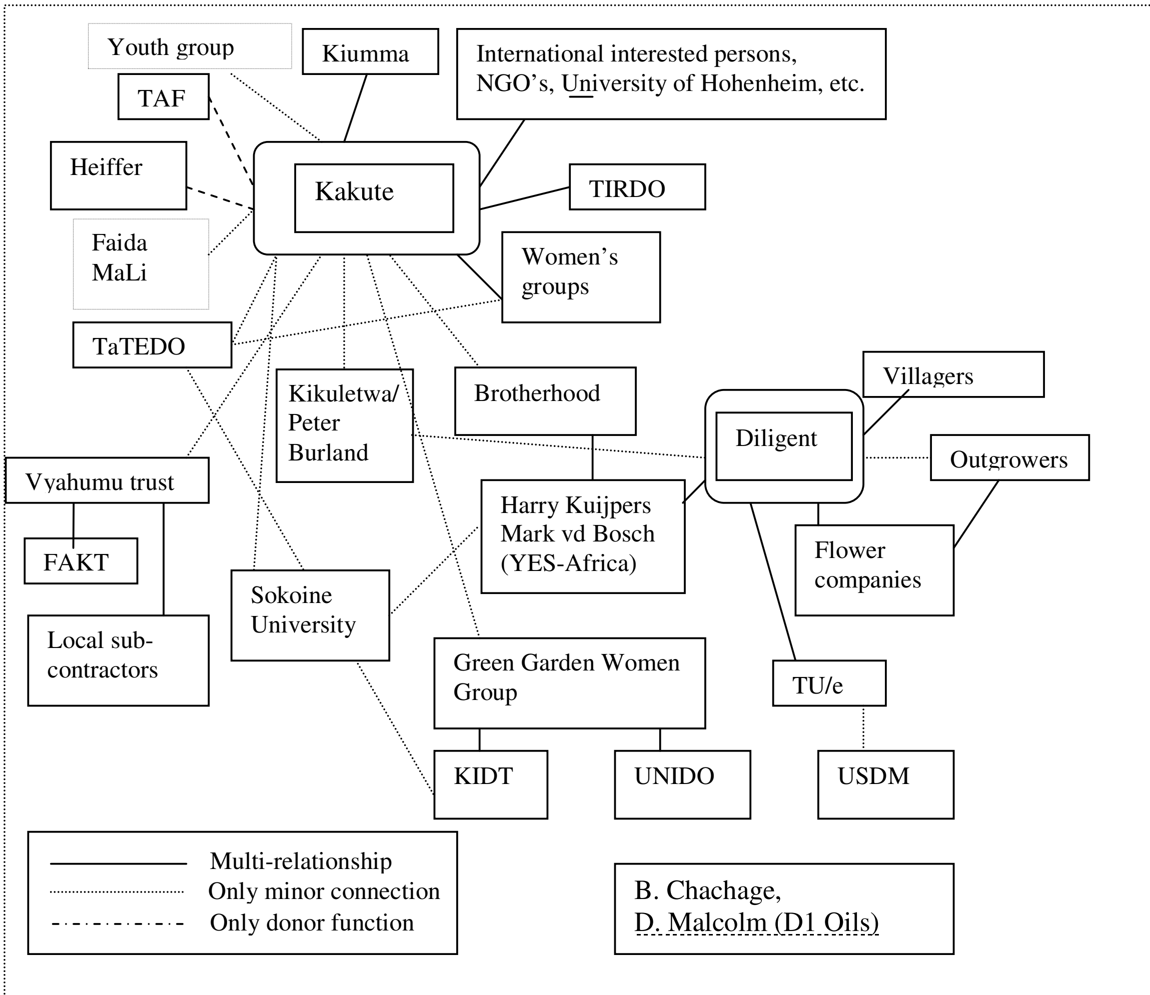

Figure 26: Actor network of Jatropha projects inTanzania, according to information given by actors.

A multi-relationship indicates that there is an active relationship, with knowledge sharing in both directions: for example, training, asking for information, etc.
Kakute is one of the most important actors in the network so far. Kakute has put efforts into training people in, for example, soap-making, oil-pressing and producing oil lamps, but these activities do not seem to be expanding rapidly. This is mainly due to the small market for these products. The network is mainly concentrated around Kakute; several NGOs are active and also serve as 'fund-raisers' since Kakute is a private company and cannot receive funds intended for NGOs. Kakute has created a high level of awareness about Jatropha in Tanzania, but a large barrier seems to be that Kakute is not showing up regularly in villages, which is not helpful in gaining the trust of villagers. Also, the role Kakute plays is not always clear; it both buys and sells seeds and oil, and sometimes the director is suspected of keepig information under wraps (Bukaza and other people mentioned this).

5 Conclusions and Recommendations

This chapter is divided into three sections. The first section discusses the research conclusions, providing answers to research questions 1 to 3. The second section, methodological reflection, discusses the SNM method. It deals with research question 4. Finally, the last section presents the recommendations (research question 5), sub-divided into recommendations for policy and for further research.

5.1 Research conclusions

The main research question is:

> *What is the status of the transition process towards Jatropha biofuels in Tanzania and how can the process be improved?*

Question 1: *What are the main processes that are important for a transition?*
Question 2: *What are the different niches or application domains for Jatropha in Tanzania?*
Question 3: *What is the influence of the related regimes and landscape on the transition process?*

Following the SNM methodology, the processes that influence the transition process were sub-divided into three levels. The analysis at landscape level describes the macro-level (both in the sense of 'national' and 'global') situation. Developments at this level cannot be influenced, but they can have a positive or negative effect on the transition. The second level is the regime level. Four different regimes were identified that could potentially influence the transition process through the extent to which they are open to new developments and niches. Important processes at regime level are alignment (high level of uncertainty or tensions indicate a low alignment), permeability (resistance from the dominant regime against new developments is low when permeability is high) and vision (the room for new developments is high when problems are recognised in the current regime). The niche processes that influence the transition process are: network dynamics, learning processes and dynamics of expectations. In addition, an economic feasibility analysis was added for each niche activity. The main findings for the three levels can be summarised as follows:

Landscape
The developments at the landscape level are almost all very positive for the success of Jatropha. Renewable energy is being stimulated worldwide, and although biofuels currently account for only a small part of the global renewable energy supply, an increasing number of countries are specifically mentioning biofuels. Some have even committed themselves to the use of biofuels as part of their total fuel supply, creating a global market for biofuels, which has a positive influence on the transition in Tanzania. The position of the Tanzanian government is unclear. Although it wants to stimulate renewable energy in principle, it could also still be a barrier in practice, since policy implementation lags behind policy pronouncements. Tanzania has enough land available to be self-supportive in fuel. The poor infrastructure does not have to be a barrier to transition when Jatropha products are used locally; however, where export is concerned, it might be a constraint.

Regime

The influences of the regimes on the transition are different for every regime. There is only one important factor that influences all the regimes in a similar way, namely the local cultural aspect. Tanzanians seem to be reluctant to take any risk, including risks associated with the introduction of new technologies.

The *agricultural regime* seems to be open to a transition. Farmers are already looking for new crops, recognising the problem caused by low prices for current crops. Jatropha is treated as just another cash crop, so a guaranteed price for Jatropha seeds is very important. Alignment is quite high, as the current rules are clear while the cultivation of Jatropha is not very different from the current practices. Cultivation of Jatropha does require more long-term investments, but there are systems to overcome this (intercropping, etc.).

A vegetable oil industry already exists, hence there is a *vegetable oil regime*. The technology in this regime shows great similarity with that of Jatropha oil expellers; however, the Jatropha oil is poisonous, which is a barrier against using the extant expelling facilities.

The *energy regime* seems to be a bit less open to changes. Currently, energy is mostly obtained from wood. The problems for Jatropha in this regime vary from health issues to insufficient energy. Villagers are used to a certain way of cooking, for example, and are not willing to extend the cooking time (which apparently occurred when they tried to cook with a jatropha-based biogas cooker). Lighting, if available, is based on kerosene. For this application, the price of Jatropha oil is important and it should be the same as, or lower than, that of kerosene – which is not (yet) the case. Diesel engines (e.g. in generators) are hardly used in rural areas, so there is little demand for diesel fuel. It is not very likely that people will pay to adapt their engines (which is necessary when Jatropha oil is used directly), but a mixture with diesel or the use of biodiesel is more in line with the current regime and offers more potential. Electricity, which can be used for lighting and cooking, is also hardly available in rural areas. Therefore, there is room for a transition, but user preferences are very important.

Finally, the *financial regime* offers (limited) room for niches. Some new developments in micro-finance could provide loans to rural people with little collateral, and this would have a positive influence on the transition.

Most regimes do not have to change radically in order to enable a transition towards Jatropha biofuels. In terms of the terminology of the Strategic Niche Management writers, it will be more an accumulation process than a substitution process.

Niche

As explained in Chapter 2, in Strategic Niche Management, a technology is still in a niche-stage when its rules are not yet clear, its market share is still low, and it still needs a protected environment. The Jatropha experiments in the different niches in Tanzania still consist of a loose set of experiments (cooking, etc.) or are at best in a niche-stage. This is because the rules of Jatropha are largely unknown yet. For example, with respect to cultivation, the rules of existing crops are well known. Farmers know how they should grow, sell and use them; they know the amount of nutrients required, what is the best height and time for pruning, where they can sell the crops, how large the market is, what applications there are, and so on. For Jatropha all these factors are still unknown.

Moreover, there is hardly any market share yet for any of the Jatropha applications. The availability of Jatropha biofuel, mostly Jatropha oil, is very limited, and the demand for it is not high. Planting Jatropha has been done so far by providing the seeds free to farmers and supporting them with technical assistance and a fixed selling price, thereby creating a protective environment. This clearly indicates that all the experiments are still (at best) in a niche-stage. None of the experiments has created a regime-change yet.

Another factor in niche analysis is expectations, which are considered to be very wide and diverse at the beginning of the transition, and then slowly moving towards more stability. In most Jatropha niches, expectations are still very wide and diverse. Only in the 'cultivation' niche, which is the first stage in the Jatropha production chain, have the expectations started to stabilise. The transition process seems to be only at the very beginning. Tanzania is still at the stage where many experimental activities have been carried out, which has created much awareness and interest in the plant.

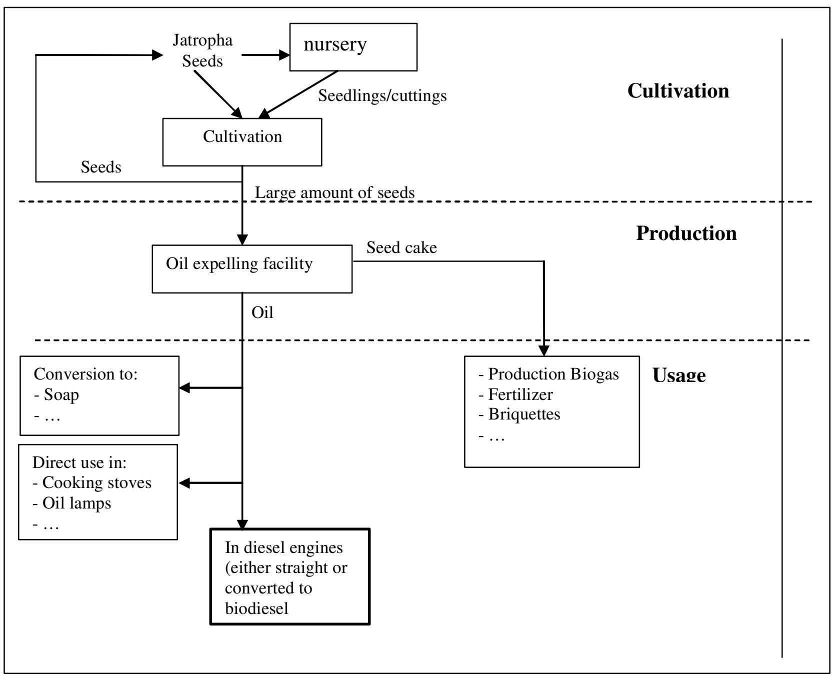

Figure 27: Jatropha production chain

The production chain (Figure 27) can help to provide understanding of which niches have contributed most to the transition process. The first stage, cultivation, is very important ,as it is the first step in the chain. It is this niche that has developed rather well so far in terms of SNM. This is visible in the high number of learning processes on various subjects, such as, for example, the system (nurseries, fencing, plantation, intercropping, etc.) but also user acceptance and so on. Calculations show that cultivating Jatropha can be very profitable; however, this depends on the scale, investment and maintenance costs and the actual yield of Jatropha seeds. The expectations are becoming more specific, which also indicates that the niche processes have developed properly. The problems and barriers in this niche are also more detailed. The actor network is expanding. New actors are, for example, farmers who are willing to shift to cultivating Jatropha instead of other crops, or villagers who have started to harvest seeds from Jatropha plants. An important reason for the enthusiasm of these actors is that they obtain a guaranteed price for their seeds, from either Diligent or Kakute. This reduces the risk for the farmer who wants to start cultivating Jatropha. However, there is still a risk: the (guaranteed) price paid for the seeds (currently by Kakute and Diligent) could be lower in future years, leaving the farmers with less or no profit. If they have stopped cultivating food crops and are no longer carrying out other income-earning activities, their situation could be precarious. However, the landscape analysis indicated that the current interest in biofuels worldwide is unlikely to be reversed, so demand from other countries could stimulate cultivation as well. The learning processes indicate that there are also systems such as intercropping or fencing that could help to overcome this problem. When other niches further down the Jatropha chain become more profitable, they will of course also influence this first stage, creating a more solid basis for sustainable cultivation based on a reliable price for the seeds.

The second step in the chain is the production (processing) step. Economic analysis shows that an oil-expelling facility can be profitable, but actual figures are lacking. There are few learning processes yet; lessons are lacking especially about infrastructure and transport. So this niche requires many more learning processes. Most contacts currently run through Kakute, so the network needs to be increased and become more interconnected.

The final step in the chain is use. So far Jatropha has hardly been used as a diesel substitute, so learning processes are lacking, especially about user acceptance and technology. This niche is still so undeveloped that it was not even possible to conduct an economic feasibility analysis. Expectations vary; some actors think the oil could best be exported, while others think the oil should be used domestically. Neither of these two options rules out the other.

While they are not central to a transition to biofuel, the niches that include the use of Jatropha seed-cake can contribute to that transition process. When the application of this seed-cake becomes commercially viable, it can gain market value. This will strengthen the Jatropha production-niche. So far, these applications have been explored only marginally.

There are also niches which constitute alternatives to the use of Jatropha oil as a biofuel. These are soap -making activities and the use of Jatropha oil for lighting and cooking. It is not clear whether the niche processes associated with these activities will contribute to the transition process. Awareness is created with the development of these niches, but if these applications become very successful they could start to compete with Jatropha for use as biofuel, by commanding a higher price for Jatropha oil. This might create a barrier to transition towards Jatropha biofuels. However, this possibility is currently rather remote, since all these niches are very small and do not show signs of substantial recent expansion. Soap-making can be a profitable business, but the marketing is inferior. The niche where Jatropha oil is used for lighting is quite small and the niche processes are not of high quality. Some actors (a youth group) abandoned the network and there were too few learning processes, especially for users. The niche where Jatropha oil is used in cooking stoves had excellent niche processes at first, but technical barriers (high emissions) and low user acceptance will probably stop these developments. According to SNM this is not a problem. SNM emphasises the need to view experiments as a process towards a regime-change. In this respect, many experiments are necessary to slowly change the regime.

Overall, the possibilities for a transition process are quite good. This is even though the government is unlikely to play a stimulating role in the near future, since its position on biofuels is unclear. When more (types of) actors are involved, all learning processes are shared by the actors in the network, and more experiments are carried out, a transition towards Jatropha biofuels could be made. However, it might still take a while before there really is a process of transition towards Jatropha biofuels in Tanzania.

5.2 Methodological reflection

The SNM framework used in this research was developed to study transitions in developed economies. This research constituted the first application of the method outside that context. A reflection on the basis of the experiences encountered with the use of SNM in Tanzania is therefore in order. Consequently, research question 4 is:

> *What lessons can be learned from analysing Jatropha experiments in Tanzania, using the SNM method?*

First, it is very hard in a developing country to obtain all the information necessary to analyse a potential transition on the basis of SNM. This is not so at the landscape level, as most developments at that level take place on a global scale. However, obtaining information for a regime analysis is rather difficult. It might not be possible to find out the 'normal way of doing things', as, for example, many rural people live in very isolated conditions. In an industrialised country, one would interview car manufacturers for their opinions on using biofuel in their cars. In a country like Tanzania, it would be very hard to obtain such opinions, even if there were such an industry.

Also on the niche level, certain information is hard to gather. For example, information on the development of the actor network, the underlying reasons for participation by persons or organisations, and the expectations of actors (or how they have changed over time) is often unavailable. Such information is not revealed, especially when it is considered to be negative; for example, an expectation that the technology might not work would not be easily shared with the researcher. The actual picture of all relationships between actors in the Jatropha sector of Tanzania might in reality look different from Figure 26: Actor network of Jatropha projects inTanzania, according to information given by actors. Actors that are not actively involved any more would perhaps not be mentioned by the current actors. The same holds true for all linkages between actors, no matter how minor they are.

Moreover, the setting in which the interviewer can ask questions is not optimal. Often there is a language barrier. Although this can be overcome to some extent by using a translator, the questions still have to be passed on by this third person and important information can get lost in the process. Projects are often located in remote areas, and in such cases it is difficult to return a second or even third time due to time constraints, lack of transport, and so on. The interviewer needs to try and obtain all the required information during the first (and often only) meeting. This, of course, is not specific to the use of SNM as such; it holds true for every research method used in a developing country.

The main difference between the outcome of an SNM analysis in a developed country and one in a developing country is that most of the time the government in a developing country does not yet have an active policy on a 'new' sustainable technology. In Tanzania the government is often more a constraint than a supporting force (due to need for bribes, etc.), while in a developed country government policies can be a fruitful starting point for a transition.

The main subjects SNM is focusing on are quite useful: actor network, learning processes and expectations. The lessons people have learnt from their projects are especially very useful for data collection. By asking questions on all aspects of SNM it is possible to get a good picture quickly of how the experiment is going. In that sense, SNM is very suitable for projects in developing countries. A nice extra is that writing down all the lessons learnt from the experiments has made this knowledge tangible. It can now be shared with other actors be used for further research.

Other theories on technological development in developing countries often mention surprisingly similar important factors that stimulate or enable innovation to happen. Most of them agree on the need for a bottom-up instead of top-down approach, and on involving users at an early stage with efficient feedback loops. Douthwaite (2002), for example, recognises that innovation is catalysed by a learning selection approach, which is consistent with SNM theory. Mog (2004) also mentions an approach to create change 'through continuous learning and adaptation'. The new aspect of SNM is that it has integrated a multi-level perspective into the theory.

Of course, using the SNM methodology does not provide a complete picture of the transition process in a developing country. This is so for two reasons: (i) it is hard to obtain all the information that is required (as explained earlier) and (ii) it is hard or even impossible to predict any new developments or innovations that might interfere with the transition process. Some developments (say, further headway in solar energy technology) might be so successful that the work on Jatropha biofuels would be abandoned. However, SNM stresses the importance of learning; even if the Jatropha activities end up being only a stepping stone towards another development, the lessons have still contributed towards that process.

One limitation of SNM that emerged in practice was that its concepts can sometimes be rather unclear. The distinction between experiments and niches, for example, is very vague. Raven (2005) also recognises this. He also distinguishes no less than four different types of niches: technological niches, regular market niches, dedicated market niches and protected market niches. In practice, the distinctions between these different types of niches are hard to make. Even distinguishing between experiments and niches proved to be difficult to do for some activities. In this report I have chosen to view all applications which use Jatropha oil, but also the cultivation and production, as niches. This might not be right according to SNM, but for analytical purposes it does not really matter how the groups of experiments are labelled. According to Raven, Jatropha biofuels can also be seen as a single niche in the energy supply, depending on the purpose of one's research. The important lesson that seems to emerge from this is that SNM has to be used in a flexible and creative manner to suit one's research objectives and the limitations set by the specific context within which the research has to be carried out.

One example of such creative use is that in addition to using the niche concept, I have chosen to add the concept of the production chain in this research. I did this in order to emphasise that certain niches are more important than others for the transition process, and to get a better grip on how the different niches hang together. SNM itself is unclear on the nature of the interrelationships between different niches (for example, whether there are any competitive or complementary linkages between them). These interdependencies influence the transition process, but it is not yet clear how. This is also recognised by Elzen et al. (2004) who state that 'from the wide variety of alternatives developed at niche level, it is necessary to select and focus, and to asses which of them should be stimulated in what way'. They propose using the method of 'socio-technical scenarios' to help make these choices.

In this study, the transition towards biofuels is analysed and recommendations are given to strengthen this process. However, the desirability of such a transition could also be questioned. The carbon cycle is closed, even though the engines driven by biofuels emit greenhouse gases. Some reports even question whether the carbon cycle is really closed, whether the use of pesticides has a negative influence, etc. To people who are questioning this transition as well, I would like to stress the importance of learning-by-dong, as SNM advocates. Even when the transition towards biofuels is not the best end-point for our energy supply, there are always lessons to be learnt. Perhaps biofuels will only play a minor role in the future, but it will not be bad to have multiple energy sources. As stated earlier, the focus of this research is not to learn about the desirability of a transition, but to learn about the processes which occur during it.

Finally, SNM has so far never been used to design experiments ex-ante with the goal of maximising the chances for a transition. Raven (2005b) indicates that SNM can be used as a practical tool, for improving the design of experiments or for designing future policies on niche management. However, Raven also observes that SNM has so far been mainly used as a research tool, and that it needs real-life experimentation in society to see if the conclusions arrived at are borne out in reality. Thus, the application of the SNM method does not yield hands-on recommendations on how to pull off a transition by mounting a specific action programme. This has to be kept in mind when reading the recommendations in the following section.

5.3 Recommendations

Taking account of the above limitation, some recommendations can still be made to increase the chances of success for a transition towards Jatropha biofuels. This section provides an answer to research question 5:

> *What recommendations can be made to improve the transition process?*

Two types of recommendations are made, policy and methodological.

Policy recommendations

Policy recommendations can be made for different levels:

- Regulation of the sector can best be done by the *government.*
- *Production chain management* should be done by organisations like NGOs or even universities, which can act as an 'umbrella' and are able to set up several experiments in specific directions, gathering and disseminating all lessons. If possible, this should be done for multiple countries.
- *Niche management:* the actors involved in the specific niches should focus on the main niche processes, such as creating a wide and diverse actor network, creating learning processes, voicing and shaping the expectations of all actors in the niche. Local 'niche-champions' could lead this process; they may include, for example, entrepreneurial farmers or foreign lead firms.

Government
Protection of the niches should be assured by financial incentives, for example by tax reduction or sponsorship. The developments should also be facilitated by adequate organisational structures, for example the Rural Energy Agency that the Tanzanian Government is planning to set up. The government should also regulate and supervise the cultivation of Jatropha. Big mono-culture plantations should be avoided as small scale projects will create more involvement of local actors and therefore have more chances of success.

Production chain management
The cultivation of Jatropha cannot be profitable without a market for the seeds. This implies that it is important to stimulate production and use of Jatropha biofuels as well. However, as the landscape level analysis showed, demand for Jatropha oil can come from other countries as well, which can stimulate cultivation. It is important to stimulate the other niches, too, because this will create a more solid base for cultivation and the transition is not complete without the utilisation of the entire production chain. The transition towards biofuels must be driven by production and use.

- Further development of the potential applications of Jatropha: attention must be paid to create high-quality niche processes.
- Awareness must be created among local people. Due to the cultural attitude towards innovation, it is important for people to actually see the technology. This can be done by, for example, setting up demonstration sites.
- Network developments must be stimulated; as many different types of actors as possible should be involved, from research institutes to local farmers and users. Also, interactions between the actors should be stimulated.
- More learning possibilities for each niche should be created, and increased sharing of that knowledge should be stimulated.
- The lessons (from all actors, such as users and research institutes, etc.) should be collected and disseminated to all actors in the network.
- The expectations of the actors should be levelled, for example by organising seminars on a regular basis to exchange experiences.
- A fund should be provided to overcome the cash flow problems during the first two years after planting, when Jatropha cannot be harvested yet. However this protection could also be provided through trade credit from international companies.

Niche management
SNM advocates close connections between all the actors in the network. This enhances/enforces the potential of feedback loops, for example from user to designer. It is much more a bottom-up approach than a top-down process; several reports mention this as a necessary condition for development processes (Douthwaite, 2002). When this strategy is followed, local people are more actively involved and this will increase the potential benefits to them.

- Experiments are important in SNM. Hoogma (2000) distinguishes four types of experiments that may play a role in creating or enforcing niches: explorative experiments (at a very early stage), pilot experiments (to raise public and industrial awareness), demonstration experiments (to show potential adopters how they may benefit) and finally replication or dissemination experiments (to disseminate tested methods through replication). All these experiments should be stimulated.

Some specific recommendations can be made for each niche.

Cultivation:

- It is important to reduce the risk that the farmer is taking by planting a new product. This can be done, for example, by guaranteeing a fixed price for the product and that the whole harvest will be bought. This creates an assured market for the farmer's product. It has been shown that the farmer will then be very eager to plant the new product. Of course, this is also based on trust; if the farmer is very sceptical of the market guarantee, he will be reluctant to take the risk.
- Develop a system for selling and transporting the seeds.
- Learning processes for cultivation should include: the amount of water that is necessary for a good yield, the amount and type of nutrients and how Jatropha should be managed (pruning, weeding, etc.). It is also important to record the seed yields under specific conditions. Other learning processes include the system of cultivating Jatropha, what are the best crops and conditions for intercropping. The Prof. Udipi Shrinivasa of the Indian Institute of Science in Bangalore is a well-known person in the area of biofuels. One of his suggestions is to use castor, a sturdy four-month crop, to bridge the period between planting Jatropha and harvesting.

Production:

- Increase the number and type of actors for this niche.
- Create an experiment where the Jatropha oil price is not fixed. This will provide lessons on the actual costs of the facility, and on how price fluctuations induced by market forces affect profitability and people's willingness to persevere with the activity.
- Learning processes on storage of Jatropha seeds are very minimal. Experiments in this direction, as well as on equipment (variation in capacity of the presses) and infrastructure (expelling in several places or in one central place) are necessary.
- Expectations are still very unclear. Interviews should be conducted with user groups to find out how the system should be set up. For example, do villagers want to press the oil themselves, what kind of capacity for the press do they want, etc.

Usage:

Diesel substitute

- A possible path to let users get used to biofuels slowly is first to mix diesel fuel with Jatropha oil at the pump, followed by making Jatropha biodiesel available at the pump as this requires only marginal adaptation to the diesel engines, and finally, when there are enough mechanics trained to modify engines, making Jatropha oil available at the pump as well.
- Involve more actors, especially users, but also mechanics and oil companies, which could mix Jatropha oil and fossil fuel at their pumps.
- An economic analysis should be carried out when more data is available.
- Research institutes are involved, but they have not yet started their research. Their activities should be linked to other research being carried out worldwide in order to prevent duplication of executed research activities.
- Many learning processes on the usage of Jatropha oil or Jatropha biodiesel as diesel substitute are necessary. User acceptance is still very unclear. Several experiments that include the users should be executed. Also, demonstration projects are necessary to increase awareness. Finally, testing by, for example, having Jatropha biodiesel available at the pump.

The niches for the application of the seed-cake should also be strengthened and explored, as this can positively influence the profitability of an oil-expelling facility. The same processes as for the other niches are important here as well; that is, creation of a wide actor network, stimulation of good learning processes (with many feedback loops) and facilitation of the voicing and shaping of expectations.

The soap niche can be expanded through increased marketing efforts. Attention has to be paid to the price of Jatropha oil. The niche where Jatropha oil is used in a cooking stove can only be further developed when the emissions from the stove are reduced, and even then it will be very hard to win user acceptance. The niche where Jatropha is used in oil lamps can be strengthened by involving more users in the network.

Methodological recommendations

- Literature on SNM should be integrated with other literature on technological development, for example studies like Douthwaite (2002) and Mog (2004) that provide more detail about the actual management of learning processes at the micro level in projects. This could help operationalise SNM as a policy tool. It will help clarify how the niches should be stimulated.
- More research is necessary on the interrelationships between the niches, how they influence the transition process and in what way they should be stimulated. Integration of a product chain concept in the SNM method could be one way forward.
- Real-life experimentation with SNM in society is necessary to see if the conclusions reached are borne out in reality.
- Develop a practical guide to analyse experiments, regimes and landscape according to SNM. Raven (2005a) has already provided a basis, but the concepts are still vague and do not fit well with the situation in developing countries.

References

Aesotope (2004) *Project Description Jatropha Philippines*. Genoa: Asia-Europe Scientists of Tomorrow Programme.
http://www.aec.asef.org/aecsep/Philippines_VersatilityJatrophaCurcasPlant.pdf

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.

Dosi, G. (1982) 'Technological paradigms and technological trajectories', *Research Policy* 11: 147-62.

Douthwaite, B., (2002) *Enabling Innovation. A Practical Guide to Understanding and Fostering Technological Change*. London and New York: Zed Books.

Elzen, B., F.W. Geels and K. Green (2004) *System Innovation and the Transition to Sustainability, Theory, Evidence and Policy*. Cheltenham, UK: Edward Elgar Publishing Limited.

Ieromonachou, P., S. Potter and M. Enoch (2004) 'Adapting SNM for evaluating radical transport policies, the case of the Durham Road Access Charging Scheme', *International Journal of Transport Management* 2 (2): 75-87.

Foidl, G., N. Foidl, E. Winkler, R. Staubmann, G.M. Gübitz and W. Steiner (1997) *Use of enzymes for oil extraction from J. curcas seeds*. Graza: Institute of Biotechnology, Graz University of Technology, and Managua: Managua University of Technology.

Forson F.K. et al. (2004) 'Performance of Jatropha oil blends in a diesel engine', *Renewable Energy* 29(2004): 1134-45.

Grimm, C. (1999) 'Evaluation of damage to physic nut (Jatropha curcas) by true bugs', *Entomologia experimentalis et applicata* 92(2): 127-36.

Grimm, C. and J.M. Maes (1997) *Arthropod Fauna Associated with Jatropha curcas L. in Nicaragua: A Synopsis of Species, Their Biology and Pest Status*. Vienna: Institute of Forest Entomology , and León, Nicaragua: Entomological Museum S.E.A.

Geels, F.W. (2002) 'Technological transition as evolutionary reconfiguration processes: a multi-level perspective and a case-study', *Research Policy* 31(8-9): 1257-74.

Geels, F.W. (2004) 'From sectoral systems of innovations to socio-technical systems: insights about dynamics and change from sociology and institutional theory', *Research Policy* 33: 897-920.

Geels, F.W. and R. Kemp (2000) 'Transities vanuit een socio-technisch perspectief', one of three reports on transition research by Rothmans, ICIS-MERIT, Maastricht Economic Research Institute on Innovation and Technology, Maastricht.

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

Henning, R. (2004) 'The Jatropha system. Integrated rural development by utilisation of Jatropha curcas L. as raw material and as renewable energy', Presentation, Hamburg, Germany. Paper presented at 'Studientag Möglichkeiten und Grenzen erneuerbarer Energien in Tansania- Erfahrungen in der Partnerschaftsarbeit' Hamburg. www.tanzania-network.de/downloads/referate_hh_energien/reinhard_henning_-Jatropha_presentation.pdf

Hoogma, R. (2000) 'Exploiting technological niches', MSc. thesis, Twente University, Enschede.

Hoogma, R., R.Kemp, J. Schot and B. Truffer (2002) *Experimenting for Sustainable Transport: The Approach of Strategic Niche Management*. London and New York: Spon Press.

Jones, N. and J.H. Miller (1993) *Jatropha curcas, a Multipurpose Species for Problematic Sites*. Washingotn, D.C.: The World Bank.

Kemp, R., P. Mulder and C.H. Reschke (1999) 'Evolutionary theorising on technological change and sustainable development', Working Paper Series 2, Maastricht Economic Research Institute on Innovation and Technology (MERIT), Maastricht University, Maastricht and Institute for Environmental Studies (IVM), Vrije Universiteit, Amsterdam.

Kuipers, H. (2004) 'Potential of biogas technology in developing countries', Projectthesis for BSc. study, Open Universiteit, the Netherlands.

Kumar, Senthil M. et al. (2003) 'An experimental comparison of methods to use methanol and Jatropha oil in a compression ignition engine', *Biomass and Bioenergy* 25: 309-18.

Lane, B.M. (2002) 'Implementation strategies for fuel-cell powered road transport systems in the United Kingdom', thesis, Open University, Milton Keynes, UK.

Meadows, D., J. Randers and D. Meadows (2004) *Limits to Growth, the 30- year Update*. Chelsea: Green Publishing.

Meena, Hubert E. and M.J. Mwandosya (1996) *Technological and Other options for the Mitigation of Greenhouse Gases in Tanzania*. Dar es Salaam: Centre for Energy, Environment, Science and Technology.

Mog, J.M. (2004) 'Struggling with sustainability, a comparative framework for evaluating sustainable development programs'. World development 32(12): 2139-60.

Mühlbauer, W., A. Esper, E. Stumpf and R. Baumann (eds.) (1998) Workshop on Rural Energy, Equity and Employment: Role of Jatropha curcas. Hohenheim, Germany: Institute for Agricultural Engineering in the Tropics and Subtropics, Hohenheim University. www.jatropha.de

Nelson, R.R. and Winter S.G. (1977) 'In search of a useful theory of innovation,' *Research Policy* 6: 36-67.

Openshaw, Keith (2000) 'A review of Jatropha curcas: an oil plant of unfulfilled promise', *Biomass and Bioenergy* 19: 1-15.

Pramanik, K. (2002) 'Properties and use of Jatropha curcas oil and diesel fuel blends in compression ignition engine', *Renewable Energy* 28: 239-48.

Rabé, E.L.M. (2004) 'Jatropha oil in Tanzania and its use in diesel engines', report for the System Integration Project II course, Technische Universiteit Eindhoven.

Raven, R. (2005a) *Strategic Niche Management voor analyse doeleinden, stappenplan voor de analyse van ontwikkeling en veranderingspotentieel van duurzame technologie niches*. Eindhoven: Technische Universiteit Eindhoven .

Raven, R. (2005b) *Strategic Niche Management for Biomass, a Comparative Study on the Experimental Introduction of Bioenergy Technologies in the Netherlands and Denmark*. Eindhoven: Technische Universiteit Eindhoven.

Renewable Energy Policy Network (REN21) (2005) *Renewables 2005 Global Status Report*. Washington, D.C.: Worldwatch Institute. http://www.mvo.nl/biobrandstoffen/download/renewables%202005%20global%20status%20report.pdf

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.
http://oregonstate.edu/international/outreach/rlc/resources/Jatropha.pdf

Staubmann, R., G. Foidl, N. Foidl, G.M. Gübitz, R.M.Lafferty, Arbizu V.M. Valencia and W. Steiner (1997) 'Production of biogas from J. curcas Seeds Press Cake', *Applied Biochemistry and Biotechnology* 63(12): 457-68.

TIRDO (n.d.) 'Use of vegetable oil as substitute for diesel oil,' paper prepared by Centre de recherché industrielle du quebec for UNIDO Vienna, Austria.

UNIDO (1983) 'The vegetable oil industries development sector, a review of policies and approaches to appropriate vegetable oil industrialisation', paper prepared by UNIDO secretariat for the 50th International Fair, Novi Sad, Yugoslavia.

Weber, M., R. Hoogma, B. Lane , and J. Schot , (1999) *Experimenting for Sustainable Transport Innovations: A Workbook for Strategic Niche Management*. Enschede: Twente University.

World Bank (2006) *Agriculture and Achieving the Millennium Development Goals* Washington, D.C.: Agriculture and Rural Development Department of the World Bank.
http://siteresources.worldbank.org/INTARD/Resources/Ag_MDGs_Complete.pdf

Statistical data

Annual Survey of Industrial Production, , Volume IIA and Volume IIB, Comprehensive report 2000, National Bureau of Statistics, President's office, Planning and Privatisation, Dar-es-Salaam, September 2003.

Basic data Agricultural sector, Tanzania Ministry of Agriculture and Food security. http://www.agriculture.go.tz/MAFS-Services/Statistics.htm (chapter 1 and chapter 2).

Household Budget Survey, 2000/01, Dar-es-Salaam, July 2002, National Bureau of Statistics Tanzania, http://www.tanzania.go.tz/hbs/HomePage_HBS.html accessed December 2005.

Special report, FAO/WFP crop and food supply assessment mission to Tanzania, August 1998. http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/004/w9479e/w9479e00.htm

National Bureau of Statistics (2000), "Integrated Agricultural Survey Report 1998/98, Rural Tanzania Mainland," Tanzania. http://www.tzonline.org/pdf/integratedagriculturalsurvey.pdf

Tanzania National Profile Data in Brief, Central Census Office, National Bureau of Statistics, Dar-es-Salaam.

Internet pages

- http://www.areed.org/country/tanzania/tanzania.pdf (Tanzania Country Assessment 2001) accessed February 2006
- http://www.agriculture.go.tz/Agr-Industry/Crops-grown-tz.htm#Pyrethrum accessed December 2005.
- http://www.bcstimes.com/dailytimes/printable.php?category=1&newsID=975 accessed February 2006.
- http://www.books.md/B/dic/biodiesel.php (Medical dictionary search engine) accessed on December 2005.
- http://www.cia.gov/cia/publications/factbook/geos/tz.html (Worldfactbook) accessed October, January 2006
- http://www.elsbett.com accessed November 2005.
- http://www.eia.doe.gov/emeu/steo/pub/contents.html accessed March 2006.
- http://en.wikipedia.org/wiki/Kyoto_Protocol accessed January 2006
- http://www.hedon.info/goto.php/TanzaniaCountrySynthesis information is based on KAALE and HIFAB (1998), who conducted a rural energy study, accessed July 2005.
- http://www.yearofmicrocredit.org/ accessed February 2006.
- http://www.jatropha.de/faq.htmm accessed November 2005.
- http://www.jatropha.de accessed December 2005.
- http://journeytoforever.org/biodiesel_yield.html accessed October 2005.
- http://www.tanzania.go.tz/agriculture.html accessed November 2005
- http://www.tanzania.go.tz/economicsurveyf.html Development in different sectors of the economy, accessed July 2005.
- http://www.tanzania.go.tz/economicsurvey1/2003/part1/financeinstitutions.htm accessed on August 2005.

Appendix I Various sources for Jatropha yield

Reference	Location	Age (years)	Yield Shrub (g)	Hectare (kg)
Avila (1949)	Cape Verde	?	700-900	n.d.[1]
Bhag Mal (pers. comm.)	India	3	n.d.	1733
Foidl (pers. comm.).	Nicaragua	?	n.d	5000
Henning (pers. comm)[2]	Mali	?	n.d.	2640
Ishii and Takeuchi (1987)	Thailand	?	n.d.	2146
Larochas (1948)	Mali	?	n.d.	8000
Martin and Mayeux (1984)	Madagascar	?	3000-3500	n.d.
Matsuno et al. (1985)	Paraguay	3	n.d.	100
Matsuno et al. (1985)	Paraguay	4	n.d.	700
Matsuno et al. (1985)	Paraguay	5	n.d.	1000
Matsuno et al. (1985)	Paraguay	6	n.d.	2000
Matsuno et al. (1985)	Paraguay	7	n.d.	3000
Matsuno et al. (1985)	Paraguay	8	n.d.	4000
Matsuno et al. (1985)	Paraguay	9	n.d.	4000
Naigeon (1987)	Cape Verde	?	n.d.	1750
Silveira (1934)	Cape Verde	?	n.d.	200-800
Stienswat et al. (1986)	Thailand	1	318	794
Sukarin et al. (1987)	Thailand	1	63.8	n.d.
Zan (1985)	Burkina Faso	diff.	955	n.d.

Table A-1: Jatropha yield from several sources (Heller, 1996)

[1] n.d. = not determined.
[2] Survey on hedges: 0.8 kg seeds per m hedge. Hectare yield assumes a distance of 3 m between the hedges.

Seed yield	Oil yield	Comments	Source
4-6 kg/yr		From average size bush	Raina, 1986
4-6 kg/yr		Mean yield for 5 yr old tree in Thailand	Basabutra and Sutiponpeibun, 1982
2-4 kg/tree		Mean yield for 5 yr old tree in Thailand	Takeda, 1982
4.6 kg/bush		Average seed yield	Banerjee, 1989
4-5 kg/tree	1.5-2.0 kg/tree	Madagascar	Martin and Mayeux, 1984
638 kg/ha		1 x 1 m spacing with no fertiliser; NE Thailand	Sukarin, Yamada, and Sakaguchi, 1987
2,146 kg/ha	751 kg/ha	Avg. annual yield; 35% oil extraction rate, Thailand	Ishil and akeuchi, 1987
400-1200 kg/ha		Commercial yield, Cape Verde	Levingston and Zamora, 1983
650-2000 kg/ha	200-600 kg/ha	Average yield; Cape Verde	Martin and Mayeaux, 1984
5000 kg/ha (kernels)	2.5 tonnes/ha	One location in Cape Verde	Martin and Mayeaux, 1984

350-1000 lb/ac			Wealth of India, 1959
3 tonnes/ha		Value assumed under rainfed conditions after 5 yr.	The World Bank, 1991
4-6 tonnes/yr (assume per ha)		Minas Gerais, Brazil	Srivastava, 1984
5 tonnes/acre/yr			Calvin, 1985
	1.5-2.3 tonnes/ha	Established plantation in Brazil	Srivastava, 1984
	3-4 tonnes/ha	3m x 3m spacing; Brazil	Forni-Martins and Diniz da Cruz, 1985

Table A-2: Jatropha yield from several sources (Jones and Miller, 1993)

Appendix II Actors and projects visited and interviewed in Tanzania

1 Organisations

1.1 University of Dar es Salaam

Location: Dar es Salaam
Date of visit: March 28th 2005
Talked to: Mr. Temu and Mr. Kibazohi

Currently a test is being performed on Jatropha biodiesel in a diesel engine. Mr. Temu is working on coconut oil while Mr. Kibazohi is working on the Jatropha diesel. They are directing their attention on the chemically modified Jatropha oil (biodiesel) because they think using the pure oil will cause too many problems in the longer term (however, there is no proof of this statement). They are also performing research on biofuelled cooking stoves and lamps. The problem with the lamps, however, is that due to the high viscosity, the flame of the lamp is getting lower as the oil gets used up. The plan is to plant 10,000 hectares themselves with Jatropha.
September 25th: Visit of Mr. Kibazohi to the Netherlands, the test is still not running. The test results will hopefully be available in November 2005.

Figure 28: Test chamber, University

Figure 29: Test chamber, University

1.2 TaTEDO

Tanzania Traditional Energy Development and Environment Organisation

Location: Dar es Salaam
Date of Visit: March 29th 2005
Talked to: director of TaTEDO; Mr. E.N. Sawe

TaTEDO is a national renewable energy development NGO. They have been involved in energy development projects and programmes in rural areas for more than 12 years. Their goals are:[43]

- To improve the quality of life of Tanzanians by contributing to the availability of improved and sustainable energy services, employment and income generating opportunities, which are essential for poverty reduction
- To reduce environmental degradation resulting from increased use of wood and fossil fuels.
- To contribute to reducing the country's dependence on imported energy.

They have several partners across Tanzania and are involved in several renewable energy sources such as micro-wind turbine, solar PV system installation and biomass.

[43] TaTEDO annual report 2003/2004

They first became aware of the possibilities of Jatropha through a connection with the successful Jatropha project in Mali. They established a partnership with Kakute, which was involved in a Jatropha project for Monduli women. Jatropha is viewed as a plant with enormous potential; first of all, the plant itself can serve as an effective fence for the farmers, and the plant will stop degradation of the soil. The oil from Jatropha can be used for soap production, as diesel substitute and on the household level in oil lamps and cooking stoves. Finally, it can also be used to create an export market. TaTEDO's main task will be to create awareness, create a network with links between farmers, seed processors, oil exporters, etc.[44] Awareness will be created by publishing a brochure for the farmers with the possibilities of Jatropha and also training private persons in, for example, Jatropha nurseries. They have also performed research on cooking stoves; this stove is still in development but will be a lot cheaper than the currently available stove from Germany. Their expectation of Jatropha is that in 3-5 years' time a lot of Jatropha will be planted, mostly by private persons.

Other important remarks:
*2-3 months ago the tax on solar panels and other forms of renewable energy was removed, so he is expecting a great increase in these sources. However, in the end Jatropha offers a lot more potential, esp. with income generation
* The government is currently busy setting up Rural Energy Agents with Rural Energy Funds, these could provide Jatropha projects with subsidies.

1.3 Faida MaLi

Location: Arusha
Date of visit: April 15th 2005
Talked to: Agri-Business Officer; Stephen Kijazi

Faida Market Linkages is a small NGO set up for Tanzanian farmers. They link the farmers with local and international markets through traders and exporters. All linkages are on a contract basis; this creates security for the farmers, who will have assured markets for their products. So far the sectors that Faida is active in include: oil crops, horticultural crops, staple crops, non-timber forest products and flower seeds. Their activities include: Market linkage facilitation, farmer producer group's formation and empowerment, market research/market chain analysis, contract farming arrangements, business awareness training, farmers' exchange visits and trade fairs/exhibition promotion.[45] They are sponsored by Cordaid and Heifer.
They were involved in the beginning of Kakute's Jatropha activities. They provided the training of the farmers and Kakute used their network of farmers to promote Jatropha.

1.4 TAF

Tanzania Association of Foresters

Location: Moshi
Date of visit: May 12th 2005
Talked to: Jon-Erik Rehn and Philipina

TAF was originally a Swedish NGO formed in 1976. Their goal is to become the best institution of forestry professional practices and advisory services in Africa. Their organisation is built through membership; there are currently about 700 members (mostly in Tanzania, some in Sweden), who pay a contribution fee or give an extra donation. There are also four full-time officers, based in Moshi. TAF is supporting several field activities which

[44] interview with Mr. E. Sawe, Executive director of TaTEDO, March 29th 2005
[45] http://www.netherlands-embassy.go.tz/organizations.htm

all have an environment conservation component, for example promoting tree-planting in Karatu to prevent soil erosion. The Association derives its finance from members' annual contributions, grants and donations from well-wishers.[46] Membership is open to all practising professional foresters holding a certificate in forestry, diploma and/or degree.
About one year ago they started working together with Kakute. (the vice president of TAF is a friend of Mr. Manyaga of Kakute) As Kakute is a private company and therefore cannot receive funds directly, TAF agreed to cooperate to support a Jatropha project in the ARUMERU district.

1.5 KIDT

Kilimanjaro Industrial Development Trust

Location: Moshi
Date of Visit: May 13th 2005
Talked to: manager; Frank A Elise

KIDT is an autonomous organisation which offers training and production operations. The Japanese Government has sponsored this organisation through UNIDO's Small and Medium Enterprises (SMEs) development project. The training programmes include: building construction, computer courses, welding and fabrication, etc.
The vocational training centre currently has about 20 full-time students. At the location in Moshi there is also a small briquette factory, producing 50-60 tonnes of briquettes each month. The briquettes are made from sawdust, waste material. They also have other programmes; for example they designed a fuel-efficient cooking stove, which they have delivered free to all primary schools around Moshi (funded by Danido, a Danish NGO). The cooking stoves use briquettes. They also produce and sell efficient charcoal stoves and they can maintain and repair all kinds of other technical equipment. (they can also produce charcoal briquettes, which do not smoke when burned; the briquettes are much cheaper than normal charcoal or other fuel sources)

1.6 FINCA

Foundation for International Community Assistance

Location: Dar es Salaam
Date of attending workshop 'Renewable Energy for Poverty Reduction' facilitated by TASEA (Tanzania Solar Energy Association):April 28th 2005
Speaker: Felistas Coutinho
Date of Visit head office: May 18th 2005
Talked to: Felistas Coutinho (Managing Director) and Mary

FINCA is a microcredit organisation which is providing credit and loans to individual persons. They are the second largest credit provider of Tanzania and are currently the fastest growing. They have 41,000 clients (at this moment 44,000) in Tanzania, of whom 99% are women. They have 1,281 village banking groups, and a total of USD 4,899,613 in outstanding loans.[47] So far they are only active around Dar es Salaam , Morogoro, Iringa and Mwanza. Their focus is mainly on rural areas and women.
Their approach is different than that of other microcredit organisations. Because many rural people do not know how to write or read, they don't require a business plan; instead they pay

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[46] document "What is TAF" 17-11-2004
[47] Webpage FINCA international: http://www.villagebanking.org/work-afr_tan.htm accessed May 17th 2005, data is from February 28th 2005

a visit to the group/individual (so the women do not have to come to Dar es Salaam). They make their own analysis of the business, and the collateral of the individual persons. When they think the business is good enough to provide credit to, they also provide training. This training consists of business planning, cost calculations, etc., to give an understanding of the implications of a loan (for example, why invest instead of eating).
The loan size varies between US$ 500 and US$ 5000, depending on the scale of the business and the collateral. Average repayment time is 12-18 months. The repayment can be done at a commercial bank branch at the village.
There are 3 conditions for the credit:

- There has to be a business
- The asset is transferred to FINCA's name; after repayment, the asset is returned to the names of those who received the credits
- There have to be assets to serve as collateral (for a $500 credit, for example, a fridge and a TV could serve as collateral)

They worked together with Umeme Jua (a commercial solar panel company) to finance womens groups who wanted to buy a solar panel. They would be very interested in providing credit to women who want to buy the Jatropha equipment.

Remarks:
- Most women are shy, so they are afraid to enter a micro-credit organisation or a bank; therefore it is important for FINCA to go to them.
- If you ask people to write out a business plan they ask someone to write something that looks good but is not necessarily the truth.
- Normally the costs for rural people to go to the bank to make the repayments are very high.

1.7 TIRDO

Tanzania Industrial Research and Development Organisation

Location: Dar es Salaam
Date of Visit: May 18th 2005
Talked to: Senior Research and Development officer; Eng. Daniel Makundi

TIRDO is a non-profit organisation under the Ministry of Industry and Trade. They carry out applied research and provide technical services to industries. They concentrate on several core areas, for example: agrotechnology, industrial chemistry, energy and environment, etc.[48]
Daniel Makundi was very interested in biodiesel; he thinks it can become very big because the oil prices are rising very high. TIRDO has done some research on biofuels, but because their library is at the moment not 'indexed' it is very difficult to find information. TIRDO can develop, design or test several technologies and equipment.

[48] Website TIRDO: http://www.sdnp.undp.org/tirdo/ accessed September 2005.

2 Companies

2.1 Kakute

This company (NGO) is listed under projects.

2.2 Diligent

This company is listed under projects.

2.3 D1 oils

It is very unclear whether they are active in Tanzania. They are active in a lot of countries with very large plantations. With Doherty Malcolm (interviewed in Dar es Salaam, see projects) they wanted to start in Tanzania three years ago. A field officer from Kakute mentioned that they were involved in a sugar estate near Arusha; however, this could not be confirmed.

3 Projects

3.1 Kiumma Project

Kituo cha Elimu na Maendeleo Matemanga

Location: Matemanga near Tunduru, at the border with Mozambique.
Information through website and e-mail contact.

Description:[49] Private development project around Matemanga hospital. The main energy supply will be derived from Jatropha oil (which is now diesel), Solar panels (photovoltaic) will be used as back-up. They will plant Jatropha themselves, but as they don't think they will be able to cover the full demand themselves, they will also motivate local farmers to produce the oil, which they can sell to others as well. A German company on solar and alternative energies (Energiebau koeln, Bernd Wolff) was the one who told them about the possibilities of Jatropha.
An old 30 kW gen-set will be replaced by a new 20 kW one,which will also run on Jatropha oil. The first batch of seeds was bought in Arusha. The gen-set was adapted to run on Jatropha oil by a German company. Planting started in December 2003.[50] From contact with Mr. Fred Heimbach, it appeared that the project is still in the starting-up phase. The seeds are planted but need more time to mature, and the diesel engine is still under construction in Europe. (March 23, 2005) According to mr. Albert Mshanga the plan is to plant 1000ha.

3.2 Bukaza Chachage

Location Dar es Salaam
Date of meeting: April 5th 2005

Bukaza Chachage has done his Master's thesis on Jatropha oil in Tanzania, at the Lund University of Sweden. In his thesis he has described several Jatropha projects in Tanzania, such as Kikuletwa Farm.
Kakute is a private company. They worked together with NGOs like Faida to get a subsidy from the UNDP. D1 oils activity stopped because the government wanted a bribe.
Activities of farmers should not be solely Jatropha, but as a hedge it can create extra income. The employees of Kakute provide far better (and more accurate) information than the manager himself. He has bought seeds in Iringa and wants to plant them in his hometown to make people aware of the potential. He has planted one hectare of Jatropha and is going to keep a record of all necessary information on soil, seeds, seedlings, costs, employment and all other related information such as amount of water and weather in general, etc. They want to have complete information on these subjects. On another hectare they are planning to mix with other crops to see their reactions.

3.3 Malcolm Doherty

Location: Dar es Salaam
Date of meeting: May 23th 2005

Malcolm is an Englishman who has been living in Tanzania for the past three years. His background is mechanical engineering and later he specialised in environmental issues.

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[49] http://www.jatropha.de/tanzania/kiuma/kiumma-project.htm accessed on March 22, 2005
[50] http://www.jatropha.de/news/jcl-news.htm accessed on March 23, 2005

Malcolm has been trying to get Jatropha projects going for a long time, however not successfully. He was once the director of D1 oils when they wanted to start activities in Tanzania. Even at this moment he could get a plot of 100,000 acres (or hectares) in total around Dar es Salaam with the back-up support of an Austrian company Gapco, but nobody wants to actually do it. (Bukaza, for example, did not do what he promised, as is the case with all other Tanzanians, so Malcom says)
Malcolm is of the opinion that you should never plant Jatropha alone. It is much better to plant, for example, Moringe with it (see Figure 30). Moringe is an edible plant; it has so many nutrients (when you dry and grind the Moringe leaves, a baby could survive on just that). So Moringe could be used as feedstock.

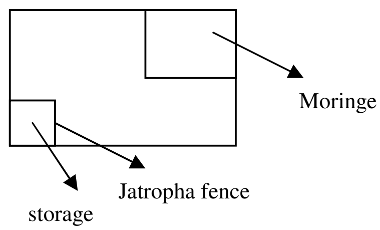

Figure 30: Example of farmer's plot

In the Kisarawe region he worked with pyrethrum, a plant whose oil has insect-repellent with no chemicals added. In the UK they did not like it; can't you add chemicals, they said.
If you were to take Jatropha oil, pyrethrum oil and avocado oil you would have a very good insect repellent. (pyrethrum alone decays with UV radiation)

Barriers
- The problems arise when it is done on a large scale: the logistics. How are you going to get into the middle of a 1000 ha plot? Do you want people to walk in there and pick the seeds, or do you want big and heavy equipment? (Most of the time they want to drive with their tractor 5 miles straight turn 90 degrees and drive another 5 miles straight;, that would destroy the landscape)
- Another barrier is the amount of information that is still lacking on growing Jatropha.

Lessons
- There were farmers who used to grow cashewnuts and switched to Jatropha. They did not treat the soil properly; the top layer was ploughed but the old roots from the cashew were still deep in the soil. The Jatropha was choking and after 2 years all Jatropha had died at that spot.
- For the pesticide, a large company bought it, in tonnes at the same time. The farmers formed cooperatives, it was transported altogether to Dar es Salaam, where the big company weighed the material and said, for example, that the quality was not good so the price was very low (the driver does not care that they pay so little, the driver gets his money), the cooperative takes money for the building and other equipment and finally the farmer is left with almost nothing.
- According to Malcolm, an expeller designed for sunflower seeds will never give a good yield on Jatropha seeds, the pressure for a sunflower seed expeller is much lower. At one place they said they had an oil yield of 80% (groundnuts); when he went there, they did not even have a weighing scale, so they were just guessing. When they expelled another batch, the yield was only 15%.
- When Jatropha cuttings are used, the roots will not go as deep as the roots of seedlings. In the end cuttings will thus not help to stop soil erosion.

- About three years ago he had everything ready to start a large-scale Jatropha and Moringe project with D1 oils. He was promised 1 million ha around Dodoma. But the authorities wanted a title deed (guaranteed use of the land for over 99 years, instead of the normal 10 years), for 20 million pound sterling. Malcolm did not want this and walked away. A title deed is never good for a country, the government should not do this.
- If Jatropha is grown without fertiliser, the yield will get less over the years.
- A Canadian firm has planted 100,000 ha with wheat. This monoculture is not good for the environment of Tanzania, it caused desertification of the entire area.
- D1 oils is at the moment active in, among other countries, Egypt, with a Jatropha plantation of over 5000 ha. Although the website on the Internet shows promising figures, the actual payback period is very long, about 15 years. This is due to the fact that, for example, they used heavy equipment like bulldozers to cultivate the land. They are working on far too big a scale, it is destroying the landscape.
- Optima was a company that has been doing something that Malcolm calls 'robbery'. They have given Jatropha and Moringe a bad name. They do not seem to have morals, only money is what they are interested in. They bought Jatropha and Moringe seeds for TZS 300 from the farmers and let them buy them back for TZS 4000.
- Jatropha storage is important; because of the high humidity in Tanzania the seeds would germinate; a normal silo would do, but could get too warm.

Expectations
A lot more research has to be done on several aspects (like growing/cultivation) of Jatropha (and Moringe). The ecosystem is fragile and unstable, there can be huge effects which work up all the way through the food-chain. The influence of Jatropha plantations has to be researched first. They should make test plots to measure, for example, how deep the root of cuttings and seedlings actually go, the amount of fertiliser (nitrate) that works best, and so on. When it goes wrong, the reputation of Jatropha will be destroyed.

3.4 Kikuletwa Farm

Location: TPC near Moshi
Date of visit and interview: April 12th 2005
Talked to: Peter Burland

Introduction
Peter Burland is an English farmer who owns 1000 acres of land in the West Kilimanjaro region. His main crops are Aloë vera and Jatropha. He started planting Jatropha about 3 years ago after he had visited a demonstration on the possibilities of Jatropha by Kakute Ltd., at an agricultural exhibition in Arusha. His main goal is to establish a large plantation of Jatropha with expelling equipment to produce Straight Vegetable Oil (until this equipment is installed, the seeds are pressed in Arusha). This oil can be sold to villagers and they can use it in oil lamps and cooking stoves. He also sells seedlings and cuttings. He started by planting one acre of seeds which where bought from Kakute (this species can be harvested twice a year if irrigated) and from the first harvest of seeds and cuttings (the Jatropha is pruned at about 1.5 meters) the plantation has expanded. So far he has established about 200 hectares with Jatropha plants from different age groups (18 months, 3 years and a nursery) aprox. 1000 seedlings. He uses a system of intercropping with involvement of local villagers

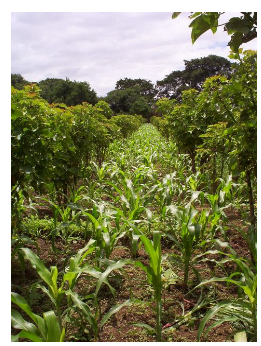

Figure 31: Intercropping at Kikuletwa farm

(see Figure 31); villagers are given half an acre of land[51] on which Jatropha is planted with 2x2m distance. They can plant crops in between the Jatropha rows and they irrigate and weed their area. By doing this they are looking after the Jatropha too. They have to return the Jatropha seeds but they can keep the crops. The crops that they can use for intercropping vary; they are mostly beans and onions, maize was planted, too, but became too big and was disturbing the Jatropha. The farm is located near two rivers from where the villagers can take the water they need.

Actors
Initially the first batch of seeds was bought from Kakute, but now Kakute goes to him for information on the Jatropha plant; for example, how it should be irrigated. Kakute is also sending other people to Kikuletwa Farm for information, for example a women's group from Mto Mwa Mbu and also people from Germany, Switzerland and other countries. Kakute now wants cooperation with him, but so far they have not really contributed anything but the seeds. Negotiations with Diligent have now started as well.
Missing actors: so far no other initiative is implemented on a large scale, only pilot projects. This should be done on large scale, according to Mr. Burland.

Economic analysis
Peter Burland is growing Jatropha as well as Aloë vera. The latter crop will not be taken into account. He is selling the Jatropha seeds as well as Jatropha seedlings. So far Mr. Burland has only marginally sold the Jatropha seeds; however, for the calculations the assumption is made that all seeds can be sold to Diligent. The expenses are listed in Table A-2. The initial seeds were bought from Kakute for TZS 150/kg. Globally Mr. Burland has indicated that until he could harvest the seeds he spent about $100 per hectare (Chachage, 2003). Because at that time he was employing the villagers to look after the Jatropha (as well as planting a little bit for themselves) the expenses for the years after the first harvest are much lower.

Expenses first 2 years	TZS
$100 per hectare (110,000 TZS)	22,000,000
Per year	11,000,000
Expenses later years	TZS
Water	0
Labour for weeding and irrigation	0
Supervision	100,000 /month(1person)
Other costs like insecticide, diesel fuel etc.	±100,000 / year
Total 3rd to nth year	1,300,000

Table A-2: Expenses of Jatropha at Kikuletwa Farm

Kikuletwa Farm is asking TZS 150/tree (either cutting or seedling).
The seed-cake left after pressing has no monetary value and is put back on the land.
The Jatropha plants can be harvested twice a year (April and November); each tree will yield 4-5 kg of seeds per harvest, according to Mr. Burland's measurement, so this makes 8-10 kg a year. The economic analysis is summarised in Table A-3.

Assumptions in calculation:

- 1000 seedlings, all sold as trees, revenue: 150,000 TZS ($136)
- 2500 trees per hectare, 200 hectares of Jatropha is about 500,000 Jatropha trees. 8-10 kg a year will yield: 4,000,000 to 5,000,000kg of seeds a year.
- All seeds sold to Diligent for TZS 80per kg

[51] ≈0.20 hectare

- First two years without yield, in 3rd year 50% yield, 75% in 4th year and 100%[52] in 5th year.
- Real discount rate (r): 9.8%, calculated by using inflation (p) of 4.4% and the average interest rate (i) on medium- and long-term loans in 2003 which was 14.6%,[53] in the formula: $r=(1+i)/(1+p)-1$.
- Project running time: 5 years
- No loan necessary to get start-up capital (no loan repayment costs).

Year	Expenses (TZS) (cash outflow)	Revenue (TZS) (cash inflow)	Profit (TZS) (non finan. cash inflow)	US Dollars (USD)	Discounted cash flows (TZS)	US Dollars[54] (USD)
0	11,000,000	0	- 11,000,000	-$10,000	-11,000,000	-$10,000
1	11,000,000	0	- 11,000,000	-$10,000	-10,020,942	-$9,110
2	1,300,000	160,150,000 to 200,150,000	158,850,000 to 198,850,000	$144,409 to $180,773	131,831,436 to 165,027,894	$119,847 to $150,025
3	1,300,000	240,150,000 to 300,000,000	238,850,000 to 298,850,000	$217,136 to $271,682	180,581,347 to 225,944,047	$164,165 to $205,404
4	1,300,000	320,150,000 to 400,150,000	318,850,000 to 398,850,000	$289,864 to $362,591	219,608,904 to 274,709,147	$199,644 to $249,736

Table A-3: Economic analysis, Jatropha at Kikuletwa Farm (8 kg/plant to 10 kg/plant), current prices

The following economic parameters are derived from the table:

NPV, Net Present Value: between 511,000,745 ($464,546)
(sum of discounted cash flows) and 644,660,146 ($586,055)
IRR, Internal Rate of Return: between 315 % and 359 %
BCR, Benefit/Cost Ratio: between 22 and 28
PBP, Payback Period: between 2 and 3 years.

Barriers

- The main barrier is a cultural one, according to Mr. Burland. People in the region are from the Chagga tribe[55] and seem to lack any incentive whatsoever. You will have to charge them for e.g., land to push them to do something with it. When given seeds free, they will not use them. When Peter Burland was still working with other crops they used to steal as much as they could (from 8 acres of maize, 7 were stolen), not only crops but also diesel fuel, insecticide, etc. Getting them to understand why this Jatropha is important is difficult, although Peter Burland suggested he could pay them in vegetable oil, which they will then have to use in cooking stoves, etc. At the moment they are too poor to pay for kerosene or charcoal (which costs TZS 200) so

[52] Mr. Burland was able to harvest the first seeds after only 8 months. However, while the exact figures are not known the calculation is made with the same estimates as for the other projects with Jatropha.
[53] This is the medium- and long-term interest rate charged by commercial banks. Source: http://www.tanzania.go.tz/economicsurvey1/2003/part1/financeinstitutions.htm accessed on August 30th 2005.
[54] 1 US Dollar = TZS 1100 (May 2005)
[55] This tribe was strongly influenced by Christian missionary work and Western education and are therefore often disproportionably represented in government and business circles on the mainland.(Source: LonleyPlanet) Most Chagga people will go to urban areas and the 'less- developed' ones are staying behind (Source: Fons Nijenhuis).

letting them pay for something they can cook on will not be easy. (According to Peter Burland, this could also be due to property being nationalised during the Ujamaa socialist reforms; nationalising it could have made them somewhat used to 'stealing'. They don't even consider it to be wrong (only from *Wazungu* – westerners – and the government)

- Possible barrier: the government; the only importance is to keep the oil from being taxed, otherwise it will be too expensive.
- Transportation is really expensive; transporting a lorry-load from Dar es Salaam to Kilimanjaro region costs $1000.

Lessons

- Water is very important; the plants which received a lot of water were growing very fast and with a high yield. The plants which received less water (for example, at the end of a row) were growing much slower.
- The Jatropha tree is cut at about 1,5 meter; these cuttings were used to grow new plants. A plant from a cutting will establish much faster than one from a seed (seedling). However, some reports mention that the root will not establish properly in the long term.
- Jatropha was planted and then left idle for 18 months (no water); the plants did not grow at all even after they were properly watered again. Also, at places where not much water was given to the plants (e.g. at the end of a row, see picture) the Jatropha plants were much smaller than the ones which received lots of water. So water is extremely important.
- Not many people want to press Jatropha seeds because they are poisonous.
- The government does not seem to be interested in extra employment creation for hundreds of people (on his farm). 'What's in it for me?' is their only concern.
- Intercropping is a useful way to get villagers to look after Jatropha well.

Expectations

When Mr. Burland started he did not think much money would be generated by it (a barrel of oil was then $30) but now with oil prices of nearly $50 a barrel it is getting much more interesting.

Mobile expellers could be used, which are placed, for example, on a lorry. They can come to your farm twice a year to press the seeds on the spot.

Other remarks

-Jatropha soap will not be suitable for export due to low quality; however, for local usage it is fine.

-There was a project a while ago on Moringe (which has about the same properties as Jatropha). It was heavily sponsored with UNDP money. They lived in big houses and flew in private jets; there was absolutely no community commitment and therefore the project ended in a complete failure. The project leaders ran away with the money and have not been seen again!

-No tax has to be paid for diesel for agricultural purposes; however, this is very hard to control/supervise.

3.5 Brotherhood of Jesus the Good Shepherd

Location: Hedaru (Pare Region, near Same, Kilimanjaro)
Date of visit: April 17th – April 20th

Introduction

Seven Brothers are starting a new facility at Mabilione, which is close to Hedaru. They formerly stayed at Chanjale, which is close to Same and there they established a Vocational

Training Centre with biogas facilities. Harry Kuijpers, who lives in Eindhoven, was involved in that project and told them about the potential of Jatropha. In their new compound they want to build a house for themselves as well as another Vocational Training Centre. Their compound is 2 hectares and part of this land will be reserved for Jatropha. This will be partly sponsored and guided by Harry Kuijpers and Mark van den Bosch, who started an organisation called Washiriki. The Brothers want to demonstrate the technology for Jatropha and try to convince the villagers to plant Jatropha to prevent soil erosion. The area in Mabilione, which is assigned to them by the government, is not cultivated yet. They have cleared a small plot near a river where they have started a small Jatropha nursery(see Figure 32) with 1 kg of seeds bought from Kakute (in total they bought three kg). All 7 Brothers visited Kakute, were they were given a demonstration of the techniques for nurseries (one seed per small black plastic bag filled with a mixture of cow dung and soil) and pressing of oil. The seeds were planted March 1st; so far about 1000 seedlings have developed (about 1 month old) and they have replanted 500 seedlings. The replanted seedlings are planted 1 meter x 2 feet from each other. Their plan is to expand to 3000 plants and even more after experience is gained. They employed one villager, who is busy full-time with the Jatropha plants. His activities range from setting up the nursery to watering the plants, clearing the area and replanting the plants from the nursery.

Figure 32: Jatropha nursery at Mabilione

Actors
Brother Moses is the one who is in charge of the Jatropha project, although the other Brothers are very interested, too. Harry Kuijpers and Mark van den Bosch are the project leaders of Washiriki. However, since they live in the Netherlands contact with the Brothers is difficult. Kakute was the supplier of the seeds and they also demonstrated the technology for the nusery. There has also been contact with Diligent. The seeds might be sold to Diligent or Kakute.

Economic analysis
One person is employed full-time for the Jatropha activities. In the first month he prepared the plastic bagss for the nursery, cleared the area and made the cow dung/soil mixture for the nursery. There are some one-time fixed costs, (see Table A-4) and some running costs which will be incurred during the whole project. Table lists the expenses for the Jatropha plantation, as anticipated by the Brothers themselves. A water pump with water tank will probably be installed at a later stage; some of the costs are already listed in the table, but in the calculations this pump will not be taken into account.

Fixed costs	TZS
Seeds	TZS 1,500/kg x 3 kg= 4,500
Clearing land	15,000 per acre (tractor+labour+fuel) (only necessary once, including driver of tractor TZS 1,000/day)
Installation of water tank	TZS 8,500/bag cement, detailed estimate will be made by the brothers later
Plastic bags for seedlings in nursery	6,000 (enough for 3 kg of seeds)
Total (without water tank)	25,500
Running costs	
Labour (irrigation, weeding etc)	30,000/month; 360,000/year
Diesel fuel for water pump (1 liter/hour)	3000/week; 156,000/year

Diesel fuel for 4x4n jeep to check activities in the field	8000/week; 416,000/year (brothers mentioned 15,000/week)
Total (without water pump)	776,000

Table A-4: Expenses for Jatropha plantation of the Brotherhood

Assumptions in calculation:

- Yield: 4 -8 kg of seeds per plant,[56] 1000 plants will generate 4 to 8 tonnes of seeds.
- First two years without yield, in 3rd year 50% yield, 75% in 4th year and 100%[57] in 5th year.
- After one year, the remaining 2000 plants will be planted, according to the same yield prospect.
- Seeds sold to Diligent at TZS 80/kg (revenue: TZS 320,000-640,000 a year) and seeds are sold to Kakute at TZS 150/kg (revenue: TZS 600,000-1,2000,000 a year)
- Interest rate: 14%[58]
- No loan necessary to get start-up capital (no loan repayment costs).

Table A-5 gives the economic analysis of the Brotherhood. The low estimate is made with a yield of 4 kg/plant and a seed price of TZS 80/kg, the higher estimate is made with a yield of 8 kg/plant and a selling price of TZS 150/kg for the seeds.

Year	Expenses (TZS)	Revenue (TZS)	Profit (TZS)	Discounted cash flow	US Dollars[59] (USD)
0	801,500	0	-801,500	-801,500	-$729
1	776,000	0	-776,000	-706,932	-$619
2	776,000	160,000 to 600,000	-616,000 to -176,000	-511,225 to -146,064	-$465 to -$133
3	776,000	244,000 to 2,100,000	-532,000 to 1,324,000	-402,216 to 1,001,004	-$366 to $910
4	776,000	800,000 to 3,000,000	24,000 to 2,224,000	16,530 to 1,531,787	$15 to $1,393

Table A-5: Economic analysis for Brotherhood, without water pump

The following economic parameters can be derived:
NPV: from -2,405,343 to 878,294 (-$2,187 to $798)
IRR: ## to 26%
BCR: from 0.3 to 1.3
PBP: from more than 15 years to between 4 and 5 years.

If the selling price of the seeds was TZS 80/kg in the high estimate as well instead of TZS 150/kg, (so only a higher yield of 8 kg) then the PBP would be between 5 and 6 years, the NPV between -$2,187 and -$963 and the BCR would then range from 0.3 to 0.7.

[56] Kakute's experience is a yield of up to 6 kg/year per plant, Diligent's estimate is a minimum of 2kg/year per plant and Mr. Burland's experience is 8-10 kg/year per plant. Calculations here will be made with an output of 4-8 kg/year to limit the range.

[57] Mr. Burland was able to harvest the first seeds after only 8 months; however, while the exact figures are not known, the calculation is made with the same estimates as for the other projects with Jatropha.

[58] This is the medium- long-term interest rate charged by commercial banks. Source: http://www.tanzania.go.tz/economicsurvey1/2003/part1/financeinstitutions.htm accessed on August 30th 2005.

[59] 1 US Dollar = TZS 1100 (May 2005)

Conclusion: Expansion to 3 acres is necessary to be financially viable, but in the lower estimate the viability is still not very good. The costs of monthly labour and supervision (one employee and diesel costs) are too high compared with the output of Jatropha.

Barriers
Currently the area suffers heavily from soil erosion. If people need a piece of land for agricultural purposes they just chop down the trees. The people will have to become aware that trees are necessary for fertile land.

Lessons
As the project is only 2 months old, few lessons have been learnt so far. The mixture of cowdung/soil seems to work fine, although almost 40% of the seeds in the nursery did not germinate.
For their next replanting of 500 seedlings, they will dig trenches in the land and plant the seedlings on the elevated soil (see Figure 33). When the water pump is installed, it will be much easier to water the plants automatically.

Expectations

- The expectation of the Brothers is that the Jatropha activities will be self-sufficient in the end. Some villagers will be employed and these costs will have to be borne from the sale of Jatropha seeds (or at a later stage, from selling soap or oil).
- In the beginning they will only sell the seeds, but in the longer term, if they can finance it, they would like the equipment for pressing oil and soap-making.
- Mr. Manyanga of Kakute told them they could sell the seeds to them. They also are willing to sell to Diligent, but they would like to get the highest price possible.


Figure 33 Replanted Jatropha at Mabilione

Other remarks:
1 bag of charcoal is TZS 2500; it will last for 1 to 2 weeks (depending on family size). Soap bought from Kakute costs TZS 500/ piece

3.6 Diligent Energy Systems

Future location of the factory: Moshi, Tanzania
Dutch 'headquarters': Technical University Eindhoven campus
Talked to: Ruud van Eck (director), Thijs Adriaans[60] and partners in Tanzania

Introduction
Diligent Energy Systems is a Dutch company based in Eindhoven. They want to become a large player in the biofuel market as a supplier of Jatropha oil from Tanzania. They are also active in research. As the company is located on the TU/e campus, they have a lot of linkages with students from the university as well as research in other institutions. They are also involved in several organisations (international as well as national).

They started their activities in 2004 and have started a joint venture with a Tanzanian partner. They have contracted local farmers (small farmers as well as bigger ones) to plant the Jatropha for them. They guarantee the farmers that they will buy the seeds (or oil) from them, so the farmer has a guaranteed market for his seeds. They will export the Jatropha oil back to the Netherlands or other countries in Europe, although they will probably also try to sell the

[60] Also an interview by Wouter v.d. Laak, March 11th 2005, with Thijs Adriaans has provided input.

oil locally. Whether this will be the Straight Vegetable Oil (SVO) or chemically modified oil is not clear yet.

Diligent is using the outgrowers network from the flower/vegetable seed companies Multiflower, Arushacuttings and Vasso-agro (Dutch-owned) to contact farmers and make them aware of the potential of the plant.

Tjerk Scheltema is the one who is going to push farmers in the region around Arusha (as far as the Ngorogoro Crater, Arusha National Park), while Fons Nijenhuis is going to try to push farmers in the region around Moshi. Extra field officers will/can be employed as well. As soon as a lot of Jatropha is planted in the regions and the first seeds are harvested, they will start building a factory in Moshi which will press the Jatropha seeds to extract oil. Whether they will also modify the oil in Tanzania is not clear yet; perhaps this will be done in the Netherlands. Also, they are currently thinking about the structure of the company; while transportation of the seeds is quite expensive, it is possible that smaller extraction units will be set up, from which the oil can be transported to the factory in Moshi.

They will pay farmers TZS 80 per kg of Jatropha seeds. Although this is less than what Kakute pays (TZS 120-150) the farmers are assured that all seeds will be bought, no matter what quantity. The strategy seems successful, with several farmers already asking for more seeds and at least one farmer starting a big plantation of Jatropha (80 acres, see Ismael Manang).

The location of the factory will probably be next to the railway line; the oil can then be transported to Tanga by rail, from where it will be shipped in containers (which are lined with plastic bags) to Europe.

Actors

- Diligent
- Tanzanian partner, flower companies in Tanzania
- Dutch Ministry of Foreign Affairs (subsidy),
- SenterNovem (they support the research activities with a subsidy)
- Several cooperative activities with Technical University Eindhoven (TU/e) and Technical University Twente

Contacts with several other actors, like companies which are active in the chemical conversion of oil.

Economic analysis

A substantial part of the investment is paid through a subsidy from the Dutch Ministry of Foreign Affairs (in collaboration with Economic Affairs?). (The responsible persons from this ministry have paid a visit to farmer Ismael Manang.) This subsidy is meant for entrepreneurs who have a good idea for an export product in a developing country.

The TZS 80/kg price is based on the maximum selling price of the oil in the Netherlands. With the oil content of Jatropha seeds being about 33%, you need at least 3 kg of oil (TZS 240); transportation costs and refinery costs (filtering, modifying) will have to be added to this. In the Netherlands diesel fuel is now about €1 (TZS 1400); the price of Jatropha oil will have to be lower than this. In Tanzania the diesel price is currently fluctuating around TZS 900-990 (March-April 2005); if you want to sell Jatropha oil in Tanzania the price should be lower than TZS 900.

Exact figures will not be made public, but for Diligent it is clear that the larger the quantity of seeds that can be obtained, the better the results for the company will be.

Barriers

- The tax on fuels in the Netherlands is currently the largest barrier; the government is taking a long time to set up a longterm plan for biofuels and it is still not clear whether biofuels will get a tax reduction. Currently the tax in the Netherlands is €0,37/l for every product that is put in a tank. This will make the biofuel from Jatropha too expensive. However, the expectation is that the Dutch government will reduce this tax by the start of next year.
- The quality of African equipment; for example, you will probably need spare parts every 2-3 weeks.
- Cultural barriers like not trying anything new before other people in your neighbourhood have tried it.
- No idea yet how much oil will be transported to the Netherlands in bulk, for example by ship; to negotiate with chemical modifiers, this has to be known.
- No idea whether or not the poisonous content remains in the glycerine (which is created by chemical modification).
- Time; due to the rainy season, the best time for planting is from February till April. You have to have some oil available already to start building your customer network.

Lessons

- There is no use asking questions about press temperature and so on to producers of the presses; when the press is working, it's working.
- Because Jatropha is poisonous, it is hard to find people who want to press the seeds. It's better to tell them the seeds are not for human consumption than tell them they are poisonous because they get scared.
- We lack knowledge about processing oil from the Jatropha seeds and the marketing aspects of the oil, as well as knowledge about emissions, CDM, etc. Further research is necessary.
- It is taking a lot of time to have large-scale production of Jatropha seeds.
- Several spin-offs have occurred already, more initiatives with Jatropha since Diligent has started

Expectations

- By the end of next year we should be able to have planted 1000 hectare.
- 1500 litres/hectare, 4.5 tonnes of seed/hectare. So with 1000 ha about 1500 tonnes of oil.
- The seed-cake will be used as fertiliser
- SVO (straight vegetable oil) will have a transitional role in Europe
- Jatropha has several advantages over rapeseed oil; Jatropha can be grown on degraded land, so it is not grown on expensive and scarce land. It cannot be eaten, we would not want to export a food crop from a country where some people do not have enough food themselves. And thirdly, the energy balance for Jatropha is better than the one for rapeseed oil (which is used in the Netherlands); it is not planted mechanically, the seeds are picked by hand, the plant can be productive for over 50 years, not much fertiliser and not much water is needed and you don't need a lot of insecticide; all these aspects are worse with rapeseed oil.
- It is possible to obtain even more energy from Jatropha when you use the eed-cake as well; for example as fertiliser, detoxify, or burning. Using for biogas when composted and using the sludge as fertiliser.
- Most farmers will not transfer to Jatropha completely; to survive the 2 years without harvest they maintain other activities.
- The oil will be used by people who want to have a 'green' image. Not for people who just want to have the cheapest fuel.

3.6.1 ArushaCuttings-Multiflower-Greenstar

Location: Arusha
Date of visit: April 14th, April 26th
Talked to: director; Tjerk Scheltema, field officer; Julius

Introduction

Multiflower is a flower company which has been active in the region for over 10 years. It is directed by Tjerk Scheltema, who is also the director of ArushaCuttings and Greenstar. The companies have several departments: flower seeds, vegetable seeds and now Jatropha. Another company which is closely linked is Combifleur, directed by Hans Baart. All the companies are located in the same compound. Their outgrowers network consists of about 300 outgrowers. The outgrowers (small or medium farmers in several areas) are given flower- or vegetable seeds, and after the plants have developed, the flowers or vegetables are bought back from the growers.

The Jatropha activities of Tjerk Scheltema vary from paying visits to farmers (about once a week, often in remote areas) and talking with farmers to giving seminars to village groups. He also arranges meetings in the field to discuss the growing method. The farmers are not asked to sign a contract, so there is a risk that at a later stage, when there is a lot of Jatropha in the region, other buyers will appear and Diligent will be left with nothing. Still, they are willing to try to convince farmers. He also tried to interest the Kilimanjaro International Airport (KIA); the area there is very dry and Jatropha is one of the few plants that could be established there. However, so far they have not responded positively.

Actors

According to Tjerk Scheltema, all organisations (TAF, Kakute etc.), private persons and the government should be involved at the same time. Organise seminars together, do the promotion together and just be open to the farmers. So tell them that with Kakute they will get more money for the seeds but Kakute cannot buy everything and the Dutch company can and will buy everything.

Barriers

- Transportation is going to be the big problem: how can all the seeds be transported, the amounts for the factory are tonnes of seeds a day. Perhaps small expellers and refine the oil in one place.
- Kakute was already active in this area. He does not want a clash of interests with this organisation, so he hopes they can work together on the promotion and let the farmers decide to whom they sell their seeds, Diligent will tell them Kakute will pay more but will not be able to buy everything.

Lessons

- One farmer had already picked a bag full of Jatropha seeds to sell to Kakute. While Kakute's the field officer was there, the farmer was (in the end) willing to sell the seeds to Diligent for TZS 80/kg. He said, who comes first will get the seeds (in other words, the farmer needed the money). Tjerk paid extra, he paid the Kakute price to create goodwill, but next time he will pay the 80 shillings.

Expectations

- Tjerk Scheltema expects a yield of 2 kg a plant.
- Tanzanians will not pay money to convert their cars, so the oil will have to be converted.
- Rapeseed oil is currently pushed by the European governments to provide the countries with the biodiesel which is required by the European guidelines. It is only a success because the government is putting money into it; if the government stopped

doing this, it would become too expensive. Jatropha oil from Tanzania should be able to compete with this type of oil.

- Planting Jatropha will provide a lot of possibilities: hedges, nursery, cuttings, it will help to stop erosion
- In Tanzania you will not get a good price for the 'funny' soap which is made from Jatropha, but in Europe you can get a good price for such soap.
- Perhaps at a later stage, also involve the government, which can profit because of less soil erosion and could perhaps provide women with subsidies for this.
- Kakute is planting 2x3 m and we are 2x2, so 1600 trees/hectare for Kakute and 2700 trees/hectare for Diligent
- At a later stage the seed-cake which is left after pressing the Jatropha seeds could be used to fill flower pots; currently, the material for this (coconut fibre) is imported from Thailand/Sri Lanka (?)
- Suppose 300 acre, 1000 trees per acre; 300,000 trees, yield of 2 tonnes / acre (2 kg per tree) will give 6 tonnes 6000 kg, which will give the farmer TZS 480,000. Oil content is 30%, so 2000 litres of oil. The farmer can grow 300 acres of Jatropha, he will give the seeds to us and will get some diesel in return.
- Jatropha can grow in very dry areas. This can be seen throughout the country, so it would be a waste to use valuable irrigated land for Jatropha, that land is better used for food crops. (note from author: however the yield can be significantly higher if irrigated).
- Tjerk Scheltema thinks it is much better to modify the oil in Tanzania itself so the local people can profit from the technology and buy fuel for their car, etc.. This is in contrast with the view of Hans Baart, who wants to export the oil and modify it in the Netherlands.

3.6.2 CombiFleur

Location: Arusha
Talked to: director; Hans Baart

Introduction
CombiFleur is a flower company. The Jatropha activities with Ruud van Eck started in April 2004. In December 2004 they got a subsidy from the Ministry of Economic Affairs of the Netherlands. The conditions for this kind of subsidy were:
* being innovative
* creating an economic impulse for the region
* creating employment

Expectations
At first the idea (with Ruud van Eck from Diligent) was to plant 10,000 ha with Jatropha themselves, but at a later stage they agreed it was better to invest in knowledge instead of in capacity. So now they leave the planting to their outgrowers with whom they were working already. When farmers ask for more money, they will just have to wait and eventually they will sell them for 80 or 85 shillings anyway. Demand for diesel will always be there. The modified oil is better.

3.6.3 VassoAgro

Location: near Moshi
Date of Visit: April 13th 2005
Talked to: Fons Nijenhuis

Introduction

VassoAgro is a flower company owned by a Dutchman named Fons Nijenhuis. The farm consists of 100 ha of land in the Moshi region. They mainly export flower seeds and cuttings to the Netherlands. Also, the government requires 40% of the land to be planted with coffee. There are some large greenhouses on the plot. The plot is surrounded by other plots, mainly owned by a cooperative of villagers. Eight months ago they were given some seeds (9kg) by Tjerk Scheltema of ArushaCuttings to gain some experience with Jatropha. The seeds were derived from farmers in the region where ArushaCuttings was active (e.g. near Arusha National Park). It is not clear what kind of variety of Jatropha this was. Fons Nijenhuis has much land available, therefore Tjerk came to him. The idea is to plant Jatropha as a hedge and on some marginally used plots of land (e.g. on a slope near the river), Jatropha will remain a by-product for VassoAgro. The surrounding land is owned by cooperatives; they will have to be pushed somewhat to start planting too. Fons Nijenhuis himself will lead the new project to establish company Diligent Tanzania in Moshi, which will use the seeds for oil production.

Actors

Ruud van Eck from Diligent and Hans Baart from Combifleur got into contact with each other. Hans Baart is in Tanzania 10 days a month on average and already knew Tjerk Scheltema from ArushaCuttings and Fons Nijenhuis from VassoAgro. If Ruud van Eck did not plan to set up a factory in Moshi, they would never have started planting Jatropha. The employees are from the Chagga tribe (but some are mixed with Masaai). There is another partner involved, a Tanzanian who has been a friend of Fons Nijenhuis for a long time. He knows his way around at the government level and knows who to go to for licences, etc.

Economic Analysis

Inputs: Seeds were free
Land is rented for a minimum period of 30 years
Labour costs for planting, irrigating and harvesting; unknown
Outputs: 85 shilling per kg will be paid by Diligent

Barriers

- The Chagga people think they already know all there is to know and are very reserved in trying out new things. You cannot push them too hard, they slowly have to get used to it.
- Enough land has to be available. Most land in this region is owned by cooperatives. All members then have to agree on Jatropha. These cooperatives consist of large groups which, for example, all help one day to harvest or to weed.
- Water has to be available.

Lessons

Lessons so far are mainly on the ‘growing’ of Jatropha.

- After 6-8 months the seedlings in the nursery should be replanted to their permanent spot. If this is done later, the taproot will be destroyed and the plant will not establish properly. This was learned because plants were replanted after a longer time and they did not grow properly, remaining very small (although this could also be caused by marginal soil or the fact that those plants were also given fertilisers; it is unclear whether they need this).
- Jatropha planted in marginal soil does not establish properly. It was planted on a slope, could be that the temperature at night is too low (this area is under the influence of Mount Kilimanjaro, which creates a somewhat colder atmosphere at night/in the early morning).
- You have to have someone involved who knows his way around at the government level.

Expectations

- Predicted yield is reported at 1500 kg/acre, but this seems to be on the positive side.
- Big money can be made by exporting the oil to the Netherlands; if this was not the case they would not have thought about it.

3.6.4 Farmer Ismael Manang

Location: one hour from Arusha
Date of Interview: April 27th 2005

Introduction

Ismael Manang is working a farm of 1500 acres, Multiflower already had contact with this farmer. On this farm they grow maize and beans and keep cattle and goats. About two months ago (March 2005) they started the activities for planting 80 acres with Jatropha. The funding for this was given by Multiflower/Diligent (Tjerk Scheltema) who pre-financed the farmer with TZS 400,000[61] (a barrel of 200 litres of diesel and some money for other expenses). Six weeks ago 75 acres were planted by just sowing seeds, and 5 acres by planting cuttings. Trenches of 2x2 m were made by a tractor with a plough, pegs with ropes were used to mark a straight line for the tractor driver. The Jatropha seeds (two per hole) were planted at the junctions of the trenches. A small nursery (now 8 weeks old) will provide seedlings for the places were the Jatropha seeds did not germinate.

Actors

Ismael Manang, the farmer (he is well-educated; formerly he worked for an NGO)
Tjerk Scheltema on behalf of Diligent

Expenses per acre,[62] first year	TZS
* Pegs 140 pieces (costs are for labour, pegs are made of wood)	1000
* Paint (for the pegs) ½ litre	450
* Painting of pegs, labour charge	1000
* Seed sowing	1000
* Seeds 35x35=1225 (2 per hole) x2=2450 no charges yet	
* Diesel for tractor 6,5 litres, to make trenches	6500
* Survey team, 1 supervisor + 4 people TZS 3200+1000	4200
* weeding 3 times a year (2 times spot-weeding, 1time complete) TZS 4000 for complete weeding, 2500 for spot-weeding x2=5000	9000
* Equipment; brush (1000,-), tape measure (6000,-), hammer (5000,-), sisal rope (2500,-), panga (machete to clear the area) (3000,-), total: 17,600 for 80 acres, per acre:	220
Total per acre	23,370
Total 80 acre	1,869,600
Expenses for 2nd year	
Weeding	9000
Expenses for 3rd year to η year	
Weeding	9000
Picking seeds	4500
Total	13,500

Table A-6: Jatropha Expenses, Ismael Manang

61 ≈ € 285,-
62 2.4 acre = 1 hectare

Economic analysis
Ismael Manang has provided a detailed list with all expenses for one acre of Jatropha, see Table A-6. As the farmer is currently in the first year of planting, he has made an estimate for the expenses for later years.

These are the minimal expenses based on a positive scenario; there is always a possibility that they will have to do more weeding or so on, which would cause the expenses to rise. Also, it might turn out to be necessary to have an irrigation system; of course this would increase the expenses heavily.
So far the seeds (245 kg) have been obtained free. Tjerk Scheltema provided him with 200 kg (which he bought from several villagers for TZS 80/kg, total TZS 16,000 –(€12), and 45 kg were given to him by other villagers. He has been given about TZS 400,000 in advance by Tjerk Scheltema to cover some expenses, like two times a barrel of 200 litres of diesel. The other means of finance are the profits from other products of this (big) farm. No loan was necessary.

To make an economic analysis, several assumptions are necessary:

- Yield: 4 -8 kg of seeds per plant.[63]
- Expected output: 1225 trees will generate: 4900-9800 kg seeds. The seeds will be sold for TZS 80, so this will generate TZS 392,000 -784000 per acre. For the whole 80-acre plot, this means revenue of TZS 31,360,000 - 62,720,000.
- First two years without yield, in 3rd year 50% yield, 75% in 4th year and 100% in 5th year.
- Interest rate: 14%[64]

Table A-7 presents an economic analysis is made for 80 acres of Jatropha during five years.

Year	Expenses (TZS)	Revenue (TZS)	Profit (TZS)	Discounted cash flow	US Dollars[65] (USD)
0	1,869,500	0	-1,869,500	-1,869,500	-$1,700
1	9000	0	-9,000	-8,199	-$7
2	13,200	15,680,000 to 31,360,000	15,666,800 to 31,346,800	13,022,057 to 26,015,069	$11,820 to $23,650
3	13,200	23,520,000 to 47,040,000	23,506,800 to 47,026,800	17,772,199 to 35,554,377	$16,157 to $32,322
4	13,200	31,360,000 to 62,720,000	31,346,800 to 62,706,800	21,590,204 to 43,189,499	$19,627 to $39,263

Table A-7: Economic analysis for 80 acres of Jatropha

The following economic parameters can be derived:
NPV: 50,486,760 to 102,881,245 ($45,897 to $93,528)
IRR: 262% to 384%
BCR: 27 to 55
PBP: between 2 and 3 years

Conclusion: very large profits, all parameters are positive.

[63] Diligent's estimate is a minimum of 2kg/year per plant. Kakute's experience is a yield of up to 6 kg/year per plant and Mr. Burland's experience is 8-10 kg/year per plant. Calculations here will be made with an output of 4-8 kg/year to limit the range.
[64] This is the medium- and long-term interest rate charged by commercial banks. Source: http://www.tanzania.go.tz/economicsurvey1/2003/part1/financeinstitutions.htm accessed on August 30th 2005.
[65] 1 USDollar = TZS 1100 (May 2005)

Barriers
Money for the farmer:, it will take some time before the Jatropha starts to make some money, in the meantime the farmer has some expenses.

Lessons
- 30% of seeds did not germinate (because they were not sorted, normally seeds for sowing have to be sorted)
- spot-weeding is enough for the moment, but before drought it is necessary to weed completely because Masaai herders will come to the field to graze their cattle.
- Lessons in future on: pruning (when and at what height is the best), fertiliser, water, weeding. Some of the land will receive irrigation, some not, thereby lessons can be learnt on how to deal exactly with this plant.

Expectations
Many things will have to be learnt in the future: is fertiliser necessary, is pruning necessary, is irrigation necessary?
Expectation is that irrigation is not necessary. The rains were good this year so they already received a lot of water.

3.6.5 Farmers around Arusha National Park

Location: near Arusha National Park.
Date of visit: April 15th 2005

René Geelhoed and Bianca van Haperen are working on the Tanzanian Vegetable Seed Programme (TVSP). They are trying to raise the income of Tanzanian farmers by spreading adapted and tested varieties of vegetables and teaching them new technologies. They travel in the Arusha region to demonstrate and train the farmers. While travelling, René Geelhoed crosses a region where the Jatropha plant is traditionally used as a hedge. When he passes the farmers he shows them which kind of seeds he wants and after one hour the farmers deliver their seeds to him. He pays them TZS 80per kg. The seeds are for ArushaCuttings/Diligent. About one year ago Kakute also passed through this area and asked the farmers to collect seeds for them. They told them they would pay 200 shilling per kg, but never returned. When René was passing through this area again, the farmers began to ask for more money for their seeds.

Lessons
- You have to show up regularly and keep promises, otherwise the people will not trust you any more.
- There is a chance that people will start to ask for more money for the seeds

3.6.6 Farmers around Dar-es-Salaam

A group of 11 farmer-leaders from the Pwani region have come to the office of Multiflower/Diligent. They were very enthusiastic about starting to plant Jatropha and selling the seeds to Diligent. Each farmer-leader represents about 30 farmers and each has about 5-10 acres available for Jatropha. Their main crop until now was cashewnuts, but the price for this crop has fallen and they were looking for another crop. In total they will have 330*5=1650-3300 acres available for Jatropha plantations. According to Julius (employee of Diligent/Multiflower responsible for the Jatropha activities) Jatropha grows very well where cassava and cashew grow well; this is because they are drought-resistant crops.

Lesson
Local people are positive about the potential of Jatropha.

3.7 Kakute

Location: Arusha
Date of visit and interview with Ms Edith April 15th 2005
Date of visit and interview with Mr. Albert Mshanga April 26th 2005

Introduction
Kakute Ltd. is a private company, with Mr. Manyanga as the director. It was established in 1995 and has been engaged in a variety of activities in the field of rural technologies. Some of their services include oil-seed processing, low-cost housing, new and renewable energies, etc. There is close collaboration with several NGOs, such as Heifer. Subsidies are only given to NGOs, not to private companies. They support several women's groups in the region, 32 in total, as well as several schools. The activities in the schools and women's groups vary from starting nurseries or Jatropha plantations to oil-expelling and soap-making activities. Kakute is sponsored by the McKnight Foundation. Mr. Albert is a field officer who has been working for Kakute for three years and is responsible for 17 women's groups in the Monduli district. Kakute is involved in promotion of Jatropha by organising seminars, providing training, designing/researching and selling cooking stoves, oil lamps and ram-presses. They are the leading company in the Jatropha sector in Tanzania at the moment; most projects run through them and an increasing network of interested persons and NGOs enables them to disseminate the Jatropha knowledge. For example, they got an order for 3 tonnes of seeds from Malawi; D1 oils Ltd, 2 German companies and Americans have also shown interest. As Kakute is a private company, they are also trying to make a profit. What they do currently is buy seeds from one group and sell them to others, according to Bukaza Chachage.
Karanga Suger Estate is currently planting Jatropha, 20 ha, D1 oils is involved here.

Actors
Mr. Manyanga is the director of Kakute as well as the director of Heifer. Several other NGOs, such as TaTEDO, Faida-MaLi, UNDP cross-border project, etc., are partners of Kakute. The Jatropha activities are sponsored by the McKnight Foundation, this is why women's groups are supported (condition by McKnight).

Oil lamps are sold for TZS 1700 each. The factory only produces on demand, and has a capacity of about 1000 lamps/year. They are made from small Africafe tins.

3.7.1 Monduli women's group

Location: Monduli
Date of visit: April 27th 2005

Introduction
16 women are working together to maintain a nursery in Monduli (which is located at an altitude of 1700 m). Even before Kakute got into contact with them they were selling seedlings of 'cash trees' like fruit trees and wood trees. Because Kakute is now involved, they have also started selling Jatropha seedlings. They sell Jatropha seedlings for about 100 TZS each. Kakute can buy them for TZS 50 each. Most seedlings are bought by Kakute, not many local people buy them. They sell about 10,000 seedlings a year. The group also owns 2.5 acres of land, which they hedged off with Jatropha about 3 years ago. The plants are about 1.5 m high and are starting to produce now; so far they have not been able to yield, also because the plants were disturbed by Masaai cows. They buy the Jatropha seeds for the nursery from Kakute. Another NGO, TaTEDO, has funded a biogas project at the women's house. A floating drum system was installed in which they use cow dung as well as Jatropha seed-cake

(in mixture of 75/25). The biogas obtained from the system is enough to provide them with fuel for warming water for tea at breakfast, for lunch and dinner. The Jatropha seed-cake produces much more biogas than cow dung; the system uses 20 kg of cow dung a day, which could also be covered by 2 kg of Jatropha cake.

Actors
16 women in the women's group, Kakute (Mr. Albert Mshanga is field officer for this district), TaTEDO, which funded the biogas project. TaTEDO also provided the women's group with a fuel-efficient stove (which uses firewood).

Economic analysis
Trees sold for TZS 100 (or 50) a tree, 10 thousand a year: 500,000- 1,000,000 TZS/year

Input: Jatropha seeds bought from Kakute: TZS 200/kg
Biogas cooker: TZS 10,000
(Jatropha cooker from Kakute would costs TZS 50,000)

Lessons

- The Jatropha seedlings in the nursery were now 6 months old but appeared very small (see Fugure 34). The women's group has cut the tap-root because it was growing too deep into the soil. The women think this will harden the plant and perhaps create more lateral roots. The plants do establish properly, according to what the women said. Tjerk Scheltema bought some of these seedlings and will plant them to see if this is true; so far they thought the taproot should not be destroyed.
- Although the women have biogas available, they were cooking with firewood. When asked why they did not use the biogas cooker they said that they only use it during rainy season when firewood is not easy to find. Also, when the biogas cooker was demonstrated, the pressure of the gas seemed quite low; therefore, cooking water takes a long time. The women said they would be willing even to pay for the Jatropha cake as it produces much more biogas.
- While the altitude in this area is quite high (1700m) and the area is quite dry, plants will not establish easily and therefore it is better to buy seedligs from a nursery.
- The women wanted a seminar organised for them to explain more about Jatropha. This seems to be a wish of many people, not only women's groups but also farmers; they would rather have a day of lectures in a classroom than actually go to the field to see what is happening.

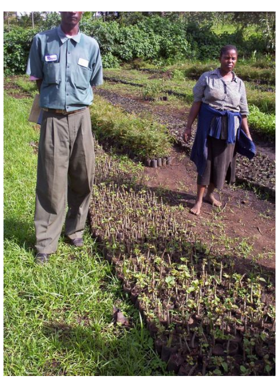

Figure 34: Nursery at Monduli, Jatropha 6 months old

3.7.2 Teachers' college

Location: Monduli
Date of visit: April 27th 2005

Introduction

This college gives teacher-training to several hundred students, for posting somewhere in the country. Kakute thought this is an excellent way to disseminate the Jatropha knowledge (the teachers will spread knowledge of the technology all throughout the country) and there were environmental groups at this college; so, they started a Jatropha plantation here. The plantation is about 1 ha, but will be expanded in the near future. The Jatropha was planted and left without any management, no weeding and no irrigation. Although the plants were not really big, they did establish; however, the yield would probably be bigger with proper management. So far they have not collected seeds. Kakute will show them the technology for expelling the oil.

Lessons

- Weeding and irrigation is not necessary, although it could increase yield.
- Around termite hills the soil is more fertile; the termites seem to bring nutrients up (research on this topic was done by Mr. Albert Mshanga)

Other lessons from Kakute (and Mr. Albert Mshanga)

- Masaai women form a special group and are more difficult to persuade to grow Jatropha. This is because they don't own the land (owned by men). With mixed tribes this cultural problem is much less.
- A small tight hedge of Jatropha cuttings is necessary to prevent Masaai cows from damaging small saplings.
- In Engaruka, Kakute trained the youth to make oil lamps, but after this knowledge was passed on, the youth did not do anything with it.
- Kakute has a link with a microcredit facility; in Engaruka some farmers got credit of TZS 50,000 to 100,000 or TZS 500,000.
- Recently they installed a screw expeller from China; its capacity is 20 bags x 60 kg/day, 8 hours a day (150 kg/hour).
- Swahili name for Jatropha is Mbono Kaburi (graveyard tree)
- To modify the engine of a car costs about TZS 600,000, Elsbett, a 2-tank system with a pre-heater.
- A German in Arusha has converted his car; he uses sunflower oil in his engine.
- TIRDO in Arusha is now doing research on the Jatropha cooking stove; while the oil is poisonous, the emissions exhausted while cooking could possibly be dangerous to health.

3.7.3 Selela Village

Location: 30 km from Mto Mwa Mbu and 30 km from Engaruka (near Ngorogoro Crater area)

Date of visit: April 26th 2005
May 11th 2005

Introduction

Kakute's field officer, Albert, started creating awareness amongst farmers in this Masaai-village to grow Jatropha here as well. This village is close to Engaruka, so the villagers here have an example and see it is profitable. Some Jatropha is traditionally used as a hedge; those trees are already quite big and the villagers also started to plant Jatropha cuttings along their agricultural fields about 2 months ago. The cuttings came from neighbours with large Jatropha trees. We had an interview with the assistant village head. He thinks Jatropha will be big in the future and is going to push his villagers to grow more of it. There are 13 farmer-leaders in this village and they would like to be given a seminar. In the beginning they will

only sell seeds, but perhaps at a later stage they will also try to expel the oil themselves, as they are doing in Engaruka. He himself owns an oil lamp; he buys the oil for this lamp in Engaruka village for TZS 2000/litre. The land in this area is irrigated, so they can start planting Jatropha any time they want (not necessarily just before the rainy season).
Next time, at the seminar, they will establish a test plot of 1 acre, and hedge this off with cuttings which they will buy in the neighbourhood.
During another visit, on May 11th, the village ward himself was also very enthusiastic. Because one of the employers of Multiflower originally comes from this village, he had already asked the villagers to collect seeds; by this time they had 6 bags of 60 kg ready. They took into account the transportation costs for these seeds as they were collected near Engaruka; therefore, this time they did not agree to the price of 80 TZS, but next time they will.

Economic analysis
The farmer and his wife were picking seeds for the last 1,5 weeks (not constantly). They now have a bag of 20 kg (actually it was probably less, but there were no scales to weigh them). Diligent will pay him 20x 80= TZS 1600, Kakute will pay 20 x 150= TZS 3000 (however, because it was the first time Diligent also paid TZS 3000) This is additional income for the farmer of, on average, 1,5 to 3 days.

Expectations
The village heads and farmer were very enthusiastic and are willing to plant a lot of Jatropha. The farmer has already started planting 8 acres because he thinks it will be very profitable.

Figure 35: Weighing the seeds

3.7.4 Women's group, Engaruka

Location: Engaruka
Date of visit: May 11th 2005
Spoken to: Village head + assistant village head (Simon Solomon)

Introduction
Around Engaruka village a lot of Jatropha has been planted, mostly as a hedge. Kakute has been active in this village for a long time. They are working with a women's group. The group has a ram-press and they make oil (for oil lamps) and soap. Soon Kakute will install a biogas unit in which the Jatropha seed-cake, material left after pressing the seeds, can be used. Another possibility for this oil-cake (it still has a small quantity of oil in it) is pressing the material into bricks. The bricks can be used for cooking. According to Barriki (employee of Multiflower) they are already practising this technique in Engaruka.

Actors
Women's group, Kakute. During the visit, there were only men busy with pressing the oil, so presumably there are also men involved.

Economic analysis
There are two activities in Engaruka, soap-making and seed-picking. (and oilselling).

Soap-making
There are three different ways to get the oil for the process:

- Picking seeds and pressing them in a press
- Buying seeds and pressing them in a press
- Buying Jatropha oil

In Engaruka, a press is available and they are making oil; however, according to data from Albert (and Henning) they are buying the oil for the soap-making process. The oil is currently bought from Kakute. Five litres of oil are needed for 60/70 tablets of soap. Other expenses are listed in Table A-8.

Expenses		TZS
Oil (19 litres)	TZS 2000 /l	38,000
Caustic soda	5,000/65 pcs	18,500
Wrapping	Polythene (3,000/65pcs)	11,000
Labour, 26 hours (16+10)*	(soap-making and various jobs)	-
Rent for space (for laying out the soap)	8 square feet (≈2 m2) TZS 1,000 /day	2,000
	Total	69,500 ($63)

Table A-8: Expenses of soap-making, Engaruka (*source: Henning, 2004)

The soap is sold for TZS 500 per piece. They sell about 20 pcs a month to the villagers and to Kakute, on a yearly basis this is 240 pieces. An economic analysis is made in Table A-9 for a project lifetime of 5 years and a real interest rate of 9.8% (see other calculations).

Year	Expenses (TZS)	Revenue (TZS)	Profit (TZS)	Discounted cash flow	US Dollars[66] (USD)
0	69,500	120,000	50,500	50,500	$46
1	69,500	120,000	50,500	46,005	$42
2	69,500	120,000	50,500	41,911	$38
3	69,500	120,000	50,500	38,180	$35
4	69,500	120,000	50,500	34,782	$32

Table A-9: Economic analysis of soap-making, oil bought

The profit is not really high, but still about one-and-a-half times the average monthly wage over a year. For 26 hours of work, the profit is TZS 50,500; this is about TZS 1,950 per hour (almost twice the normal *daily* payment on average in Tanzania). The NPV for a project lifetime of 5 years is TZS 211,378 ($192) and the Benefit/Cost Ratio is 1.73.

They can also press the seeds themselves to obtain the oil. A ram-press (hand-press) can be bought from Kakute for $250. The ram-press can press 10 litres/day; they work 5 hours a day, so 2 litres per hour according to A. Mshanga. The data from Kakute 2003 (Henning, 2004) mentions 1 litre/hour, so calculations will be made with 1.5 l/hour.

You need 5 litres for 65 pcs, so about 19 litres of oil per year for 240 pcs. 1 litre can be obtained from about 5 kg of seeds (Henning, 2004) (a ram-press does not have a good

[66] 1 USDollar = TZS 1100 (May 2005)

efficiency) so 95 kg of seeds are needed yearly. They can be obtained from 12 to 24 trees (4-8 kg/tree). For other expenses, see Table A-10.

Expenses		TZS	
Seeds	95 kg	0	
Labour seed picking (95kg)	2 kg/hour*	48 hour	
Ram press	Lifetime 5 years	275,000	
Labour for pressing (19 l)	1.5 l/hour	13 hour	
Labour for filtering the oil	2 l/hour*	10 hour	
Other yearly expenses	See Table	31,500	26 hour
	Total first year	306,500	97 hour
	Total ηth year	31,500	97 hour

Table A-10: Expenses of soap-making, including press (*source: see Henning, 2004)

The economic analysis is given in Table A-11. The difference with Table A-10 is the extra investment cost of a ram-press (275,000 TZS) and the lower expenses because the oil (TZS 38,000) does not have to be bought any more.

Year	Expenses (TZS)	Revenue (TZS)	Profit (TZS)	Discounted cash flow	US Dollars[67] (USD)
0	306,500	120,000	-186,500	-186,500	-$170
1	31,500	120,000	88,500	807,623	$73
2	31,500	120,000	88,500	73,447	$67
3	31,500	120,000	88,500	66,910	$61
4	31,500	120,000	88,500	60,955	$55

Table A-11: Economic analysis of soap-making by pressing seeds

The economic parameters are positive for this project; the NPV is 95,435 TZS ($87), the IRR is 32% and the BCR is 1.23 (>1). The Pay back period is between 3 and 4 years.

The third option for soap-making is to buy the seeds instead of picking them yourself. The only change from the last two tables is that the expenses will rise by (95kg* TZS 80) TZS 7,600 ($7). This will create more chances for 'seed-pickers' to obtain an income. The NPV is TZS 63,623 ($58), the IRR 24%, the BCR is 1.15 and the Payback Period is 3-4 years, which is the same as when the seeds are picked free.

Conclusion

- All projects make a profit in 5 years' time. Especially when you look at the number of hours compared with the profits made, the labour is very profitable.
- However, the market is currently too small; with a quantity of 20pcs a month the additional income and BCR is very low. It is important to try to find ways to increase the market.
- With the selling quantity of 240 pcs it is more profitable to buy oil instead of buying a press. However, the profits made by pressing your own seeds are higher, so if quantity of the sold pieces of soap rises, having a press would be the best option.
- The Jatropha cake which is left after the seeds are pressed can be used as a fertiliser. Cuurently there is insufficient material to sell it as fertiliser to farmers, but when production increases they will probably ask a price for this material (or for the biogas sludge). So, instead of only obtaining revenue from selling soap, the by-products could create extra revenue as well.

[67] 1 USDollar = TZS 1100 (May 2005)

- Largest share of costs is due to the ram-press; if this press were available through a subsidy, the profits from soap-making could be substantial. (BCR of 3.8)

Comparison with alternatives:
Price of charcoal: TZS 3000 for a bag which can last for 2 weeks, however, the majority in this village are using fuelwood, which is collected free.

The price of other soap in this village is TZS 250-350; however, because of the medicinal properties, people are willing to pay a higher price for this soap.

Seed-picking
The village ward expects a harvest of 300 bags of Jatropha each season; the Jatropha is growing indigenously but they are currently planting cuttings as a hedge. The labour for picking the seeds is not included as costs in Table A-12.

Jatropha seeds			Revenue
300 bags of Jatropha each season	60 kg per bag, 2 harvests per year	36,000 kg/year	*80=2,880,000 TZS/year ($2,618)

Table A-12: Economic analysis of Jatropha seeds, Engaruka (expectations of village ward)

Barriers
Kakute is paying a higher price for the seeds, so in the beginning the villagers think they are getting paid too little. However, when it is explained to them that Kakute can only buy a limited amount of seeds and Diligent will pay for any amount of seeds, whether it is 1 kg or 10,000 kg, they agree.

The problem with Kakute was that they don't buy seeds on a regular basis; at some places they told farmers to collect seeds but then never returned, so some people might be a little sceptical about this foreign company.

Lessons
- When passing through Engaruka village, we saw that some of the Jatropha plants had been pruned. This is not the right season to do this, as the plant can be harvested in a month's time. When asked why they were doing this, the village head said they were not really stimulated to increase production as Kakute has limited resources. However, the village head said he would right away start telling people they should not prune the Jatropha now.
- At one place near Engaruka, several Jatropha plants, about 30 years old, were growing. Insects/termites had clearly been affecting one stem of the Jatropha; the termites had completely eaten the stem at one particular spot and the stem had broken off (Figure 36). The villagers said they had once tried to trap these termites and they would try again. In this group of about 5 Jatropha bushes, only one stem was affected.

Figure 36 Insect damage on Jatropha stem at Engaruka

Expectations

- The villagers and village heads seemed to be really enthusiastic about the idea of selling Jatropha seeds to Diligent. They really think they can make a lot of money. Because the rains were not so good during the last years, they now want to plant Jatropha instead of maize and beans. This indicates that they have a great trust in the future of Jatropha.
- The village ward was not happy with the low capacity of the ram-press; he wants bigger (electrical) equipment for the expelling process.
- The village ward said they can harvest 300 bags of Jatropha each season; each bag contains about 60 kg, so 18,000 kg of Jatropha seeds twice a year if sold to Diligent would bring a profit of TZS 2,880,000 a year.

3.7.5 AruMeru disctrict with TAF

Location: Moshi
Date of Visit TAF: May 12th 2005
Talked to: Jon-Erik Rehn, Philipina (also see TAF description under Organisations)

Introduction

The set-up is almost equal to that of the ARI-Monduli project, already executed by Kakute in the Monduli region. The Jatropha will be grown by women's groups (required by McKnight) and the Jatropha seeds will be used to produce soap and fuel oil; the seed-cake will be used as fertiliser. The goal is to improve the villagers' income. McKnight is sponsors this project with 60% of the finance, Kakute will carry out the fieldwork (implementing, organising, giving training, etc.), while TAF will be the monitoring organisation. They started in October 2004. Most activities so far have involved writing the proposal for the McKnight foundation. After the AruMeru district, TAF also wants to work on a similar project for the Moshi region.

TAF first started promoting Jatropha as a support for vanilla vines. Vanilla was promoted because they wanted to provide the traditional 'coffee' district with an alternative. Jatropha is often used as a support for this vine; for example, in Machame. Possibly this is because Jatropha can be established easily. They gave away 2000 seedlings free in three villages, although not all villagers accepted the offer. Jatropha does not like shadow; where Jatropha was planted under banana trees, it did not grow well. So the villagers would have to have a somewhat open space to plant the Jatropha.

Actors

Kakute and TAF had so far never worked together, so it took some time to establish a contract which described how the cooperation was going to be worked out.

Economic analysis
The project is 60% funded by the McKnight Foundation; for three years the costs are USD 238,613[68]

Comparison with other regimes:
Normal yield for maize is 4-5 bags of 100 kg/acre; this would be enough for one family for own consumption (3 bags per acre also, depending on season and soil). The price of maize fluctuates widely, between TZS 6000 and 30,000/bag; currently, it is TZS 20,000 (so per acre: TZS 80,000-100,000 as profit if maize was sold)

Lessons

- Jon-Erik himself has planted some Jatropha seeds as a test; he planted them just after the rainy season, so at the start of the dry season. The saplings that were not given water did not survive. The ones that were given a small amount of water did survive (about 80-90% of the total).
- Jon-Erik has planted some Jatropha in his garden as well; it seems to grow well in some places and not so well in others. Plants as close as 2 metres from each other planted at the same time can vary widely in size.
- We visited a place where Jatropha was used as a support for vanilla (see Figure 37); this was a demonstration site. There were 4 Jatropha plants, 2 of them were quite big and entwined by vanilla, but the other two were very small, with a large vanilla vine around them. It is not clear whether the vanilla caused the plants to be smaller than normal.
- Jatropha does not like shadow.
- Not all people are willing to try something new, so not all villagers would accept free Jatropha seedlings.

Figure37: Jatropha used as support for vanilla vine

Other remarks:

- In the Monduli region a lot of trees were chopped down because the tse-tse fly was active in this region and people believed they were hiding in the trees.
- He price of coffee (which is traditionally grown in the Moshi region) has decreased dramatically on the world market, therefore people are looking for new crops.
- Jatropha curcas is an indigenous plant, this is very helpful for the adoption process. What TAF/Kakute is telling people (to plant Jatropha) is not completely new for them, so they are less sceptical.
- In the Harya language (Victoria Lake) Jatropha is called: Mwitankoba or 'thunder-killer tree' Every house was supposed to have at least one Jatropha tree to prevent it from being damaged during a thunder-storm.
- In the Jita language (also near Victoria Lake) Jatropha is called Mkarekare.
- The traditional use for Jatropha, planting it on a grave, is probably because Jatropha can establish in any season, so when a person dies Jatropha cuttings are planted on the grave. Another use for Jatropha is a medicinal one. They break the leaves at the stem and the milky sap can be rubbed on the skin when there is a cut; the cut will heal quickly.

3.8 Green Garden Women Group

Location: Moshi
Date of visit: May 12th
Talked to: Mama Leema (chair of the group)

[68] Word document on 'What is TAF', 17-11-2004.

Introduction

In 1995 the UNDP sponsored a project with the Green Garden Women Group. They created an energy farm, with timber, woodfuel and fuel-efficient stoves. The Green Garden Women Group consists of 17 women and together they own 7 acres of land in Machame, a small village near Moshi.

In 2003 they started Jatropha activities after someone from the UNDP told them about its possibilities. They started a nursery in Machame (there is another small demonstration nursery in Moshi) and planted two acres, with 800 plants in total, distance 5x5feet. This plot is irrigated by a constant stream of water through trenches; the water is derived from a spring. Last January they harvested for the first time, although the harvest was small. They have a ram-press and pressed the Jatropha seeds. They have all been to Kakute in Arusha to make soap at the Kakute factory. The soap is sold to people within the community and small shops in Moshi. They also sell Jatropha cooking stoves.

Actors

17 women of the Green Garden Women Group,

UNDP,

Kakute: the group can use Kakute's factory to make the soap, but Kakute is not subsidising them in any other way because Kakute is subsidised itself and doesn't have a lot of money (according to Mama Leema)

Economic analysis

1 gallon of oil can give 500 pcs of soap

(not correct; data from Kakute and literature mentions something else)

soap is sold for TZS 500.

In the nursery the Jatropha seedlings are sold for TZS 500each.

800 plants on the 2 acres could yield: 800 x 4= 3200 kg to 800x8=6400 kg per harvest.

So far 2 cooking stoves have been sold, for TZS 12,000 each.The woman buy the stoves from KIDT (says Mama Leema).

Barriers

- Mama Leema is not using the Jatropha cooking stove herself, she is afraid that the smoke might cause health problems. She also does not know anybody who is using the cooking stove at the moment, although they have sold 2 of them so far. (one in West Kili and one in Uhuru)
- The Swahili name for Jatropha, Mbono Kaburi (graveyard tree) is causing some scepticism because it is used in graveyards and people have associations with that.

Lessons

- The women also planted Jatropha on a 5-acre plot;, there was no supervision, so this turned out to be a failure. Cows came and destroyed the plants. They did not use a fence.
- The Jatropha soap is a very good medicinal soap. It is used for the body as well as the face. It has anti-fungal properties. Mama Leema is using it herself a lot; according to her, Jatropha soap is better than Neem soap and Aloë vera soap.
- One of the sale points for the Jatropha soap is the small gift shop at the Kinderoko Hotel in Moshi. Here they also sell the Neem soap and the Jatropha soap, both for TZS 1500. According to the shop assistant, not many soap tablets are sold; this could be due to the fact that the wrapping of the Jatropha soap was of much lower quality than the ones of the other soaps.

Expectations

Their original plan was to plant 5 acres with Jatropha and 2 acres with Aloë vera. Money is the problem currently. If they obtained some monetary support, they would try to plant the 5 acres with Jatropha again, this time with a fence.
If they had the money and proper equipment for soap-making, they would want to make the soap in Moshi, but until that time they will keep going to Kakute in Arusha. The Jatropha soap is a really good product, according to Mama Leema.

Figure 38: Nursery for several types of trees, Moshi

Similar regimes
- Charcoal, kerosene and woodfuel are used instead of Jatropha oil as fuel for cooking stoves.
- Similar to Jatropha soap is Neem soap and Aloë vera soap, although the Jatropha soap has the strongest medicinal properties. Normal soap in Moshi costs about TZS 250, the Jatropha soap is twice this price but people are willing to pay that. Neem soap and Aloë vera soap have the same price as Jatropha soap.
- A lot of sisal is growing in this region, it is often used as a hedge. Because even Jatropha cuttings take some time to establish, sisal could be planted to keep the cows away from the Jatropha saplings.

3.9 KIDT

Kilimanjaro Industrial Development Trust
Location: Moshi
Date of visit: May 13th 2005
Talked to: Frank A. Elise

Introduction
For a description of KIDT, see section on organisations. The women of the Green Garden Women Group brought a prototype of their Jatropha cooking stove to KIDT (see Figure 39). It was not working properly. KIDT increased the air intake, but it still did not work properly, due to the high viscosity of the oil. KIDT was not able to continue the tests because no more Jatropha oil was available.

Figure 39: Jatropha cooking stove at KIDT

Actors

-Green Garden Women Group
-KIDT
-UNIDO

Economic analysis
The Jatropha cooking stove will cost TZS 20,000

Alternative:
A charcoal stove: TZS 15,000
Charcoal: US$ 0.16/kg (data from KIDT)
Kerosene: US$ 0.75/kg
Briquettes: US$ 0.08/kg

Barriers

- Viscosity of the oil
- Availability of Jatropha oil

Lessons/expectations
According to Mr. Frank A. Elise, the viscosity of the pure Jatropha oil is too high to make good burning in stoves possible. The oil is like raw natural oil. It would be better to modify the oil into biodiesel.

3.10 YAHUMU trust

Location: Morogoro
Date of visit: May 19th 2005
Talked to: Mary Elfasi

This is a company subsidised and set up in 1999 by FAKT, a German company. They developed a press, The Sayari oil-expeller (see Figure 41), which can press a variety of seeds. They sell machinery and spare parts, and they also have a press at their factory where you can get your seeds pressed for a fee. The aim of Vyahumu trust is not to make a lot of money but to meet the needs of the farmers.
They support individuals and groups to establish and operate oil mills and provide oil-expelling services to farmers to improve the economic returns of small oil-seed farmers.[69]

The machine was designed in Germany and Vyahumu has the licence. The manufacturing is done in several workshops all over the country.
They don't make a lot of profit on sales of the machine, since the manufacturers get the lion's share. Building one machine took about 1 week when they had a lot of orders, now that it is much more quiet it takes about one month.

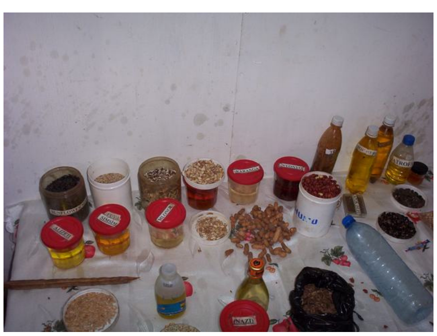

Figure 40: Examples of different seeds at Vyahumu

Figure 41: Sayari oil-expeller

They have had Jatropha orders from Iringa, Mbeya and Malawi.

[69] This information is derived from the website http://www.Jatropha.de

They had samples in the office of several varieties of seeds and oil (see Figure 40);, for example: Neem, safflower, sunflower, groundnut, moringe and castor.
The castor seeds are very much like Jatropha seeds.
The seeds that are not for consumption (Neem, castor, Jatropha) are pressed separately from the edible seeds.
The machine can use either electricity or diesel fuel, depending on what the customer wants.
In July last year FAKT stopped subsidising Vyahumu. Now money is a problem. Before this, 9 people were working at Vyahumu, now 7. The director lives in Arusha, only when there are problems does he come to Morogoro.
You first have to filter the oil before it can be used.
At the time of this visit, it was the rainy season and therefore it was very quiet in the factory; but Mrs Elfasi said that after harvest time it would be very busy.
So far nobody has bought the expeller with the purpose of expelling Jatropha seeds. Someone (a white man) came a few months ago to get 5kg of Jatropha seeds pressed.

Economic analysis
Price of the machine: TZS 3.5 million
Pressing sunflower seeds: TZS 60/kg (quicker than other seeds, so less electricity or diesel).
Pressing of other seeds: TZS 90/kg
Lifetime of the machine: according to Peter, who built the machine, for planning purposesit is safe to take 5 years. However, Ms. Mary said the first machines they built 6 years ago are still working very well and the lifetime can be more than 10 years, if properly managed.

Test results:

Cone (mm)	Seed quantity (kg)	Time taken (min)	Oil yield (kg)	Seed quantity/ Oil yield (%)	Oil seedcake (kg)
90	59	45	15	0.25	41
96	71	43	12	0.17	59
98	193	150	60	0.31	148

Table A-13: Test result of the Sayari expeller with Jatropha seeds

From the test results in Table 33, it appears that the expeller has a capacity of about 75-100 kg seeds/hour or 17-24 litres/hour. A larger cone seems to give a higher oil yield.

Barriers
Money, currently Vyahumu is looking for new funds.

Lessons

- The hulls of Jatropha seeds are quite hard, but pressing in the Sayari oil expeller went very well; cone adjustment is necessary.
- Most people are very satisfied with the machine; if the machine breaks down, it is mostly because it was used improperly.
- The quality of the seeds is very important; when the seeds are old, they yield less oil, but if you use fresh seeds the yield is quite high. Drying and maturity are important.
- To test the assumption of Jatropha oil as a diesel fuel, they tried the Jatropha oil in their own machine; it worked well.

Appendix III Contact addresses

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Appendix IV Interview questions

Project
What is the main goal of the project?
What are the activities of the project?
When did you start your activities?
Have the activities expanded over time? Try to indicate production / sales trend.
Who are involved, & who is / are the leading actor(s)? (groups, persons, institutions). Who took the initiative to start this project (is it mainly a top-down initiative or initiated by the local people themselves?

How did you get to know about the possibilities of Jatropha?
With whom did you get in contact to access more information on Jatropha, the seeds etc.?
For which purposes will you be using Jatropha, as diesel substitution, like soap production, oil lamps etc.?

Economic
What did you pay for the seeds, to establish the first round of Jatropha?
What other expenses did you have for the first batch (labour, pressing equipment, transport, land rent, other costs)
What do you expect the costs will be for the next batch (when the first batch has generated enough seeds to expand)
How much earnings, sales revenue, from selling Jatropha products (specify per batch, or month, or year, as well as possible seasonal fluctuations)? (or if for own use, how much cost reduction (idem))
Did you require any loan / credit in order to start your project? If yes, how much, and appr. how long will you need before you can repay?

Actors
Were there other actors involved during the lifetime of the project? (Maybe some disappeared -> if, so pl. indicate why they left or some entered at a later point in time)
Could you describe the actors involved as being part of a network?
Do you still miss some important actors in your project (car producers, government, customers? etc).
How did the network between the actors develop? Did they know each other before entering this project? Where there, or are there still, problems during the project between them?

Barriers
What are or were the barriers throughout the project (at start-up, and later on)?
For example:
- lack of markets
- problems with technology
- problems with seed supply
- financing problems
- labour problems
- cultural problems (lack of risk-taking entrepreneurs)
- regime: to strong lobby from oil companies or agricultural organisations
- lack of adequate government support etc. etc.

How do other actors regard your activities?
Did you notice a resistance, or critical questions from persons or groups?

Lessons
What are the most important lessons so far?

In technical areas
On infrastructure/ logistics
On social impact
On policies
Organisational & institutional issues in the project itself (incl. networking)
On how to develop a market / compete with established products....

Expectations

Did the expectations you had at the beginning of the project come out right? Or where they changed (slightly) during the process? If so, were actions taken to improve things or change project activities?
Did your project generate a discussion, are more people talking about it? And will the project create a spin-off? Or competition?
How do you think the future for Jatropha in Tanzania will develop? And how do you see the role played by your project in this?

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