LOCAL BIOFUEL PRODUCTION FOR USE IN TELECOMMUNICATIONS APPLICATIONS IN SOUTH EASTERN TANZANIA

Feasibility Study
Final report

Commissioned by: **UNEP, Division of Technology, Industry and Economics**

Prepared by: **Diligent Energy Services, Netherlands**
Ameco Environmental Services, Netherlands

Date: **October 19th, 2006**

DILIGENT
energy systems

Colofon

Title:	**Local Biofuel Production For Use In Telecommunications Applications In South Eastern Tanzania – Feasibility Study** Final Report
Project Code:	
Produced by:	Diligent Energy Services Horsten 1 5612 AX Eindhoven The Netherlands Phone: 00-31- 40 236 4322 Contact: Ruud van Eck, Director E-mail: ruud.van.eck@diligent.nl URL: www.diligent.nl and Ameco Environmental services Koningslaan 60 3583 GN Utrecht The Netherlands Phone: 00-31-30-2545840 Contact: Koen Peters, Senior Consultant E-mail: k.peters@ameco-ut.nl URL: www.ameco-ut.nl
Client:	United Nations Environment Programme Division of Technology, Industry and Economics Tour Mirabeau -39-43, quai André Citroën 757 39 Paris, Cedex 15, France Contact: Marie Holmlund, Energy Programme Officer Tel: +33-1 44 37 30 07 Fax +33-1 44 37 14 74 URL: www.uneptie.org/energy
Date:	October, 2006
Abstract:	This report delivers the findings of a feasibility study on local biofuel production in the Lindi and Mtwara regions in south-eastern Tanzania. The biofuel production is to be linked to the energy demand from a series of mobile telephone antenna's that are to be installed by the Tanzanian company Rural Netco Ltd. Since a large share of the antenna's is to be placed in regions with no access to the main electricity grid, antenna's will need to be powered with individual diesel generators. The study has been requested by UNEP, in order to assess the possibility of an environmentally beneficial alternative for conventional diesel oil. The study assesses the technical, financial, social and environmental impacts of this proposal, and reviews the possible business models for the implementation of such a project. Analysis has been based on research of literature, satellite data, as well as interviews with stakeholders related to the Rural Netco investment and to plant oil production in the region.

Contents

1 Introduction

1.1 The project idea and rationale

The underlying feasibility study assesses the feasibility of biofuel production in the Tanzanian regions of Lindi and Mtwara, to provide fuel for diesel generators that provide GSM antenna's with electrical power.

UNDP is running a programme called 'Growing Sustainable Businesses' in Tanzania. As one of the initiatives coming out of this programme, the Swedish telecom company Ericsson is currently developing a rural GSM telecom project in the regions of Lindi and Mtwara, in the south-eastern coastal area of Tanzania. For this project, Ericsson is establishing the company Rural Netco Ltd. Rural Netco invests in rural telecom infrastructure, specifically in a network of GSM antennas, which will be made available to a wide range of GSM network operators. The objective is to make it thus easier and cheaper for GSM network operators to offer their services in this rural part of Tanzania, and to offer their services also at lower rates. The project intends to be a pilot, and if successful can be replicated elsewhere in Tanzania and possibly other countries. The activities in other countries will probably be implemented under different entities.

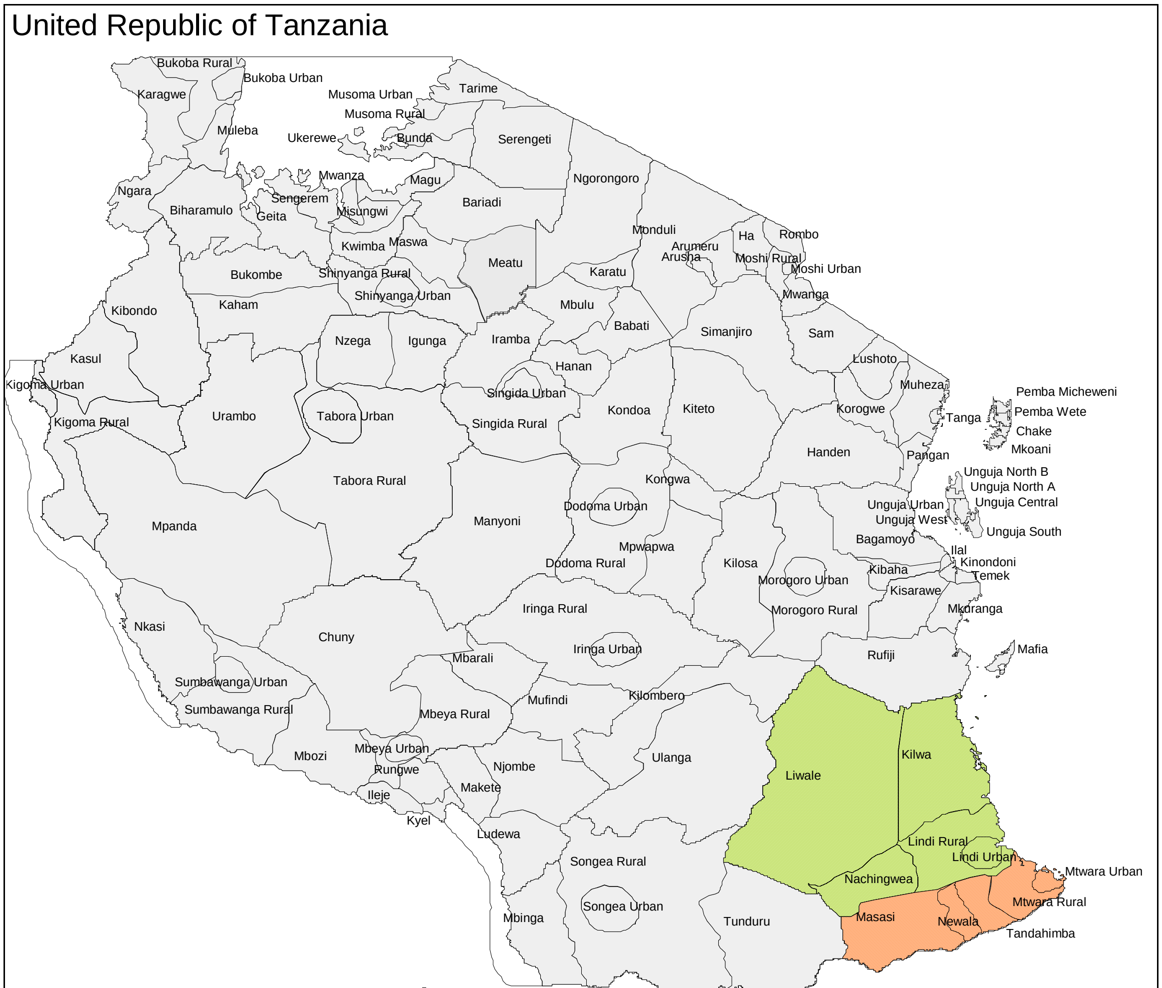
One of the issues to be addressed in setting up this antenna network is the provision of a continuous and reliable source of electricity. As most antennas will be placed in areas with no connection to the electricity grid, antennas will be equipped with diesel generators. The socio-economic ICT connectivity study that was carried out for this project recommended that alternatives for the energy provision be reviewed, in particular the possibility to use locally or regionally produced biofuel as an alternative for (imported) diesel from fossil fuel. This may generate important benefits such as decreased dependency on imported materials and community involvement as well. In total, some 50 antennas are currently foreseen to be established, each requiring about 9,000 litre of diesel per year. The speed of implementation, however, depends on the involvement of the telecom providers in Tanzania. According to Rural Netco Ltd., in principle two of the three largest telecom providers should be contracted to make the establishment of the tower economical attractive. As of now, no contract has been signed.

This study reviews the possibility of using locally or regionally produced biofuel to replace fossil fuel diesel for the energy needs of the antennas. The contracting agent for this study, UNEP, does this in order to promote environmentally sustainable business development. Neither UNEP, nor Ericsson, are interested to become directly involved in biofuel production themselves. The management of Rural Netco Ltd. states it may consider the possibility of being directly involved in establishing the biofuel facility in initial stage (if the business model is attractive enough), or alternatively to discuss a buyers-guarantee contract with another investor. Other possible actors that can be involved in establishing the biofuel production therefore need to be assessed too.

The study will therefore lead to a general conclusion on whether biofuel production in the Lindi/Mtwara regions is feasible (and suitable for providing antenna's with electricity), and if so, how it can be promoted.

1.2 Description of the project area

The project is focussed on the Lindi/Mtwara region in South Eastern Tanzania. Mtwara and Lindi region came into being in 1971 as a result of the division of Mtwara and Lindi as a single region into two separate regions. The following map indicates the location of the Lindi and Mtwara regions within Tanzania:



Statistics			
Town	Area (km^2)	Population	Population Density
Mtwara	16,707	1,128,523	68
Lindi	66,046	792,360	12

Figure 1: Lindi and Mtwara regions and their sub-regions. *Source: Tanzania Sensa 2002*
Note: "Lindi region" consists of the entire green shaded area and has five sub-regions including Lindi Urban sub-region; "Mtwara region" consists of the entire red shaded area and also has five sub-regions, including Mtwara Urban sub-region.

1.2.1 Lindi region1

The town of Lindi is one of the oldest towns in Tanzania. It was established as a trade link between Zanzibar and the mainland in the 11th century by Arab traders whose culture and religion still dominate the town and, to a smaller extent, the surrounding rural areas. In economic terms, the region is one of the poorest in Tanzania and its population has low educational levels. The region is the most sparsely populated in Tanzania (less then 12 people/ km^2). Islam is the predominant religion.

Infrastructure
Lindi town has a small port at the mouth of the Lukuledi River. Its port facilities allow one or two cargo (maximum of 600ton) or passenger boats at a time. During the rainy season access to Lindi is only by air and sea, with roads open during the dry season (which lasts for six months from June to November). A new tarmac road under development connecting with Dar es Salaam and Mtwara should make Lindi accessible by road year round.

Business
The main occupations are smallholder agriculture and small-scale trading, with a substantial number of urban residents depending on agriculture. Farms are located outside the urban boundaries about 20 km away where patches of fertile lands can be acquired. In Lindi town, the Arab and Indian merchants form the bulk of the businesses, the other inhabitants are mainly engaged in fisheries. Lindi region used to have important sisal producing plantation.

Ecological
From the coast the land rises sharply to the hills of Mtanda. In ecological terms Lindi town and its surrounding settlements fall into a relatively dry upland area suitable mainly for cassava and cashew nuts. Another cash crop is coconuts, which are sold and consumed within the region.

1.2.2 Mtwara region[2]

Mtwara is one of the southern regions of Tanzania which have been underdeveloped for a long time for various reasons and constraints. Mtwara region is the most densely populated region in the southern zone.

Infrastructure
Among the development constraints for Mtwara is not the lack of resources but the lack of proper infrastructures as roads and energy. Mtwara is now looking up and waking up to enormous development possibilities and exciting times ahead as contruction of the road from Dar-es-Salaam to Mtwara is expected to be finished in two years time. This road, the Dar-Kibiti-Lindi-Mtwara road has been given a boost after the completion of the Mkapa Bridge over the mighty Rufiji River. Energywise, Mnazi Bay gas promises to provide the most needed reliable and adequate electricity for powering industrial and commercial activities in the region.

Ecological

---

[1] *Source: wikipedia at* *http://en.wikipedia.org/wiki/Lindi* and
Lerise, F.; Kibadu, A.; Mbutolwe, E; Mushi, M (october 2001). “case of Lindi and its region, southern Tanzania” Working Paper 2 Series on Rural-Urban Interactions and Livelihood Strategies, IIED
[2] *Source: Wikipedia at* *http://en.wikipedia.org/wiki/Mtwara_Region*

The boundary with Mozambique to the south is formed by the Ruvuma River. To the west, the Mtwara Region is bordered by the Ruvuma Region, to the North, by the Lindi Region, and to the East the region is bordered by the Indian Ocean. There is monomodal rainfall averaging 600 mm to 1000 mm in 5-7 months growing season (November/ December –April/May). Like elsewhere in Tanzania the forest resources of Mtwara region are drastically reduced due to from demand for fuel by an increasing population.

Business

The main occupation of the inhabitants of Mtwara region is farming. Approximately 85 percent of the region's total area is arable land. However, less than 20 percent of this is under cultivation. The main food crops are cassava, sorghum, millet and with increasing importance maize and paddy. Cashew nut is the most important cash crop. Sesame and groundnuts also contribute to the cash income of the peasant farmer. Coconut is important along the Coast.

1.2.3 Cashew nut production

Lindi and Mtwara regions are internationally known for their high quality cashew nuts, produced almost exclusively by smallholders. The cashew nuts grow along the coast line and inwards in tropical climate. Most of the households engaged in cash crop cultivation have a number of cashew nut trees as a source of income. Most of the owners are older people who have either established their farms or inherited them. Cashew nuts have their first harvest after three years and the harvest is once in year (from September to November). In all major towns, primary societies buy the cashew nuts of the farmers. The large processing / export companies buy the nuts from these societies. Because of the large volumes requested, the processing/ export companies set the price of the cashew nut. Whereby in the past several cashew nut processing plants were in full operation, at the moment there is one manual processing plant in Mtwara: Olam, and (possibly) two other mechanical plants. Another large buyer of cashew nuts is Mohammed Enterprises Ltd (see chapter 3), who processes the cashew nuts in Dar es Salaam.

Both Mtwara and Lindi region authorities are promoting awareness among their farmers to do intercropping with groundnuts and/or cowpeas in order to make them less dependent on cashew farming. Some new initiatives with sesame farming (with a Japanese investor) will start soon.

1.3 Description of stakeholders

Various stakeholders will play a role in this project. It is important to realise that at this moment, the project is being promoted by a group of stakeholders that wishes to benefit from the project, but will not implement it themselves. The implementing actor has not been identified yet. Roles of various actors may also vary depending on the business model and route that will be chosen to implement the project.

The following roles can be identified, with stakeholders that can be identified for that role:

- **Clients for biofuel (SVO or biodiesel):**
    - Rural Netco (Ericsson)
    - Regional fleet owners
    - Retail fuel traders at local markets

- **Agricultural producers:**
    - Smallholder farmers, individual or in farmer groups

- Large farmers operating as contract farmers (outgrowers)
- Plantation owners

- **Processors (oil pressing and processing, storage, marketing)**
  - Private business
  - Farmer associations or groups

- **Government (regulation, taxation and duties, land provision, infrastructure)**
  - National
  - Regional/local

- **Financiers**
  - Local/regional microfinance organisations and SACCOs
  - National banks
  - Investment funds & private equity
  - Subsidy schemes

- **Knowledge providers**
  - Dar es Salaam University
  - Naliendele Agricultural Research Institute, Mtwara
  - Expert NGOs (TaTEDO), Consultants

Representatives of most of these stakeholder groups were met. Further analysis of important stakeholders is given in paragraph 3.4. Please also refer to Annex I for a list of individuals and organisations met.

1.4 Methodology

For this research a two-way approach has been followed:

1. Desk research in Netherlands and Tanzania

The deskwork included:
- A review of technical aspects of crop production and harvesting, oil production, operational logistics, storage and transport aspects, and use of oil products in diesel engines.
- Policy and licensing aspects.
- Generic environmental and social implications of biofuel production
- Preparatory work for the inventory of relevant stakeholders
- Preparatory work for the economic and financial assessment of biofuel production, including an evaluation of the possibility to apply the Clean Development Mechanism

Deskwork has been based on literature resources within Diligent's and Ameco's own libraries (including some university studies that are not published), internet search, and analysis of available satellite data.

2. Field research in Tanzania, including local stakeholder inventory

The field research has been based on the desk research, and concentrated on the following components:
- Inventory of suitable partners to establish and manage a biofuel production company – including a global assessment of their competencies and weaknesses, and provisional interest to be involved

- Inventory of interested land owners and managers (farmers), and available acreage, for growing biofuel crops, including an assessment of conditions that should be met before biofuel crop production is sufficiently attractive to land owners/managers
- Inventory of potentially suitable sites for establishing biofuel processing facilities that meet basic infrastructure and logistical requirements
- Collection of locally relevant data on economic/financial aspects of biofuel production
- Collection of locally relevant data on financing possibilities

Field research has been carried out through interviews and site visits. Organisations and individuals that were visited had been selected based on our own networks, references by the client and client's partners, references by other stakeholders, and on the basis of information found during the desk research.

Data collected has been analysed at our office, resulting in this feasibility study report.

2 Technical aspects

2.1 Fuel supply

2.1.1 Biofuel definitions

Biofuels are fuels produced from biomass (waste from agricultural or forest and planted biomass). The most important biofuels are:

Straight Vegetable Oil:	(Pure Plant Oil) Oil obtained from oil holding seeds (rapeseed, sunflower, jatropha, etc) by pressing and filtering, no other process steps
Biodiesel:	Vegetable oil which is chemically modified (esterification). Methanol or ethanol is added to the oil to form diesel and glycerine. The glycerine is then separated from the diesel. The end product has properties similar to fossil diesel.
Bio-ethanol:	Fermentation of sugar and starch holding plant, like grain, sugarcane, etc.
Bio-methanol:	Gasification of biomass and transformation into methanol by methanol synthesis.

The scope of the feasibility study is limited to Straight Vegetable Oil (SVO) and biodiesel, as these are the fuels that are suitable for using in the diesel generators for the antennas.

2.1.2 Selection of crops

The selection of oil holding seeds, suitable for the production of Straight Vegetable Oil or Biodiesel, is based on a number of criteria:

- Suitability of climate conditions in Mtwara and Lindi: soil type, rainfall and temperature
- Because largest cash crop is cashew in Lindi and Mtwara, the crop should not transmit pest and diseases to cashew trees
- Oil yield per hectare
- Limited dependency on external input (fertilizers, pesticide, and labour)
- Price of raw material (seeds)
- No competition in harvest season with cashew nuts
- Crop should already grow in Tanzania and preferably Lindi/ Mtwara region

The scheme below provides basic details for a number of the most appropriate crops:

Oil crop	Climate condition	Annual/ perennial	First Harvest	Oil content	Price / kg seeds (tshs)	L Oil/ Hectare	Litres / 10 kg Seeds	Others	Suitable Mtwara/ Lindi
Rape seed	Moderate Climate								No; wrong climate conditions
Sunflower	▪ 600-1000mm rainfall ▪ Rotation required: 2 yrs not after 1 yr	Annual	3-8 mths	35-40%	200	950	4	▪ Edible oil ▪ Shortage of national production	Yes
Jatropha	▪ >400mm rainfall ▪ <1500 m above sealevel	Perennial	2-3 yrs (cuttings 1 yr)	32-35%	80-120	900-1800	2-3	▪ Seeds, oil and residues poisonous for humans and animals ▪ low maintenance ▪ no pesticide ▪ press cake for charcoal	Yes
Palm Oil	▪ >2000mm	Perennial	3-4 yrs					High viscosity- cannot be used as SVO	No; rainfall not sufficient
Groundnut	▪ not < 13˚C ▪ no clay soil ▪ rotation ▪ 500-700 mm rainfall	Annual	7-9 weeks	40-50%	600-1,000	1059	3.5	Residue can be used as animal fodder	Yes
Castor		Annual	4 months	40-60%	Weed	1413	5	Can transmit diseases to cashew	No; diseases to cashew
Coconut (dried nut)		Perennial	>5 yrs	69-70%	500/ kg dried nut	2690	2-4	Only grows in coast areas	Potentially, but expensive and with restrictions
sesame		annual	4-5 months	55%	750	696	3-5		Potentially, but expensive

Table 1: specifics of various oil-yielding crops. *Source: NRI, interviews, own experiences Diligent Tanzania*

On the basis of these data, four crops seem to meet the criteria to varying degrees: sunflower; jatropha; ground nut; and sesame. The cost price of the oil they contain, based on current market prices of the seeds, is as follows:

Crop	Price in TSh/l	Price in EUR/l
Sunflower	TSh 500/l	€ 0.31
Jatropha	TSh 600/l	€ 0.38
Ground nut	TSh 1800/l	€ 1.13
Sesame	TSh 1500/l	€ 0.94

Table 2: current market prices of oils contained in oilseeds, calculated as price per litre oil

These prices do not include the costs of transport, storage, processing and marketing yet. While it is not stated as a precondition for the project that biofuel needs to be cheaper than fossil fuel diesel to make the project worthwhile (social and environmental benefits may also provide arguments to invest in biofuel), it is assumed that prices should at least be in the vicinity of fossil fuel diesel to make the project attractive. On the basis of the preliminary assessment, only sunflower and jatropha would be able to compete also on costs.

It should be noted, however, that many of the data in the above table remain highly uncertain.

For jatropha, all data are premature as there are still very limited experiences with commercial scale production in plantation or other forms. Experiences of Diligent Tanzania show that data provided in literature (e.g. for seed production per plant, or oil yield per kg of seeds) are overly optimistic and have never been realized by them in practice. Whether other projects for commercial jatropha production have achieved better yields could not be confirmed. The data in the table therefore include figures that have been achieved to date, as the lower range of expected yields. However, there is also still much scope for improvement. For example, experiences show that yields are very dependent on rainfall (or irrigation). In the Lindi/Mtwara regions this will generally be better than in the Arusha region, where Diligent is currently active. Further development of planting and cropping methods, and improved seed quality, are also likely to lead to substantial improvements in yields in future years. Furthermore, market prices for seeds now reflect the fact that demand is much higher than supply.

Sunflower has been grown for oil for longer periods. As a consequence, there is more experience with this crop. However, the current volume in the market will not be sufficient to address additional demand to use sunflower oil as fuel, and prices may fluctuate if this additional demand develops.

Groundnut and sesame oil have not been used for fuel to date, and their demand for edible oils is also very limited. Therefore, prices may still change considerably if demand goes up.

2.1.3 Grow methods

Various planting methods can be applied to obtain the highest revenues from of a hectare of land without exhausting the soil.

Figure 2: Intercropping jatropha and Maize in Tanzania

1. Intercropping

A popular cropping method is intercropping at the moment. Various crops are sowed in rows and take turns with each other. Intercropping is particularly suitable for jatropha because of the long period until the first harvest of jatropha, the limited demand jatropha places on the soil, the lack of competition for water between jatropha and other plants (jatropha has a taproot which goes down to seven metres depth). Also, that there is still little experience with the growth of jatropha in Lindi and Mtwara, and with intercropping the risk that land will not provide sufficient revenue is thus reduced. jatropha seeds can be harvested once or twice a year, depending on the amount and period of rainfall. The jatropha tree can be planted in a 3*3 meter distance between the plants. Another oil holding plant, like sunflower can then be grown in between the rows to guarantee seed harvest in the first year. It is also possible to cultivate other crops like beans or onions in between the rows. In this way the farmer can get revenue from the land while waiting for the energy crops to mature.

Intercropping with cashew nuts is only suitable with crops that need only limited sunshine to grow (beans, tomatoes, groundnuts). This is therefore not possible with jatropha or sunflower, as these crops require larger amounts of sunshine

2. Fencing

Another way of growing jatropha is in a hedgerow. Since jatropha is not browsed by animals, this is one of the traditional ways jatropha is being grown. Jatropha as hedgerow will also protect the young seedlings of other crops from wind, and indicate the boundaries of one's property. Fencing is very suitable for food crop farmers

2.1.4 Risks and constraints

As indicated above, jatropha and sunflower appear to be the most suitable crops for biofuel production in the Lindi/Mtwara regions. A number of risks and constraints are observed by the Consultant, namely:

- The acceptability to use edible oils for fuel is yet unclear. Tanzania is now producing sufficient sunflower oil for own food markets, but this may change as demand increases when it is used as a engine fuel.
- As mentioned earlier, there are still a lot of unknowns about commercial production of jatropha, since there is very limited experience with large scale production to date, and the crop takes several years to mature. Much data available in literature is related to how the plant behaves when it grows in the wild or as a hedge plant. Its reported low sensitivity to diseases and pests may decrease if the plant is grown in plantations with focus on maximal output.
- Like many other annual crops, sunflower cannot be planted at the same place every year. Crop rotation is required - in the case of sunflower, there should be at least two years of alternative crop following one season year of sunflower production.
- Seasonal influences in the supply of seeds
- Theft of sunflower, groundnuts, etc may be expected due to value of the crop itself. Jatropha is not edible and does not have an extra value so theft will be less likely.

2.2 Fuel processing

2.2.1 Introduction

Straight Vegetable Oil has a high viscosity. The oil is thicker than conventional diesel and flows less easily through fuel lines. In cold climates or in small engines (e.g. cars) the SVO needs to be pre-heated and this requires some modifications to the engine. However, large engines and / or generators often have an inbuilt pre-heater, operate during long periods, which makes modifications not necessary. Another solution to make SVO thinner is chemical modification of SVO into biodiesel. Biodiesel has comparable properties to fossil diesel fuel (i.e. about the same viscosity), and requires no or only slight modifications to the engine.

2.2.2 Processing steps for SVO

There are two steps in producing SVO:

1. *Pressing*
   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. An engine driven screw press is mostly used for pressing oilseeds and is most suitable, since it is a continuous process. A ram press is a manual press and would for the production of large quantities of oil require too much time and labour. Hydraulic presses are hardly used and chemical extraction would be too complex for the region and expected scale of operation, as it requires highly skilled workers and surroundings.

2. *Filtering*
   After the oil is obtained it should be filtered to remove contaminations. Several filtering steps are necessary, the first one is pre-filtering using a filter with a large maze size, e.g. 200 micron. The second step is using a filterpress. This press uses a pump to press the oil through several layers of cloth. The final step is to pour the oil through a 1 micron filter.

When the seeds are pressed and the oil is obtained, the presscake is left as residue. The presscake can then be used as animal feed (sunflower), or as fertilizer. jatropha- and castor seedcake are not edible. These presscakes can be used as fertilizer, or as energy source when pressed into briquettes or processed to charcoal. It can also be used to produce biogas. The by-products currently have little value, however, as no markets have been developed for them.

2.2.3 Processing steps for Biodiesel

The chemical modification of SVO into biodiesel, called esterification process requires specific inputs:

- Methanol or Ethanol
- Caustic soda
- Laboratory environment

The SVO should be mixed with the caustic soda, the methanol or ethanol and then left to stand. Glycerine is obtained during this process and will settle to the bottom of the tank, leaving the biodiesel (also known as methyl(ethyl) ester) at the top. Methanol is highly flammable and toxic so this requires specialized equipment. Also, it is very important to monitor the quality of the fuel, so a laboratory setting is necessary. The conversion rate can be close to 100% (i.e. one litre of SVO produces 1 litre biodiesel), depending on the quality of the input oil.

The glycerine can be used for several purposes (for example, to make 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).[3]

2.2.4 Need for transformation into Biodiesel

The main reason to modify SVO into biodiesel is to lower the viscosity of SVO and make it suitable for use in normal engines. However, when the SVO is warm, the viscosity becomes lower and the flow through the fuel lines is as easy as with fossil diesel. For the use of generators, it is therefore not really necessary to convert SVO into biodiesel, since small technical modifications can address this aspect as easily..

A second considerations is that, according to literature at least, SVO can be kept for only six months. Over longer periods, the chemical composition changes making the oil more acid, and thus more corrosive for engines. Own practical experience of Diligent to date, however, suggests that this risk is not so great. Biodiesel can be, in principle, indefinitely.

Both SVO and biodiesel can be blended with fossil diesel. Biodiesel can be mixed with fossil diesel in any ratio. SVO can also be blend in any ratio if the engine is modified to handle SVO. A blend with 97.4% diesel and 2.6% SVO (Jatropha) has an even better engine performance (higher cetane number) than 100% diesel fuel and it can thus be used as an ignition-accelerator additive (Forson et al., 2004)[4].

2.2.5 Risks and constraints

The objective of the transformation from SVO to Biodiesel is to modify the characteristics of SVO to similar ones as fossil diesel. The risks and constraints to transfer SVO into biodiesel are:

- Not enough supply of the caustic soda, methanol or ethanol. Ethanol is quite easily available in Tanzania, methanol has to be imported.
- A laboratory setting is required to be able to monitor the quality. This requires staff with adequate skills and education
- As the degree of processing costs in the total end product costs increases, the project becomes more sensitive to the efficient management of production processes.

Because of the little extra advantage of processing SVO into biodiesel, the Consultant advises to use SVO, or to blend SVO with normal diesel, in the first years. When larger seed availability is guaranteed, the transformation from SVO to biodiesel becomes an attractive step.

---

[3] 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
[4] Forson F.K. et al. (2004) 'Performance of Jatropha oil blends in a diesel engine', Renewable Energy 29(2004): 1134-45.

2.3 Use of fuel in generators

Generators are usually driven by a diesel engine and as it is the diesel engine that should be suitable for SVO or biodiesel.

1. *Generator modification for biodiesel and SVO*
   As biodiesel has comparable properties to fossil diesel, all diesel engines, with no modification other than the replacing of natural rubber with synthetic rubber hoses (which late model engines do not have anyway), can run on biodiesel.
   When SVO is used some modifications are usually necessary, although some literature resources (e.g. Heller[5]) report 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, for example in India, have shown that only changing the nozzles and fuel lines is enough for the engine to work properly. Other tests with vegetable oils, however, have shown that the overall functioning of the motor is affected and causes premature wear. Long-term testing demonstrated the following problems, according to a report by TIRDO[6]:

   - 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, among others:

- preheating of the fuel to improve the flow of the oil; or
- use of a dual fuel tank system

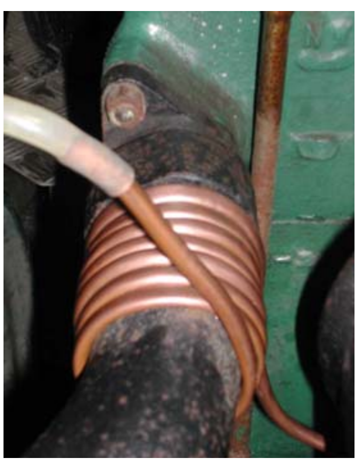


Figure 3: Modification of Lister engine to run on SVO

With a dual fuel tank system the engine is started with normal diesel fuel and switched over to the tank with SVO 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 €900[7]. The modifications of the engine for the generator are quite simple and can be executed by workshops or Vocational Training Centres in Mtwara/Lindi, as Lister type engines are available in Tanzania. The heat of the exhaust pipe can be used to preheat the SVO before it enters the injector pump. A copper tube can be used for this, see Figure 3[8]. A local workshop or Vocational Training Centre should be able to do this for about 700,000 Tsh. Some generator suppliers are currently developing pre-modified engines (for example Energiebau Koln), however these are not yet available on the market

---

5 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

6 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.

7 www.elsbett.com

8 source: http://www.geocities.com/ wastewatts/listers.html]

The use of lubricating oil based on vegetable oil will avoid shortened durability of the oil.

2. Maintenance Costs

Maintenance of diesel generator engines basically consists of changing the fuel/oil filter and air cleaner, which is a normal process for diesel generators. When SVO is used in engines of which the cylinders are worn, the SVO and lubricant may mix. This reduces the durability of the lubricant oil. Hence, lubricant oil should be changed more often – up to twice as often as with normal diesel. The normal interval is defined in the specifications given by the manufacturer and the conditions under which the generator runs. In average a 12kVa generator should have its oil changed after 150-200 hours of operating. The price of changing the engine oil (average 12 liters), ranges between 15.000 and 45.000 Tsh (between € 9 and € 28).

Besides that, the injector nozzles will have to be checked more often than with normal fossil diesel because the SVO can cake onto the nozzles more easily than normal diesel.

3. Possible suppliers, warrantees and services

The consultant understands that Rural Netco Ltd and its partners already have experience with diesel generators as power source for antenna masts, but did not receive further details on manufacturers and experiences. A possible supplier is Rift Valley Machinery in Dar-es-Salaam (see Annex I for contact details). They use a Lister engine with a Welland generator set, and can provide a range from 5 to 30 kVA. The necessary capacity for one telecom-tower will be 12 kVA (data provided by client).

The price of their 12kVA lister-engine driven generator is Tsh 15,000,000 (€ 9,375.-)[9]. No commitments were given regarding warrantees in case biofuel is used. From one Japanese supplier (Yanmar) information was received that their warranty may be negatively affected if more than 5% biofuel in a mix with conventional fuel is used. No other data were obtained.

4. *Storage requirements*

Depending on the quality of the filter process, SVO might still contain some impurities. When stored for a period longer than a couple of weeks, these impurities might settle down. Therefore it is better not to store the SVO for a long time. This is not applicable for biodiesel, it can be stored as long as fossil diesel. The *Flash point* indicates the temperature at which the vapour-air mixture can just ignite. Because the flashpoint of SVO and biodiesel is higher than the flashpoint of fossil diesel it is actually safer to store SVO and biodiesel than fossil diesel. However in warm climates like in Mtwara and Lindi it is not advisable to store the SVO or biodiesel (or fossil diesel for that matter) in a tank outside, it should rather be stored in a tank underground.

2.4 Conclusions

From a technical point of view, biofuel production in the Lindi and Mtwara regions appears feasible.

The most suitable crop selection appears to be jatropha. This crop is very suitable to the climatic conditions in the region, gives a good yield per hectare, and requires the least investment and maintenance. It can be planted in a variety of ways, including as hedgerow and through intercropping

[9] € 1,00equals about TSh 1600

with other crops. It has two main disadvantages, however. Firstly, it takes about 3 years before the plants start to provide reasonable yields. Occasionally, this can be speeded up to one year if cuttings are used instead of seeds for planting, but only if planting is followed up by sufficient rain or irrigation. Secondly, jatropha is still hardly known as an agricultural crop. There is still limited knowledge on how this crop performs on the longer term, if being planted in larger amounts (e.g. yields over longer periods; vulnerability to diseases and plagues). Contrary to sunflower, improved varieties of jatropha do not yet exist.

In order to overcome the long period to the first harvest, jatropha may be intercropped with annual crops that provide yields much faster, in particular sunflower.

In order to reduce production complexities, it appears wise to limit production, at least initially, to SVO. The technical complexities and risks involved with modifying a limited number of diesel engines so that they can use SVO (if required at all), are much smaller than those involved with commercial scale biodiesel production involving an esterification process. If there is not enough supply of SVO it is possible to at least blend the fossil diesel with SVO. As the project evolves and it becomes increasingly attracting to serve other markets such as local retail markets, expanding the project with biodiesel production capacity may be considered in order to tap into new customer groups.

Insufficient information is available to determine how SVO use affects warranties of diesel generators.

3 Business and Finances aspects

3.1 Market

As with any business, the demand for the final product is a key success factor for the business model. In the case of biofuels, demand is presumably very large, although much of it is still latent. Potential clients include:

1. Organisations (community based or private) providing electricity with generators for rural villages
2. Energy depending companies seeking (backup) power supply by generators
3. Regional fleet owners
4. Retail fuel traders at local markets

The first two groups of clients (which would include Rural Netco Ltd) could be quite easily served with SVO (or biodiesel), if production was available. Companies piloting biofuel production such as Diligent find that they receive many requests for supplies from such customers, which they currently cannot meet. In addition to production and selling of SVO, such clients may need some additional technical assistance to help address questions regarding required modifications, warranties and quality control, but this would not amount to a major challenge. If the number of clients becomes larger, the need to establish more elaborate marketing and sales capacity would also increase.

Servicing groups 3 and 4 requires SVO or biodiesel to be sold as a transport fuel, which may be more complex from an administrative (taxation, licensing) and technical (biodiesel production, quality control) point of view. In particular the administrative aspects remain difficult to assess, as the government is still elaborating its policy on this (see paragraph 3.6). Wholesale selling to retail traders may also require a more elaborated marketing and sales capacity.

For the assessment of the feasibility of the project, the Consultant considers that market demand from groups 1 and 2 is already more than sufficient for any project that can be implemented in the near future. The feasibility of the project, and the scope at which it should be implemented, therefore depends much more on the potential of entrepreneurs and investors to develop production capacity, and their ability to control costs such that end products can be sold at prices competitive with conventional fuel.

3.2 Key actors and stakeholders

As mentioned in chapter 1.3 various stakeholders have been taken into consideration. Below, the interests, current activities and capacities of various stakeholders have been elaborated in more detail.

3.2.1 Clients for biofuel (SVO or biodiesel):

- Rural Netco Ltd (Ericsson)
- Electricity supply by generators for rural villages
- Backup power supply by generators for energy depending companies
- Regional fleet owners
- Retail fuel traders at local markets

Rural Netco Ltd (2006)	
Region Tanzania with first priority Lindi/ Mtwara	**Product** Infrastructure implementation of GSM antennes for multiple lease structure.
Business Model Outsourcing of most of the activities- mainly overall management. Tower preferably has a local owner who offers multiple services: i.e phone charging, airtime, security, etc.	**Number of antennes:** 50-100
Competencies: ▪ Strong shareholders ▪ Large network of stakeholders in Tanzania ▪ Strong marketing capacity	**Weakness:** ▪ Still a 'paper' company. ▪ New business model so "child diseases" not known ▪ No investment money for own biodiesel production facility
Interest to be involved: High interest in biofuel for own energy needs, possibly also in production. Rural Netco will consider initial ownership of the processing facility, or consider a supply contract with a processor.	

3.2.2 Agricultural producers

- *Smallholder farmers, individual or in farmer groups*

The majority of the agricultural producers are cashew nut smallholder farmers. The tendency, supported by the regional government and the Cashewnut Board of Tanzania, is to motivate smallholder farms to organise themselves in farmer associations and to start intercropping to make them less depend on the cashew nut harvest. Farmers need to be ensured that the necessary inputs (seeds, pesticides, etc) are provided and the market is guaranteed to start a new business.

- *Large farmers operating as contract farmers (outgrowers)*

The concept of contract farming is rather new in Mtwara and Lindi region. The first initiative in large scale contract farming is implemented by a Japanese company for the production of sesame in Masasi district- Mtwara. The company provides the necessary inputs and guarantees to buy the seeds for Tshs 750/ kg. The Japanese closely collaborate with the regional authorities. More then 1,000 farmers have shown interest.

- *Plantation owners*

The concept of large scale agricultural plantations has been implemented by the sisal industry in the past. The three plantations in Lindi are all abandoned. The sisal industry has never been active in Mtwara. Two of the three former sisal estates are still manned by the former employees and the infrastructure (offices, etc) is intact. The commissioner welcomes the interested investor to "re-activate" the sisal plantation for the production of oil yielding seeds.

3.2.3 Processors (oil pressing and processing, storage, marketing)

- *Private business*

Two of the larger buyers of the cashew nuts are Mohammed Enterprises and Olam. They both have experience with the whole chain of cashew nut processing industry and are active in Mtwara and Lindi (see the analysis below). Some other oil pressing companies, e.g. Murzah Oil Mills Ltd, are based in Dar es Salaam. In Mtwara region, several cashew nut processing plants have been in operation but due to the collapse in the cashew nut prices most of them are closed. A sleeping processing factory of coconut oil has been visited. The factory Hyderi Oil Mills & Soap Factory (located on the way between Mtwara and Lindi, at Mnasi Moja) has been established in 1952. The owner is in Canada, the machinery is old fashioned and the production of coconut oil is no longer economical feasible.

Olam Ltd	
Region ▪ All over the world ▪ 19 operations in Africa (Tz, Ke, Ug, Moz) ▪ Cashew nut Processing plant in Mtwara: capacity 48ton/ day; 4,000 labour	**Products (in TZ)** ▪ cashewnut/ sesame ▪ coffee ▪ cocoa ▪ cotton
Hectare Expecting to start cashewnut plantation for "biological market".	**Oil related activities:** None
Competencies: ▪ processing knowledge ▪ strong back up from mother company ▪ large employment creation	**Weaknesses:** ▪ motivation labour low
Interest to be involved: Not clearly indicated	

Mohammed Enterprises Tanzania Ltd (1980)	
Region ▪ *Manufacturing units*: Tabora, Moshi, Tabora, Morogoro, Mbeya ▪ *Upcountry Branches*: all regional towns including Lindi and Mtwara ▪ *Agricultural Estates*: 16, not in Mtwara/ Lindi ▪ *Import and Export*	**Products (among others)** ▪ *Afritex Ltd*- fabrics and cottons ▪ *Ap&Ap*- Agro-Processing and Allied Products Ltd ▪ *Mo Cashews Ltd*- cashewnut processing factory ▪ *TPM* – sisal bag manufacturing business ▪ *Tradeco Soap Industries*
Hectare 16 farms; over 37,300 Ha across 5 regions	**Oil related activities:** Developing state-of-the-art edible oil refinery, a fractionation plant and a soap manufacturing plant close to harbour in DSM.
Competencies: ▪ strong management ▪ experience in full chain: plantation-export ▪ ready to invest (see below) ▪ director agriculture grows jatropha in India	**Weaknesses:** ▪ little flexibility for test cases
Interest to be involved: Interested in cooperating with a pilot model (have been approached by the UNDP) and investing in the whole chain (logistics, processing, marketing, etc) if raw materials is guaranteed.	

- *Farmer associations or groups*

Most of the farmer associations are still young and have weak management. Most farmers organise themselves in SACCOs because of the financial support they need. During the time of this feasibility study, no farmer association was identified as capable to start an immediate form of cooperation with.

3.2.4 Government (regulation, taxation and duties, land provision, infrastructure)

- *National*

As is mentioned in chapter 3.2 the Tanzanian government welcomes private investors to invest in the agricultural sector. Because of the number of requests for large areas for oil holding crop production and the cross-ministry involvement of the production and use of biofuel, a Biofuel Task Force has been established to streamline all policies and regulation. The expectation is that end 2007 all regulations are sound and clear.

- *Regional/local*

Both regional commissioners are very much interested in improving the economic and agricultural activities in their regions. According to the commissioners, land availability, willingness of farmers to cooperate and full support of the local authorities will not be a problem. While the commissioner of Mtwara strongly favours an outgrower model, the commissioner of Lindi prefers the re-activation of old sisal estates.

3.2.5 Financiers

- *Local/regional microfinance organisations and SACCOs*

Tanzania has traditionally known a system of rural Saving and Credit Cooperative Societies (SACCOs), which has provided the largest share of financing services in rural areas to date. Most SACCOs inherited from the former socialist system collapsed. Because of the lack of financial services for farmers by microfinance and commercial financial institutions, the focus on SACCO development is again in the picture. Most SACCOs have limited financial power and the management capacities vary strongly between the cooperatives. SCCULT, the umbrella organisation of over 700 SACCOs in the whole country and more than 30 in Mtwara/ Lindi region, has a strong interest in providing business support to the SACCOs. The regional office in Mtwara introduced the team to a well organised and strong SACCO: Mwananchi, which showed interest in cooperation in the implementation of the local production of biofuel.

SCCULT: Savings and Credit Cooperative Union League of Tanzania (1992)	
Region ▪ all regions: one branch in Mtwara covering Mtwara and Lindi region ▪ 28 member SACCOs in Mtwara (9 agricultural)[10] ▪ 11 member SACCOs in Lindi (2 agricultural)[11]	**Products (among others)** ▪ financial support ▪ business support/ training ▪ awareness creation programs
	Oil related activities: Implementing sesame project with SACCOs in Mtwara/

[10] See Annex IV for list of Sacco's in Mtwara and Lindi region
[11] See Annex IVfor list of Sacco's in Mtwara and Lindi region

	Lindi region in cooperation with Naliendele research institute
Competencies: ▪ Long track record of SACCO support ▪ In house training capacity ▪ Good link for multiplication to other SACCOs	**Weaknesses:** ▪ strong governmental involvement ▪ no commercial sense ▪ lack of financial capital ▪ bureaucratic
Interest to be involved: Interested to expand their business support to SACCOs and provide a better life for the farmers.	

Mwananchi: Mtwara/ Masasi Co-operate Union Ltd	
Region ▪ Mtwara region ▪ Corporate Members: 37 (of which some are Primary Societies with over 100 farmers) ▪ Individual Members: 123	**Products (among others)** ▪ financial support (one year loans with interest of 15%) ▪ business support is delivered in cooperation with SCCULT
Competencies: ▪ Extensive network of farmer organizations and farmers ▪ Strong capacity financial analysis of business plan ▪ Excess to money to finance farmers	**Weaknesses:** ▪ No business support / training experience ▪ Bureaucratic organization
Interest to be involved: Interested in working together to financially support and motivate their members to cooperate with the entrepreneur to start jatropha planting. However, only after positive support of growing jatropha in Mtwara Region by the Naliendele Research Institute.	

- *National banks*

The financial sector isdeveloping. Lack of capital is not the bottleneck for financial support. The challenge is to design a feasible business plan. This stakeholder is not further researched in the feasibility study but the outcome of this feasibility study can be a good first start to investigate the interest of national banks to invest in this business.

- *Investment funds & private equity*

Not yet investigated in this feasibility study.

- *Subsidy schemes*

The UNDP has indicated that they will develop a new support program, the investment capital fund. This fund will be host by an independent entity and is established to reduce the risk for public-private investment to implement new business models and industries. Investments between US$30,000 and 500,000 can be applied for. The technical support program up to a maximum of US$ 30,000 is also available.

Another possibility is to attract investment capital via the AREED (African Rural Energy Enterprise Development). The AREED manager of the fund indicated that the production of biofuel will fit under their program.

3.2.6 Knowledge providers

- *Dar es Salaam University*

The department of chemical & process engineering has extensive knowledge on various aspect of the processing of oils and edible and non edible oil holding seeds. Besides that, the department has practical experience with the implementation of CDM projects in Tanzania.

- *Naliendele Agricultural Research Institute, Mtwara*

The commissioners of the two regions cooperate closely with the Naliendele Agricultural Research Institute. The jatropha seeds that the institute has planted are acquired via the commissioner for Mtwara.

Naliendele Research Institute (1956 Nachingwea/ 1968 headquarters to Mtwara)	
Region ▪Mtwara ▪Nachingwea (Lindi)	**Products (among others)** *Research into:* Cashew nut, sesame and jatropha farming
Hectare Two small plots with jatropha in Mtwara and one in Nachingwea	**Oil related activities:** Started planting jatropha in March 2006
Competencies: ▪Very eager to research on jatropha ▪Trustful party towards farmers ▪Good demonstration centre	**Weaknesses:** ▪strong governmental involvement ▪no commercial sense
Interest to be involved: Eager to research the growth of jatropha to make sure that when farmers in Mtwara and Lindi start with this new crop, they will not be surprised by unknown side effects.	

- *Expert NGOs (TaTEDO), Consultants*

TaTEDO has understanding of the biofuel sector through a number of initiatives. Among other, it has been involved in the GTZ project “Liquid biofuels for Tanzania: Potential and Implications for Sustainable Agriculture and Energy in the 21st Century”. Furthermore, TaTEDO is implementing in cooperation with Kakute and Diligent Tanzania a multifunctional platform in Arusha region, which should run on jatropha oil produced by the smallholder farmers.

3.3 Business model options

3.3.1 Introduction

The supply chain for biofuel has various elements

1. Seed production
2. Seed collection and storage
3. Seed processing (pressing and filtering, possibly further processing through esterification)
4. Selling and transport to corporate clients

Within this supply chain, choices can be made with a number of variables, determining the set up of the eventual business model. Variables that relate to technical choices have been addressed in Chapter 2. Below, the organisational aspects of the supply chain are evaluated.

In spite of the large media attention for biofuel production, practical initiatives to implement a business model for the production of biofuel remain quite limited worldwide. In the case of Tanzania, there is only a handful – all young and in development. In annex II, the (intended) initiatives for the production of biofuel in Tanzania are listed. The most common business models applied to date vary from a strong cooperation between processor of the seeds and farmer organisations/ association (SafiAnzania Ltd) via contract farming with individual farmers (Diligent Energy Systems) to the establishment of a plantation (Bioshape Ltd).

Based on the limitations of available oil-holding seeds and the foreseen quick demand of Rural Netco Ltd. as described in chapters one and two, some assumptions has been taken into account for the various business models:

- The business should involve combined oil holding seed production of jatropha (long term investment, harvest after three years) and sunflower (first harvest within one year). Sunflower production will need to be rotated with other crops.
- Intercropping with cashew nut trees is not possible (par 2.1.3). However, most of the cashew nut farmers have other crops whereby intercropping is possible (e.g. sorghum, cassava and paddy) and/or bare land which can be cultivated with jatropha.
- There is no competition in harvest period between cashew nut (September-December) and jatropha and sunflower (May to June).
- The minimum land requirement is about 1,000 hectare (see also paragraph 4.1) to produce sufficient biofuel to power the antennas. If yields are good, this will lead to excess capacity but markets should be easily available for that
- Processing of the SVO to biodiesel is not recommended initially. It may be opted for in a later stage when the availability of seeds is large enough to enable also sales to other market segments, which would require biodiesel.

All options are analysed in the subparagraphs below. The term "investor" is used for the buyer of seeds or the processor of the seeds into SVO/ biodiesel.

3.3.2 Smallholder farmer in farmer group

Smallholder farmers are traditional farmers with a small piece of land, not exceeding one hectare. Most smallholders use methods of farming that have been inherited from previous generations. The tools used are often very basic and the farmers' financial position very weak. The incentive of the (local) government is to build capacity of the smallholder farmers and to mobilise them to establish farmer groups or associations. The farmers will be easily convinced to start a new business when all inputs are pre financed / provided and the market is guaranteed.

Business model:

1. Work with existing farmer association or organise farmers in farmer groups (20 groups of >50 farmers each)
2. Farmer groups invest in local press machine. Filter pressing is done at the investors location
3. Investor collects pressed oil on monthly basis for market price
4. Investor invest in production facility

SWOT ANALYSIS Farmer Groups			
Strenghts ↓	▪ No investment in own land ▪ High local commitment ▪ Low transport cost ▪ Easy dissemination of new production methods ▪ Centralised collection point ▪ Farmer guaranteed of market ▪ Sustainable development of farmers ▪ Farmers over the whole region can participate	▪ Young organizations ▪ No influence on production methods: management of land ▪ No direct contact with farmers ▪ Leader of farmer group act as middleman (farmers benefit less) ▪ Harvest quantity is difficult too predict	↑Weaknesses
Opportunities ↓	▪ Farmer group can decide to use SVO for own purposes: waterpumping, trucks, etc ▪ Farmer groups can continue even as market for biofuel never effectuated ▪ Modernisation of normal life	▪ Farmer group managers suppress farmers ▪ Farmer group sets high prices for seeds/ pressed oil ▪ Farmer group decide that other crops should be grown ▪ Other buyer offers better price for seeds/ oil	↑ Threaths

3.3.3 Outgrowers model/ Contract farming

Outgrowers are minimum-sized farmers with a direct contract with the investor. This method will only be interesting when the farms exceed 2 hectares in size and are within a radius of 25 km from the processing plant. All inputs will be delivered by the "investor", including training and the price for the seeds to be collected is agreed upon.

Business model:
Step 1: District council will assist with allocating medium sized farmers, interested to start a new line of business
Step 2: Contract will be established, whereby seeds and input will be provided and price per kg seeds is determined before hand.
Step 3: Seeds will be collected by the investor from the farmers location, and filtered and processed in the production facility.

SWOT ANALYSIS Contract Farming			
Strenghts↓	▪ No investment in land ▪ Direct contact with farmers ▪ Realistic projection of seed harvest ▪ Control of purchasing prices erosions ▪ Guarantee of flow of income for the farmers	▪ Only farms that exceed 2 hectare can participated ▪ Farm should be located within 25 km from the processing farm ▪ Buying price of seeds fixed for a certain period of time	↑Weaknesses

Opportunities ↓	▪ Justified investment in biodiesel production facility possible ▪	▪ Competition of other biofuel processors ▪	↑Threaths

3.3.4 Company owned farms/ plantations

A third model is where the whole chain is in control of the investor. The investor leases 1,000 hectare to grow jatropha intercropped with, among others, sunflower. Farmers will be employed to work on the farm.

Business model:
Step 1: Allocate piece of land and start clearings procedures
Step 2: Employ farmers and start seeding
Step 3: Market the SVO
Step 3: Volume of seeds sufficient, investment in processing plant

SWOT ANALYSIS Own farm/ plantation			
Strenghts↓	▪ Transport costs low ▪ Good management/Highest revenue per hectare ▪ Environmental control ▪ Social security for farmers	▪ Investment capital for land necessary ▪ All risk at company (e.g. fire, diseases) ▪ Availability of seasonal employees ▪ Clearing of land (inherited trees, etc)	↑Weaknesses
Opportunities ↓	▪ Justified investment in biodiesel production facility possible ▪ Direct Marketing for export market ▪ Additional training programs among farmers possible (HIV, TB, forest conservation, improved cooking, etc	▪ Development of the market for biofuel unsure ▪ Change of government policy (lands, agricultural) ▪ Unknown diseases for sunflower/ jatropha/ cashewnuts ▪ the dialectics of progress	↑ Threaths

3.4 Elaboration of selected models on key business factors

Previous paragraphs described that there is currently a large, but partly latent, and still unserved demand. The investments and skills required to establish production capacity to serve this demand have to date not been mobilised. The energy need of Rural Netco Ltd implies that there will be a large customer with a guaranteed demand over several years – which may create sufficient security to trigger potential actors into making the initial investments in establishing local/regional production capacity. As a consequence, Rural Netco Ltd (or its shareholders) can play a significant role in promoting biofuel production in the region.

Based on this key role of Rural Netco as the initial, production triggering, customer for biofuel production, four models (one with three variations) have been elaborated with varying approaches to the organisation of the supply chain. These analyse the requirements for marketing potential, management requirements, community involvement, financing needs and possibilities, growth potential of the model, and risks and constraints.

As can be concluded from the matrix on the following pages, there are a number of ‘trade-offs’:

- A supply chain involving less actors provides more control for these actors, but increases the demands on them in terms of management requirements and financing needs
- Community involvement will generally be greater in models that involve contract farming rather than plantations, but such models are more complex and time-consuming to establish.
- The chance that production will be generated at sufficient volumes to address the needs of Rural Netco will be greater if Rural Netco would be willing to invest more in supporting the establishment of this capacity
- A greater involvement of Rural Netco Ltd in establishing production capacity will also increase their leverage in determining the degree to which the project should take sustainability aspects, such as community involvement and nature conservation concerns, into account.

Table 3: elaboration of potential models on key business factors

Nr	Model Description	Marketing potential	Management requirements	Community involvement	Financing	Growth potential	Risks and constraints	Comment
1	Own plantation & processing by Rural Netco Ltd	Production for own consumption; possibly expansion by selling to other clients but presumably this is not the first interest of Rural Netco Ltd.	Rural Netco Ltd would need to hire additional management capacity with experience/ expertise in plantation management and processing industries	Community benefit would be limited to job creation at the plantation and processing plant. Possibly, excess production could be shared with local community as a way to increase community support	All investments to be financed by Rural Netco Ltd.	Limited, as model would be developed mostly with a view to serve own fuel consumption needs	Rural Netco Ltd would bear all risks. Given that the company has no expertise in this industry, production risks may be rather high. On the other hand, the model allows Rural Netco the greatest possible control over costs, quality and quantity of production	This model may be of strategic interest (supply guarantee, quality control, diversification of company activities). With limited growth potential, there may not be much benefit from economy of scale, while initial costs might be rather high as the company still needs to learn how to manage such a business.
2	Rural Netco purchasing seeds, own processing (or outsourced processing of Rural Netco's seeds)	Production for own consumption; possible expansion by selling to other clients but presumably this is not the first interest of Rural Netco Ltd.	Rural Netco Ltd would need to hire additional management capacity with experience/ expertise in establishing relations with farmer groups and contract outgrowers, as well as with processing industries	More community involvement than with model 1, as farmer groups and contract outgrowers would be able to establish their own business in supplying to Rural Netco.	Investments in seed production to be financed by outgrowers and farmer groups (possibly with external support); processing by Rural Netco Ltd.	Limited, as model would be developed mostly with a view to serve own fuel consumption needs. Rural Netco may choose to establish excess capacity in order to serve demand of local communities for processing	Risks would differ from model 1 in that some of the production risks would be transferred to farmers. However, it introduces an alternative risk associated with establishing sufficient contracts for production. There is less control on quantity of supply, and it is likely that some	In this model, Rural Netco would become active in trading for their own energy needs. Processing may be done under own management or outsourced, the choice mostly depending on whether outsourcing is possible with sufficient guarantee for quality and continuity, and whether sufficient scale can be

Nr	Model Description	Marketing potential	Management requirements	Community involvement	Financing	Growth potential	Risks and constraints	Comment
							time is required to reach adequate supply amounts.	achieved for own processing. Farmers may need extensive support and education to start growing oil crops.
3	Rural Netco purchasing SVO from supplier							
3a.	Purchase of SVO on market, production development through fixed purchase contracts only	Established companies (e.g. Mohammed Enterprises, Diligent Tanzania) may be able to develop supply capacity for Rural Netco but would (presumably) be interested to serve larger markets. Demand for this would need to be established but is likely to be very large	This model requires the least management capacity from Rural Netco – only to close purchase contracts and monitor quantities and qualities of supplies as per these contracts	Limited: suppliers that would be able to conclude such contracts would be mostly larger enterprises working on national scale. Regional job creation would possibly occur but would be less in control of Rural Netco Ltd	Rural Netco would need to ensure it can pay for the supplies as per contract terms. Suppliers would be responsible for investments in productions and processing, for which they may need external support	Substantial growth potential for the suppliers as the supply contracts would give them a baseline market from which they can easily expand.	Least risks for Rural Netco, almost all production risks are transferred to supplier. In order to encourage suppliers to enter into supply obligations, Rural Netco may need to offer an above-market pay or preferential payment conditions such as support with initial investments	There are currently a handful of actors that may be able to enter into such an agreement, but it is not sure whether any of them is willing to do this without further support.
3b.	Purchase of SVO from selected entrepreneur, assistance with development of pilot plantation	As with 3a. Depending on the degree of support Rural Netco may offer, more actors may be capable or willing to enter into	As with 3a, with additional need to manage the support scheme. Management requirements for this depending on	This option may enable more community involvement as regional actors may be able to play a bigger role in	Financing requirements for investments in plants and processing would be shared between Rural	As with 3a, with possibly even larger growth potential as suppliers would have to engage less of their own	Risks would be shared between Rural Netco and supplier. Support for initial investments may lead to lower	Support offered may include financial support (grant, loan, guarantee) or management support (including technical assistance). A

Nr	Model Description	Marketing potential	Management requirements	Community involvement	Financing	Growth potential	Risks and constraints	Comment
	and processing facility	supply agreements	support offered	establishing the required capacities, depending on the degree of support provided. Also, Rural Netco Ltd may impose more demands for community involvement in return for its support.	Netco and the supplier, depending on degree of support offered. Alternatively, support might be provided by 3rd party, possibly facilitated by Rural Netco Ltd.	financial resources in initial investments, leaving more capacity for expansion	guaranteed prices in supply contracts	combination of this (more like an intermediary form between options 1 and 3b) is that Rural Netco takes a share in a joint venture company that will manage the plantation and processing
3c.	Purchase of SVO from selected entrepreneur, assistance with development of a delivery network from farmer groups and contract farmers	As with 3b. Depending on the degree of support Rural Netco may offer, more actors may be capable or willing to enter into supply agreements	As with 3b, with additional need to manage the support scheme. Management requirements for this depending on support offered	Large scope for community involvement, as the assistance offered may enable local farmer groups and other actors to become involved and will enable Rural Netco Ltd to demand community involvement from entrepreneurs in return for support	Financing requirements would be shared between Rural Netco (support); supplier (production and processing capacity); and the farmers (production capacity). Alternatively (or additionally), support might be provided by 3rd party, possibly facilitated by Rural Netco Ltd.	As with 3a, but growth may be restricted by the speed with which the farmer group contracts and outgrower contracts can be established	This model entails more risks in the initial stages as the most actors are involved, but may also provide a higher degree of sustainability as there is more community involvement and financing requirements (initial and for expansion) are shared by more actors.	Support offered may include financial support (grant, loan, guarantee) or management support (including technical assistance). A combination of this (more like an intermediary form between options 1 and 3c) is that Rural Netco takes a share in a joint venture company that will manage the outgrower network and and processing facility
4.	Rural Netco purchasing biodiesel from supplier	Established companies (e.g. Mohammed Enterprises,	This model requires low management capacity from	No commitment required. Fossil diesel as an alternitive will be	Rural Netco would need to ensure it can pay for the supplies as per	As with 3a	Least risks for Rural Netco, almost all production risks are transferred to	low commitment to local society

Nr	Model Description	Marketing potential	Management requirements	Community involvement	Financing	Growth potential	Risks and constraints	Comment
		Diligent Tanzania) may be able to develop supply capacity for Rural Netco but would (presumably) be interested in serving larger markets. High investment from supplier is expected (bio diesel processing)	Rural Netco – only to close purchase contracts and monitor quantities and qualities of complex bio diesel specifications of supplies as per these contracts	available if needed	contract terms. Suppliers would be responsible for investments in productions and processing, for which they may need external support		supplier. Rural Netco is always able to move to fossil fuel if supply shows to be a constraint	

On the whole, the Consultant considers that a combination of model 3b and 3c is the most logical and suitable approach: Rural Netco Ltd would be a guaranteed customer for, and provides support to, a processing company that will establish its own pilot plantation and also purchases seeds from a network of contract farmers. The company can be either one of the existing companies active in this industry (e.g. Olam, Mohammed Enterprises, Diligent Tanzania), or a newly established Joint Venture company involving Rural Netco Ltd, one of such companies, and/or local farming organisations.

Whether or not the company would be a joint venture of various actors or would have a single owner, strong cooperation between various actors will be necessary to make the project a success. Rural Netco can use its position as a large company with strong and reputable international shareholding to mobilise funding for the project. The private sector company will need to provide the expertise and management capacity for establishing the plantation and processing capacity. Local farming organisations actors will need to be involved from the beginning to set up contract farming networks, educate and inform candidate farmers, and help build trust among farmers. It should be noted, however, that during the Consultant's field research no farming organisations where met that would be strong enough to be an equal partner to the other actors.

3.5 Policy, regulation and taxation

As for now, no special policy or regulation is in place for the production and use of SVO and biodiesel. Because of the interest of various players to invest in biofuel production, the Tanzanian government recognises a need for establishing clear guidelines for biodiesel production and use. The first step has been the establishment of the Biofuel Task Force in which various stakeholders take a seat, among others: Tanzania Petroleum Corporation, Ministry of Planning, Ministry of Energy and Minerals, University of Dar-es-Salaam, Private Sector Players (e.g. Diligent Tanzania, Kakute, sugar companies) and NGOs (TaTEDO). The draft guidelines are expected to be completed in September 2007. The guidelines include among others, application procedures for investors, taxation procedures, settlement plans, etc. A consultant will be hired to make a final plan which should let to regulations and policy before the end of 2007 (source: Ministry of energy and Minerals).

Taxes on (conventional) fuel are a very significant source of revenue collection for Tanzania, accounting for about 18% of total tax revenues. The Finance Minister has executed measures to remove the VAT on fuel, but increase road toll and excise duty. The overall effect of the changes is a small reduction in the pump price for the consumer (although local media reports that this is not reflected in pump prices, as petrol companies have simply increased their margins). A real concern for VAT registered businesses (for whom the VAT is recoverable and therefore not a cost) is that the changes increased their costs.

	REAL PRICES (SHS/LT)	***EXCISE DUTY (SHS/LT)***	***ROAD TOLL (SHS/LT)***	***VAT over real price (SHS/LT)***	***MARKET PRICES (SHS/LT)***
Before June 2006	947	127	90	20% (236)	1400
After June 2006	947	292	100	0%	1339

Table: price structure road fuel [Source: PriceWaterHouseCoopers, Tanzanian Budget Review, East Africa Highlights]

There has been a significant reduction in excise duty on kerosene. One of the aims of this measure is to reduce the environmentally harmful use of charcoal and firewood.

For industrial diesel, however, the excise duty has been increased to TSh 366/litre (was: TSh 201/litre). Assuming equal basic price for industrial diesel, the end price is close to the retail price for transport diesel, namely TSh 1340/litre. This is equivalent to approximately € 0.83/litre (as of September 2006)

Based on information received from government officials, the Consultant concludes that for SVO in industrial applications, only the VAT is applicable. Assuming that for corporate clients the VAT can be recovered (and is thus not a cost), SVO therefore needs to be available at, say, about € 0,80 per litre in order to be cost-competitive with industrial diesel.

For retail purposes, however, the price including the VAT would need to be competitive, i.e the price of SVO excluding the VAT needs to be at around € 0.66 per litre.

3.6 Financing and technical support availability

3.6.1 Micro Finance Organisations

Small holder farmers have little financial capacity and have most need for technical support to make improve their land management. In Lindi and Mtwara, not many micro finance organisations are active. As for Mtwara, only Pride has an active office. In addition, most of the farmers do not have a land title and will therefore not meet required collateral criteria.

3.6.2 Saving and Credit Cooperatives (SACCOs)

A better solution for farmers might be to acquire financial and technical support via Saving and Credit Cooperatives. A new impulse is giving to mobilise farmers to become member of SACCOs. The established farmer SACCOs are generally still very poor in management and financial capacity. If the financial capacity is there to provide credit to farmers, probably most of the farmers will not meet the criteria for the new and unknown business of biofuel production: the loan request should not exceed a year and the farmer should manage to provide a convincing business model.

3.6.3 Commercial Banks

While it will be difficult for commercial banks to provide loans to individual farmers and/ or newly established farmer groups, the investor (buyer of oilseeds/ processor of the vegetable oil) will have various possibilities to acquire investment capital if a strong business model is designed. The business model in which the investor will establish both an owned plantation and group farming contracting model will make investment in the smallholders inputs available, e.g. via rural investment banks like AREED and E+Co. Besides that, possibilities for the financing of technical support to farmers are most likely to be supported by various rural development programmes of the WB and the UNDP.

3.6.4 Clean development Mechanism

The Clean Development Mechanism (CDM), under the United Nations Framework Convention on Climate Change, is a mechanism through which projects and activities that reduce emissions of greenhouse gases in developing countries, can 'sell' the credits for these emission reductions to developed countries that have quantitative emission reduction targets under the Kyoto Protocol.

CDM is expected to be applicable for biofuel, as biofuel leads directly to a reduction from greenhouse gas emissions. No approved projects exist to date. In Thailand, the first Project Design Document (PDD) has been submitted for jatropha. If the project is approved, the methodology used can be the guidelines for the CDM proposal under this program. Some conditions and criteria should be taken into account:

1. Emission reduction credits can be claimed on the basis of carbon absorption from the growth of trees, or on the basis of emissions that are avoided from fossil fuel that is replaced by biofuel. Claiming credits for carbon absorption via the planting of trees is not recommended. Only 10% of the carbon absorbed by a plantation can be approved for a CDM project, in order to compensate for e.g. leaves falling on the ground (bringing CO2 back in the environment), fire, etc. The monitoring of the CDM credit will be easiest if the fuel switch from fossil diesel to SVO/ biodiesel is the basis for carbon credit calculation.
2. Local ownership of the submitter of the CDM project needs to be at least 50%
3. The project should preferably be allocated as small scale, which is possible if the project involves less than 15,000 ton CO2 emission credits. In this case, registration fees will be US$ 5,000 and the transaction costs likely US$20,000. For large scale projects an Environmental Impact Assessment is required, which will increase transaction costs substantially
4. The carbon credits can be fixed for a 10 year period, without renewal, or a 7 year period with the possibility to renew it for two times another 7 years (in total 21 years).

The experience with CDM in Tanzania and Africa as a whole is still very limited. As of today, only five CDM project are approved in Africa, of which two in South Africa and three in Morocco, none relating to biofuel (source: http://cdm.unfccc.int/Projects/registered.html)

In the table below, a calculation of the expected reduction of CO_2, with CDM value per antenna system, based on a usage of 9000 litres per year / antenna system.

Emmission factor for fossil diesel [12]	**73**	***(kg CO_2/GJ)***
Net heating value for fossil diesel	**35,9**	***(MJ/l)***
Emission / litre	**2,62**	***(kg CO_2)***
Reduction @ 9000 litre/year [13]	**23,59**	***(ton CO_2 /year)***
Value carbon credits (23/8/06)	**€ 16,35**	***(euro / ton CO_2)***
Credits / antenna system	**€ 386**	***(Euro / year)***

The CDM revenues will fall to the party that submits for the CDM project. The most suitable actor for this is the actor that is responsible for the production and marketing of biofuel. Producers of seeds, and final consumers, may benefit indirectly if the CDM credit enables higher prices to be paid for seeds, and lower prices to be charged for SVO, but this is likely only when the processor is not in a monopoly position or not able to use this monopoly position to determine prices.

In the table below, a calculation is given of the expected reduction of CO_2, with CDM value, for a 1000 ha plantation in full production with an average production of 1,5 million litres SVO.

[12] Source for net heating value and emission factor: Brink, R.M.M. van den (2000): "Verkeer en vervoer in de Milieubalans 2000". RIVM, 251701044, December 2000.
[13] One litre SVO will replace approximately one litre of fossil Diesel

Emmission factor	**73**	***(kg CO_2/GJ)***
Net heating value	**35.9**	***(MJ/l)***
Emmision / litre	**2.62**	***(kg CO_2)***
Reduction @ 1.5M litre/year	**3 931**	***(ton CO_2 /year)***
Value carbon credits (23/8/06)	**€ 16,35**	***(euro / ton CO_2)***
Credits / 1000 ha	**€ 64 272**	***(Euro / year)***

3.7 Selection of location

1. Availability of land

As is presented in the table below, in Lindi and Mtwara still has enough land available for large scale farming, even if the areas indicated as protected areas and high biodiversity areas as the coastal forest are excluded (see chapter 4). However, the Tanzanian Investment Centre (TIC) and also the local authorities see a huge raise in demand for land in the Mtwara / Lindi region. Based on the requests (over ten interested investors) the TIC is sure of availability of the requested area in one plot (750-1,000 ha) through the first half of 2007.

Table: Ownership and use of Area under Large Farms by Regions

Region	***Private Area***	***Total Area***	***% Private***	***Share of Private Area Cropped***	***Share of Government Area Cropped***
Lindi	8,981	28,442	32%	71%	6%
Mtwara	1,136	34,136	3%	100%	

Source: Tanzania Bureau of Statistics, 2004

In Mtwara region, the regional commissioner and the agricultural adviser have expressed their preference for an outgrowers model via farmer associations, in close cooperation with the Naliendele Research Institute.

The regional commissioner in Lindi sees a better opportunity in activation of an abundant "sisal estate". Most of the sisal estates are still occupied by their former employees, who are eager to be employed again.

In general, the lease of land will cost Tshs 200/ acre/ year. The lease period can be for 33 or 99 years.

2. Access to land

According to traditional practices in Lindi and Mtwara, inheritance does not involve land, but rather productive trees. This means that available land can still have trees that are owned by other people. Through allocation by village councils, it is possible to acquire rights on coconut trees on a plot of land owned by another person under customary tenure arrangements.

In conclusion:

- Information received indicates that availability of land should not be a major bottleneck for the success of the local biofuel production in Mtwara and Lindi. A larger concern is the time and resources necessary to clear the selected ground. Private organisations interviewed indicated that this 'clearing' – ensuring that all claims to rights of land or tree use are identified and bought, can be a time consuming and sometimes costly affairs.
- Based on current land ownership and farming activities, in the Mtwara region a bigger emphasis on contract farming would be reasonable as land will be less easily available for new to be established plantations
- In Lindi region, large scale plantations are more feasible as it will not be difficult to obtain land use rights, and also because there are less established farmers to engage into contract farming
- In Lindi region, there are also former sisal plantations available, which already offer some basis infrastructure (e.g. buildings) and where labour is already available. Whether this is an attractive option or not depends on the conditions at which the use of these former plantations could be made available.

3.8 Project scope

Chapter 2 has highlighted a number of the technical risks and constraints involved in biofuel production and use. One of the main conclusions is that experience is still very limited and that there are many uncertainties involved with biofuel production. On the basis of this, it can be concluded that commercial scale capacity should be developed gradually, so that lessons can be learned from earlier mistakes. At the same time, the scale should be sufficient to ensure that adequate economies of scale can be achieved. A guaranteed demand from Rural Netco Ltd will be required to ensure risks can be limited to production only.

On the basis of this, the Consultant suggests that the project should aim for an initial size that is adequate to serve the needs of Rural Netco Ltd even at a pessimistic assessment of yields, with some excess capacity. This will provide flexibility to develop a better understanding of production aspects in initial years while still being able to serve the demands of Rural Netco Ltd, and also start developing sales to other markets.

With a foreseen demand from 50 masts, each requiring 9000 litres yearly, total annual demand from Rural Netco should be about 450,000 litres. With a minimum yield of 660 litres oil per hectare, minimum planted area should therefore be around 680 hectares. On the basis of this, the consultant recommends an initial project scope of up to 1000 hectares in order to provide this room for learning curve and spare capacity.

Processing the seeds for this 450,000 litre would require a processing capacity of about 1800 ton per year, equivalent to about 470 kg/hour (assuming 40 weeks production of 6 days/week, 16 hours per day). In case, however, that the 1000 ha planted area provides yields in the optimistic range, production capacity needs to be about 5000 ton per year.

Given that investment needs for a 1000 kg/hr press and filter are only some 25% higher than for a 500 kg/hr press, the Consultant suggests that 1000 kg/hr would be a good initial size of the project.

3.9 Conclusions

There is a substantial, immediate market for biofuel. The easiest market to tap in to will be those customers that will use it in stationary diesel engines: local communities using it for community electricity provision, or energy-dependant businesses. Rural Netco Ltd is part of that second group. Its guaranteed consumption would help to generate local production capacity.

Also from business point of view, SVO production seems to make good sense, biodiesel production less. The advantage of developing biodiesel production would be that a much larger market can be reached, including use in transport. Given that production capacity is likely to be the limiting factor of this industry for some time to come, this advantage will not bring much commercial benefit.

If biofuel needs to be cost competitive with fossil diesel, taxation may become a potential deal killer. Uncertainty remains high with regard to the duties, taxes and levies that are applicable. Most of the officials spoken think that no taxes are applicable other than standard VAT if SVOs are traded for industrial use, but that road taxation is payable if the fuel is to be used for transport. This is also the standpoint taken by Diligent Tanzania, to date. If this is indeed the case, biofuel may provide for a very attractive alternative, at least for industrial customers. If it turns out, however, that the government interprets taxation rules differently or changes regulation, biofuel may not be able to compete with fossil diesel on cost basis. A government task force has already been established to clarify this.

Roles of various partners and stakeholders remain open. Rural Netco Ltd is in the best placed actor to take first steps on deciding upon their own role and the roles they envisage for others, as their demand would be the trigger element of this project

In case the production of seeds is through contract farming, the processor may choose to facilitate the necessary financial and technical support for the farmers. By providing support for the smallholder farm and a guaranteed market after harvest, the processor will be assured of a high commitment among its contracted farms and a larger collection of seed. In its place, the processor may need financial support from Rural Netco Ltd (or from others, possibly arranged with assistance of Rural Netco Ltd.) to be able to do this.

Within the two regions, there are not many actors that could play a meaningful role in such businesses whenever large investment potential and more management capacity is required. There are, however, a handful of organizations nationally that may be stimulated to engage in biofuel production or processing – provided they find the potential rewards sufficiently offsetting the risks. Third parties may assist in providing support to reduce investment risks, e.g. through investment co-financing.

Models differ in management implications, costs and risks for Rural Netco, and growth potential. The plantation model seems to be the simplest approach, and can deliver reasonable production volumes rather quickly. This will, however, require a larger investment from one individual entrepreneur and demands more management skills. The contract farming model enables higher community involvement, leads to less costs for obtaining land use rights, and also means that more of the economic benefits stay in the region. On the other hand, it is complex and time-consuming to establish, and requires adequate levels of trust to be build between various players.

Choice of location depends also on choice of the model: in Lindi, a plantation model would work best because there is ample available land, but not many farmers. In Mtwara, however, limited land is available for large plantations and here the outgrower model could work better.

4 Financial evaluation

4.1 Seed production

4.1.1 Model assumptions

In Annex V, a financial projection is given of a combined plantation of jatropha and sunflower for the production of SVO. The model assumes a plantation of a 1000 ha, of which the entire area is planted with jatropha in rows 3 metres apart, hence allowing intercropping in the remaining space. Of this intercropping space, one third will be planted each year with sunflower in a rotating fashion. The remaining space may be used for other crops but has not been taken into account in this evaluation.

Pages 1-3 of Annex V provide the basic assumptions for setting up and operating such a plantation. Pages 4 and 5 provide simplified financial projections per year, for a ten-year duration of the project. Page 6 of the annex demonstrates how the result of the entire project, indicated by the Internal Rate of Return, is affected if the scale of the plantation is varied, with all other assumptions remaining the same.

For the initial investments in the plantation as well as the production of both crops, the costs are assessed in both a pessimistic and optimistic scenario. Between the two scenario's, assumptions vary on the initial investment costs of acquiring land; the amount of jatropha seeds to be produced per hectare; the time required to harvest a kilo of seeds (both jatropha and sunflower); and the price obtained per kg of jatropha seeds produced. The spread in data for jatropha is much wider than for sunflower, because there is much more uncertainty about the yields that can actually be achieved in practice. Furthermore, for sunflower the consultant had to rely more on data from literature than from practical experiences.

While the harvest of sunflower will be the same every year from the first year onwards, the harvest of jatropha seeds only starts at year 3. It may further improve after the initial years, but in the absence of reliable data on this, harvest has been assumed constant from year 3 in this model. The actual amounts of seeds collected may go up further, if the plantation act as a demonstration plot and farmers copy the growth of jatropha and bring the seeds to the plantation. In order to maintain simplicity on the financial projections, however, the plantation is treated as an isolated establishment.

4.1.2 Evaluation

In the table below, the total cost of investment, annual results, and the results over the entire project period are given. The Net Present Value is calculated at a relatively high discount rate of 15%, which is justified by the high degree of uncertainty. This discount rate may, in fact, still be rather low for the risk profile of the investment. It should be noted that the calculated Internal Rate of Return (IRR) is overly optimistic, because it does not include costs for taxation and interest. On the other hand, the horizon for the investment in jatropha plantations will presumably be longer than 10 year.

This evaluation shows that the project can be profitable if assumptions of the optimistic scenario can be achieved; but will be loss-making if assumptions of the pessimistic scenario come true. Whichever is more likely, is difficult to be stated at the moment: for both scenario's, assumptions have been chosen that are found to be realistic in practice or are supported by literature. The estimation should be taken with great caution, however, as not all underlying assumption could be checked against actual conditions in practice.

Indicator	Scenario	
	Pessimistic	Optimistic
Initial investment required	€ 602,667	€ 464,333
Annual results (from year 3 onwards)		
Seeds yielded (tons)		
Jatropha	3300	4950
Sunflower	800	800
Sales of seeds	€ 265,000	€ 471,250
Costs of production	€ 262,333	€ 260,667
Net earnings	€ 2,667	€ 210,583
Results of project (10 yr period)		
Cumulative net earnings (EBITDA)	- € 581,333	€ 1,220,333
Net Present Value	- € 479,165	€ 252,410
(at discount rate 15%)		
Internal Rate of Return	not meaningful	28%

For production via contract farming, the cost basis is not assessed as not sufficient data is available for this. It is assumed that seeds can be purchased from farmers at current market prices (and lower) while still allowing farmers to make sufficient income on the product.

4.1.3 Break-even analysis

Given the high margins of uncertainty, it is rather difficult to establish the level of production volume at which the plantation achieves 'break even'. An important factor is made up by intitial investment costs. Various options are available. The Tanzanian government can make land available at a very low annual lease. However, generally this is land that will still require much investment in infrastructure (roads, buildings, possibly housing, schools and dispensary for staff etc). Also there may still be many formal or informal user rights, including rights to individual trees. Clearing such rights can be a time consuming and therefore costly operation. Alternatively, already productive agricultural land may be taken over, such as abandoned plantations. This, however, requires that a price is paid for the assets taken over. In the assessment, a price estimate varying from € 150 (optimistic) to € 275 (pessimistic) per hectare is used for initial investments in obtaining land and preparing it for agricultural production.

Another important aspect of the fixed costs is made up by the management costs. At which level these costs will be, depends very much on who will be the plantation owner, and how he chooses to manage the plantation. If an 'expat' plantation manager is appointed, fixed annual costs may quickly rise to € 50,000 or more, but an experienced local plantation manager might expect a much lower salary. The owner/investor might also choose to manage the plantation himself and be paid out of revenues from the plantation, or let the manager be co-owner and have (part of) his salary be paid out of revenues. For the purpose of the financial evaluation, it is assumed that the costs for plantation manager will be at about € 30,000 per year, i.e. a medium range salary level for an experienced plantation manager.

An evaluation is made of how the Internal Rate of Return (IRR) of the project varies if the scale of the project is altered. The results are given in Annex V. This demonstrates that, for the optimistic scenario, a plantation with a size of 500 ha. gives an IRR of 8% - which is probably not sufficient for financiers to justify investment in such an uncertain business. The IRR increases, however, to 21% for a plantation of 750 ha, which may already be considered a good return for this investment. At a level of 10,000 ha, the IRR increases to 54%.

In the pessimistic scenario, positive IRR is only achieved at a level of 5000 ha, but also at 10,000 ha the IRR does not become more than 7%. Furthermore, this assessment will be even overly optimistic, as in the evaluation investments and overhead have been kept constant – which will not be realistic for a tenfold increased plantation size.

4.2 Processing

4.2.1 Model assumptions

Annex V also includes the financial projections for processing. Page 7 of Annex 5 analyses the required minimum capacity of the facility, and the investment needs associated with this. Page 8 and 9 provide a financial forecast for a 10 year operation of the processing facility. Summarised data are given in page 10, while on page 11 and 12 it is shown how the project results vary if basic model assumptions are changed.

For a project with a scope as given in paragraph 3.8, the Consultant estimates that processing facilities require investments in the magnitude of € 380,000, including buildings, processing equipment, storage and transport equipment, laboratory, offices, and a 15% contingency.

Revenues will be generated primarily from the sale of SVO. In order to provide a cost-effective alternative for conventional diesel, a selling price of € 0.66 per litre is assumed. In practice, this will depend heavily on the fluctuations in conventional diesel prices, and taxation rules. Based on the processing of seeds produced in the pilot plantation (and not yet estimating for other seeds), the total revenues will increase to about € 800,000 per year from year 3 onwards. Additional revenue may be generated from CDM credits. On the assumption that credits are worth € 16.35 per ton CO_2 (current market price), this would amount to another € 50,000 per year. Added to the selling price of one litre of SVO, that results in a total income of about € 0.70 per litre SVO produced.

Costs are created by the purchase of seeds (assuming processing is a separate business from seeds production); processing; and overhead.

Depreciation of investments is not taken into account, neither are replacement investments. It is assumed that equipment will last for the duration of the project (10 years), although annual maintenance will gradually increase.

4.2.2 Evaluation

The tables below summarise financial forecasts in year 3 for the total processing plant; and broken down as cost elements for the processing of 1 ton of seeds respectively 1000 litres of oil.

Summary data – processing

Indicator	Forecast
Initial investments	**€ 379,500**
Annual results	
Sales of SVO in litres	1,145,000
Sales income, at € 0,70 /litre	€ 755,700
CDM revenues	€ 49,048
Total income	**€ 804,748**
Costs of seeds	€ 380,300
Processing	€ 102,500
Overhead	€ 102,000
Total costs	**€ 584,800**
EBITDA	**€ 219,948**
Project results (10 yr)	
Net Present Value	€ 330,724
(at discount rate 15%)	
IRR	32%

Cost breakdown per ton seeds, and per 1000 l oil

Jatropha Curcas	per ton seeds	per 1000 l oil	
		250	l/ton seeds average
Purchase of seeds	€ 75.00	€ 300.00	49%
Transport	€ 8.00	€ 32.00	5%
Pressing	€ 21.00	€ 84.00	14%
Filtering	€ 4.00	€ 16.00	3%
Overhead	€ 46.62	€ 186.46	30%
Total jatropha SVO production costs	€ 154.62	€ 618.46	100%
Sunflower	per ton seeds	per 1000 l oil	
		400	l/ton seeds average
Purchase of seeds	€ 125.00	€ 312.50	54%
Transport	€ 8.00	€ 20.00	3%
Pressing	€ 21.00	€ 52.50	9%
Filtering	€ 4.00	€ 10.00	2%
Overhead	€ 74.59	€ 186.46	32%
Total sunflower SVO production costs	€ 232.59	€ 581.46	100%

The model demonstrates that, with the assumptions used, processing of oil-bearing seeds at this scale can be a profitable undertaking.

4.2.3 Break-even and sensitivity analysis

An evaluation has been made to see how the project results are influenced when one particular assumption is altered, while all other remain the same. This has been done in particular for the assumptions with the greatest amount of uncertainty. Outcomes are as follows:

Capacity used: as can be expected, project results will deteriorate when the volume of seeds being processed stays behind the forecasted amount. At 50% capacity use, the operation will not be profitable anymore. At 75% of forecasted volume, still a reasonable IRR of 19% is foreseen. If more seeds can be purchased (e.g. from additional contract farmers), up to 150% of expected volumes, the IRR will further improve to 53%. This level, however, requires a very efficient use of the technical production capacity will almost fully continuous production and little downtime.

Selling price of SVO: As described before, the selling price is uncertain. It is both linked to the market price of fossil diesel, and to the (future) taxation policy of the government. The analysis shows that a modest positive IRR of 9% can be achieved with selling prices from € 0.55 per litre of SVO, with obviously better results at higher selling prices.

Cost price of seeds: As purchase costs of the raw material make up some 50% of the total production costs, fluctuations in this price obviously impact project results significantly. Current market prices are 120 TSh/kg for jatropha (€ 0.75), and 200 TSh/kg for sunflower (€ 1.25). It is assumed that prices for both seeds are linked: if the market price for one goes up, so will the other. The analysis shows that with prices increasing to 200 TSh/kg for jatropha resp. 250 TSh/kg for sunflower, the project still gives a modest positive IRR of 9%. If prices increase further, the project will not be profitable.

Impact of processing costs: Based on Diligents' own experiences and literature analysis, processing costs have been estimated at about € 21 per ton of seeds for pressing, and € 4/per ton seeds for filtering. Both steps are processes that require a reasonable degree of skill in order to achieve good efficiency, minimise downtime, and keep maintenance costs limited. They therefore include a certain amount of uncertainty of what can be achieved in practice. The analysis shows that, even when actual costs of pressing and filtering double compared to the basic assumptions, the project IRR remains quite acceptable at 15%.

Impact of oil yield: As can be expected, the amount of oil that can be obtained per ton of seeds has a crucial impact on the viability of the project. Extraction rates of 250 l per ton of jatropha, and 400 l per ton of sunflower should be feasible based on practical experience and literature data. Again, however, this requires a degree of skill from the staff operating the press and filtering steps. Lower yields for both jatropha and sunflower, at e.g. 200 l/ton for jatropha and 350 l/ton for sunflower will already lead to an unsatisfying rate of return of 4%. Higher yield quickly lead to much better results.

4.3 Use in diesel generators

As is explained in paragraph 2.3, there is mixed information on the degree of engine modification costs and additional maintenance costs associated with the use of SVO instead of fossil diesel. Without further detail being available to the Consultant on the type of diesel engine and system lay-out that would be used for a conventional (fossil diesel) approach, it is difficult to assess the additional costs in practice, however.

For engine modification, the securest and most thorough approach is probably to fit an 'Elsbeth' adaption kit to the engine. This will require an initial investment of up to € 900 for the kit, plus some € 600 for installation in a professional Tanzanian workshop. Literature data show, however, that many diesel generator engines work perfectly fine with much smaller modifications, that would cost no more than € 450 per engine.

Furthermore, it is generally claimed that up to twice the amount of lubrication oil changes are required. Diesel generator producers suggest lubrication oil changes after about 150-200 hrs of operation, i.e. a bit less than once a week. Additional costs of using SVO would therefore be about 50 times the cost of a change of lubrication oil, estimated at about € 20 per change, plus an estimated additional € 4 per change for checking and cleaning nozzles and replacing filters. With 9000 litres of diesel being consumed per year (data provided by client), that means a maximum additional cost of about € 0.133 per litre. Other sources, however, suggest that this estimate is an exaggeration, and that SVO may in fact reduce maintenance costs compared to fossil diesel because it is often purer than fossil diesel locally available in rural African markets.

An analysis was made using a highly conservative estimate of maximum modification costs of €1500 per engine, and maximum € 1200 per year (50 * € 24) for additional lubrication oil changes and maintenance. With a fossil diesel price of € 0.88 per litre (TSh 1400) and the price of SVO estimated at € 0.66 per litre (assuming the client to be a registered company, therefore VAT being deductible), the price difference is just above € 0.08 per liter. This means that SVO becomes cheaper than fossil diesel when (€ 1500 divided by € 0.08) more than 18750 liters are being consumed, i.e. after about two years and one month of operation. If a simpler modification, requiring an investment of € 500, is applied, the turning point is after 6250 litres, i.e. after about 8 months of operation.

5 Environmental aspects

Though most of the environmental aspects have been taken into account during the crop selection process, the most important aspects are elaborated in the paragraphs below.

5.1 Available water and soil resources

1. Availability of water
During the period November/December to April/May the dominant winds are from the north-east, which gives a hot humid rainy season to the region. The rainy season is single peaked, the peak being reached in January but occasionally in February or March. The amount of total annual precipitation tends to vary with altitude (see table below for rainfall per district and Annex VI).

Landscape unit and Climatic station	Dry year	Average	Wet year
Coastal plains			
Kilwa Kivinje	648	929	1271
Lindi	692	935	1216
Mtwara port	602	925	1290
Plateaux			
Tunduru	656	1016	1379
Naliendele (Mtwara)	649	1132	1505
Newala	688	1245	1912
Central plains			
Nachingwea	605	823	1025
Liwale	503	868	1220
Masasi	538	873	1550

Source: Naliendele Agricultural Research Institute, Mtwara, Tanzania

After the rainy season, the wind blows from south-east direction, which is dry, cooler and less humid.

In the Mtwara/Lindi region the possibilities for irrigation are very limited (see annex VII). Some areas close to the valleys (e.g. Nangaru, Rutamba), the Mambi Plain and Ruvuma river have possibilities of irrigation. However, rainfall in Mtwara/ Lindi should allow jatropha and sunflower to grow without irrigation and should not lead to more water withdrawal then is naturally provided.

2. Soil Resources
The region has mainly two geological zones (see Annex VIII) and hence two main geologically determined soils types (Annex VIX).

- **Eco-climatic Zone III**

This zone is geologically the coastal sedimentary formation extending some 125 km from the Indian Ocean to the edge of the Makonde Plateau of Newala. This zone produces deep, well drained, sandy soils of low fertility and low moisture holding capacity.

o **Eco-climatic Zone IV**

The second zone geologically extends west of the coastal sediments. It is a zone of pre-Cambrian basement rocks consisting of gneisses and granulites. Soils from this basement are variable, from red clays to grained sandy.

5.2 Expected environmental impacts

The growth of jatropha combined with sunflower (as the best solution concluded in chapter 2 and 3) can have a negative impact on the environment if certain aspects are not taken into account.

1. *Land use*

   One of the primary environmental consequences of biofuel production is that it occupies land – which is therefore no longer available for nature, food production, or other functions. Currently, parts of Africa, including Tanzania and, for this case, Lindi region (Mtwara region to a much smaller degree) contain vast stretches of arable land that is not yet put into use. That does not mean that the land has no function, however – since they may still be home to nomadic groups or inhabit wildlife, and if often also not yet cleared of bushes or forest even when designated as having and agricultural function. At the scale of this pilot, the amount of land taken can be considered not very significant. The burden on land use can be further reduced if biofuel is being produced on land that has in the past already been put into agricultural use but is currently not productive, or if biofuel crops can grow next to other crops on the same land (intercropping). The advantage of jatropha is that it can grow on marginal soil quality ground. Above average fertile grounds should be considered for other food crops that do not survive on the other grounds.

   Jatropha can also help to protect land from erosion (by holding soil with its deep taproots, and shielding from wind) and excessive sun radiation.

2. *The use of fertilizers and pesticides*

   Excessive use of fertilizers can lead to eutrophication of ground and surface water resources, and in larger concentrations nitrogen can also be toxic. Research and experience so far indicates that jatropha does not need any fertilizers when planted. Because jatropha is not a nitrogen-fixing plant some of the presscake (which contains nitrogen) should be brought back to the land to prevent yield decrease after the first four years. Sunflower, on the other hand, gives a better yield when using fertilizers. However, with proper crop rotation and the combined growth with jatropha, the fertilizer use is very limited.

   Another important reason for crop rotation is pest control. Rotations can be used to prevent or partially control several pests and reduce the reliance on chemical and mechanical control.

3. *Pollution from exhaust emissions*

   Using SVO or biodiesel in an engine lowers numerous emissions (see below), but the NOx emissions are slightly higher. NOx emissions can contribute to acid rain and, particularly in urban areas, to smog. The additional NOx emissions caused by the scale of this project is unlikely to be significant, however, and substantially off-set by the environmental benefits.

4. *Pollution and safety risks from processing (especially with esterification)*

   The transformation from SVO into Biodiesel (methylesther or ethyl Esther) creates glycerine. Unrecovered glycerine contributes to high chemical oxygen demand (COD) of wastewater. Glycerine recovery at the source will eliminate the chemical coagulant which is needed for treating wastewater. The glycerine recovered should be purified before it can be sold to the in the pharmaceutical and cosmetics industries.

Production of biodiesel also requires stocks of methanol or ethanol to be kept – both are highly explosive, and adequate precaution needs to be taken to avoid incidents. Storage of SVO or biodiesel in fact involves less explosion risk than would be involved with conventional diesel, as the flame point is much higher.

When taken into account the negative side effects on the environment by producing and using SVO or Biodiesel, many positive effects on the environment are expected too:

1. *Positive use of degraded land*
Jatropha is a plant that grows on land that is not suitable for any other vegetation, and can contribute to reduction of erosion by holding soil and providing windshielding (Jatropha is currently being planted for this purpose, as well as for oil production, at Kilimanjaro international airport). It should be noted, however, that in such conditions yields will also be very low per hectare.

2. *Avoided emissions and pollution*
Using SVO or biodiesel in a conventional diesel engine substantially reduces emissions of hydrocarbons, carbon monoxide, sulfates, aromatic hydrocarbons, and particulate matter.

Due to the fact that more oxygen in SVO and biodiesel leads to more complete combustion into CO_2, biodiesel decreases the solid carbon fraction of particulate matter in emissions. Pure biodiesel burning reduces carbon dioxide emissions by more than 75% over petroleum diesel. Using a blend of 20% biodiesel reduces carbon dioxide emissions by 15%.

Typically the agricultural machinery could be run on biodiesel, which will lead to immediate environmental improvements in agriculture. Among other things, spillage and leaking of fuel would be harmless.

Figure 4: press cake in burner (picture:J.van Eijck)

3. *By-products can replace alternative products*
During pressing of the seeds, press cake is the by product which is 60 to 80% of the volume. The press cake of sunflower seeds is both a good fertilizer and a livestock fodder, which can be sold on the local market. Because jatropha is not edible, it can not be used as livestock fodder. It is a good fertilizer, rich in Nitrogen, Phosphorus and potassium[14]. Diligent has done several research studies to determine the energetic value of the press cake, which is now being tested as energy source in closed burner. Another ongoing research study is on the production of charcoal from the jatropha press cake. If the right formula for making charcoal is found, the jatropha charcoal may have a large impact on forest conservation.

4. *Reduced risk of explosion of stored fuel*
As mentioned in chapter 2.3, The *flash point* of SVO and biodiesel is higher than the flashpoint of fossil diesel, and there is hence a lower risk of fire.

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

5.3 Sustainability of biofuel production

The sustainability of biofuel production with jatropha is expected to be very high. First of all, the plant survives on poor ground condition without little or no maintenance. Once the tree has survived its first year (and the roots have found there way down),it has a high chance of survival. That is why it is locally known as the "tree of the graves". The tree has been used as a grave mark because you are sure that after years the tree is still there. Further more, for the oil production, only the fruits are fetched from the tree so the growing process is not harmed.

Sunflower, however, is an annual crop, which needs more maintenance through the year and need either some fertilizers or rotation to avoid soil degradation.

5.4 Assessment of impacts on biodiversity

Some of Africa's richest and most diverse flora is found in Tanzania. Mtwara and Lindi have two key biodiversity areas (see Annex X), Lindi district coastal forestry and Newala District Coastal Forestry. There is only one protected area in the two regions, the Mnazi Bay in Mtwara (reference Critical Ecosystem Partnership Fund). The biggest proportion of the forest cover in the Mtwara region is in Masasi district.

Historically, commercial agriculture has been responsible for some clearance and fragmentation of forest in Tanzania (see Annex XI) which took mainly place in Iringa, Tanga and Kagera where large tea estates replaced formerly forested land. In the lowlands, sisal estates also cleared large areas of forest, especially around the East Usambaras in Tanzania. The largest current threats, however, come from the commercial cultivation of vegetables, which are sold in the local markets and from the growing of cardamom and other spices under forest cover. These activities result in forest clearance and the destruction of undergrowth in the forest.

Especially in the Coastal Forests, seven threats on biodiversity have been identified: settlement, urbanisation, fuelwood, carving wood, salt winning and tourism. The habitats are notably fragmented, making threatened species within key sites highly vulnerable to extinction and further habitat loss. Agricultural encroachment, timber extraction and charcoal production are the greatest threats to habitat, although weak management capacity within government and communities is a serious issue. (source: CEPF)

In general, the production of biofuel by growing jatropha and sunflower won't be a threat for biodiversity if the location for the plantations is properly chosen. The production of biofuel locally, can even have a positive effect when it turns out that the press cake can be used as charcoal (researched at Diligent) and special education programs are implemented when motivating smallholders to grow jatropha.

5.5 Assessment of impacts on greenhouse gas emissions

As mentioned in paragraph 3.3.4 and 4.2, the use of SVO or Biodiesel reduces the emission of greenhouse gases (except NOx emissions). SVO avoids about 4 kg CO2/litre compared to the emission of using fossil diesel. However, some losses should be taken into account during pressing and filtering of the seeds, on average 10%. If SVO is converted into biodiesel, another 10% loss should be included. On the other hand, additional emission avoidance is created when the by-products (e.g. jatropha press cake as a source of energy) can be used as energy source instead of conventional energy sources.

5.6 Conclusions

Overall, it can be concluded that there are more environmental benefits than risks for the production of biofuel in Lindi and Mtwara region:

- Fertility and water content of soil stay intact by growing jatropha and rotational growth of sunflower. Jatropha will grow on land with low fertility and will even upgrade the land by holding the nitrogen level intact. The climate conditions in Mtwara and Lindi are good for the production of jatropha and sunflower and when the land is good selected, no competition with the biodiversity will exist.
- The press cake of the sunflower- and jatropha seeds can be used as fertilizer and as energy source (Jatropha charcoal/ briquettes), which means conservation of the soil quality, a significant emission reduction and a part of the solution to the deforestation problem.
- The usage of SVO or biodiesel in engines will significantly reduce the emission of greenhouse gases
- The sustainability of the production of SVO via jatropha is guaranteed due to the unique characteristics of the tree. The sustainability of biofuel production via an annual and more demanding crop (like sunflower) depends more on good management.

Conditions that need to be taken into account, however, are:

- High value biodiversity areas should be avoided for use of biofuel production
- Proper care measures should be taken with the processing of biofuel, specifically if biodiesel is being produced, to avoid pollution of the environment with substances such as or methanol, glycerine, or excessive amounts of biofuel, and to avoid accidents with explosive substances
- Further analysis should be done on the impact of biofuel production on land use and the long-term consequences of that, should the project be scaled up in a significant way.

6 Social aspects

6.1 Job creation

The establishment of local biofuel on the scale necessary to provide enough biofuel for the telecommunication towers will create substantial job opportunities. Job generation includes permanent positions at the pilot plantation and processing facilities (in our estimates, increasing to about 20 staff for plantation and 35 for processing facilities), temporary work for contract workers for field clearing, maintenance, and harvesting (in total about 120-140 days per hectare), and additional work and income for farmers currently depending on cashew nut harvest.

Most work at the plantation will be unskilled labour; employment at the processing facility will involve a mixture of skilled (management; education and extension work; administrative; laboratory) and unskilled work.

6.2 Risks and benefits for communities

The support of the community is a key factors in making the proposed business models successful. The support of the community will depend on the villagers perception of risk and benefit of the new industry. Some of the risks and benefits are presented in the table below.

Risks	***Benefits***
▪ *Farmers "neglect" food crop production* High demand and high price push farmers in the biofuel production and they undermine their food crop production	▪ *Job creation* Jobs on the plantation and via promotion among smallholders to plant jatropha/ sunflower
▪ *Clearance of land* Farmers are attracted by the short term advantage of getting money for clearing their cashew nut plantations, but, in the long term, end poorer.	▪ *Pension fund* Planting jatropha is an investment for the long term. jatropha will grow for years to come; demand for seeds is likely to grow and may lead to higher prices per kg seeds
▪ *Biodiesel not fulfilling its promise* If government decides to tax biofuels as conventional fuels, it will be much harder for biofuel to compete, and the demand for biofuel may never reach its potential	▪ *Improvement of infrastructure* Road improvements by investor in the biofuel business
▪ *Government does not support biofuels* Government officials do not support the cultivation of energycrops, which would discourage farmers.	▪ *Less dependent on cashew nut harvest and price*
▪ *Low yield of energycrop* Due to various reasons the yield of the energycrop might be lower than expected, leaving the farmer with less income than expected.	▪ *Community programs* Other community programs can be organised such as HIV awareness campaigns, business support, improvement of tools

	▪ *Self sustaining villages* SVO of biodiesel can be used for local production of electricity/ multifunctional platforms, diesel for trucks, waterpumps, etc

6.3 Food security

At the moment, both regions produce enough food to meet local demand (ISSD), though soil degradation is noticed and food shortages are expected in Lindi region if population increases and local food production stays equal. The introduction of the various business models for the local biofuel production won't in any case compete with the food growing activities of the farmers. During the introduction of the new business models, cashew nut farmers will be motivated to start growing the sunflower and jatropha on fallow land. Besides that, only one third of the plantation will be planted with sunflower seeds and will rotate every year. Another one third of the land can be intercropped with food crops.

Land availability is good in Mtwara / Lindi region so fertile grounds for food crop production extension will not compete with the growth of jatropha/ sunflower.

7 Conclusions

7.1 Feasibility of the project idea

In the Consultant's opinion, the project's feasibility can be justified on a 'pilot commercial' scale, for SVO production only, based on a combination of sunflower and jatropha production. 'Pilot commercial' scale means a production level sufficient to meet Rural Netco's demand plus some excess capacity, in order to have sufficient flexibility to test assumptions, learn from practice, and gradually develop the project. Substantial further expansion should be possible after the initial years, once more data and know-how have been gathered. The most critical challenge for this will be to establish a volume of seed production that is sufficient to make the processing commercially attractive, and to do this quickly enough while maintaining costs within limits.

A number of (pre-)conditions are attached to this conclusion, however:

- Rural Netco Ltd can provide contractual guarantees for long-term purchase of SVO
- Production and processing needs to be developed under management with adequate capacities, skills and experience in both plantation management, the development of a network of contract growers, and industrial processing of plant oil
- Rural communities should be involved to ensure that economic benefits of the use of extensive areas of arable land also reaches them
- Adequate training, education and information should be given to farmers to teach them the do's and don'ts of biofuel production
- Production volumes of jatropha should be carefully monitored, and lessons from other areas taken into account, to ensure sufficient yields can be obtained
- Costs, in particular initial investment and overhead costs, should be kept under strict control
- Government policy to be followed closely in order to be aware of any potential change in taxation or other relevant policy aspects
- Manufacturers and suppliers of diesel engines for the Rural Netco Ltd antennas should be asked to specify warranty conditions when SVO is used (as part of delivery terms), and be invited to participate in the pilot to test long-term impact on their engines
- Land use impacts are to be carefully monitored, and valuable biodiversity areas to be avoided
- Prices of oil seeds are to be carefully monitored during the project and their impact on the economic viability of the project to be assessed

Attracting a private sector partner with the necessary management skills probably also requires that further support is available to share investment costs and risks, particularly in the initial years. To specify this need for support, however, further debate with candidate partners (including Olam, Mohammed Enterprises, Diligent Tanzania, and possibly others) is required to see what support they believe they require.

Additional benefit may be obtained by applying for CDM. If successfully approved, this would generate attractive additional revenues, primarily for the processor

The Consultant considers that the most suitable model for establishing this project is:

- Rural Netco Ltd being an initiator by providing long-term supply contracts and initiating debate with potential partners
- A private sector partner to be identified with necessary skills and capacities who assumes responsibility of establishing and operating a pilot plantation; a contract farming network including education/training schemes for farmers; and a processing plant including sales/marketing and laboratory functions.
- Local farmer groups to be included or set up that participate in involving farmers in contract growing, and in mobilising/channelling available financing to individual farmers
- Local knowledge organisations should be given pragmatic and clear research tasks in order to develop over the years scientific understanding of optimal production conditions
- External parties (such as, e.g., UNEP or UNDP) to support with investment financing or loan guarantees in order to share the burden of initial investment risks, and possibly with the funding of research activities by local/regional universities in order to develop a publicly accessible pool of knowledge on biofuel production aspects.

All other technical, socio-economical, environmental and financial projections do not give any reason to doubt that the local production of biofuel in Mtwara/ Lindi can be commercially feasible.

In a fully positive scenario, the future for biodiesel looks bright. For Tanzania, it will bring clear advantages to become a pioneer in the production of biodiesel. It can create a win-win situation for all main actors involved:

1. Ericsson as a telecom provider with a green image
2. Rural Netco
3. UNDP and UNEP
4. Government of Tanzania
5. Private sector
6. Research institutes
7. Smallholder farms

7.2 Recommended business model

Based on the principal that the business model should be seen as a pilot, a combination of models 3b and 3c as discussed in paragraph 3.4 is recommended, because:

1. Using SVO in engines for generators is possible and is not a complex process to adapt to.
2. The private sector partner can develop the whole chain and knows exactly were the bottlenecks for guaranteed biofuel production are
3. The establishment of the processing plant and the delivery model from farmers groups can be piloted without having influence on the activities of Rural Netco.
4. This model can supply biofuel faster than models with no own pilot plantation, while this will encourage more farmers to grow biofuel crops.

7.3 Applicability of the findings to other areas in Tanzania and Africa

Some data found in the previous chapters is very specific to the region, like the existence of organised SACCOs, established cashew nut plantations, and support of the local government. Other data like the proposed business models, land availability, the demand for biofuel and the demand for electrification

(hence generators) apply for most other regions in Tanzania and Africa. It will be a matter of finding regions where similar circumstances apply. After successful implementation of this pilot, the business concept can be easily enrolled to these other places.
A customer who can assure the market can justify investments and/or facilitate the acquisition of funds. The concept will be most applicable to those areas in Africa where land is still abundant, land prices are low, labour is available, climate conditions are favourable and where government officials are willing to support such a project. Most of these issues apply for large areas in Tanzania (for example Singida) and Africa. But the most important aspect is the willingness of the farmers and the local government to implement such a project. Without their support realizing a pilot project will face many discouragements. This attitude can only be addressed after some initial awareness creation.

In areas where infrastructure is of low quality, or even absent, the investment costs will be higher, as the seeds need to be transported to a processing unit, and the oil to the customer.

The applicability of the Rural Netco ltd. system is unknown, but it is anticipated that there will be demand for biofuel (for other uses like in cars) in other regions as well. Once this pilot has proven to be successful other areas can be indicated of which another feasibility study should provide the inputs for

Annexes

I. *Contacts of individuals and organizations met*
II. *Biofuel initiatives in Tanzania*
III. *Trade value of 1 ton of CO2*
IV. *List of SACCOs*
V. *Financial Assessment*

Maps

VI. *Mean Annual Rainfall*
VII. *Irrigation*
VIII. *Eco-climatic Zones*
IX. *Soil Types*
X. *Game and Forest Reserves*
XI. *Infrastructure*
XII. *Biodiversity*

Annex I – Contacts of individuals and organisations met

Sector	Organisation	Person	Position	Address	Phone/ Email
Government	Ministry of Energy and Minerals	Mr Bashir J. Mrindoko	Commissioner for energy & Petroleum Affairs	PO Box 2000 Dar es Salaam	022-2117156 0784-784958 mrindoko@mem.go.tz
		Mr Styden N. Rwebangila	Energy Engineer	PO Box 2000 Dar es Salaam	0754-420537 stydenr@yahoo.com
	Regional Council Mtwara	Mr Henry Shekifu	Regional Commissioner Mtwara	PO Box Mtwara	023-2333217 0784-620561
		Mr Shangwe Twamala	Agricultural Adviser	PO Box Mtwara	023-2333194 0784-808669 Shangwe_twamala@yahoo.co.uk
	Regional Council Lindi	Mr Saidi Meck Sadiki	Regional Commissioner Lindi	PO Box Lindi	023-2202502 0784-840010
		Mr Augustinus J. Makumbezi	Agricultural Field officer	PO Box Lindi	023-2202098
		Mr Likangu	Agricultural Adviser	PO Box Lindi	0784-721503 023-2202098
	Naliendele Agricultural Research Inst	Prof Elly M Kafiriti	Principal Agronomist	PO Box 509 Mtwara	023-2333836 0784-809938
		Mr Louis J.F. Kasuga	Country coordinator	PO Box 509 Mtwara	023-2333836 0748-791445 ljkasuga@yahoo.com
	University of DSM	Mr Kibazohi	Professor, chemical and process engineering	PO Box 35131 Dar es Salaam	022-2410368 0741 296 883

	Cashew Board of Tanzania (CBT)	Mr A.M. Beno Mhagama	Director General	PO Box 533 Mtwara	023-2333303 cbt@makondenet.com
Private Sector	Hyderi Oil Mills&Soap Factory	Mr Saidin Msusa	Property Manager	Mnasi Moja, Lindi	0784-323269
	Rural Netco Ltd	Mr Alex Moshi	Manager	PO Box 3164 Dar es Salaam	022-2113021 0784-780464 moshi@adelaide.on.net
	METL	Dr N. Subbaiah	Director- Agriculture	PO Box 20660 Dar es Salaam	022-2121866 0745-213568 agriculture@metl.net subbiahmetl@yahoo.co.in
	OLAM	Mr Shweth Rai	Factory- incharge	PO Box 71062 Dar es Salaam	0787-089869 shweth@olamnet.com
	Safi Anzania Ltd	Mr Andreas Boehringer	Director		0744- 038226 aboehringer@bioboe.org
	Rift Valley Machinery (T)	Mr Peter Muthike	General Manager	PO Box 811 DSM	022-2139610 0744-563707
	VYAHUMU Trust		Oil expeller supplier	P.O. Box 189 Kihonda Industrial Area Morogoro	023-2600391 vyahumu@hotmail.com
	Kumar Industrial Work		Oil expeller supplier	43-45 Sidco Industrial estate Five roads, Salem India	0091-427-2448443 kiwkumar@yahoo.com
Financial	SCCULT	Mr Mshaweji Abdul	Excecutive Secretary	PO Box 20640 Dar es Salaam	022-2180529 0784-326719 sccult@yahoo.co.uk
		Mr Peter T. Mashingia	Operations Manager	PO Box 20640 Dar es Salaam	022-2180529 0713-251099

					sccult@yahoo.co.uk
		Mr Kika J.K. Paschal	Zonal Manager Mtwara/Lindi	PO Box 585 Mtwara	023-2333866 0744-633915 kikashiyeyere@yahoo.co.uk
	Masasi / Mtwara Co-operate Union	Mr Suleiman A. Libuburu	General Manager	PO Box 660 Mtwara	023-2333167 0744-628278
	AREED	Mr Lema	Manager	PO Box 32794 Dar es Salaam	022-2700438 oscartz90@hotmail.com
Others	TIC	Mr Kivinge	Landofficer		022-2116328
	UNDP	Mr Michael Griffin	GSB Programme Manager	PO Box 9182 Dar es Salaam	022-2113269 0786-111593
	TaTEDO	Mr Sawe	Excecutive Director	PO Box 32794 Dar es Salaam	022-2761269 0744-279868
Biodiversity	WCST	Mr Paul	Conservation officer		022-2112518
	FAO	Mr Rommert Schram	Associate Professional Officer	PO Box 2 Dar es Salaam	022-2113070 0743-482626

Annex II – Biofuel initiatives in Tanzania

The interest in biodiesel production and use is high. Various initiatives have been reported via different stakeholders. However, the level of implementation is still at a limited stage. Most of the initiatives are small scale. The reported initiatives are listed below:

Kakute Ltd (1995) Pioneers in the jatropha production	
Region Arusha region- Monduli	**Crop** Jatropha
Business Model Demo plantation and smallholders	**Hectare** 25
End product Jatropha soap, cooking and lighting oil	**Future plan** Sustainable expansion of the activities
Competencies: ▪Most experience with growth of jatropha in Tanzania ▪Technology development for local use of jatropha for lighting/ cooking ▪Strong network among NGOs and government	**Weakness:** ▪Lack of capital to expand activities ▪No strong business model implemented ▪Weak marketing approach
Main activity: Soap making factory by small holders, awareness creation, women group trainings and other rural technology promotion	

Prokon Ltd (1995) Germany based company active in windmills and adaptation of truck engines	
Region Mpanda Region	**Crop** Jatropha
Business Model Contract farming with small holders	**Hectare** ?
End product Diesel for generator- electricity supply	**Future plans** Diesel for truck and export
Competencies: ▪-	**Weakness:** ▪-
Main activity: 300 farms contracted and discussion with TaNESCO for local biodiesel supply	

FELISA (Farming for Energy for better Livelihoods in Southern Africa)	
Region Kigoma Region	**Crop** Palm trees- Oil Palm
Business Model Plantations and smallholders	**Hectare** ?
End product Vegetable oil- future biodiesel	**Future plans:** 10 biofuel and 10 bioethanol plants
Competencies: ▪-	**Weakness:** ▪-
Main Activity: Awareness and promotion of biofuel among farmers, job creation and fuel producer for local towns in the future	

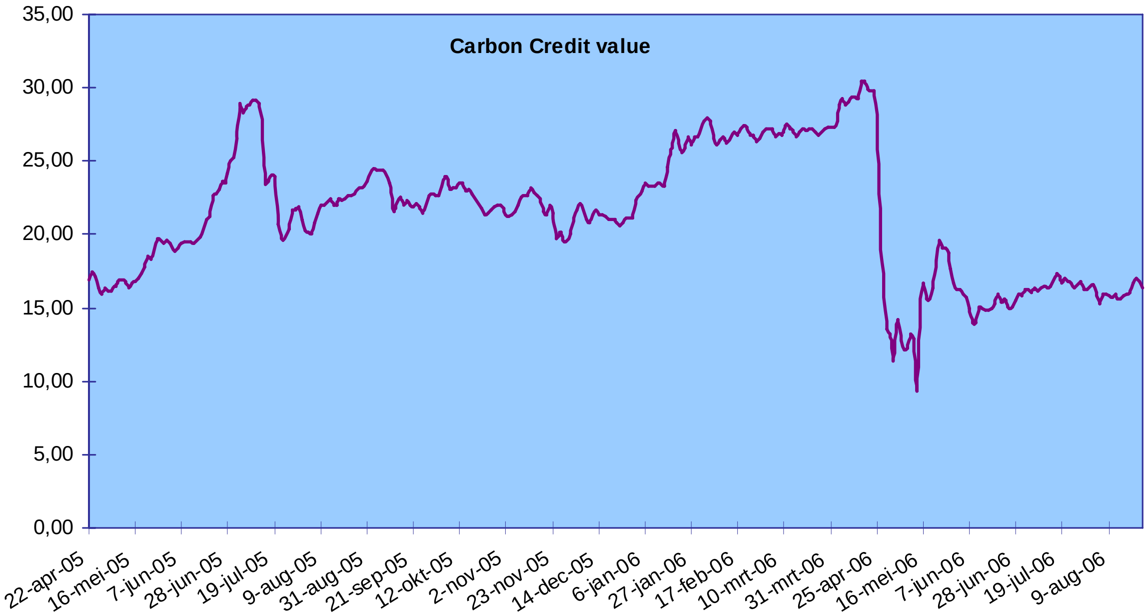
Safi Anzania Ltd (2005)	
Region Coast and Dodoma Region	**Crop** Jatropha
Business Model Outgrowers via cooperation with Mviwata- national farmer network	**Hectare** Calculate in trees (>1,000 trees per farmer as hedge row farming)
End product Oil for cooking and Lighting	**Future plans:** Biodiesel production for export
Competencies: ▪-strong business case with farmer group ▪ large network of interested investors ▪	**Weakness:** ▪no practical experience ▪no strong partner contact in Mtwara/ Lindi ▪
Main Activity: Agreements with farmers. First planting of seeds before next raining season (Oct-Nov)	

Diligent Tanzania Ltd (2005) Sister Company of Dutch based Diligent Energy Systems	
Region Northern Tanzania	**Crop** Jatropha- jatropha oil
Business Model Contract farming	**Hectares** 700
End product SVO Own car runs on jatropha oil	**Future Plans** Production of Biodiesel, investment in own plantations all over Tanzania
Competencies: ▪two years active in implementing outgrowers model ▪experience in pressing jatropha seed ▪experience in modification of car engines	**Weakness:** ▪No experience in Mtwara/ Lindi region ▪Lack of investment capital to start up in new region

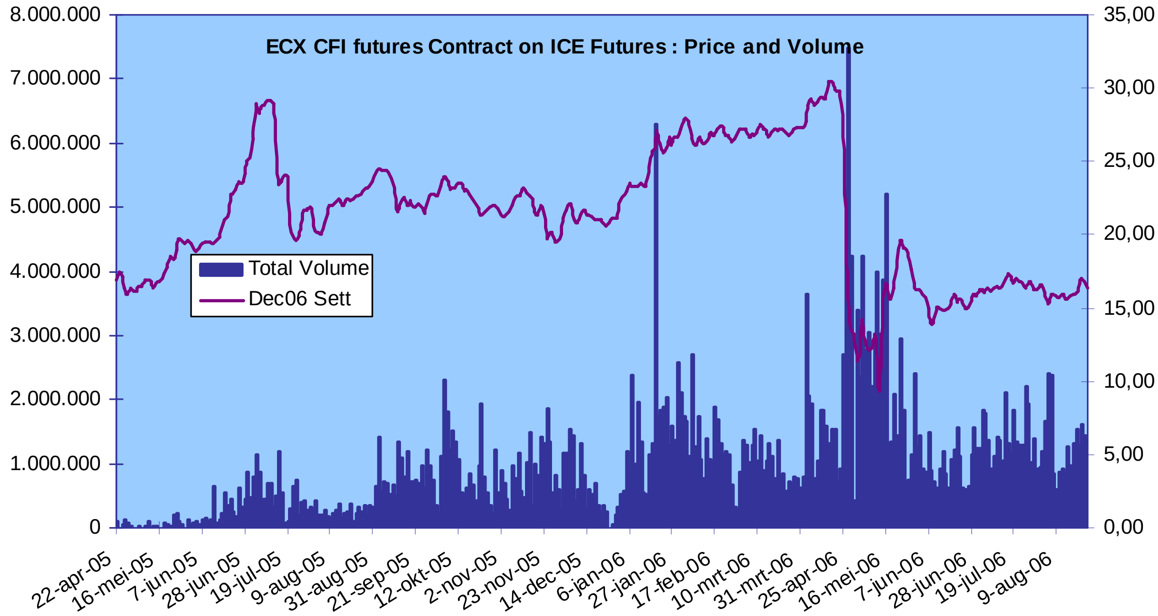
▪research in presscake possibilities and commercial stage is to expect soon ▪marketing / consultancies ▪large network of important stakeholders	
Main Activity Business Development support to farmers, market development, consultancies, research on jatropha oil processing and press cake, production of oil	

Bioshape Ltd (2006)	
Region Probably Lindi	**Crop** Jatropha
Business Model Plantations (old Sisal estate)	**Hectare** ?
End product Vegetable oil	**Future plans:** Biodiesel export
Competencies: ▪-	**Weakness:** ▪-
Main Activity: Not yet started	

Annex III – Trade value of 1 ton of CO2



Current trade value for 1 ton CO_2 is € 16,35 (date: 24/8/06)



Notes:
Settlement prices (Sett) reflect the weighted average of trades during the daily settlement period (16:00- 16:15 hours GMT)
Front Sett reflects the front month contract settlement price (Mar06 for 3 Jan-27 March, Jun06 for 28 March- 26 June, Sep06 for 27 June-25 Sept)
The Mar06 contract expired on 27 March, the Jun06 contract expired on 26 June
Volume and Open Interest reflect all contracts traded. Open Interest figures are published at 11:00 hours GMT for the previous business day.
EFP (Exchange for Physical) contracts are cleared bilateral trades that are brought onto the Exchange as futures positions

Annex IV – List of SACCOs

List of SACCO's in Lindi

In Mtwara and Lindi, 15 agricultural SACCO's are member of SCCULT. In the table below, all Sacco's registered at SCCULT are listed. These Sacco's have in total 5092 individual members, of who are 1677 female and 3415 male.

SACCO name	Region		SACCO name	Region
Mtwara Mikindani	Mtwara		Majili	Lindi
MTR Urb. Teachers	Mtwara		Kilino Lindi	Lindi
Ligula Hospital	Mtwara		Mtwara district	Mtwara
Mtwara chamber	Mtwara		Chaume rural	Tandahimba
Ndwika	Masasi		Lindi rural Teachers	Lindi
Mtr. Rural teach.	Mtwara		Kilimo Kilwa	Kilwa
Masasi Teachers	Masasi		TRA Lindi	Lindi
Newala Teachers	Newala		Washami	Mtwara
Nanyamba rural	Mtwara		Bandari Mtwara	Mtwara
Muugano Kitama ii	Tandahimba		Veta Mtwara	Mtwara
Lembela rural	Tandahimba		Mfumwaki	Kilwa Masoko
Kimita rural	Tandahimba		Bomani Lindi	Lindi
Mwananami rural	Tandahimba		W/Kazi MTR Vijijini	Mtwara
Tulinge rural	Tandahimba		Kurugenzi Mtwara	Mtwara
Mchichira rural	Tandahimba		Afya Mtwara	Mtwara
Lukokoda rural	Tandahimba		Mwananchi	Mtwara/Masasi
Ukombozi chingungwe	Tandahimba		Naiwo	Mtwara
Nachingwea Teachers	Nachingwea		Ukombozi Kitere	Mtwara
Ujamaa / ushirika	Nachingwea		Muungano Mahurunga	Mtwara
Lindi T/Council	Lindi			
Bomali	Lindi			

Source: SCCULT

Annex V – Financial assessment

- Plantation
  - Cost analysis of the plantation
  - Cash flow projections for the plantation
  - Assessment of impact of size
- Processing
  - Investments required
  - Cash flow projections for processing
  - Processing summary data
  - Processing sensitivity analysis

o

Cost analysis - Plantation

Plantation costs - general

	Pessimistic		Optimistic		Notes
Plantation size, ha	1000		1000		Initial size to service demand of Rural Netco
of which planted with Jatropha Curcas	1000		1000		Total area, plant density allowing intercropping
of which planted with Sunflower	333		333		Three year crop rotation cycle assumed
General investment costs, total plantation					
Buildings	€ 50,000		€ 50,000		Provisional estimate
Vehicles					
4WD	€ 15,000		€ 15,000		Provisional estimate
Truck	€ 20,000		€ 20,000		Provisional estimate
Total general investments, total plantation	€ 85,000		€ 85,000		
Initial land-related investment costs, per ha					
Obtaining land use rights	€ 200.00		€ 100.00		Mostly costs associated with ensuring there are no other remaining user rights
Land clearing, preparation and fencing (EUR)	€ 75.00		€ 50.00		Assumption based on own experiences
Total land-related investments per ha	€ 275.00		€ 150.00		
Total land-related investments, total plantation	€ 275,000		€ 150,000		
Total plantation investments	**€ 360,000**		**€ 235,000**		
Total plantation investments, per ha.	€ 360.00		€ 235.00		
Annual management and operation costs					
Plantation supervisor, EUR/yr	€ 30,000.00		€ 30,000.00		Provisional estimate
Other plantation general staff					
Average salary, EUR/month	€ 200.00		€ 200.00		Assumption based on own experiences
Average salary, EUR/year	€ 2,400.00		€ 2,400.00		
Number of staff (excl. maintenance/harvesting labour)	10		10		Assumption based on own experiences
Staffing costs	€ 54,000.00		€ 54,000.00		
Transportation costs, EUR/month	€ 1,000.00		€ 1,000.00		Assumption based on own experiences
Transportation costs, EUR/year	€ 12,000.00		€ 12,000.00		
Other overhead, EUR/month	€ 1,000.00		€ 1,000.00		Assumption based on own experiences
Other overhead, EUR/year	€ 12,000.00		€ 12,000.00		
Total mgmt and overhead, EUR/yr	**€ 78,000.00**		**€ 78,000.00**		
Total mgmt and overhead, per ha.	€ 78.00		€ 78.00		

Costs of Jatropha Curcas Production

	Pessimistic	Optimistic	Notes
Yield assumptions			
Plants per hectare	1650	1650	Intercropping with rows 3m apart, 2m spacing in between
Seeds per plant (kg)	2	3	Literature data suggests yields up to 6kg/plant, but practical experience does not support this.
Seeds per hectare (kg)	3300	4950	
Initial costs, per ha			
Planting (EUR), per ha	€ 50.00	€ 50.00	Assumption based on own experiences
Planting (EUR), total plantation	€ 50,000	€ 50,000	
Annual production costs			
Yearly maintenance			
Labour costs (EUR), per ha	€ 50.00	€ 50.00	Assumption based on own experiences
Labour costs (EUR), total plantation	€ 50,000	€ 50,000	
Harvesting			
Labour costs, per worker per day (EUR)	€ 2.00	€ 2.00	Assumption based on own experiences
Seeds picked per worker per day (kg)	100	140	Assumption based on own experiences
Number of labour days required, per ha	33	35	
Length of harvesting season, in days	60	60	Assumption based on own experiences
Number of workers required	550	589	
Harvesting costs (EUR), per ha	€ 66.00	€ 71.00	
Harvesting costs (EUR), total plantation	€ 66,000	€ 71,000	
Total annual production costs, total plantation	€ 116,000	€ 121,000	
Summary data, per kg seed produced			
Maintenance	€ 0.015	€ 0.010	
Harvesting	€ 0.020	€ 0.014	
Costs of production	€ 0.035	€ 0.024	
Market price per kg of seeds	€ 0.050	€ 0.075	Current market price paid by Diligent is TSh 120/kg (€ 0,075/kg), prices will presumably fall if supply increases
Gross margin per kg of seeds	€ 0.015	€ 0.051	Excluding planting costs, general investments and overhead

Costs of Sunflower Production	Pessimistic		Optimistic		Notes
Yield assumptions					
Seeds per hectare (kg)		2400		2400	Literature data
Oil yield (l) per kg		0.4		0.4	Literature data
Oil yield per hectare (l)		960		960	
Operational costs					
Yearly maintenance, per ha					
Sow materials and fertilizer	€	25.00	€	25.00	Data received from Mohammed Enterprise
Labour costs (EUR), per ha	€	100.00	€	100.00	Assumption based on own experiences
Total maintenance (EUR), per ha	€	125.00	€	125.00	
Total maintenance (EUR), total plantation	€	41,667	€	41,667	
Harvesting					
Labour costs, per worker per day (EUR)	€	2.00	€	2.00	Assumption based on own experiences
Seeds collected/separated, kg per worker/day		60		80	Assumption based on own experiences
Number of labour days required, per ha		40		30	
Length of harvesting season, in days		60		60	Assumption based on own experiences
Number of workers required		222		167	
Harvesting costs (EUR), per ha	€	80.00	€	60.00	
Harvesting costs (EUR), total plantation	€	26,667	€	20,000	
Total annual production costs, total plantation	€	68,333	€	61,667	
Summary data, per kg seed					
Annual sowing and maintenance costs	€	0.052	€	0.052	
Harvesting	€	0.033	€	0.025	
Market price per kg of seeds	€	0.125	€	0.125	Data received from Mohammed Enterprise
Gross margin per kg of seeds	€	0.040	€	0.048	Excluding general investments and overhead

Plantation - Cash flow

PESSIMISTIC SCENARIO											
	Yr 0	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Yr 6**	**Yr 7**	**Yr 8**	**Yr 9**	**Yr 10**
Jatropha - pessimistic											
Jatropha seed production (x1000 kg)	0	0	0	3300	3300	3300	3300	3300	3300	3300	3300
Sales price, EUR	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00	€ 50.00
Total sales revenue (EUR), per ha	€ -	€ -	€ -	€ 165,000	€ 165,000	€ 165,000	€ 165,000	€ 165,000	€ 165,000	€ 165,000	€ 165,000
Initial costs	€ -	€ 50,000	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Maintenance costs	€ -	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000
Harvesting costs	€ -	€ -	€ -	€ 66,000	€ 66,000	€ 66,000	€ 66,000	€ 66,000	€ 66,000	€ 66,000	€ 66,000
Gross income - Jatropha, pessimistic	€ -	-€ 100,000	-€ 50,000	€ 49,000	€ 49,000	€ 49,000	€ 49,000	€ 49,000	€ 49,000	€ 49,000	€ 49,000
Sunflower - pessimistic											
Sunflower seed production (x1000 kg)	0	800	800	800	800	800	800	800	800	800	800
Sales price, EUR	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00
Total sales revenue (EUR), per ha	€ -	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000
Sowing and maintenance costs	€ -	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667
Harvesting costs	€ -	€ 26,667	€ 26,667	€ 26,667	€ 26,667	€ 26,667	€ 26,667	€ 26,667	€ 26,667	€ 26,667	€ 26,667
Gross income - Sunflower, pessimistic	€ -	€ 31,667	€ 31,667	€ 31,667	€ 31,667	€ 31,667	€ 31,667	€ 31,667	€ 31,667	€ 31,667	€ 31,667
Total gross income, pessimistic	**€ -**	**-€ 68,333**	**-€ 18,333**	**€ 80,667**	**€ 80,667**	**€ 80,667**	**€ 80,667**	**€ 80,667**	**€ 80,667**	**€ 80,667**	**€ 80,667**
Plantation costs											
Investment	€ 360,000	€ -	€ -	€ -	€ -	£ -	€ -	€ -	€ -	€ -	€ -
Management and overhead	€ -	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00
Total plantation costs	**€ 360,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**
EBITDA, total plantation	**-€ 360,000**	**-€ 146,333**	**-€ 96,333**	**€ 2,667**	**€ 2,667**	**€ 2,667**	**€ 2,667**	**€ 2,667**	**€ 2,667**	**€ 2,667**	**€ 2,667**
Cumulative	-€ 360,000	-€ 506,333	-€ 602,667	-€ 600,000	-€ 597,333	-€ 594,667	-€ 592,000	-€ 589,333	-€ 586,667	-€ 584,000	-€ 581,333
Net Present Value (NPV)	-€ 479,165										
at discount rate	15%										
Internal rate of return (IRR):	Not meaningful, cumulative net cashflow remains negative										

OPTIMISTIC SCENARIO											
	Yr 0	**Yr 1**	**Yr 2**	**Yr 3**	**Yr 4**	**Yr 5**	**Yr 6**	**Yr 7**	**Yr 8**	**Yr 9**	**Yr 10**
Jatropha - optimistic											
Jatropha seed production (x1000 kg)	0	0	0	4950	4950	4950	4950	4950	4950	4950	4950
Sales price, EUR	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00	€ 75.00
Total sales revenue (EUR), per ha	€ -	€ -	€ -	€ 371,250	€ 371,250	€ 371,250	€ 371,250	€ 371,250	€ 371,250	€ 371,250	€ 371,250
Initial costs	€ -	€ 50,000	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
Maintenance costs	€ -	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000	€ 50,000
Harvesting costs	€ -	€ -	€ -	€ 71,000	€ 71,000	€ 71,000	€ 71,000	€ 71,000	€ 71,000	€ 71,000	€ 71,000
Gross income - Jatropha, pessimistic	€ -	-€ 100,000	-€ 50,000	€ 250,250	€ 250,250	€ 250,250	€ 250,250	€ 250,250	€ 250,250	€ 250,250	€ 250,250
Sunflower - optimistic											
Sunflower seed production (x1000 kg)	0	800	800	800	800	800	800	800	800	800	800
Sales price, EUR	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00	€ 125.00
Total sales revenue (EUR), per ha	€ -	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000	€ 100,000
Sowing and maintenance costs	€ -	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667	€ 41,667
Harvesting costs	€ -	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000	€ 20,000
Gross income - Sunflower, pessimistic	€ -	€ 38,333	€ 38,333	€ 38,333	€ 38,333	€ 38,333	€ 38,333	€ 38,333	€ 38,333	€ 38,333	€ 38,333
Total gross income, pessimistic	**€ -**	**-€ 61,667**	**-€ 11,667**	**€ 288,583**	**€ 288,583**	**€ 288,583**	**€ 288,583**	**€ 288,583**	**€ 288,583**	**€ 288,583**	**€ 288,583**
Plantation costs											
Investment	€ 235,000	€ -	€ -	€ -	€ -	£ -	€ -	€ -	€ -	€ -	€ -
Management and overhead	€ -	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00	€ 78,000.00
Total plantation costs	**€ 235,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**	**€ 78,000**
EBITDA, total plantation	**-€ 235,000**	**-€ 139,667**	**-€ 89,667**	**€ 210,583**	**€ 210,583**	**€ 210,583**	**€ 210,583**	**€ 210,583**	**€ 210,583**	**€ 210,583**	**€ 210,583**
Cumulative	-€ 235,000	-€ 374,667	-€ 464,333	-€ 253,750	-€ 43,167	€ 167,417	€ 378,000	€ 588,583	€ 799,167	€ 1,009,750	€ 1,220,333
Net Present Value (NPV)	€ 252,410										
at discount rate	15%										
Internal rate of return (IRR):	28%										
Notes:											
- NPV and IRR calculations are overly optimistic as interest and taxes are not included											
- estimates to be taken with great caution, as underlying assumptions could not be sufficiently checked against actual practices											

PLANTATION		
Scale of operation		
	IRR	IRR
Plantation size, ha	Pessimistic	Optimistic
250	n.m.	n.m.
500	n.m.	8%
750	n.m.	21%
1000	n.m.	28%	Assumed in financial evaluation
1500	n.m.	36%
2000	n.m.	41%
5000	4%	50%
10000	7%	54%

Processing - investment needs		Notes
Minimum capacity required		
Required minimum annual output:		
Fuel demand per antenna (l/yr)	9000	Data provided by client
Number of antennas foreseen	50	Data provided by Rural Netco Ltd.
Annual SVO production (l)	450,000	
Average oil (l) yield per kg of seed	0.25	Conservative estimate based on mix of seeds - actual yield may be higher
Seeds to be processed annually (kg)	1,800,000	
Estimated available production days/yr	242	40 weeks x 6 days, remaining time for maintenance
Production hours/day	16	Two shifts per day
Total production hours/yr	3872	
Required minimum processing capacity (kg/hr)	470	Rounded upwards
Truck capacity for seed collection (ton)	7	Estimate based on own experiences
Efficiency of capacity use	70%	Estimate based on own experiences
Truckloads to be collected	370	
Trucks required for seed collection	2	
Investment needs - processing facility		
Factory building, storage bunkers and yards	€ 60,000.00	Estimate based on own experiences
Press & Filter, 1000 kg/hr	€ 100,000.00	Approximately 25% more expensive than 500 kg/hr equipment
Storage tank	€ 10,000.00	Estimate based on own experiences
2 second-hand trucks for seed collection	€ 60,000.00	Estimate based on own experiences
Tanker-truck for oil delivery	€ 30,000.00	Estimate based on own experiences
Other company vehicles (4WD, motorcycles)	€ 25,000.00	Estimate based on own experiences
Forklift	€ 15,000.00	Estimate based on own experiences
Laboratory	€ 20,000.00	Estimate based on own experiences
Office, including equipment and furniture	€ 10,000.00	Estimate based on own experiences
Contingency	€ 49,500.00	15%
Total investment needs	**€ 379,500.00**	

Processing - cash flow		Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
INCOME												
Sales												
SVO, liters			320,000	320,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000
Selling price/l	€ 0.66											
Total sales			€ 211,200	€ 211,200	€ 755,700	€ 755,700	€ 755,700	€ 755,700	€ 755,700	€ 755,700	€ 755,700	€ 755,700
Other income												
CDM credits, per litre	€ 0.043											
Total CDM income			€ 13,708	€ 13,708	€ 49,048	€ 49,048	€ 49,048	€ 49,048	€ 49,048	€ 49,048	€ 49,048	€ 49,048
Total income sales and other			**€ 224,908**	**€ 224,908**	**€ 804,748**	**€ 804,748**	**€ 804,748**	**€ 804,748**	**€ 804,748**	**€ 804,748**	**€ 804,748**	**€ 804,748**
COSTS												
Cost of sales												
Jatropha												
Amount of seeds, in tons			0	0	3300	3300	3300	3300	3300	3300	3300	3300
seed purchase/ton	€ 75.00											
transport to factory/per ton	€ 8.00											
costs of seeds, total			€ -	€ -	€ 273,900	€ 273,900	€ 273,900	€ 273,900	€ 273,900	€ 273,900	€ 273,900	€ 273,900
oil yield, l/ton	250											
oil yield total			-	-	825,000	825,000	825,000	825,000	825,000	825,000	825,000	825,000
Sunflower												
Amount of seeds, in tons			800	800	800	800	800	800	800	800	800	800
seed purchase/ton	€ 125.00											
transport to factory/per ton	€ 8.00											
costs of seeds, total			€ 106,400	€ 106,400	€ 106,400	€ 106,400	€ 106,400	€ 106,400	€ 106,400	€ 106,400	€ 106,400	€ 106,400
oil yield, l/ton	400											
oil yield total			320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000	320,000
Mix												
Jatropha			0%	0%	72%	72%	72%	72%	72%	72%	72%	72%
Sunflower			100%	100%	28%	28%	28%	28%	28%	28%	28%	28%
Total cost of sales												
Amount of seeds, in tons			800	800	4100	4100	4100	4100	4100	4100	4100	4100
costs of seeds			**€ 106,400**	**€ 106,400**	**€ 380,300**	**€ 380,300**	**€ 380,300**	**€ 380,300**	**€ 380,300**	**€ 380,300**	**€ 380,300**	**€ 380,300**
oil yield total (l)			320,000	320,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000	1,145,000
Gross income			***€ 118,508***	***€ 118,508***	***€ 424,448***	***€ 424,448***	***€ 424,448***	***€ 424,448***	***€ 424,448***	***€ 424,448***	***€ 424,448***	***€ 424,448***

Operation costs												
Processing costs												
Pressing, EUR/ton seeds	€ 21.00											
Filtering, EUR/ton seeds	€ 4.00											
Processing costs			€ 20,000	€ 20,000	€ 102,500	€ 102,500	€ 102,500	€ 102,500	€ 102,500	€ 102,500	€ 102,500	€ 102,500
Staffing, transport and other costs												
Staffing												
Average staff salary, EUR per month	€ 250.00											
Number of staff			15	20	25	25	25	25	25	25	25	25
Staffing costs, EUR per year			€ 45,000	€ 60,000	€ 75,000	€ 75,000	€ 75,000	€ 75,000	€ 75,000	€ 75,000	€ 75,000	€ 75,000
Transport, EUR per year			€ 6,000	€ 9,000	€ 9,000	€ 9,000	€ 9,000	€ 9,000	€ 9,000	€ 9,000	€ 9,000	€ 9,000
Other costs, EUR per year			€ 12,000	€ 15,000	€ 18,000	€ 21,000	€ 24,000	€ 27,000	€ 30,000	€ 33,000	€ 36,000	€ 39,000
Total operation costs, EUR per year			***€ 83,000***	***€ 104,000***	***€ 204,500***	***€ 207,500***	***€ 210,500***	***€ 213,500***	***€ 216,500***	***€ 219,500***	***€ 222,500***	***€ 225,500***
EBITDA			**€ 35,508**	**€ 14,508**	**€ 219,948**	**€ 216,948**	**€ 213,948**	**€ 210,948**	**€ 207,948**	**€ 204,948**	**€ 201,948**	**€ 198,948**
Investment		**€ 379,500**										
Net free cash flow, excluding interest and taxes		-€ 379,500	€ 35,508	€ 14,508	€ 219,948	€ 216,948	€ 213,948	€ 210,948	€ 207,948	€ 204,948	€ 201,948	€ 198,948
Cumulative		-€ 379,500	-€ 343,992	-€ 329,484	-€ 109,536	€ 107,412	€ 321,361	€ 532,309	€ 740,258	€ 945,206	€ 1,147,154	€ 1,346,103
Net Present Value (NPV)		**€ 330,724**										
at discount rate		15%										
IRR		**32%**										

SVO Production costs - summary			
Initial investments	€ 379,500		
Annual revenues			
Sales of SVO in litres	1,145,000		
at € 0,70 /litre	€ 755,700		
CDM revenues	€ 49,048		
Total income	€ 804,748		
Costs of seeds	€ 380,300		
Processing	€ 102,500		
Overhead	€ 102,000		
Total costs	€ 584,800		
EBITDA	€ 219,948		
Net Present Value	€ 330,724		
at discount rate	15%		
IRR	32%		
Cost breakdown per ton seeds, and per 1000 l oil			
Jatropha Curcas	per ton seeds	per 1000 l oil	
		250	l/ton seeds average
Purchase of seeds	€ 75.00	€ 300.00	49%
Transport	€ 8.00	€ 32.00	5%
Pressing	€ 21.00	€ 84.00	14%
Filtering	€ 4.00	€ 16.00	3%
Overhead	€ 46.62	€ 186.46	30%
Total Jatropha SVO production costs	€ 154.62	€ 618.46	100%
Sunflower	per ton seeds	per 1000 l oil	
		400	l/ton seeds average
Purchase of seeds	€ 125.00	€ 312.50	54%
Transport	€ 8.00	€ 20.00	3%
Pressing	€ 21.00	€ 52.50	9%
Filtering	€ 4.00	€ 10.00	2%
Overhead	€ 74.59	€ 186.46	32%
Total Sunflower SVO production costs	€ 232.59	€ 581.46	100%

PROCESSING SENTIVITY ANALYSIS

Scale of operation

Design maximum (ton seeds)	8760	at 24hr/day, 365 days/yr use at full capacity		
Seeds processed as % of modelling assumptions	50%	75%	100%	150%
Jatropha seeds (ton)	1650	2475	3300	4950
Sunflower seeds (ton)	400	600	800	1200
Total seeds (ton)	2050	3075	4100	6150
Total oil yield (ton)	572.5	858.75	1,145	1717.5
IRR	-3%	19%	36%	53%
			Assumed in financial evaluation	

Impact of selling price

Selling price of SVO, EUR/1000l		
Jatropha seeds	IRR	
€ 500.00	n.m.	
€ 550.00	9%	
€ 570.00	14%	
€ 600.00	21%	
€ 630.00	27%	
€ 660.00	32%	Assumed in financial evaluation
€ 700.00	38%	

Impact of raw material costs

Cost price, EUR/ton			
Jatropha seeds	Sunflower seeds	IRR	
€ 37.50	€ 93.75	50%	
€ 50.00	€ 93.75	46%	
€ 62.50	€ 125.00	37%	
€ 75.00	€ 125.00	32%	Assumed in financial evaluation
€ 93.75	€ 156.25	17%	
€ 106.25	€ 156.25	9%	
€ 125.00	€ 187.50	n.m.	

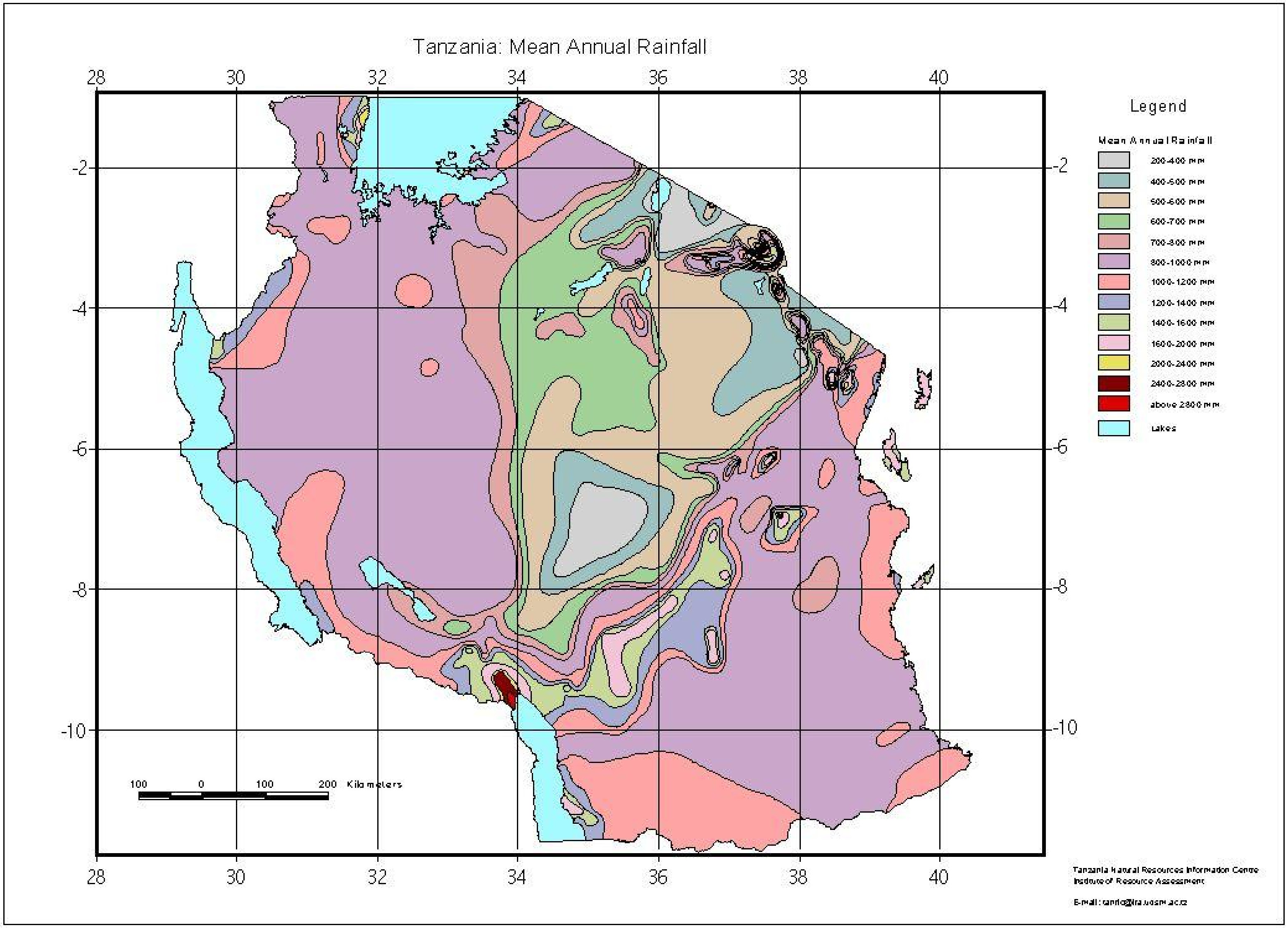
Impact of processing costs

Pressing and Filtering costs as % of model assumptions	Pressing in EUR/ton seeds	Filtering in EUR/ton seeds	IRR	
50%	€ 10.50	€ 2.00	39%	
75%	€ 15.75	€ 3.00	36%	
100%	€ 21.00	€ 4.00	32%	Assumed in financial evaluation
150%	€ 31.50	€ 6.00	24%	
200%	€ 42.00	€ 8.00	15%	

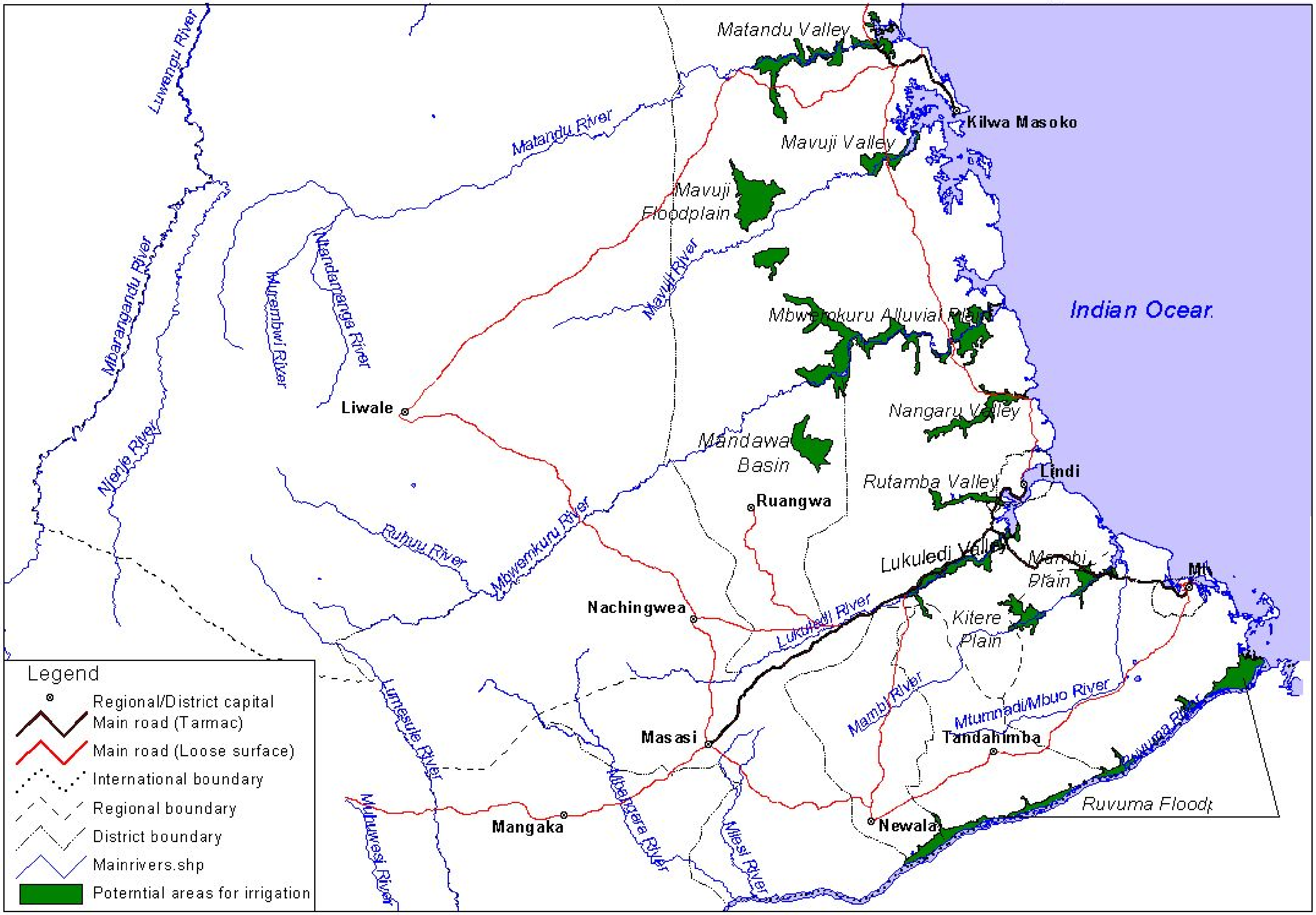
Impact of oil yield

Processing efficiency (Liters oil per kg seed)	Jatropha	Sunflower	IRR	
Poor	0.200	0.300	n.m.	
	0.200	0.350	4%	
Medium	0.250	0.300	20%	
	0.250	0.350	26%	
	0.250	0.400	36%	Assumed in financial evaluation
Good	0.300	0.400	47%	
	0.300	0.450	52%	
Very good	0.350	0.400	56%	
	0.350	0.450	62%	

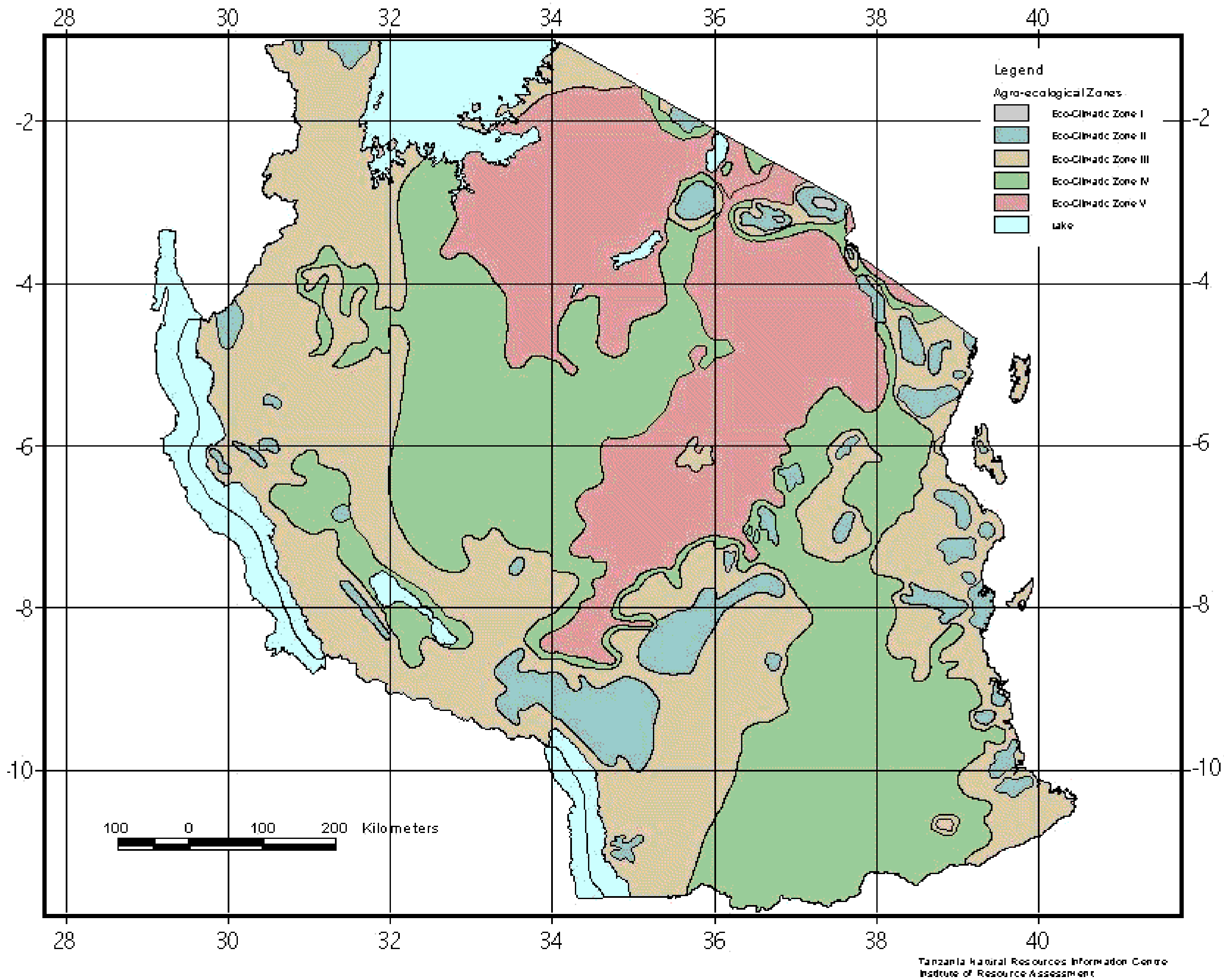
Annex VI – XII: MAPS


Tanzania: Mean Annual Rainfall
28
30
32
34
36
38
40
-2
-4
-6
-8
-10
Legend
Mean Annual Rainfall
200-400 mm
400-500 mm
500-600 mm
600-700 mm
700-800 mm
800-1000 mm
1000-1200 mm
1200-1400 mm
1400-1600 mm
1600-2000 mm
2000-2400 mm
2400-2800 mm
above 2800 mm
Lakes
100 0 100 200 Kilometers
Tanzania Natural Resources Information Centre
Institute of Resource Assessment

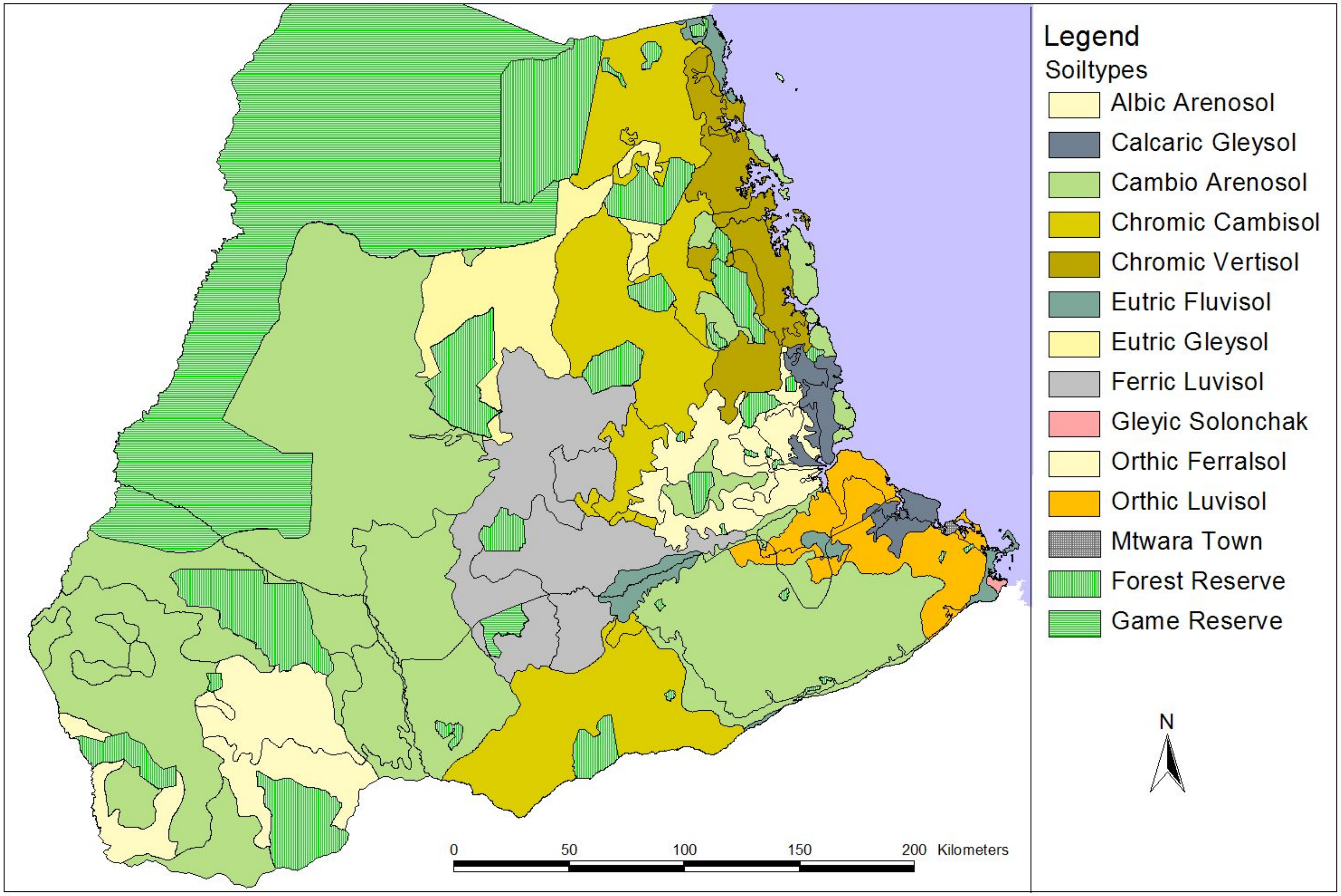
Potential Areas for Small Scale Irrigation in Lindi and Mtwara Regions



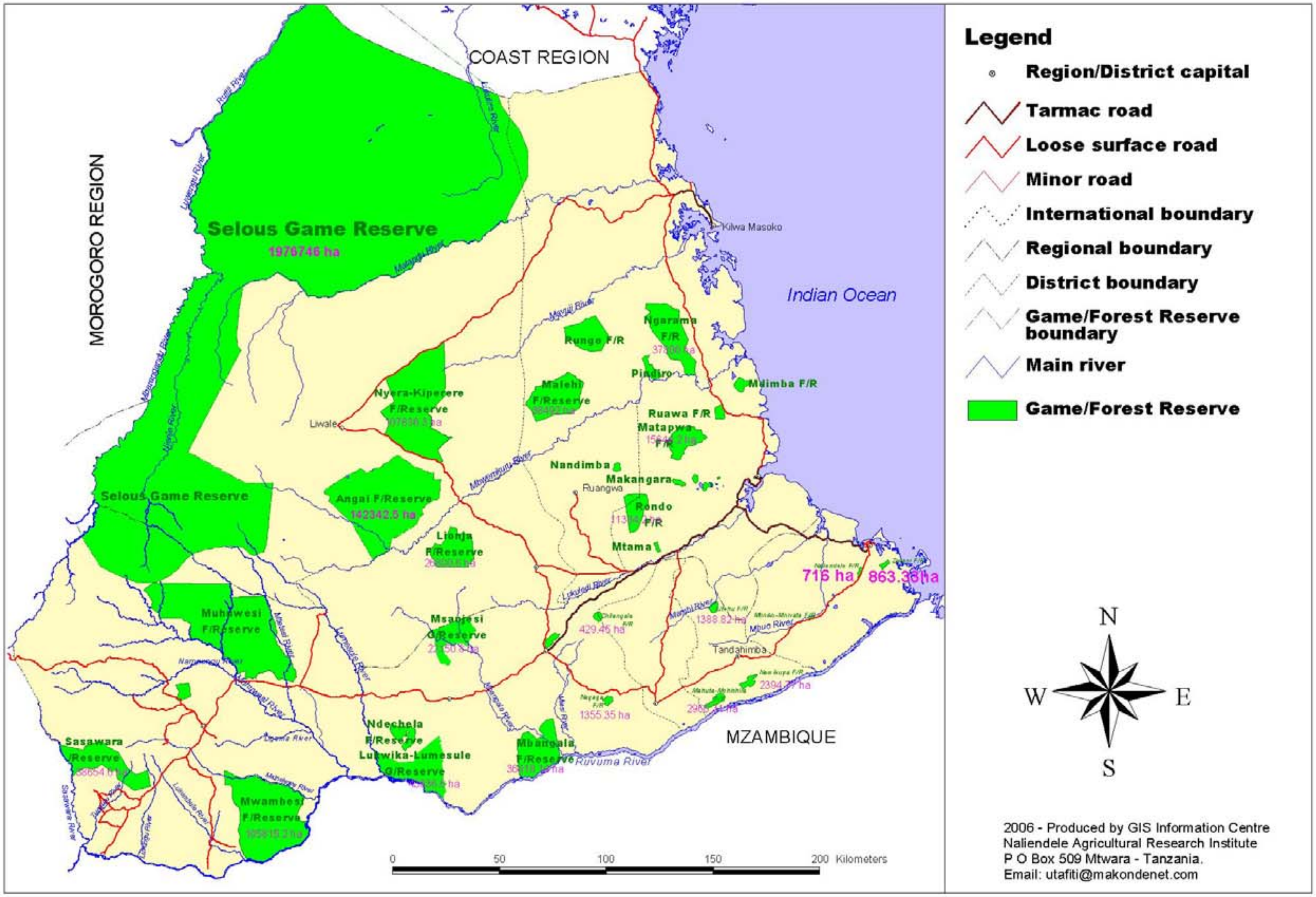
Tanzania: Eco-climatic zones



Soil Types of The Southern Zone(Adopted from Benett)



Southern Zone: Game and Forest Reserves



Southern Zone: Districts, Villages and Road Network