Berlin School of Economics and Law

Institute of Management Berlin

Master-Programme Sustainability and Quality Management

Supervised by

Prof. Dr. Anja Grothe

Co-supervised by

Dr. Götz Uckert

Institute of Socio-Economics

Leibnitz-Centre for Agricultural Landscape Research (ZALF)

Master thesis:

Opportunities for a sustainable rural energy supply through renewable energies in developing countries.

Socio-economic feasibility study of the operation of a multi-functional platform in the village of Laela, Tanzania on locally produced biofuels.

Submitted by

Jan Rordorf

Karl-Marx-Str. 41

12043 Berlin

Matrikel-Nr.: 258234

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List of figures

List of tables

Abbreviations

ADB	Asian Development Bank
Ah	Ampere hour
Amp	Ampere
BMZ	German Ministry for Economic Development and Cooperation
DAP	Diammonium phosphate
ESMAP	Energy Sector Management Assistance Program
ESP	Energy Service Platform
FAO	Food and Agriculture Organization of the United Nations
FNR	Fachagentur Nachwachsende Rohstoffe
Geni	Global Energy Network Institute
GIZ	Gesellschaft für Internationale Zusammenarbeit
GTZ	Gesellschaft für Technische Zusammenarbeit
GVEP	Global Village Energy Partnership
ha	Hectare
HIV	Human immunodeficiency virus
hp	Horse power
ICRAF	World Agroforestry Centre
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
km	Kilometer
kWh	Kilowatt hour
l	Litre
LAC	Laela Agricultural Centre
MDGs	Millennium Development Goals
MFP	Multi-functional platform
MJ	Megajoule
mm	Millimeter
NFRA	National Food Reserve Agency of Tanzania
NGO	non-governmental organisation
NRECA	National Rural Electric Cooperative Association
rpm	Revolutions per minute
SVO	Straight vegetable oil
TaTEDO	Tanzania Traditional Energy Development and Environment Organization
TZS	Tanzanian Shillings
UNDP	United Nations Development Programme
V	Volt

1. Introduction

This Master thesis examines whether it is feasible from an economic, social, and ecological perspective to run a village electricity system in rural Tanzania on locally produced straight vegetable oil (SVO) as a substitute for fossil diesel. It is assessed whether the cultivation and processing of SVO in the village contributes to rural development and poverty reduction. Additionally, ecological impacts of a local biofuel production are evaluated. Based on this, proposals for the establishment of a local value-chain for biofuels are developed.

Research on rural electrification through locally produced biofuels is relevant as a number of significant global issues are addressed:

The substitution of fossil energy consumption potentially reduces the negative impacts associated with climate change which particularly affects Sub-Saharan countries (IPCC, 2007: 23).

In Sub-Saharan Africa only roughly 14% of the population in rural areas have access to electricity (IEA, 2009). This closely interrelates with poverty as modern energy is a prerequisite for development. Thus, by extending rural electrification, poverty can effectively be reduced.

Rural poverty and hunger often do not result from food shortages but from a lack of income opportunities in rural areas. By processing a larger share of the locally produced agricultural resources within the region, local value-addition takes place, potentially generating additional income for the rural poor. Additionally, expenses for fossil energies can be reduced and remain within the region.

1.1 Research questions

The following research question is explored:

> *Is the operation of a small-scale electricity system based on a multi-functional platform in Laela, Tanzania on locally produced biofuels. feasible from an economic, social and ecological perspective?*

The research object of the thesis is a rural energy access project implemented by the Tanzanian NGO TaTEDO[1] in late 2009 in the remote village of Laela. The project involves a multi-functional platform (MFP), a diesel engine coupled with an electricity generator and a battery charging system to provide power to villagers through a mini-grid and rechargeable batteries.

The field research conducted in the village in November and December 2010 was guided by the following additional research questions:

- To which extent are oil fruits currently cultivated and processed in the village and region? Are SVOs currently used as biofuels (market characteristics)?
- What actors are involved in the local value chain for SVO? How are power and revenue streams distributed between actors (value chain analysis)?
- What are the energy needs of the local population? How much income is spent on energy?

[1] "Tanzania Traditional Energy Development and Environment Organization". TaTEDO is based in the capital of Tanzania Dar-es-Salaam.

- What agricultural potentials exist in the village for (additional) SVO production without reducing food production?
- Is the cultivation and processing of biofuel feedstocks competitive under local conditions (energy prices, ability and willingness to pay)?
- Which oil plants are most suitable for the region in agricultural and socio-economic perspective (income potential, experiences and acceptance among the local population)?
- Which socio-economic impacts on poverty reduction and sustainable rural development would the cultivation of biofuel feedstocks have (impact assessment)?
- What gender-related impacts can be expected? To what extent would women benefit from new income opportunities related to the cultivation and processing of oil crops?
- How could the cultivation and processing of oil crops be optimally organized to reduce rural poverty?
- Which (additional) incentives and interventions are needed to initiate the development of a value chain for SVO (e.g. initial financing, capacity building, agricultural extension service)?

1.2 Research approach

After a theoretical introduction on the relevance of rural electrification through biofuels for rural development and poverty reduction and the development concept of the MFP, the socio-economic situation, the agricultural potentials and current energy use in the village of Laela are analysed. Two economic analyses of local SVO production (sunflower and Jatropha curcas) are conducted, assessing socio-economic impacts of different processing scenarios. Recommendations are developed on the promotion of a local value-chain for SVO.

2. Theoretical background

2.1 Relevance of Energy and Development

Currently 2.8 billion people worldwide live on less than one U.S. dollar per day – according to the World Bank the minimum income threshold of absolute poverty (the World Bank, 2010). Poverty not only refers to a lack of material wealth but in particular to the inability to satisfy basic human needs regarding adequate food, education, culture, medical care, clean water, etc.

Large parts of the population especially in rural areas of developing countries are not able to satisfy these basic human needs which is most often a result of limited access to modern energy sources such as electricity, liquid and gaseous fuels. In contrast, traditional or low-tech energy, such as firewood, charcoal, candles, kerosene lamps or car batteries are widely used in areas that are not connected to the electricity grid. Closely related to the use of such forms of energy are a variety of social and health problems. Large part of the household´s disposable income is used for a low quality energy supply; large amounts of time that could be used for productive activities have to be spent on collecting energy resources such as firewood, particularly by women and children.

Thus, a secure supply of modern energy sources is of central importance for sustainable development and poverty reduction. "Energy services are essential to both social and economic development and [...] much wider and greater access to energy services is critical in achieving all of the Millennium Development Goals [of the United Nations]" (UNDP, 2002). In rural areas, energy is used for food preparation, for lighting, for supplying drinking and irrigation water and for the processing of agricultural and forestry products thereby using local productive potentials. Access to energy is therefore a prerequisite for economic and social development.

2.2 Potential of renewable energies for rural energy supply

Currently, nearly 1.5 billion people worldwide are still without access to electricity because of insufficient population density and low number of potential customers in rural areas, lack of public funds and private disposable income. Therefore, electrification at affordable prices through the extension of the central electricity grid will most likely not be available in the foreseeable future (Denkhaus, 2004: 4) so that decentralized renewable energy technologies are already the most economical option for electrification of remote regions (REN21, 2008: 14). Given the continuously rising energy and commodity prices, it can be expected that the use of decentralized renewable energies will be even more attractive and competitive in the future. This is especially relevant in Sub-Saharan Africa where only 14.3% of the population in rural areas have access to electricity (IEA, 2009).

The use of bioenergy in particular can stimulate additional income generation and extra value addition in rural areas, if locally available agricultural products are not exported but processed within the region. Currently, agricultural products are mostly processed outside the villages as processing costs are high due to high energy costs and a lack of economies of scale. Local income generation can further be stimulated by substituting energy that would have been imported from outside the region with locally produced energy.

Electrification through decentralized renewable energies has also significant ecological benefits. Although the electrification of rural areas in developing countries substitutes only a comparably small amount of fossil fuels[2], the future expansion of fossil-based energy use is prevented and also deforestation through over-exploitation of wood and charcoal resources may potentially be reduced considerably. Thus, has the electrification of rural areas through renewable energies significant secondary effects for climate protection (Denkhaus, 2004: 6).

2.3 Rural electrification through biofuels

Compared to other renewable energy technologies, electrification through biofuels – if cultivated locally and sustainably – can potentially provide electricity at lower up-front and running costs. Additionally, income for small farmers would be generated if the required oilseeds are produced on a small share of the available agricultural land. Biofuels have a broad field of application and can e.g. be used as domestic fuel for cooking or lighting thereby replacing wood or charcoal or for the use in a diesel engine to produce electricity or to power agro-processing machines.

If locally produced SVO is used in basic decentralized energy technologies (e.g. small diesel engines with connected generators, oil burners for cooking) and without being processed to biodiesel or ethanol which would require high investments in processing technology, a large amount of value creation is realized within the production region.

When using fossil or other renewable energy technologies to provide electricity to rural areas such as solar, wind and hydro energy, a large share of the value creation is taking place outside the region (through production, planning, installation and maintenance processes of renewable energy technologies and through extraction, processing and distribution of fossil energies).

2.4 Concept Multifunctional Platform

The Multifunctional Platform (MFP)[3] is a low-cost technology to provide rural energy services potentially through the use of locally produced biofuels. The technology is comparably simple that can relatively easy be installed and maintained even in remote areas of developing countries. An MFP consists of a diesel engine "that is mounted on a chassis and to which a variety of end-use equipment can be added" (UNDP 2004: 18). Usually, simple Lister diesel engines are used which require low maintenance and repair, however, to insure a stable performance over time, the operators of the system need to be adequately trained. Lister engines are also technically capable of running on various SVOs either mixed with fossil diesel or used as only fuel. The use of SVO in MFPs, including the promotion of local oil plant cultivation (mainly Jatropha) and the processing in an expeller attached to the system has been an integral part of many MFP projects.

The diesel engine of the MFP is used to operate various mechanical and energy applications such as grain mills, oil presses, circular saws, dehulling machines, a generator to power a mini-grid or a battery recharger, water pumps, welding and carpentry equipment. The choice of applications are adjusted to the specific needs of the community benefiting from the MFP. An MFP can therefore potentially stimulate and modernize productive activities in the village (e.g. blacksmiths, mechanics, carpenters, processing of natural resources etc.) and improve access to modern energy services (UNDP 2004: 19) which potentially improves living standards for women and children in particular as time spent on reproductive activities such as fetching water, grinding cereals, collecting firewood etc. would be reduced (UNDP, 2004:

[2] e.g. kerosene used for lighting and diesel or petrol used in small household-scale generators.

[3] Referred to as Energy Service Platform (ESP) in some projects.

26) and time for other activities such as income generation, education or recreation is being freed up.

The purchasing costs for an MFP differ with the site specific equipment and according to TaTEDO (2008b: 11) range from TZS 5,000,000[4] for a basic system to TZS 20,000,000 for large systems with oil seed press[5] and a mini-grid[6] which connects 50 to 100 costumers.

The development concept of the MFP was first implemented by the UNDP in Mali in the late 1980s. Evaluations of past MFP projects showed that a key factor to a long-term success of projects is that a functioning organisation operates and maintains the system in a stable and reliable way (such as a private business, a cooperative from the village community, a women´s group etc.). Crucial to a sustainable operation of the MFP is that a share of the income generated by the user fees is put aside safely to regularly maintain the system and create savings for repairs and overhauls (UNDP 2004: 20).

In Tanzania the NGO TaTEDO has installed four MFPs in different regions of the country[7] as a pilot project for the large-scale implementation of MFPs in Tanzania. The projects were funded by different international donors[8] and are aimed at using Jatropha oil in the mid-term to gradually substitute the diesel consumption of the system.[9]

According to TaTEDO, all projects are currently operational, although minor technical and management difficulties occured. The MFP in Laela however, has not been operational since late 2009 (see below).

Currently, TaTEDO is starting the implementation of a larger MFP project involving about 50 MFPs. The project is financed by the European Union and the Dutch foundation Hivos. The first MFPs are expected to be installed in the third quarter of 2011.[10]

In summary, the MFP concept includes a number of potential benefits such as providing a low cost modern energy supply in remote rural areas, a sustainable use of locally produced renewable energy resources (if run on locally produced SVO), improved options for small and medium enterprise development and local value chain optimisation (through additional local processing of agricultural products).

On the other hand, there is a risk of disappointment among small farmers, if Jatropha is promoted as a new cash crop and income opportunity, but access to markets turns out to be limited or yields stay below expectations.

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[4] € 2.476 (if not indicated otherwise, an exchange rate of € 1 = TZS 2,019 is used in the thesis, representing the average exchange rate during the field visit in November and December 2010)

[5] According to personal communication with TaTEDO, an oil press powered by the MFP with a capacity of pressing 100kg of seeds per hour amounts to about TZS 5,000,000

[6] According to TaTEDO (2008b: 67): capital costs for a MFP with mini-grid include:

- generator set, platform: TZS 2,500,000
- cables […]:TZS 5,800,000
- pole top hardware […]:TZS 1,700,000
- other hardware […]:TZS 800,000
- house wiring materials TZS 6,800,000
  total costs: TZS 17,600,000

[7] Rukwa, Arumeru, Monduli, and Kinondoni

[8] The Netherlands, ESMAP/GVEP and the World Bank

[9] Personal communication with Mr. Shukuru Meena, TaTEDO, Dar es Salaam.

[10] Personal communication with Mr. Shukuru Meena, TaTEDO, Dar es Salaam.

3. Methodology

The primary data used in the thesis were generated through semi-structured qualitative interviews with local stakeholders and a quantitative socio-economic household survey compiled in a three-week field visit in Laela, Tanzania in November and December 2010.

The field research was part of the international research project "Biofuel Evaluation for Technological Tanzanian Efficiency using Renewables - integrated Strategies (Better-iS)" supervised by the Leibnitz-Centre for Agricultural Landscape Research (ZALF) and funded by the German Ministry for Economic Development and Cooperation (BMZ) through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

3.1 Qualititative data collection

A total of eight expert and focus group interviews with various stakeholders were conducted in Laela village, and in the Tanzanian capital Dar es Salaam.

In the village, five focus group interviews with selected stakeholders such as members of local committees, teachers, village officials and local farmers were conducted.[11]

3.2 Quantitative data collection

In the household survey a total number of 160 households were interviewed representing the five sub-villages of Laela and four predefined income groups, developed in collaboration with local stakeholders. To select a representative sample of households, each sub-village head was asked to compile a list of all household heads and the total number of inhabitants in their sub-village. In a second step all households were assigned by the sub-village heads to the four income groups that were defined according to the following criteria developed by the villagers in one of the focus group interviews:

Table 1: Definition of income groups according to local villagers

Income Group	Regular income	Definition (by villagers)
1	High	Farmers with high agricultural surplus Affluent businesspeople in town (trader, owners of pressing and milling machine, bars and restaurants, shops)
2	Medium	Farmers with enough land and capital to produce a small surplus Small businesspeople
3	Low	Families are also subsistence farmers but have sufficient production for own food consumption No surplus is produced
4	Very low	Families can only afford to feed themselves for about 3-4 months per year from their own agricultural production In the rest of the year family members work as agricultural labourers on other farms or depend on casual labour Often large families People with disabilities and old people without relatives supporting them Many families in this income group are involved in charcoal-making

The household survey was conducted by a team of two previously trained enumerators from Dar es Salaam[12] and two local enumerators[13]. Parts of the data could be used in this thesis.

[11] See Annex II for an overview of all stakeholder interviews.

An additional quantitative survey was conducted among 18 households operating small generator-sets asking for technical and economic data as well as consumer satisfaction regarding the operation of the generator.

3.3 Scientific limitations and difficulties

A main problem concerning the representativity of the survey data is related to the selection of the households interviewed. As no lists of villagers were accessible, the field team requested hand-written lists from the sub-village heads. Based on these lists, households were chosen randomly in accordance to their income classes. As many of the household heads could not be interviewed at the first visit, other households of the same income group were interviewed as replacements.

Additionally, in some cases the household head was not available for an interview so that interviews with other household members had to be conducted.

From a scientific point of view the approach applied here presents some limitations as it was entirely left to the sub-village heads to attribute each household in the respective sub-village in one of the four income groups. This attribution was only based on the estimation of the sub-village heads and not on socio-economic criteria (such as income data) which were not available. Therefore, the income group attribution by the sub-village heads was rather based on personal estimations than on objective criteria.

Additionally, income and wealth levels in the different sub-villages differ significantly from each other. The most affluent households in Laela Kati have much higher incomes etc. than the households categorized as income group 1 in the poorest sub-village Mtindilo. Thus, comparability of the different income groups and sub-villages is somewhat limited.

Under the difficult research conditions given in the case study village this approach however, was regarded as the most pragmatic and scientifically adequate.

Table 2 Table 3 depict the distribution of sub-villages and income groups in the sample of the household survey and in the total population of Laela A.

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[12] Better-iS already collected data in March to July 2010 – these two enumerators (master students of agricultural studies) participated successfully in the first survey and were therefore also involved in the 2nd data collection.

[13] An elementary school teacher and an agricultural extension officer.

Table 2: Population size and income group distribution in all sub-villages of Laela A

Sub-village	Kamyalile	Maporomoko	Mtindilo (Kasakalawe)	Kivukomteta	Kati	Total Laela A
Name of sub-village head	Efren Masumbko	Longino Kizinga	Sebastian Sikazwe	Athanaeli Dodozi	Datus Kisunga	-
Households (number)	244	264	215	253	284	1.260
Share of total households in Laela A	*19,37%*	*20,95%*	*17,06%*	*20,08%*	*22,54%*	*100,00%*
Inhabitants (number)	1.244	1.201	900	627	1.488	5.460
Share of total inhabitants in Laela A	*22,78%*	*22,00%*	*16,48%*	*11,48%*	*27,25%*	*100,00%*
Share of income groups in sub-village						
Income group I (high)	5,00%	10,00%	5,00%	10,00%	30,00%	12,69%
Income group II	20,00%	25,00%	10,00%	20,00%	25,00%	20,47%
Income group III	15,00%	50,00%	15,00%	40,00%	30,00%	30,73%
Income group IV (low)	60,00%	15,00%	70,00%	30,00%	15,00%	36,11%
Total	*100,00%*	*100,00%*	*100,00%*	*100,00%*	*100,00%*	*100,00%*

Table 3: Distribution of sub-villages and income groups in household survey sample

	Kamyalile			Maporomoko			Mtindilo (Kasakalawe)			Kivukomteta			Kati			Total Laela A		
	Share of income groups in sub-village	Number of interviews conducted	Share of income groups in sample	Share of income groups in sub-village	Number of interviews conducted	Share of income groups in sample	Share of income groups in sub-village	Number of interviews conducted	Share of income groups in sample	Share of income groups in sub-village	Number of interviews conducted	Share of income groups in sample	Share of income groups in sub-village	Number of interviews conducted	Share of income groups in sample	Share of income groups in village	Number of interviews conducted	Share of income groups in sample
Income group I (high)	5,00%	1	3,23%	10,00%	5	13,16%	5,00%	3	9,38%	10,00%	4	12,50%	30,00%	20	67,86%	12,69%	33	20,63%
Income group II	20,00%	9	29,03%	25,00%	7	18,42%	10,00%	5	18,75%	20,00%	6	18,75%	25,00%	1	3,57%	20,47%	28	17,50%
Income group III	15,00%	11	35,48%	50,00%	18	47,37%	15,00%	12	37,50%	40,00%	16	53,13%	30,00%	6	21,43%	30,73%	63	39,38%
Income group IV (low)	60,00%	10	32,26%	15,00%	8	21,05%	70,00%	11	34,38%	30,00%	5	15,63%	15,00%	2	7,14%	36,11%	36	22,50%
Total	100,00%	31		100,00%	38		100,00%	31		100,00%	31		100,00%	29		100,00%	160	
% of households covered		*12,70%*			*14,39%*			*14,88%*			*12,65%*			*9,86%*			*12,78%*	

As can be seen in the last three columns of Table 4, is the distribution of income groups in the sample significantly skewed in comparison to the income group distribution in the total population (i.e. in all 1,260 households in Laela A). If the sample would be perfectly representative of the total population in Laela A, the distribution of data in the sample could be multiplied by a factor of 7.875 to draw conclusions about the total number of households in Laela A[14]. As however, all four income groups in the sample are either over or under represented when compared to the distribution in the village as estimated by the sub-village heads, the multiplication factor for estimating the numbers of occurrences in the total population needs to be corrected, taking into account the incorrect representation in the sample. For this purpose, a correction factor has been calculated for each income group (see column six in Table 4). Thus, to calculate the distribution of a certain item in the total population,

a) the distribution of this item in the sample is disaggregated per income group,
b) the number of occurrences of the item in every income group is multiplied with the respective correction factor,
c) the number of occurrences per income group is multiplied by the factor 7.875,
d) finally, the distribution if the items in all income groups are aggregated again.

Table 4: Differences between sample and total population and correction factor per income group

Income group	Share of income group in Laela A	Share of income group in sample	Difference (percentage points)	Difference (percentage)	Correction factor
1	12.69%	20.63%	7.94%	+62.57%	0.3743
2	20.47%	17.5%	-2.97%	-14.5%	1.145
3	30.73%	39.38%	8.64%	+28.11%	0.7189
4	36.11%	22.5%	-13.61%	-37.69%	1.3769

[14] As the sample size of 160 households represents 12.70% of the total number of households of 1,260, the sample would have to be multiplied by 7.875 to be representative of the total number of households.

4. The settlement of Laela

4.1 Background and geographical setting

The village of Laela is situated approximately 160 km west of Mbeya in the Rukwa region in Western Tanzania. Its geographical situation is mainly characterized by its comparable remoteness, although the unpaved highway 122, which is connecting Tunduma at the Zambian boarder with the regional capital Sumbawanga, is running through the settlement. The nearest larger cities are Sumbawanga (93 km) and Tunduma (130 km). From Tunduma the regional economic and administrative centre of Mbeya can be reached on another 105 km on the paved Tanzam Highway.

An important factor for the future development of Laela is a new tarmac pavement of the highway between Sumbawanga and Tunduma, which is currently under construction and due to be finalized in 2013.

Laela is subdivided into two administrative units: Laela A and Laela B[15], whereby Laela A was chosen as survey region due to the installation of the MFP in this part of the village. In total, the population of Laela A was estimated by local officials at 5,460 inhabitants living in 1,260 households[16]. Laela A consists of five different sub-villages including Laela Kati, the centre of town. Generally, the population of all sub-villages is growing comparably fast, especially due to migration as labour opportunities in Laela are better in comparison to more remote villages. This is reflected in the relatively high number of children under 15 years in the 160 households interviewed in the village survey:

Table 5: Average number of household members and distribution by age in household sample

Average number of household members	Average number of household members			
	under age 15	between age 15 and 30	between age 30 and 45	above age 45
6.47	2.76	1.95	1.09	0.73

The growing population is increasingly depleting the natural resources of the surrounding area, especially the forest areas still left at the slopes of the Mbizi Mountains east of the settlement.

4.2 Economic activities

Laela can be characterized as a regional trading centre for agricultural products, especially maize. Especially during harvesting time farmers from surrounding villages transport their products to Laela to sell them to local and external traders. Additionally local traders buy directly from the farmers and sell it to other traders or to agro-processing industries in the

[15] Laela B consists of another 3,500 inhabitants which according to the official estimation would amount to approximately another 800 households. Laela B consists of the newer parts in the outskirts of the village on the left of the main road leading from Tunduma to Sumbawanga. The inhabitants of Laela B are mostly migrants from the surrounding region that recently moved to Laela. The inhabitants of Laela B were characterized by the village officials as having lower incomes, smaller plot sizes of the farmers and a higher share of rural labourers without land ownership.

[16] Based on the official estimations this would amount to 4.36 members per household. In the survey village however, an average household size of 6.47 was calculated (including 3.71 members above age 15).

most proximate cities. Even though at the time of the survey an export ban on agricultural products was in place in Tanzania, regional farmers sell to foreign traders during harvesting season and even smuggle agricultural products to neighbouring countries where higher market prices can be reached.

As an alternative sales channel, a warehouse of the National Food Reserve Agency of Tanzania (NFRA), a governmental institution for the domestic distribution of food, is located in Laela. The agency buys staple crops in regions with high agricultural surplus ("food baskets") to distribute it in regions where food shortages occur. In Laela, the agency buys a limited amount of maize at a prize of TZS 300 per kg (TZS 27.000 per standard bag of 90 kg) which is up to 140% of the price paid directly by the traders. As neither farmers nor the buyers use weighing devices[17], the farmers may thus sell up to 20 kg additional weight per bag than the standard bag of the National Food Reserve Agency. The intermediaries thus have a significant advantage over small farmers.

According to local sources, very few wealthy farmers are able to sell directly to the Agency which prefers to buy a maximum amount of crops from individual traders to lower their transaction costs. On the other hand are local traders effectively controlling access to the Agency by paying bribes to the local employees. In addition to these barriers are small-scale farmers often lacking the capacities and capabilities of transporting their products to the Agency, dealing with officials, waiting for a long time in the queue etc. Thus, the Agency effectively supports and strengthens the position of intermediaries.[18]

Processing of agricultural products takes place mostly externally as the local processing facilities in Laela are limited[19] and processing cost are comparably high. Also selling opportunities for local farmers and traders are rather limited as high transportation costs and risks result in only a small number of external traders operating in Laela. On the other hand are transportation capacities in Laela very limited as only seven individuals own trucks to transport agricultural products to other regions.

Thus, many villagers expect future trading opportunities in Laela to be much more favourable as a result of the road improvement. As a larger number of external traders are expected to come to Laela, higher sales prices for agricultural products are expected. Also, lower retail prices for agricultural implements, consumer goods and energy products are expected.

4.3 Agricultural activities

Rukwa region is characterized by the Tanzanian government as a "food basket" region, resulting in specific political restrictions such as a ban of food exports outside the country and on the use of food crops for energetic purposes. The main crop produced in Laela is maize, followed by finger millet and sunflower. Additionally, groundnuts, beans and sorghum are commonly produced. Livestock keeping is also common as nearly 75% of the farmers use oxen for ploughing and transport.

In a focus group interview the villagers stated that 75% of the territory in Laela is used for agricultural activities, 20% are covered by (mostly degraded) forest and 5% are used for the settlement itself. The territory in Laela is entirely divided among individual farms and local

[17] Instead measurements such as "tins", "buckets" or "bags" are used.

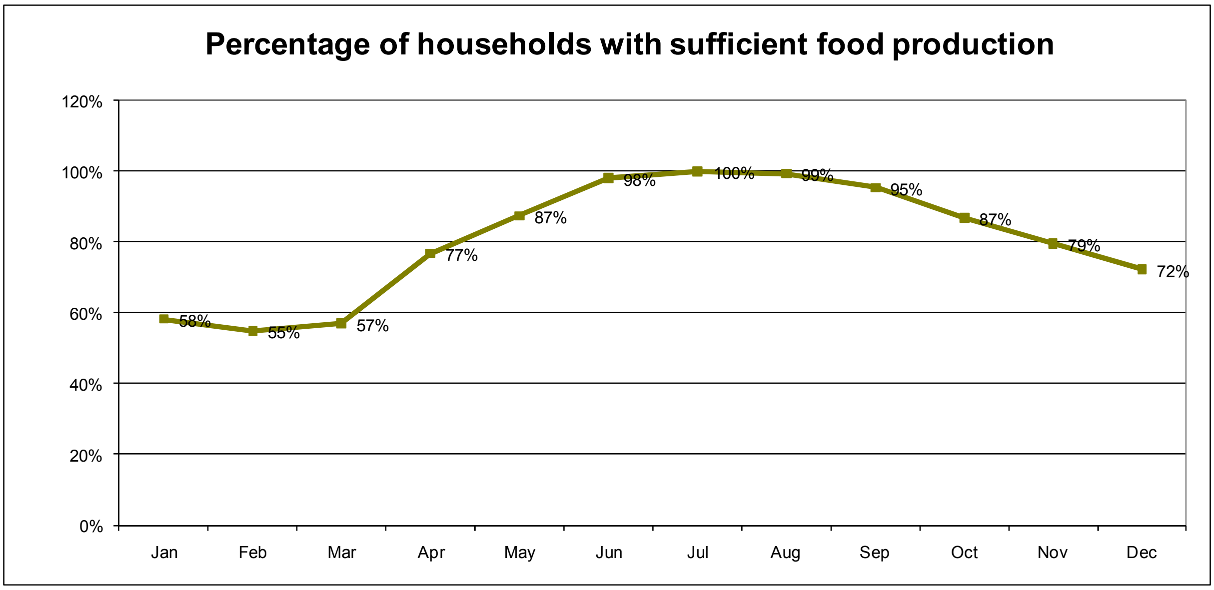
[18] Information based on a discussion with an employee of the storing place in Laela and as confirmed by villagers.

[19] About 10 milling and dehulling machines and two oil pressing machines exist

institutions such as the schools or the Laela Agricultural Centre (LAC)[20] that own large amount of land or it is used as common land – unclaimed land does not exist. As the population is constantly growing and the land is divided among the next generation, average farm sizes are constantly decreasing.

On the other hand, villagers stated that a significant share of the land is not productively used. Thus, no general shortage of land exists as many plots lie fallow or are used very extensively or with low productivity[21] which is a result of highly uneven land distribution. Some of the larger farmers and institutions do not cultivate the entire land they own while many subsistence farmers, due to the constant practice of splitting up the inherited land, are not able to generate enough income to feed their family from their own land. The lack of food is clearly reflected in the survey results as the participants were asked in which months their agricultural production is sufficient to feed their family. Figure 1 shows that food sufficiency is especially low in the early months of the rain season when food supplies are exhausted and crops not yet harvested. Up to March more than 40% of all households have insufficient food supplies to feed their families. In these months poor farmers are forced to work as casual labourers for other farmers or pursue unsustainable and potentially illegal income opportunities such as logging, charcoal making or hunting.

Figure 1: Food sufficiency in Laela



Many of the villagers interviewed also agreed that agricultural outputs in the village could be significantly increased by using a higher amount of agricultural implements, a practice currently not very common due to high costs and lack of capital.

4.3.1 Water availability

The existing water supply systems in the village were regarded as highly insufficient as the few public water tabs available are dysfunctional, water supply from the river Kanteza is only seasonally available and water fetched from wells is of poor quality. Therefore, many people depend on rain as drinking water.

[20] The Laela Agricultural Centre is an agricultural extension centre and agricultural school founded by the Catholic church of Sumbawanga.
[21] In Laela only one tractor is owned by one of the larger farmers (cultivating 30 acres of land).

Especially during the dry season, which takes up to six months, water shortages are a severe problem. Many villagers depend on using their own wells which are often polluted as latrines are likely to be close to the wells. Diarrhea, potentially killing young children and the elderly, is common. Public wells are distant and regularly run dry.

4.3.2 Environment and soil erosion

The environmental degradation in the region was pointed out as highly problematic. Agricultural and pasture lands are overused and deforestation is pervasive due to firewood collection and livestock keeping; reforestation efforts are not existent.

According to local experts, the state of soil erosion is "alarming" and leads to constantly declining soil fertility and yields. It is estimated that 45% of all arable land is affected. Deforestation leads furthermore to high amounts of runoff water washing away soils and destroying infrastructure.

A main indicator for erosion are massively decreasing yields. Around 50% of the agricultural area were labelled by the villagers as being affected by erosion. This situation is worsening as subsistence farmers are continuously forced into the vicious cycle of ever decreasing yields and the resulting higher intensity usage of the plots.

Local knowledge about erosion control measures does exist among many farmers. When asked about countermeasures, especially the planting of trees on farmland boundaries and regular rotation of crops were mentioned. However, only very few farmers practice protection measures as they are perceived as additional labor which is not paying off.

The problems of poor soils and soil erosion are clearly reflected in the survey as almost 80% of the plots cultivated by the villagers interviewed were characterised as being affected by a decrease of soil fertility:

Table 6: Changes in soil fertility[22]

"How would you assess the fertility of the plot now compared to the fertility at acquisition?"		
	Number of mentioning	**Percentage**
Fertility reduced	241	79.28%
Fertility stayed the same	55	18.09%
Fertility improved	8	2.63%

When asked for the reasons for the changes in soil fertility, the participants stated the following main causes:

[22] Total number of replies: 304

Table 7: Main causes attributed to soil fertility change[23]

„Why do you think soil fertility has been reduced or improved?“		
	Number of mentioning	**Percentage**
„Overcultivation“	135	42.32%
„Plot used for a long time“	48	15.05%
„Soil erosion“	14	4.39%
„Water logging“	12	3.76%
„Fertility was *reduced* because fertilizer *was not* applied“	11	3.45%
„Fertility was *improved* because fertilizer *was* applied“	9	2.82%
„Poor farming methods“	9	2.82%

Of the eight plots profiting from improved soil fertility, seven cases were attributed to the application of organic and synthetic fertilizer. This result is confirmed by an estimation of local stakeholders that only 10-15% of the agricultural land of Laela is suitable for continuous agricultural production without any kind of management or inputs.

4.3.3 Forest use and deforestation

The remaining approximately 20% of woodlands in Laela are increasingly under pressure. Villagers relate deforestation, which they perceive as one of the major problems in the village, mainly to charcoal production and firewood collection. Additionally, are houses built from burnt bricks and therefore, as the only potentially successful production requires hot fires over a period of several days, this issue was also considered responsible for deforestation. Furthermore, fires are set to weed grasslands and farm areas which regularly spread into the remaining forests, especially at the end of the dry season. Another reason is the practice of feeding cattle in the remaining forest areas, preventing a natural rejuvenation.

As underlying causes for this, villagers stated that no other option exists for them as (low-cost) energy and income opportunities during the dry season are not available. In addition, many villagers are not aware of the problem as (environmental) education is not practiced in the village. One major protection measure could therefore be awareness raising for the positive benefits of sustainable forest management and tree planting campaigns.

Forest areas are generally not actively managed nor protected by the government that formally owns most forests. One exception is the forest management system the LAC is enforcing in their forest areas.

4.4 Current energy consumption patterns

Lack of energy – especially of electricity – is seen as the most relevant socio-economic problem in the village as has been stated by various individuals and the participants of the focus group interviews.[24] Available energy forms in the village such as kerosene, candles and batteries are perceived as too costly. Additionally, no expertise exists in the village for

[23] Total number of answers: 250; no answer: 69;

[24] Additionally, TaTEDO conducted a village workshop in Laela in 2008 with 23 village officials and individuals from the village including five women. The participants were asked to identify and rank the most important issues and problems in the village. In this ranking energy was regarded as the most important problems.

the installation and maintenance of solar photovoltaic systems which and are only available in the most proximate cities at high prices (TaTEDO, 2008a: 3). Generally, solar home systems are becoming common in rural Tanzania as the government is subsidizing the installation (GTZ, 2009a: 43).

As in most areas in rural Tanzania, the main energy source for cooking is firewood, cut or collected in the local forests whereby its supply is seen as highly insufficient. Firewood collection requires a large share of the daily time especially of women and children as forest resources are dwindling and longer distances have to be crossed to gather firewood.

Although charcoal consumption is not common among farmers, the largest share of the charcoal production is, consumed locally by households mainly working in non-agricultural activities as high transportation costs permit charcoal export.

Figure 2: Charcoal production in Laela

Regarding modern energy sources, only kerosene is widely consumed in nearly every household for lighting purposes. 94% of all households interviewed in the survey used kerosene, consuming an average of 0.96 litres per week[25]. At a price of TZS 1,800[26] per litre, an average household spends about TZS 90,000 per year on kerosene. As no street lighting exists in Laela many people use battery flash lights if walking around at night at average costs of about TZS 42,000.[27]

[25] Ranging between 0.25 and 5 litres per week.

[26] Kerosene prices in Laela are significantly higher than in Sumbawanga (TZS 1,250; 31% lower) and Dar es Salaam (TZS 1,190; 34% lower).

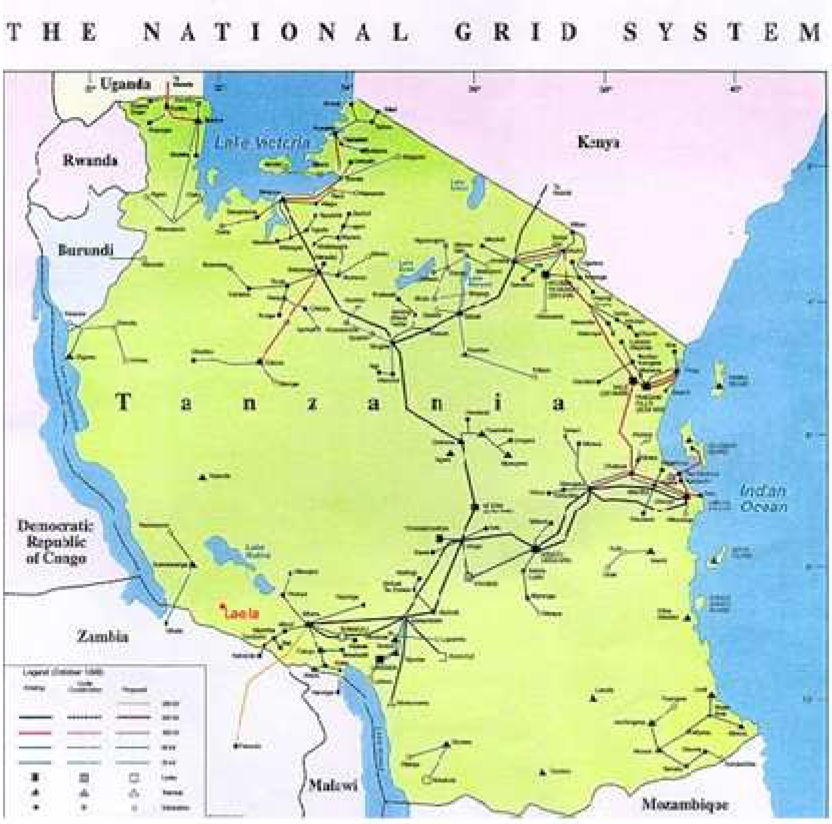
[27] An average family uses two batteries per week amounting to TZS 41,600 per year (TaTEDO, 2008: 23).

4.4.1 Electricity consumption

Typical for rural areas in Tanzania where only 2% of households are connected to the national electricity grid of the state-owned utility Tanesco[28], Laela has no access to grid electricity.

As can be seen in figure 1 the closest electricity transmission lines are not running near the village and are not expected to be extended to Laela in the mid-term.

Figure 3: National Electricity Grid System Tanzania[29]



Some of the more affluent households in Laela use small generator-sets powered with diesel or petrol to produce electricity for very few small applications during some hours per day (e.g. lights, radio, TV, mobile phones). Most of the smaller systems are only used to power individual homes or businesses.

Currently, only one businessman is operating a diesel generator to sell electricity to other costumers. For this purpose a mini-grid of 50 m length was constructed to power seven businesses in Laela Kati which are each charged TZS 5,000 per week.

A comparable business operation which supplied 10 consumers was stopped in October 2010 as the generator building was demolished due to road construction. It is planned to restart the business.

The chairman of the MFP operating company used to run a small energy service company supplying electricity to about 45 houses and businesses through a mini-grid. No installation

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[28] GTZ, 2009: Projektentwicklungsprogramm Ostafrika. Business Guide Erneuerbare Energien Tansania (http://www.gtz.de/de/dokumente/gtz2009-de-business-guide-tansania-draft.pdf)

[29] Source: Geni, 2011

fee was charged but a weekly user fee of TZS 4,000 for private households and TZS 15,000 for businesses. The amount of electricity consumed was not restricted as no electricity meters or load limiting devices[30] were used but certain appliances were prohibited (e.g. electric cattles or cookers and ironing). When the MFP was installed in Laela, the businessman sold the generator and the existing mini-grid was integrated in the newly constructed system.

In very few households and small businesses solar photovoltaic systems are installed which are in most cases coupled with a 12 V direct current battery system to run basic lighting and small appliances such as radios and mobile phone rechargers. In even fewer households inverters are installed to transform the electricity to alternating current to run regular 230 V electrical appliances. Based on the survey it is estimated that about 90 households in Laela A own a solar panel system with at least one solar panel. The average purchasing price for one panel amounted to about TZS 184,000. The only larger photovoltaic system exists in the LAC[31].

4.4.2 Use of electricity generators

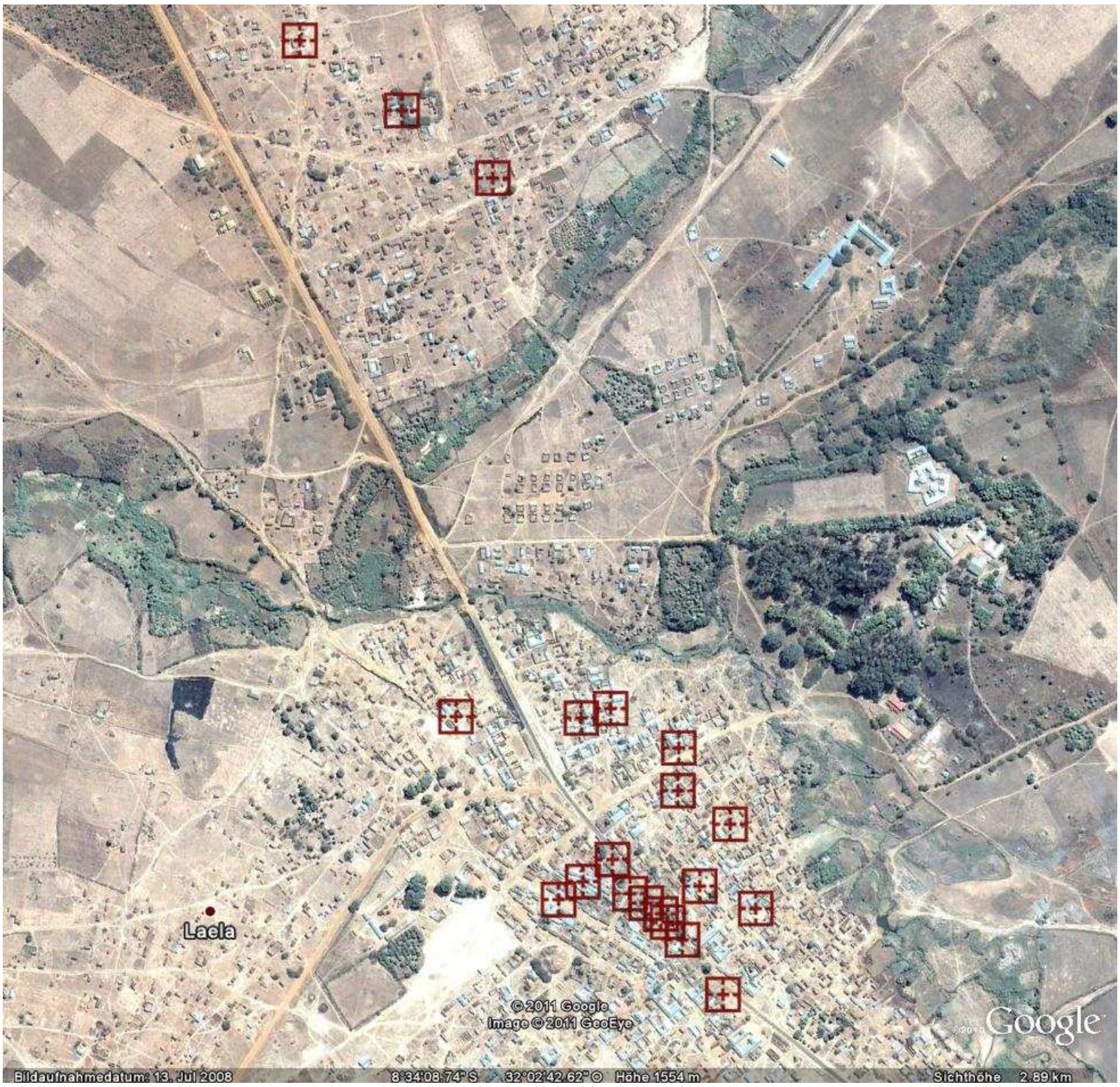
Of the households interviewed in the survey 13.75% (22) own a total number of 33 small- or medium-sized generators, whereby most households (15) only own one generator.

[30] As the costs for metering devices are often prohibitively high, in many small-scale mini-grids the maximum current to be consumed by each costumer is limited to a predetermined and agreed upon level and paid on the basis of this level. Load limiters are overcurrent cutout devices that disconnect a household from the grid if a current is consumed that is higher than what the consumer is paying for or what is agreed upon. The consumer pays a fixed monthly fee according to the rating of his load limiter, irrespective of the kilowatt-hour consumption (NRECA, 2000: 219).

[31] 12 solar panels with 65 Watt peak electrical capacity (0.78 kWp in total), a 3kW inverter and transformer to provide an alternating current 230 V electricity supply including a 100 Amp battery charger and four batteries with each 210 Ah capacity.

Figure 4 depicts the locations of generators in Laela A.

Figure 4: Location of generators in Laela[32]



[32] Two generators in the remote sub-village of Kivuko Mteta are not included.

Table 8 shows the distribution of generators among the four income groups based on the sample and an extrapolation to the total population of Laela A.

Table 8: Distribution of generators according to income group in sample and total population

Income group	Sample		Estimation for total population	
	Number of households owning at least one generator	Number of generators per income group	Number of households owning at least one generator	Number of generators per income group
1	16	26	47	77
2	4	5	36	45
3	1	1	7	6
4	1	1	11	11
Total	**22**	**33**	**100**	**138**

Thus, it can be assumed that about 100 households in Laela A own at least one generator.

4.4.3 Estimation of fuel consumption for electricity production

Based on 21 households interviewed on the performance of their generators, an average consumption of 0.45 litres of fuel per hour of operation was calculated (0.45 litres for petrol generators and 0.48 litres for diesel generators). Of 12 of the generators the electrical capacity and fuel consumption per hour was known so that a total consumption of 4.32 litres of petrol per hour could be calculated to provide a total electrical output of 6,300 W. Thus, it is assumed here that decentralised electricity production with small generators requires an average petrol consumption of about 0.69 litres[33] or 511 g[34] per kWh of electricity.

4.5 Current status of the MFP project

The MFP was installed by TaTEDO in November 2009 as one of the first four MFPs installed in Tanzania by the NGO. Laela was chosen as a site for the MFP project after a group of local businessmen formed a consortium and asked TaTEDO for assistance in implementing a rural electrification system. TaTEDO installed the system and financed the initial investment costs of TZS 3.400.000 According to a contract and a Memorandum of Understanding between TaTEDO and the operating company the ownership of the MFP was transferred to the four entrepreneurs that own and operate the business on equal terms. The initial investment costs were to be paid back in the course of 12 months at a zero interest rate. The entrepreneurs invested an additional TZS 3,000,000 in the construction of the mini-grid[35].

The MFP in Laela consists of a modified two tank 24 hp diesel engine which is adopted to run on SVO, an alternator to power the mini-grid, a battery charging system, and, initially, a milling machine which has meanwhile been sold to purchase a peanut dehuller.

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[33] 4.32 litres per hour to provide 6,300 Wh or 0.685914285 litres per kWh.

[34] Density of one litre of petrol fuel amounts to 0.74 kg (FNR, 2010: 5).

[35] Initially, 32 households were connected to the mini-grid, whereby an expansion of up to 200 households was planned in the mid-term according to the chairman of the operating company. The entrepreneurs paid for the wiring and poles of the mini-grid and generator building; the housewiring had to paid by the costumers that were connected to the grid.

Figure 5: Diesel engine of the MFP

Currently, the MFP in Laela is not operating and has only been in operation for three weeks after installation in November 2009, as major technical difficulties occurred. According to the investors, the main problems were current fluctuations within the mini-grid destroying electrical devices of the costumers (lighting bulbs, TV sets, the electrical motor of a dehulling machine) as well as general quality problems as e.g. the car batteries for supplying electricity to not grid-connected households could not be charged[36].

Further technical difficulties were experienced with the size of the flywheels of both the engine and the alternator which are connected by transmission belts which could result from the fact that the engine runs at a speed of 2,000 rpm but the generator requires only 1,500 rpm for operation. Therefore, the flywheels have to be sized accordingly (engine to generator at a relation of 3 by 4) otherwise the generator would run too fast leading to over-current of the mini-grid explaining why devices were damaged.[37]

TaTEDO and the MFP operating company constructed the mini-grid and the household connection lines but the indoor electrical wiring had to be paid by the costumer. A weekly user fee of TZS 3,000 for households and TZS 10,000 for businesses was charged. However, as the system was only running very unreliably for about three weeks and led to the problems mentioned above, no income was generated.

[36] The low quality of the batteries was proven by the unsuccessful attempt to recharge the batteries in the nearest larger town Sumbawanga

[37] Based on expert input by Simon Gallinger.

To provide electricity to households not connected to the mini-grid, TaTEDO provided 10 batteries and installed a basic electric system in each participating household. The costumers had to make an up-front payment of TZS 10,000 plus down payments of TZS 40,000 in total to be repaid during the following three months.

For grid-connected households the same restrictions applied as in the former systems (see above). Each household was supposed to pay a weekly flat rate for unlimited use (households TZS 3,000, businesses TZS 10,000 per week).[38]

Figure 6: Mini-grid in Laela

4.5.1 Fuel consumption of the MFP[39]

According to its technical specifications, the generator[40] installed in Laela requires a mechanical input power of 20 kW of which 0.6 kW is used for running the generator[41]. Thus, the electrical power provided by the generator amounts to 14.44 kW[42]. As the diesel engine installed in Laela only has an output of 18 kW the generator in the system cannot be run on full efficiency.

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[38] Information based on personal communication on behalf of the author conducted by Ewald Gervas Emil, ICRAF with Mr. Shukuru Meena, TaTEDO project manager of MFP implementation in Laela as well as multiple interviews with Mr. Mahamud Mohamed chairman of the MFP operating company.

[39] The calculations in this section are based on expert input by Simon Gallinger.

[40] Chinese-made Fiadong type with 26 hp/20kW

[41] 94 V * 6.4 A = 0.6 kW

[42] 180 V * 38 A =14.44 kW – the difference between input and output power can be attributed to frictional losses

The generator produces three phases of alternating current at a voltage level of 380 V and current level of 38 A. As the capacity of the engine lacks an output of 10% for the generator to reach full efficiency the electrical output of the system (at the generator) reaches about 12 kW.

The output of the generator cannot be regulated as it requires a constant speed of 1,500 rpm to produce electricity. Based on the technical specification of the equipment manufacturers the system would consume about 390 g of diesel at full capacity (equivalent to about 0.47 litre[43]) to produce one kilowatt hour of electricity. Accordingly, each litre of diesel produces about 2.13 kWh.[44] In one hour of operation the system provides 12 kWh of electricity and consumes about 5.64 litres of diesel.[45] Thus, the daily diesel consumption of the MFP if operated for 14 hours would amount to 78.96 litres of diesel.

NRECA (2000: 44) states that mid-sized diesel generators used to power mini-grids in rural areas of developing countries produce 2 to 3 kWh per litre of diesel (0.4-0.5 litres or 332-415 grams per kWh). Therefore, a generation of 2.13 kWh per litre calculated for the MFP can be considered accurate.

If the fuel consumption for electricity production of the MFP is compared to the decentralized production through small-scale generators (see Table 9), the centralized option is more efficient by about 35%, excluding transmission losses of the mini-grid.

Table 9: Fuel consumption of small and large generators (in litres per kWh)[46]

	Fuel consumption small-scale generators	Fuel consumption large-scale generators
Diesel		0.47
MJ		16.86
Petrol	0.69	
MJ	22.41	

Thus, a central generator can potentially provide electricity at a significantly lower price than what owners of individual energy systems currently pay, still allowing an adequate profit margin for private investments. Based on the calculations above, fuel costs for one kWh of electricity in the MFP (not taking into account generator depreciation costs and tansmission losses) would amount to TZS 1,490[47]. In areas that are connected to the electricity grid, the

[43] Density of one litre of diesel fuel amounts to 0.83 kg (FNR, 2010: 5).

[44] Fuel specific consumption of the engine at rated output according to manufacturer: 253-258,3 g/kW * hr; fuel consumption engine * engine capacity / generator capacity = fuel consumption system: 258.3 g/kWh * 18 kW / 12 kW = 387.5 g/kWh

[45] According to the chairman of the MFP operating company the system consumed 18 litres of diesel for 14 hours of operation (1.3 litres per hour). If the electrical output calculated above of 12 kW is assumed this would amount to a fuel consumption of 9.33 kWh per litre or 0.11 litres per kWh. This figure is highly unlikely and should be much higher. This is especially the case as the owners of the MFP stated that the fuel consumption was significantly higher than they expected.

[46] Based on a heating value of 32.48 MJ/l of petrol and 35.87 MJ//l of diesel (FNR, 2010: 4).

[47] Based on average petrol prices in Laela of TZS 2,160 per litre (five price samples ranging between TZS 2,000 and 2,200).

Tanzanian state utility Tanesco charges TZS 40 to 128 per kWh for small electricity consumers[48] which is a much lower pricer.

4.5.2 Biofuel use in the MFP

In the mid- to long term the MFP in Laela was planned to be run on SVO as all other MFP projects by TaTEDO, in this case from Jatropha curcas.[49] For this purpose the engine has been equipped with a dual tank system and is able to run on SVO without further modification.

Some first attempts to initiate Jatropha production in Laela have been made by TaTEDO but failed thus far. On request of the investors, TaTEDO sent 30kg of Jatropha seeds to Laela in late 2009, as the entrepreneurs planned to cultivate eight acres with Jatropha to produce SVO for running the MFP. However, the germination rate of the seeds was less than 10% thus, the establishment of Jatropha plantations failed and initial plans to add an expeller to the MFP were abandoned. [50]

4.5.3 Future of the MFP project

To restart the project, the members of the operating company are planning to relocate the MFP to the centre of Laela, where the density of businesses with electricity demand is highest. As electricity supply is currently highly inefficient and expensive a business opportunity clearly exists for selling centrally produced electricity to the stores, bars and small businesses in the centre. For this, and the installation of a new mini-grid, an additional investment of approximately TZS 2,000,000[51] would be necessary. Furthermore, technical staff would have to be trained adequately to allow a long-term sustainability of the project.
According to the chairman of the operating company is the lack of technical capability a major bottleneck in operating the MFP and the related mini-grid sustainably. In nearby cities only semiskilled electricians are available.

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[48] The tariff depends on the amount of electricity consumed and on the voltage level required: if less than 50 kWh per month are consumed a subsidized tariff of TZS 40 per kWh is charged. If the consumption remains between 50 and 283 kWh the tariff is raised to TZS 128 (GTZ, 2009a: 30).
[49] Personal communication with Shukuru Meena, TaTEDO
[50] Personal communications with Mr. Balton Mwakitalima, Sumbawanga District Agricultural and Livestock Development Officer, Chairperson of the District Sustainable Energy Cluster and contact person of TaTEDO in Laela.
[51] TZS 1,000,000 for the acquisition of a new building in Laela centre and TZS 1,000,000 for the installation of a new mini-grid.

5. Feasibility of sunflower oil production in Laela

As Jatropha cultivation is currently neither planned by TaTEDO[52] nor by the owners of the MFP, and the establishment of a significant Jatropha production would require at least three years, in the following section the suitability of sunflower SVO as a substitute for fossil diesel is evaluated. Sunflower has been cultivated successfully and widely in the region for many years and the oil could be used without adjustment in the MFP.

5.1 Value chain analysis of current sunflower production in Laela

5.1.1 Current cultivation of sunflower

According to the villagers is sunflower grown on 15% of the arable land in Laela and is therefore the third most important crop.[53]

As many of the farmers practice intercropping, the total acreage of sunflower is difficult to estimate. Of all 66 sunflower farmers interviewed in the household sample, 27% cultivated the crop in mono culture on 18 plots, summing up to an area of 30.5 acres. The other 73% cultivated sunflower on 51 plots in intercropping systems, summing up to an area of 292.75 acres. As sunflower was cultivated together with up to five additional crops and the exact acreage of each crop on intercropped plots is unknown (in most cases also to the farmers), an estimation of 88 acres of sunflower (mono culture-) cultivation on intercropped plots is assumed.[54] Thus, it can be concluded that the 160 households interviewed together cultivate a minimum of 118.5 acres representing about 9% of the total agricultural land of all 160 households interviewed (1,295 acres).

To estimate the total area in Laela A currently cultivated with sunflower, the figures from the sample are corrected by income group and extrapolated (see Table 10).

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[52] Personal communication with Shukuru Meena, TaTEDO

[53] After 55% of maize and equally with groundnuts (15%), followed by finger millet (10%) and beans (5%).

[54] If for example the farmer stated that sunflower and four additional crops were grown on a plot of five acres, an average area of one acre was assumed to be cultivated with sunflower (equal share of each crop). In reality this figure can expected to be much higher as for instance mango or banana trees growing on the side of the same plot with sunflower often require less space than the main crop.

Table 10: Cultivation of sunflower per income group in sample and total population of Laela A (household based extrapolation with correction factors for income group distribution)

Income group	Sample		Estimation for total population	
	Number of farmers cultivating sunflower	Acres cultivated with sunflower	Number of farmers cultivating sunflower	Acres cultivated with sunflower
1	14	45	41	133
2	17	31.5	153	284
3	28	35	159	198
4	7	7	76	76
Total	**66**	**118.5**	**429**	**691**

Thus, based on the sample data, it can be assumed that sunflower is currently cultivated in Laela A by a total of 429 households cultivating a minimum of 691 acres of sunflower (mono culture and intercropped).

5.1.2 Share of arable land used for sunflower cultivation

Table 11 shows the survey results regarding the total number of plots cultivated, the total acreage and the average plot size per income group from the 160 households interviewed and the extrapolation to Laela A. As can be expected, the average plot sizes decrease with the income group. All 1,260 households in Laela A are assumed to cultivate a total number of 2,047 plots with an acreage of 7,403 acres. Based on the calculations above, 691 acres (9.3%) of that land would currently be used for sunflower cultivation which is a bit less than the villager´s estimation (15%).

Table 11: Cultivated land per income group in sample and total population of Laela A (plot based extrapolation)

Income group	Sample			Estimation for total population		
	Total number of plots cultivated	Total acreage cultivated	Average plot size (in acres)	Total number of plots cultivated	Total acreage cultivated	Average plot size (in acres)
1	66	517	7.8	195	1,524	7.8
2	62	258.5	4.2	559	2,331	4.2
3	127	402.25	3.2	719	2,277	3.2
4	53	117.25	2.2	575	1,271	2.2
Total	**308**	**1,295**	**4.2**	**2,047**	**7,403**	**4.2**

5.1.3 Yield estimations for sunflower in Laela

As a result of intercropping are yields per acre as difficult to estimate as the total cultivation area. All 66 farmers interviewed in the sample that cultivate sunflower, produced a total amount of 23,516 to 28,071 kg[55] on a 118.5 acres. Thus, the average yield per acre of sunflower ranges between 198 and 237 kg.

[55] This range of yield estimates results from the fact that the farmers use very inaccurate measurements when estimating the amount of yield they harvested. From the 65 farmers in the sample that cultivated sunflower, 25 farmers used the measurement “bag” or “bucket” without specifying the exact size or weight. Most other farmers used 100 kg bags to estimate their yields. However, experts from the LAC stated that one medium bag of sunflower seeds contains six buckets

Of these farmers 18 cultivated sunflower in mono culture and harvested between 9,778 and 9,870 kg on 30.5 acres, resulting on average to 321 to 324 kg per acre (802 to 810 kg per hectare). In comparison, average per hectare yields of sunflower in Germany between 1995 and 2009 amount to 2,276 kg[56] (Statista, 2011).

Furthermore, 48 farmers cultivated sunflower in an intercropping system and produced a total harvest of 13,738 to 18,201 kg (156 to 207 kg per acre).

Table 12: Total sunflower production of sampled farmers in Laela A during the 2009/2010 rain season (in kg)

	Minimum	Maximum
Mono cultivation	9,778	9,87
Intercropping	13,738	18,201
Total	23,516	28,071

Table 13: Per acre sunflower production of sampled farmers in Laela A during the 2009/2010 rain season (in kg)

	Minimum	Maximum
Mono cultivation	321	324
Intercropping	156	207
Total	198	237

Table 14: Average per acre yields of sunflower by income group in household sample (in kg of sunflower seeds)Table 14 shows that significant differences in average yields per acre exist depending on the income group of the household. Households with higher incomes reach higher yields per acre as more income and capital is available to invest in agricultural inputs.

Table 14: Average per acre yields of sunflower by income group in household sample (in kg of sunflower seeds)

Income group	Average yield per acre (minimum)	Average yield per acre (maximum)
1	393	413
2	262	339
3	117	220
4	260	262
Average over all income groups	258	309

To calculate the total agricultural potential of sunflower in Laela, an average yield of 225 kg per acre was selected, representing the medium value of the range of per acre yield estimates calculated above (intercropped and mono cultivation).

(often called “tins”) of each 8-10 kg, totalling 48-60 kg. Thus, when the measurement “bag” was stated by the farmers, an average weight of 55 kg and the maximum weight of 100 kg have been calculated.

[56] 910.4 kg per acre.

Varieties of calculations were based on statements of farmers and their obvious uncertainty of yield and area estimations. A detailed analysis (cross checking, correlations) of further factors affecting the yields like soil type and inputs could be done for a next step of identifying good practice.

If a minimum of 225 kg of sunflower seeds would be produced per acre of sunflower in Laela A, on the 691 acres of land currently cultivated with sunflower (in mono-culture and intercropped[57]), a total amount of 155,475 kg of sunflower seeds could potentially be produced per year in Laela A without changing the share of cultivated crops.

5.1.4 Trade and processing of sunflower seeds

The main topic of one of the focus group interviews was the local sunflower value-chain. One outcome was that around 75% of sunflower seeds produced in Laela are sold by local traders to be processed in nearby cities. Currently no outside trader buy sunflower seeds in Laela although this is expected to change with completion of the tarmac road making transportation easier.

The remaining 25% of the seeds are processed to sunflower oil by the producers using one of the three diesel powered expellers in Laela. Roughly five retailers trade with together 50-100 litres of sunflower oil per day used for cooking. According to one of the retailers is the consumption higher among households with higher incomes due to better quality and higher prices of sunflower oil. The most common cooking oil however, is imported palm oil mostly produced in Asian countries. As the participants were not aware of middlemen trading with sunflower oil, it is most likely that all sunflower oil produced in Laela is also consumed locally.

Most sunflower processing activities occur in Sumbawanga where about twenty oil mills are operating. According to a representative of a women processing cooperative in Sumbawanga, most processors are family-owned micro businesses that buy sunflower seeds during the harvesting season on the local market or hire a truck to buy directly from the farmers in nearby villages. Laela however, was considered to be too far away to buy seeds and transport them to Sumbawanga economically.

In Sumbawanga the seeds are expelled, sedimented[58] and cooked to remove impurities and odors. Refining to cooking oil is often done by larger agro-processing companies that buy the largest share of the SVO.

Generally, is processing done very rapidly to minimise post-harvesting losses or costs for storage. During the harvesting season when seeds are widely available the expeller of the cooperative in Sumbawanga runs up to 22 hours daily.

5.1.5 Price of sunflower oil

At the time of the survey the retail price of sunflower oil in Laela ranged between TZS 2,000 and TZS 3,000 per litre with an average of all samples of TZS 2,450.[59] According to a retailer one litre is mostly sold for TZS 2,500-2,700 but can go up to TZS 3,000.

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[57] Here just the share of sunflower on intercropped plots is taken into account.

[58] Sedimentation leads to the settlement of small particles and impurities in the raw plant oil by gravity force.

[59] Based on six samples taken in Laela in November and December 2011 from local retailers, expert interviews and participants of focus group interviews.

In Sumbawanga the price ranged between TZS 2,400 and 2,800 depending on the total amount purchased and if bought from retailers in the market or directly from the processor. [60]

Prices for SVO are thus very similar between Laela and the regional processing centre of Sumbawanga explaining the non-ocurance of sunflower oil trade.

During harvesting season[61] when the supply of sunflower seeds is highest the price for sunflower oil in Laela drops significantly by up to 30% ranging from TZS 2,000 to 2,100.

The presscake remaining after the pressing process is being sold to local farmers as feedstock for pork and chicken at a price of TZS 100 per kg in Laela and TZS 250 in Sumbawanga.

5.1.6 Price of sunflower seeds

According to the cooperative in Sumbawanga the price for sunflower seeds bought directly from the farmers in December 2010 was TZS 45.000 for a standard bag of about 60 kg (TZS 750 per kg). During harvesting season this price drops up to 80% to TZS 10.000 per bag (around TZS 170 per kg).

In Laela the price in December 2010 ranged between TZS 30.000 and TZS 40.000 per bag dropping to TZS 10,000 as well during harvesting season. In 2009 slightly higher prices ranging between 15,000 and 25,000 were reached.

As weighting balances are neither widely available nor trusted by the farmers in rural areas, one bag of sunflower seeds may fluctuate between about 48 and 60 kg (up to 20%).[62] Thus, assuming the maximum weight of one standard bag of 60 kg and a minimum wholesale price of TZS 10,000 per bag, the lowest price of sunflower seeds in 2010 was TZS 167 per kg. Based on all price samples collected in Laela the highest price paid for one kg of sunflower seeds would be TZS 833[63].

Ugulumu (2008) estimates production costs of sunflower seeds in Tanzania and Kenya for one acre at TZS 373,457[64] producing up to 16 bags of seeds at a weight of between 60 to 70 kg per bag (960 to 1,120 kg per acre).[65] Production costs of one kg thus amount to TZS 333 to 389 which is much higher than the lowest selling price observed in Laela. This clearly indicates the low price level for agricultural products in Laela as a result of its remoteness.

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[60] Seven price samples collected in Sumbawanga market area and at different pressing companies.

[61] According to the villagers and TaTEDO (2008: 8) sunflower is planted or sown from January to March and harvested between April and June with about three to four months until harvest time.

[62] Personal communication with Mr. Hassan, owner of one of the milling machines and Mr. Mahenge, managing director of LAC

[63] Based on a price of TZS 40,000 per bag of only 48 kg.

[64] US$ 317 based on 2008 exchange rates of TZS 1,178.1 per US$ (source: https://www.cia.gov/library/publications/the-world-factbook/geos/tz.html)

[65] Ugulumu (2008) estimates the weight of one bag higher than the villagers of Laela and the staff of the LAC (48-60 kg). Calculations in this paper are based on the weights per bag common in Laela.

5.2 Food crop implications of the use of sunflower as a biofuel

When using sunflower oil as diesel substitute, a high risk exists of replacing food crop production thereby increasing food insecurity in the village or – more likely - in other regions where the seeds would have been exported.

As currently the agricultural productivity in Laela is very low due to high transportation costs of agricultural products and inputs, it is assumed here that a higher amount of local processing of sunflower seeds would lead to additional income generation in the village, potentially increasing agricultural production through higher level of inputs. As the economic analyses below show, it is economically feasible for the MFP to buy sunflower seeds at a much higher price than the absolute minimum price available in the village and still produce SVO at a price that is competitive to the current diesel price.

The MFP of course would always buy seeds at the lowest price available and would thus not generate additional income in the short term. In the mid-term however, it is very likely, that the additional demand of the MFP could potentially increase overall price levels for sunflower seeds which would hence create additional income for the farmers. As a result, more income would be available to invest in agricultural inputs such as fertilizers, improved seeds etc., thereby potentially increasing agricultural productivity. Thus, it assumed here that in the mid-term the overall production of sunflower seeds in Laela could be increased to continue exporting the largest share of the production and additionally produce sufficient seeds to satisfy the demand of the MFP.

5.3 National regulation

The main obstacle for the establishment of a local value chain for sunflower SVO to be used as a biofuel in the MFP is the national regulation regarding biofuel production in Tanzania. Currently, the use of food crops as biofuels is prohibited by national law in regions with high production of staple crops (“food basket regions”). Thus, the use of sunflower SVO in Rukwa region is currently not possible.

In this thesis the feasibility of the use of sunflower as a biofuel for local electrification is nevertheless assessed, because it is assumed that establishing a local value-chain would create additional income and thus increase overall agricultural productivity (see above). Widespread food insecurity in Laela is not mainly seen as a result of insufficient food production as currently the largest share of agricultural production is exported (also – illegally - outside of Tanzania). Malnutrition is rather seen as a result of a lack of income opportunities especially during the dry season. Local processing of agricultural products and thus value addition could potentially improve food security for the poorest farmers in the village.

5.4 Economic analysis of sunflower oil as diesel substitute

In the following section three scenarios of local sunflower SVO production as a substitute for diesel fuel are assessed:

1) Centralized seed processing using the existing diesel powered oil expellers in Laela. The seeds are bought directly from the farmers after the harvest and processed immediately.
2) Centralized processing when demand for the expeller is lowest during the dry season requiring storage of seeds.
3) Decentralized processing using small hand-driven oil expellers provided to small-scale farmers. Processing takes place during the dry season when labour demand is lowest.

5.4.1 Economic analysis of centralised processing after harvesting

In this scenario it is assumed that processing takes places using the three existing diesel powered oil expellers in Laela. The seeds are bought directly from the farmers in Laela and the surrounding villages when the prices are at the lowest point during harvesting season. The seeds are transported and processed by workers hired by the MFP. After filtration and sedimentation, the sunflower oil is stored in oil barrels on the premises of the MFP.

Table 15 shows the results of the economic analysis of sunflower oil to be used as a diesel substitute. Each parameter of the economic analysis is elaborated in detail below.

Table 15: Economic analysis of the production costs of sunflower oil in Laela (scenario I: centralized processing after harvesting)

[redacted]

5.4.1.1 Diesel consumption

If the generator of the MFP would be properly adjusted it should consume about 5.6 litres of diesel fuel per hour to produce 12 kWh (see above). As it was planned to run the generator for 14 hours per day the daily consumption would amount to 78.4 litres of fuel per day. If the system would be operating throughout the year without failures, it would theoretically consume **28,616 litres of diesel fuel per year**.

5.4.1.2 Diesel price

One litre of diesel in Laela costs about TZS 1,800. However, as the quality level of fuels available in rural areas is often very poor as fuels are diluted to increase profit margins[66]. Also fuel quantities are often inaccurate as non-standardized containers are used so that the exact amount sold for a fixed price fluctuates significantly. Thus, real adjusted prices may be higher than the prices observed in the field. However, as the economic analysis here is conducted conservatively, a **diesel price of TZS 1,800** is used. Diesel prices at petrol

[66] According to one fuel retailer in Laela profit margins in fuel trading are extremely low as most of the little surcharge that can be added to the purchase price (if it is too high people purchase directly in Sumbawanga) is used up by the high transportation costs of bringing little quantities from Sumbawanga to Laela.

stations in Sumbawanga were the same or even higher[67] as in Laela which gives some indication that the diesel available in Laela is of lower quality. Villagers with high fuel consumption (the owners of larger generators and of agro-processing machine) stated that they buy fuels directly from brand-name petrol stations in Sumbawanga as quality and prices are better.

The future development of diesel prices in Laela is difficult to predict. Many villagers expect prices to fall significantly as soon as the tarmac road will be finalized. On the other hand, however, the increasing scarcity of fossil fuels as well as increasingly stricter climate regulation will most likely lead to an overall increase of fossil fuels in the mid to long-term.

5.4.1.3 Oil extraction rate

According to different villagers and the owner of the expeller about 3 to 3.5 kg of sunflower seeds yield one litre of sunflower oil (extraction efficiency of 26-31%)[68]. A small decentralized rape seed oil mill in Germany reaches a higher extraction efficiency of 34%.[69] Here, a conservative extraction efficiency of **3.5 kg seeds per litre of sunflower oil** (26%) is assumed.

5.4.1.4 Sunflower seed prices

Three different price scenarios are assessed:

1) The lowest price of sunflower seeds reported in Laela: TZS 170 per kg seeds[70]
2) The break-even price when the production cost of 1.1291 litres of sunflower oil (the equivalent of one litre of diesel) becomes competitive to fossil diesel: 330 TZS per kg seeds
3) The highest price of sunflower seeds reported in Laela: TZS 833 per kg seeds.

5.4.1.5 Expeller capacity

According to the owner of one of the expellers in Laela, the daily processing capacity of the expeller is 10-20 bags of sunflower seeds. Assuming that one bag weighs 50-60 kg, in a typical working day of eight hours 500-1,200 kg of seeds could be processed. Thus, the expeller reaches a capacity of 62.5 to 150 kg per hour. However, as the oil press in Sumbawanga runs for up to 22 hours daily during the harvesting time it can be assumed that the expeller in Laela also runs for more than eight hours during peak time.

Here an extraction capacity of **100 kg per hour** is assumed (20 bags of 60 kg in 12 hours). Therefore, on a typical working day of eight hours, 800 kg of sunflower seeds can be processed yielding 228.57 litres of sunflower SVO.

5.4.1.6 Wages

According to the villagers, daily wages for casual unskilled labourers in Laela range between TZS 1,000 and 3,000 depending on the season:

[67] Diesel prices at petrol stations of TZS 1,850 to 1,870 were observed.

[68] One litre of sunflower oil weighs 0.92 kg at 15°C (FNR, 2010: 4).

[69] 336 kg of oil per 1,000 kg of seeds (FNR, 2009: 64).

[70] The exact price reported by the villagers was TZS 10,000 per bag. Assuming that one bag has a maximum weight of 60 kg, the seeds would be sold at a price of TZS 167 per kg.

Table 16: Daily wages for casual unskilled workers in Laela (in TZS)[71]

	Minimum	Maximum
During dry season	1,000	1,500
During high demand periods	2,000	3,000

Here, the highest daily wage of TZS 3,000 is assumed as most of the labour would be required for the transportation and expelling of the seeds which takes place during the harvesting time when demand for labour in Laela is at its peak. One full working day is assumed to have eight hours. Thus, an **hourly wage of TZS 375** is assumed.

5.4.1.7 Expeller costs

The owner of the expellers charges TZS 1.000 for pressing about 10 kg of sunflower seeds (TZS 100 per kg). In Sumbawanga where about twenty pressing machines exist the pressing charge for one kg is about half that price (TZS 4.000 for about 90 kg of seeds or TZS 45 per kg). This further illustrates why no export of sunflower oil from Laela takes place as processing costs are much higher.

TaTEDO (2008: 43) assumes capital costs (depreciation and maintenance) for a mechanical "Sundaya" oil expeller of TZS 30 per kg seeds processed which is significantly lower than both user charges mentioned above.

However, high processing costs in Laela could be explained by the following factors:

- high fuel prices in Laela due to high transportation costs
- low utilization rate of the expeller of only six months per year
- low level of competition in the village (only three machines exist in Laela; transport of the seeds and oil to Sumbawanga and back would most likely not be competitive).

Thus, in the economic analysis, the regular charge for using the oil expeller in Laela of **TZS 100 per kg** is assumed.

[71] Based on personal communication with villagers and focus group interviews.

Figure 7: Mechanical oil expeller in Laela

5.4.1.8 Labour costs for expelling and filtration

It is assumed that the production of one litre of SVO requires 3.5 kg of seeds. As the expeller is assumed to process 100 kg per hour it would take 2.1 minutes (0.035 hours) of labour. At hourly wages of TZS 375, labour costs of TZS 13.125 for the operation of the expeller can be assumed. The processing of one kg thus would cost TZS 3.75.

TaTEDO (2008: 43) estimates the total costs of pressing one kg of Jatropha seeds at TZS 100 (TZS 70 for labour and TZS 30 for the depreciation and maintenance of the oil expeller as the investment costs are included in the economic analysis[72]). However, TaTEDO is neither indicating how much time is required for each task nor the wage paid for one hour of labour. As the processing capacities of both expellers are assumed to be similar (100 kg of sunflower seeds in Laela versus 77 kg of Jatropha seeds in TaTEDO´s estimation) and also the oil recovery rates of sunflower seeds and Jatropha seeds are similar (4 kg of Jatropha seeds are required to produce one litre of SVO[73]) the labour costs of TZS 70 per kg of oil expelling assumed be TaTEDO are considered to be too high.

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[72] TaTEDO recommends using a Sundaya oil expeller (known as Sayari in Tanzania). According to the specifications of the manufacturer it can press 80-100 kg of sunflower seeds and according to TaTEDO up to 77 kg of Jatropha seeds per hour. For the pressing of 100 kg of sunflower seeds it uses about 1.43 to 2.14 litres of diesel. Investment costs are TZS 3.2 million if the expeller is attached to the diesel engine of the MFP.

[73] Fact Foundation (2010: 39) however states that oil recovery of mechanical presses may reach 90-95% of the oil content in the seeds. Regarding Jatropha a recovery rate of 100% would yield 0.41

TaTEDO however, is not taking into account additional labour costs for the transportation of the seeds (see below) and might have included these costs in the costs required for expelling.

Here, **labour costs for expelling** of the seeds are assumed to be **TZS 5 per kg of seeds**.

Additionally, the filtration or sedimentation of the SVO is required before it can be used in the diesel engine. TaTEDO (2008: 43) estimates the labour costs for sedimentation and filtering of one litre of Jatropha oil at TZS 120 (TZS 30 per kg of processed seeds). Based on the wages assumed here this would correspond to an average labour time of about twenty minutes to filter one litre of SVO or about five minutes per kg of seeds. As no data could be collected on the labour requirements of **filtering and sedimentation** during the field research, labour costs of **TZS 30 per kg of seeds** is used here as well.

5.4.1.9 Transportation

Additional labour and capital costs are required for the transportation of the seeds from the farmers to the expeller and the SVO to the MFP.

A sunflower trader interviewed in Laela stated that the transportation of one bag of sunflower seeds from the farmer to a buyer in Sumbawanga cost him TZS 1,200 plus an additional TZS 500 for labour costs to carry the bag from the farm gate in the truck and from the truck to the warehouse. Assuming an average weight of 55 kg per bag, transportation costs amount to TZS 22 per kg, plus another TZS 9 per kg in labour costs for loading and off-loading the seeds.

Transportation costs of sunflower seeds within Laela and the surrounding villages are assumed to be more expensive than the costs stated by the trader. Although transport distances are much shorter than in the case of shipping large amounts of seeds to Sumbawanga etc., the amount transported with every shipment is assumed to be smaller as the capacity of the expeller is limited. During the harvesting time the demand for the expeller can be expected to be at its peak as most producers want to process their sunflower seeds. Therefore, the transportation needs to be done for comparably smaller amounts of seeds, thereby increasing costs. Thus, here **transportation costs** are estimated at **TZS 50 per kg** for transporting sunflower seeds from farmers in Laela and surrounding villages to the expeller and sunflower oil to the MFP. Additional labour costs for **carrying** the seeds are estimated at **TZS 10 per kg**.

Summing up the labour costs required for the transportation and processing of one kg of seeds, total costs of TZS 65 can be assumed. This figure comes close to the TZS 70 assumed by TaTEDO for the expelling of one kg of seeds.

5.4.1.10 Income from presscake

Sunflower presscake can be sold in Laela for **TZS 100 per kg** to be used as animal feed. If 3.5 kg of sunflower seeds yield one litre of sunflower oil (0.92 kg), approximately 2.6 kg of presscake are left after expelling. Thus, for each kg of seeds processed an output of 0.74 kg of presscake can be sold for TZH 74.

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litre per kg. Thus, about 2.71 kg of seeds would yield one litre of pure plant oil. TaTEDO (2010: 43) calculates with 4 kg of seeds required to produce one litre of plant oil.

5.4.1.11 Heating value of sunflower as compared to diesel

The energy content of one litre of sunflower oil (heating value: 37.1 MJ/kg) is only 87.09% of the energy content of one litre of diesel (heating value: 42.6 MJ/kg). Thus, the **energy equivalent** to one litre of fossil diesel is **1.1291 litre of sunflower oil**.[74]

5.4.1.12 Results

The economic analysis shows that sunflower oil production in Laela within the parameter specified above would be competitive to current diesel prices up to a purchase price of sunflower seeds at the farm gate of TZS 330 per kg (approximately TZS 16,000 to 20,000 per bag depending on the weight of the bag[75]). In the low price scenario (purchasing price of TZS 170 per kg of seeds), production costs of the sunflower oil equivalent to one litre of diesel amount to TZS 1,150 which is highly competitive compared with the diesel price of 1,800 per litre. Figure 1 shows the production costs of one litre of sunflower oil based on the three seed price scenarios and the cost for the fossil diesel equivalent to one litre of sunflower oil as reference scenario[76].

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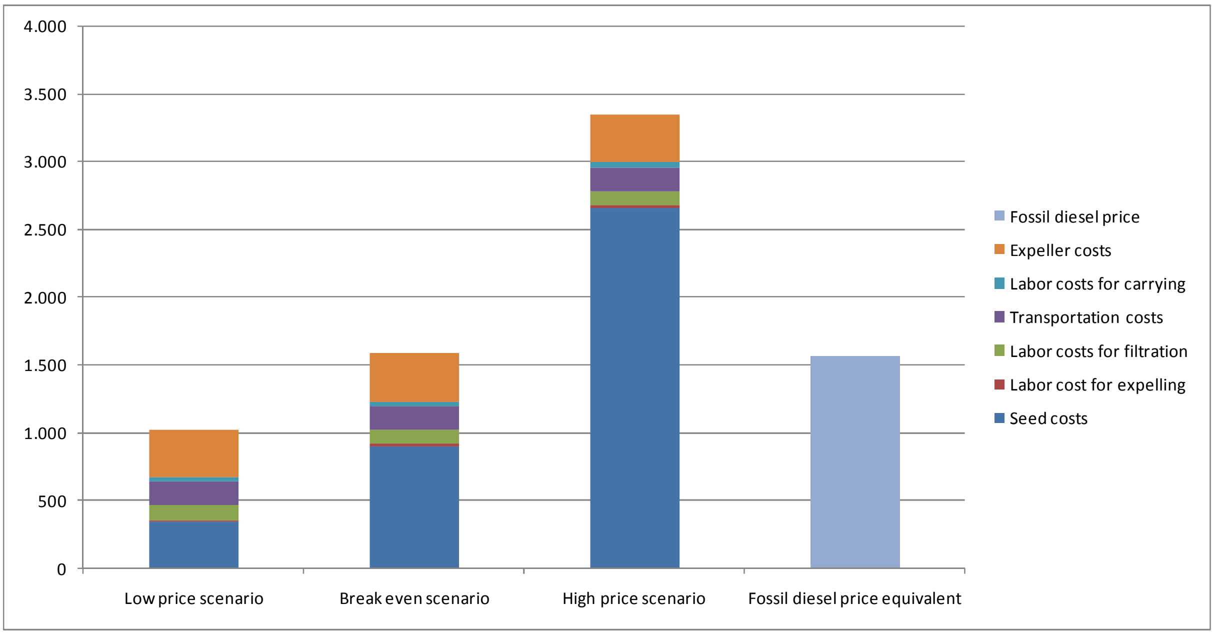
[74] Based on FNR, 2010: 4.

[75] Assuming a weight of 48-60 kg per bag.

[76] The fossil diesel equivalent to one litre of sunflower oil is 0.8709 litres at a price of TZS 1567.61. Note that the production costs for one litre of sunflower oil in the break even scenario is in fact higher than the diesel equivalent (TZS 1,578.50 as compared to TZS 1567.61 for 0.8709 litres of diesel).

Figure 8: Production costs (in TZS) of one litre of sunflower oil (scenario I)[77]



To substitute the annual diesel consumption of the MFP about 32,000 litres of sunflower oil would have to produced, requiring approximately 113,000 kg of sunflower seeds (see Table 17).

Table 17: Requirements of sunflower seeds and oil for the substitution of the annual diesel consumption of the MFP

Diesel consumption of MFP per year (l)	28.616,00
Sunflower oil consumption per year (l)	32.310,33
Sunflower seeds required (kg)	113.086,14
Number of bags (at 55 kg per bag)	2.056,11

Assuming a minimum yield of 225 kg of sunflower seeds per acre, 503 acres of land would be required to produce sufficient amounts of sunflower seeds. As the total arable land in Laela A is 7,403 acres, 6.8% of that land would be required to produce the required amount of seeds.

Based on the survey, it is assumed that a total of 691 acres were cultivated in the last rain season with sunflower in Laela A, yielding a minimum total amount of 155,475 kg of sunflower seeds. Of that amount 113,086 kg (73%) would be required to fully substitute the diesel consumption of the MFP to provide electricity for a total number of 200 households[78] for 14 hours per day[79].

[77] The income from the selling of the presscake (TZS 259 per litre) is deducted from the seed costs.

[78] According to Mr. Meena, TaTEDO, in the mid-term about 200 households were planned to be connected to the mini-grid. The existing generator is capable of providing sufficient amount of electricity without using more fuel.

[79] 14 hours of operation is rather high for small mini-grids in rural areas. According to NRECA (2000) typical operation times are about four hours during the evening. On the other hand however, in Laela various current and potential energy consumers exist with constant energy consumption (dehulling, milling and expelling machines currently run on expensive diesel fuel, bars and restaurants, barber shops etc.

As each expeller in Laela is assumed to have the capacity to process 20 bags of sunflower seeds per day the pressing of the seeds would alone require about 33 full working days using all three expellers in Laela. However, as the expellers are only operated for about six months a year sufficient capacity would be available to process this amount of seeds and further value-addition would take place in the village.

As market prices for sunflower oil in Laela are significantly higher than the production costs calculated here based on sunflower seed prices, the question is obvious why farmers would not be processing more of their seeds directly, store the oil and sell it on the market when they can reach good prices.

The reason why this is not taking place is that the local market for sunflower oil is very limited and export to other markets is not competitive. This is shown by the fact that currently no export of sunflower oil from Laela is taking place but only seeds are exported. It can be concluded that processing costs in Laela are too high to be competitive with larger and more efficient processing companies. Processing costs in Laela are high because the pressing machines in Laela are comparably old, inefficient and small. The main reason however, are high energy costs for processing the seeds using diesel-powered expellers. Most processers in Sumbawanga use much cheaper electricity-powered expeller.

Another factor inhibiting export to other markets are high transport costs from Laela. If however, energy would be available at the same price as in Sumbawanga, processing in Laela would be at a cost advantage as the energy content and thus value of sunflower oil as compared to sunflower seeds is much higher.

Additionally, the local market for SVO as cooking oil is very limited. However, the premium paid for sunflower oil in comparison to imported palm oil is not known thus it can only be assumed that locally produced sunflower oil will not be able to compete with and substitute imported palm oil.

In summary, it is assumed here that business opportunities for the production of sunflower oil in Laela to sell it on the local market or export it to other markets currently do not exist. Thus, processing for local consumption is the only market available. Two sub-markets could be differentiated: a higher priced market for cooking sunflower oil that requires certain value-addition to SVO (refining, cooking, etc.) and a lower priced market for SVO to be used in diesel engines. As the former market is very limited, the only possibility of extending the market for producers of SVO would be to sell the SVO at a lower price making it competitive with diesel. This business case is very likely only profitable if the end consumer of the diesel substitute would organize the value chain of sunflower seed processing to be able to source lower cost fuels or the producer of seeds would process the seeds directly.

5.4.2 Economic analysis of centralised processing during the dry season

The production costs of sunflower oil could be further decreased if the two largest cost factors – labour costs and expeller costs - would be optimised. Both could potentially be reduced if the processing is done during times of low demand for labour and the expeller. As the expeller is only used for about six months after harvest season, it is assumed that a lower user fee for the expeller can be negotiated with the owners when used during times when demand for the machine is low. Labour costs in Laela on the other hand decline significantly when demand for workers is at its lowest during the dry season.

Another option to reduce production costs for the MFP company would be to purchase an oil expeller itself to reduce the dependency on the owners of the oil expellers in Laela. It is assumed however, that negotiating a lower price with the owners of the existing expellers would be a more economical option as the existing expellers are not used at full capacity providing sufficient capacities to process the seed demand of the MFP. Also, an additional expeller would most likely not be used at full capacity, thereby increasing depreciation costs that would have to be taken into account which might even be higher than using the existing expellers at a reduced user charge.

In order to purchase the seeds at the lowest price and benefit from low labour and expeller costs after times of peak demand, the seeds need to be stored for some months without experiencing quality losses. Sunflower seeds need to be dried to about 9% moisture content before storage. During storage the seeds are liable to damage by insects and other storage pests so that measures such as good ventilation and application of preserving chemicals need to be applied (FAO, 1999: 5). The interviewed sunflower trader confirmed that chemicals need to be purchased to preserve sunflower seeds during storage.

Here it is assumed that the company operating the MFP would invest in a large storage facility for both the seeds and the fuel (including chemicals for preservation of the seeds) so that purchase and processing are done when prices are optimal.

Below all parameters are elaborated that have been modified in comparison to the first economic analysis.

5.4.2.1 Wages

As the processing of the seeds in this scenario would take place in the dry season, the lowest reported daily wage of TZS 1,000 (TZS 125 per hour) is assumed.

5.4.2.2 Expeller costs

It is assumed that a conservative tariff reduction of 10% (processing charge of TZS 90 per kg) could be negotiated with the owners of the expeller if the machines are used during times of low demand. This figure is not put higher as it is expected that profit margins for the operators of the machines are not much higher than this figure as high fuel and depreciation costs need to be incurred.

5.4.2.3 Labour costs for expelling, filtration and carrying

Labour costs for the operation of the expeller are reduced (by one third) to TZS 1.7 per kg of seeds, filtration and sedimentation costs to TZS 10 per kg. Costs for transportation and carrying are not reduced as these would still take place during the harvesting season.

5.4.2.4 Storage

Storage costs were assessed in the focus group interview on the value chain of sunflower seeds and oil. The sunflower traders stated that they store the seeds for some months after purchasing from the farmers right after harvesting. The storage time depends on the development of the market prices and fluctuates every year. According to the traders storage costs up to the time when the supply of seeds has declined and market prices improved, amount to an average of TZS 500 per bag (TZS 8.3 at 60 kg per bag and TZS 10.4 at 48 kg per bag) including costs for the storage facility and the chemicals needed to prevent losses through insects and pests. The dried seeds bought from the farmers are packed in bags and stored in ventilated rooms. Additionally, bags have to be purchased every year for about TZS 600 each (TZS 10 to 12.5 per kg) as the seeds are sold in bags to other traders or agro-processors.

Here, storage costs are estimated at TZS 1,000 per bag (TZS 20 per kg), because the storage is assumed to be required for a longer time as it is the case for most traders that typically sell after some months when prices have increased. In order to benefit from lower labour and expeller costs, it is very likely that the seeds need to be stored for a period of at least six months before processing. Bags are assumed to be reused for multiple times so that depreciation costs for the bags are included in the cost estimation.

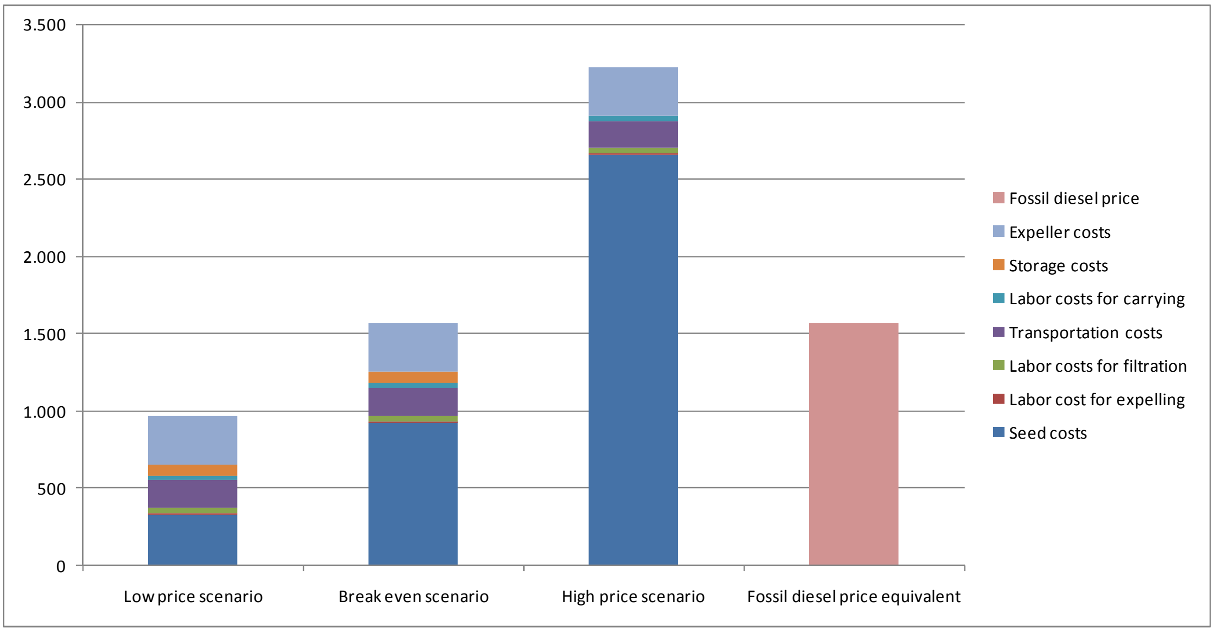
5.4.2.5 Results

The economic analysis shows that sunflower oil production in Laela when processing takes place outside of peak demand times would be slightly more competitive than the first analysis up to a purchase price of sunflower seeds at the farm gate of TZS 350 per kg (approximately TZS 16,300 to 20,400 per bag).

Table 18: Economic analysis of the production costs of sunflower oil in Laela (scenario II: centralized processing during the dry season)

Parameters	Low price scenario	Break even scenario	High price scenario
Diesel consumption MFP l / y	28.616,00	28.616,00	28.616,00
Diesel price TZS/l	1.800,00	1.800,00	1.800,00
Oil extraction rate kg/l	3,50	3,50	3,50
Price of sunflower seeds TZS/kg	170,00	350,00	833,00
Oil pressed per working day in l/day	228,57	228,57	228,57
Wages in TZS/hour	125,00	125,00	125,00
Expeller costs in TZS/kg	90,00	90,00	90,00
Labor costs for expelling seeds TZS/kg	1,70	1,70	1,70
Labor costs for filtration TZS/kg	10,00	10,00	10,00
Transportation costs TZS/kg	50,00	50,00	50,00
Labor costs for carrying TZS/kg	10,00	10,00	10,00
Storage costs TZS/kg	20,00	20,00	20,00
Income from press cake TZS/kg seed cake	100,00	100,00	100,00
Crude plant oil output in kg per kg seeds	0,26	0,26	0,26
Seed cake output kg per kg seeds	0,74	0,74	0,74
Heating value sunflower oil MJ/kg	37,10	37,10	37,10
Heating value diesel MJ/kg	42,60	42,60	42,60
Heating value sunflower oil to diesel %	87,09%	87,09%	87,09%
Sunflower oil equivalent to one litre of diesel	1,1291	1,1291	1,1291
Production costs for one liter of crude sunflower oil			
Seed costs	595,00	1.225,00	2.915,50
Labor cost for expelling	5,95	5,95	5,95
Labor costs for filtration	35,00	35,00	35,00
Transportation costs	175,00	175,00	175,00
Labor costs for carrying	35,00	35,00	35,00
Storage costs	70,00	70,00	
Expeller costs	315,00	315,00	315,00
Income from press cake	-259,00	-259,00	-259,00
One litre of sunflower oil	**971,95**	**1.601,95**	**3.222,45**
Sunflower oil equivalent to one litre of diesel	**1.097,43**	**1.808,76**	**3.638,47**

Figure 9: Production costs (in TZS) of one litre of sunflower oil (scenario II)[80]



[80] The income from the selling of the presscake (TZS 259 per litre) is deducted from the seed costs.

5.4.3 Economic analysis of small-scale manual extraction

As expelling costs are relatively high in Laela and labour costs very low during the dry season, seed processing could alternatively be done on a decentralized basis by subsistence farmers. Thereby, processing costs could be decreased and income generated for subsistence farmers.

For this purpose small hand-powered oil expellers could be provided to poor households possibly financed through a micro credit scheme to be paid back by the farmers on a long term basis. The scheme could be financed by external development financing organizations[81]. The LAC might be a suitable local partner for implementing such a financing scheme as it has a long record in extension projects with small-scale farmers and – as has been confirmed by different local stakeholders - is widely regarded by the villagers as a trustworthy partner in agricultural and financial matters. Additionally, capacity building measures such as trainings or workshops on the use of the expellers or adequate storage of seeds could be provided to the farmers by the LAC.

Profits for small-scale oil processors are potentially highest if the seeds are bought in large quantities when prices are low, stored and processed continuously over the dry season. Storage of the seeds could be organized centrally by the LAC to minimize storage costs, although this approach might increase transportation costs. The seeds could be sold to the farmers at the purchase price plus a fee for incurring the costs of storage and preservation.

Alternatively, the farmers could be provided with a suitable small storage container (i.e. a small and airtight plastic barrel closed with a lid) and potentially grain protecting chemicals to reduce post-harvest losses by pests and decay (for more information see FAO, 2011). If farmers are able to store their harvest for a prolonged time they are also able to continuously process the seeds after the busy harvest time when few income alternatives exist. By enabling local farmers to process their own sunflower seeds and sell the oil to the MFP, poverty reduction could be combined with low-cost energy provision using local energy sources. The MFP could source low-cost fuel and invest some of its profits in a continuous expansion of the mini-grid which would benefit the local population.

Small-scale processing could potentially benefit low-income women and children in particular as additional family income would be generated during the dry season when proper nutrition, school and health expenditures etc. are insufficient. As domestic work and the processing of food crops in Laela is traditionally in the responsibility of women[82], there is a higher chance that the additional money earned through seed processing would at least partly be at the disposal of the women and spent on better nutrition during the dry season, education, health etc. Case studies of different sub-Saharan African countries showed that the situation of women and children improved significantly after the introduction of a MFP that drastically reduced the daily workload for women (especially in grinding of cereals) and led to an increase of income (see for example UNDP, 2009).

A widespread problem in Laela is alcoholism especially among men who sometimes use significant parts of the family income to buy “local brew”[83]. This is especially a problem during

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[81] An analysis and recommendation of potential domestic or international governmental or non-governmental financing organisations, programmes or schemes is not in the scope of this Master thesis.

[82] For a list of typical daily activities of women in Laela see TaTEDO, 2008: 9 and Annex III.

[83] A low-price alcoholic beverage produced locally from fermented maize.

the dry season. To prevent this problem, the micro credit financing the expeller could be handed out to women only (or cooperatives of women) as it is widely practiced in various micro finance programs all around the developing world.[84]

Another benefit of small-scale processing would be that farmers producing small amounts of sunflower seeds would not be forced to sell their harvest to traders directly after the harvesting when prices are lowest. Instead, they would be enabled to store their crops and process the seeds during times of low labour and income. Even if the SVO price paid by the MFP would require processing seeds at the minimum seed price, still additional value and income for the farmer could be generated. As many small farmers are currently forced to sell their crops at a minimum price right after harvest (because they are not able to store the seeds), processing of the seeds could be beneficial to them as it would generate income through (paid) labour during the dry season. This value-chain restructuring would lead to a higher value-addition at producer level compared to external processing, e.g. outside of the village.

One example of a low-cost small-scale expeller available on the market is the Piteba press that is available at a price of about TZS 150,000 when purchased in a larger number of about ten presses (shipping costs from the Netherlands included).[85] The Piteba expeller is a low cost, manually operated oil expeller suitable for a wide variety of oil fruits. By heating the press though a small oil lamp relatively high extraction rates (when compared to the expeller currently used in Laela) of the oil content in the seeds are reached. The expeller is robust in design and supposedly needs almost no spare parts and no maintenance except for daily cleaning and greasing (Piteba, 2011).

Figure 10: Pictures of Piteba manual oil expeller[86]

When compared to the current costs of the diesel powered mechanical expellers available in the village, break even of the investment costs would be reached after about 1,500 kg of seeds were processed.[87] With a throughput of 3.4-3.6 kg of seeds per hour it would take about 430 hours or 54 working days to cover the investment costs of the expeller.

[84] In a comprehensive review of micro finance issues Brau et al. (2004) state that “women use borrowed funds better than men in Bangladesh microfinance programs” (Pitt and Khandker, 1998) and that “membership in microfinance programs among other factors is positively related to women's empowerment” (Amin et al., 1998).

[85] All information on the press are taken from the website of Piteba (2011).

[86] Source: Piteba (2011)

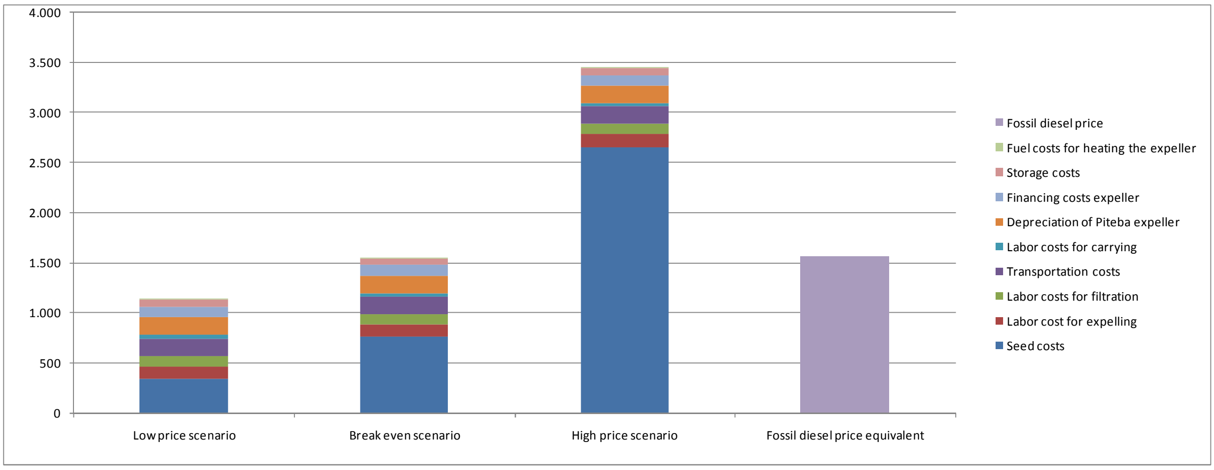
[87] Including additional operational costs of about TZS 4,300 for the purchase of kerosene to heat the expeller.

Table 19 shows the results of the economic analysis of sunflower oil to be used as a Diesel substitute as produced on a small scale.

Table 19: Economic analysis of the production costs of sunflower oil in Laela (scenario III: decentralised small-scale production)

Parameters	Low price scenario	Break even scenario	High price scenario
Diesel consumption MFP l / y	28.616,00	28.616,00	28.616,00
Diesel price TZS/l	1.800,00	1.800,00	1.800,00
Kerosene price TZS/l	1.800,00	1.800,00	1.800,00
Oil extraction rate kg/l	3,50	3,50	3,50
Price of sunflower seeds TZS/kg	170,00	320,00	833,00
Oil pressed per working day in l/day	9,13	9,13	9,13
Wages in TZS/hour	125,00	125,00	125,00
Depreciation of Piteba expeller in TZS/kg	50,00	50,00	50,00
Financing costs expeller in TZS/kg	30,00	30,00	30,00
Fuel costs for heating the expeller TZS/kg	3,00	3,00	3,00
Labor costs for expelling seeds TZS/kg	36,00	36,00	36,00
Labor costs for filtration TZS/kg	10,00	10,00	10,00
Transportation costs TZS/kg	50,00	50,00	50,00
Labor costs for carrying TZS/kg	10,00	10,00	10,00
Storage costs TZS/kg	20,00	20,00	20,00
Income from press cake TZS/kg seed cake	100,00	100,00	100,00
Crude plant oil output in kg per kg seeds	0,26	0,26	0,26
Seed cake output kg per kg seeds	0,74	0,74	0,74
Sunflower oil equivalent to one litre of diesel	1,1291	1,1291	1,1291
Production costs for one liter of crude sunflower oil			
Seed costs	595,00	1.120,00	2.915,50
Labor cost for expelling	126,00	126,00	126,00
Labor costs for filtration	35,00	35,00	35,00
Transportation costs	175,00	175,00	175,00
Labor costs for carrying	35,00	35,00	35,00
Depreciation of Piteba expeller	175,00	175,00	175,00
Financing costs expeller	105,00	105,00	105,00
Storage costs	70,00	70,00	70,00
Fuel costs for heating the expeller	10,50	10,50	10,50
Income from press cake	-259,00	-259,00	-259,00
One litre of sunflower oil	**1.067,50**	**1.592,50**	**3.388,00**
Sunflower oil equivalent to one litre of diesel	**1.205,31**	**1.798,09**	**3.825,39**

Figure 11: Production costs (in TZS) of one litre of sunflower oil (scenario III)[88]



5.4.3.1 Oil extraction rate

According to the manufacturer´s website the Piteba press, produces 1.33 litres of sunflower oil per hour at an extraction efficiency of 34-36% (1.2236 kg of oil per 3.4 to 3.6 kg of seeds). For one litre of oil thus only 2.6-2.7 kg of seeds would be required as compared to the 3.5 kg assumed for the mechanical expeller in Laela. This figure seems to be unrealistically high when compared to the mechanical press.

One reason the efficiency of the manual expeller might in fact be higher than the mechanical expeller is the fact that the Piteba press is constantly heated with a small oil lamp underneath the press cage[89] (see Figure 10). According to the manufacturer, heating the press cage during oil expelling greatly improves the extraction efficiency: "The heating liquefies the oil escaping from the press cage at the end of the expeller. The hotter the oil, the easier it is squeezed from the presscake. Also hot oil flows better to the oil outlet." (Piteba, 2011).

As however the performance of both expellers was not tested and compared under field conditions, in the economic analysis, a conservative extraction efficiency of the manual press of 3.5 kg per litre of oil (similar to the mechanical expeller) is assumed.

5.4.3.2 Capacity of the expeller

It is assumed that the expeller can process 3.4 kg per hour and 27.2 kg per full working day. Thus, a daily amount of 9.13 litres of sunflower oil (8.39 kg) would be produced with every expeller.

5.4.3.3 Labour costs

As the expellers would be provided to the poorest households in Laela lacking adequate income generating opportunities, the lowest daily wage during the dry season of TZS 1,000 per day (TZS 125 per hour) was assumed.

During the dry season, real hourly wages are most likely even lower as no income alternative exists, especially for women. Villagers stated that one of the few income opportunities during the dry season is charcoal production. However, farmers would opt out of this task as soon as better paid work is offered because the payment for charcoal production is the lowest available. As it was not possible to conduct an economic analysis of charcoal production in

[88] The income from the selling of the presscake (TZS 259 per litre) is deducted from the seed costs.
[89] Consuming 4-5 ml (4-5 g) oil per hour. One litre of lamp oil is sufficient for about one month of processing (Piteba, 2011).

Laela, it can only be assumed that hourly wages are even lower than the minimum wage[90] for casual labour.

However, in the economic analysis the minimum of TZS 1,000 per day is assumed. Further, it is assumed that the expeller processes 3.5 kg of seeds per hour. Thus, processing of one kg of seeds requires labour costs of TZS 36.

Labour costs for filtration are taken from TaTEDO (see above) and estimated at TZS 30 per kg seeds processed.

5.4.3.4 Expeller costs

In various economic analyses conducted by the manufacturer, depreciation costs of the expeller were estimated at $ 0.2 per kg oil produced (0.2% of the total investment costs of $ 100). Thus, the investment costs would be written off after 500 litres of oil are produced (by processing 1,500 kg of seeds). At an output of 1.2 kg oil per hour the investment costs would be written off after 417 hours of operation (about 52 full working days).

Considering investment costs of 150,000 per expeller, depreciation costs per kg of oil produced would amount to TZS 300 per kg of seeds processed. When compared to the current user charge of the expeller in Laela the use of a small-scale expeller would thus be higher.

Even though no figures are made available on average life-times of the Piteba expeller by the manufacturer, its ascribed robustness in construction and absence of the need for spare parts makes it very unlikely that the expeller only operates for 52 full working days. Therefore, a life time of about twice the number of hours used in the economic analyses of the manufacturer is assumed here. Therefore, depreciation costs per kg of oil produced are reduced to TZS 50 (equivalent to a lifetime of 3,000 kg of seeds processed).

5.4.3.5 Financing costs

Small-scale farmers in Laela will most likely not be able to afford a small expeller and possibly a storage container and pesticides for the seeds and for the produced plant oil up-front. The acquisition would thus have to be financed by a grant or micro credit.

Typical interest rates for micro credits range from 30-70% effective annual percentage of rate (ADB, 2006: 5).[91]

Here, it is assumed that a micro credit is provided to the farmers (i.e. through the LAC or the local Saccos – a credit and savings association) at an effective annual interest rate of 30%. Further, it is assumed that the investment costs for the expeller can be paid back in the course of a maximum of two years.

Therefore, additional financing costs (apart from the depreciation costs) for the acquisition of the expeller amount to another TZS 90,000 over the course of two years. The total price for the expeller would thus amount to TZS 240,000. If paid back over two years, every month an amount of TZS 10,000 would have to be paid back by the farmers. Alternatively, the interest

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[90] The official minimum wage in Tanzania is approximately TZS 190,000 (US-$ 140 according to GTZ (2009a: 19). At publishing time (November 2009), one US-$ was worth TZS 1,326.8 (see http://usd.exchangerates24.com/tzs/history/?q=365).

[91] Based on micro-credit schemes in different Asian countries. For a microcredit of € 100 to be paid back in the course of one year € 130 to 170 have to be paid to the micro credit institution.

payment could be charged to the farmer as a user fee to be collected every month by the implementing organisation.

It is assumed that the expeller is operated at a minimum of three hours every day on average producing 1,456 litres of oil (1,314 kg) per year. If the oil would be sold at production cost to the MFP, a minimum of TZS 228 per litre would be earned by the farmers representing the labour costs included in the economic analysis[92]. However, it is very likely that the farmers will be able to sell the oil with some profit margin. As the price difference between the diesel price in Laela and the production costs of sunflower oil are at a minimum TZS 600, it can be assumed that farmers should be able to keep up to half of that price difference. Thus, here a total income of TZS 500 per litre of sunflower oil is assumed.

Thus, if operated for an average of three hours per day all year around, the expeller can theoretically create an income of TZS 728,000 per year which would be almost five times the purchasing price of the expeller of TZS 150,000.

As the investment and financing costsare written off after the processing of 3,000 kg of seeds, TZS 30 per kg of seeds are calculated for the financing the expeller.

5.4.3.6 Fuel consumption

To heat the expeller kerosene is used in the burner. The expeller consumes about 4-5 grams of kerosene per hour of operation. The processing of one kg of seeds thus consumes about 1.29 grams of kerosene (4.5 grams per hour to process 3.5 kg of seeds). One litre of kerosene has an average weight of 0.798 kg per litre so that one kg of seeds requires 0.00162 litres of kerosene. One litre of kerosene is available in Laela for TZS 1,800. Thus, operation costs for expelling one kg of seeds are assumed to be TZS 3.

5.4.3.7 Transportation

Costs for transporting and carrying the seeds are assumed to be the same as in the centralized oil production system. However, if farmers process their own seeds transportation costs would be much lower. If transportation costs would not accrue, farmers would create an additional income of TZS 60 for every kg seeds processed.

5.4.3.8 Results

Small-scale processing is economically feasible and has the potential to create additional income for the poorest farmers in the village (if the expellers and micro credits would be provided to those farmers) thereby potentially reducing poverty. As the depreciation costs of the expeller are put at a very conservative TZS 50 per kg of seeds processed, it is very likely that profit margins of expelling are higher than assumed here.[93]

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[92] In one working hour 1.33 litres of oil can be produced thus creating income of TZS 303 per hour. This is more than twice the minimum hourly wage paid in the village (TZS 125).

[93] TaTEDO (2008: 43) assumes capital costs (depreciation and maintenance) for a mechanical "Sundaya" oil expeller of TZS 30 per kg seeds processed which is lower than the depreciation costs used here.

6. Feasibility of Jatropha SVO production

As a second option the feasibility of Jatropha SVO production to be used as diesel substitute is assessed in the following sections.

6.1 Agronomic suitability of the region for Jatropha cultivation

According to GTZ (2009: 29) the areas with optimal agronomic suitability for Jatropha include annual temperatures from 19.3-27.2 °C and annual rainfall between 1,000 and 2,000 mm based on a sample of plants found to grow naturally and in plantations. However, the plant samples from plantations cover a broader range of climatic conditions as compared to the plant samples growing naturally. Here, the temperatures range between 12.7 and 33.3°C and rainfalls between 440 and 3,121 mm. Thus, Jatropha is able to grow in climatic conditions with less precipitation which however, affects the amount of yields that can be expected.

GTZ (2009) concludes that Jatropha´s natural agronomic range includes areas with higher precipitation than the areas in which it has been planted. Jatropha is considered uncommon in regions with arid and semiarid climates as it does not naturally occur in regions with average annual precipitation of less than 944 mm per year. Jatropha yields in sites with 900–1,200 mm rainfall can be up to twice as much (5 t dry seed per hectare and year) of the production in semi-arid regions (2–3 t dry seed per hectare and year). It indicates that plantations in arid or semi-arid regions may show a low productivity or need additional irrigation.

In Laela temperatures range between about 20°C in June/July to about 28°C in September[94] and can thus be considered as optimal for Jatropha cultivation.

Annual rainfalls in Laela range between 500 and 1,100 mm with an average of 786.5 mm.[95] Rainfalls are highly unevenly distributed around the year with five to six months without precipitation and three to four months with rainfalls of 100-200 mm (TaTEDO, 2008a 8). Thus, annual rainfalls in Laela are not ideal for Jatropha cultivation and will lead to lower yields than in regions with higher precipitation.

6.2 Current use of Jatropha in Laela

In the focus group interviews farmers were asked about their knowledge and experience with Jatropha. Many farmers have heard of Jatropha especially about its characteristics as a soil protecting plant. Currently, it is only grown by one farmer in the village as a hedge surrounding his premises in the village. The hedge has been planted from cuttings that have been brought from the Mpanda region to keep animals away from his vegetable garden. The farmer is not harvesting the seeds even though the plants are up to five meters high and at the time of visit were carrying some dried and fresh fruits (see Figure 12). However, it could not be concluded weather support measures such as application of fertilizer, weeding, or direct or indirect irrigation (from nearby crops in the homestead) were applied as the farmer was not available for an interview at the time of the survey.

[94] Personal communication with LAC staff.
[95] Based on eight data points of rain data collected in the LAC: 1994: 848; 1995: 684; 1996: 888; 1997: 805; 1998: 1126; 1999: 739; 2000: 511; 2007: 691 (years 2001-2006 were not available at time of visit)

Figure 12: Jatropha hedge in Laela

Thus, it can be concluded that Jatropha could potentially be grown in the Laela region.

6.3 Suitability of Jatropha cultivation in Laela

The suitability of Jatropha cultivation in Laela was discussed extensively with local stakeholders. It was stated that good potential for Jatropha cultivation exists in Laela as sufficient land for additional cultivation of the crop would be available without reducing yields of other crops. Many plots are under-utilized or cultivated with low productivity, thus, additional agricultural potentials exist. The past attempts of Jatropha cultivation failed mainly because of the low quality seeds delivered by TaTEDO (see above).

If farmers in Laela would grow Jatropha on a small part of their land only (such as in hedges or intercropped with other plants) with little or no input of work and fertilizers required, additional income could be generated especially for subsistence farmers from selling Jatropha seeds to the MFP. If at least parts of the additional income would be invested in agricultural inputs, overall productivity of small-scale agriculture in the village could even be increased.

In order to avoid that additional income would only be consumed, the staff of the LAC and the extension officers in the village suggested that an extension service should be installed that would advise farmers on the proper cultivation of Jatropha. To avoid that farmers would invest the income from Jatropha cultivation in consumer spending only, the extension service could manage the purchase of the Jatropha seeds and provide agricultural inputs as in kind payment for a share of the Jatropha seeds.[96] If such a scheme would be successfully implemented, higher overall yields for food and cash crops might be achieved on the same amount of land.

As Jatropha yields in Laela will most likely be very low as compared to other regions, the plant should only be cultivated very extensively in hedges or fences surrounding fields without applying high inputs of labour, fertilizers, pesticides etc. Based on an economic analysis of different Jatropha cultivation models (monoculture, intercrop plantation and fence plantation) in Kenya, GTZ (2009) concludes that "the only model for growing Jatropha that makes economic sense for smallholder farmers is growing it as a natural or live fence with very few inputs." All other models have yielded negative results as the costs of inputs were higher than the income generated from the sales of seeds. Only Jatropha cultivation in fences could be a "sound investment for the farmer" (GTZ, 2009: 78).

As Laela is facing severe and worsening erosion problems as a result of soil overuse and deforestation (see above), Jatropha cultivation in fences or hedges around plots would have other positive benefits as it could contribute significantly to erosion control. The additional benefits associated with Jatropha cultivation are elaborated in the following chapter.

6.4 Additional benefits of Jatropha hedges

6.4.1 Erosion control

The most valuable property of Jatropha in the context of introducing and promoting its cultivation in Laela is its suitability to be used to control soil erosion, especially in semi-arid areas (GTZ, 2009: 27). If additionally seedcake from the production of Jatropha oil is used as as an organic fertilizer, yield losses widely experienced in Laela could be improved and agricultural outputs of the village increased in the long-term.

According to FAO (2010: 17), Jatropha has proven effective in reducing soil erosion by rainwater. The deep taproot anchors the plant in the ground while the large number of lateral and adventitious roots near the surface binds the soil and keeps it from being washed out by heavy rains (that are typically taken place during the raining season in Laela). Jatropha also improves rainwater infiltration when planted in lines to form contour bunds. Especially when planted in hedges around plots Jatropha may reduce wind erosion by lessening wind velocity and binding the soil with their surface roots.

However, these anti-erosion effects are limited by the fact that Jatropha drops its leaves in the dry season. This means there is less protection at a time when wind erosion is highest and there is no leaf canopy to protect the soil when the first heavy rains fall. This can be ameliorated by growing drought-resistant ground cover plants such as agave (FAO, 2010: 18). As sisal is widely grown as a ground-covering plant in hedges in Laela to demarcate plots, Jatropha could be integrated in existing sisal hedges to improve erosion control and produce SVO at the same time.

[96] The agricultural inputs could be distributed through the Laela Farm Input Shop run by the LAC in Laela village. On behalf of the MFP company the shop could purchase seeds at a fixed price and hand out parts of the sum as in kind payments (fertilizers, pesticides, fungicides etc.).

Figure 13: Sisal hedge in the LAC

6.4.2 Soil improvement

The seed cake that remains after pressing Jatropha oil contains high-quality proteins but also various toxins so that it cannot be used as animal feed without expensive detoxification. The seedcake can be used and potentially sold as a valuable organic fertilizer as it contains more nutrients than chicken and cattle manure (GTZ. 2009: 27).

If Jatropha trees are grown from seeds they develop deep taproots which are able to extract minerals that have leached down through the soil profile and return them up to the surface through leaf fall, fruit debris and other organic remains. In this way, Jatropha acts as a nutrient pump which helps rehabilitate degraded land (FAO, 2010: 19).

6.4.3 Biogas production

Jatropha seedcake can be used as an input for biogas production through anaerobic digestion (e.g. combined with manure) before it is used as organic fertilizer (GTZ, 2009: 27). As a (dysfunctional) biogas plant exists in the LAC that could potentially be rehabilitated, the local Jatropha value-chain could be further extended and its profitability increased.

6.4.4 Livestock barrier

In many tropical and subtropical countries, Jatropha cuttings are planted as a hedge to protect gardens, homesteads and fields from browsing animals (Fact Foundation, 2010: 21 based on Henning, 2007).

6.5 Promotion of Jatropha cultivation in Laela

One of the main obstacles associated with the introduction and promotion of Jatropha in Laela is the difficulty to persuade farmers to cultivate new (cash) crops as this always carries higher risks due to potential management problems.

The staff of the LAC confirmed this view: as part of its agricultural extension work the Centre has put high efforts in promoting new cash crops in the region to provide additional income opportunities. In the early 1990s the LAC has introduced and promoted sunflower as a new food and cash crop which has proven difficult and required constant efforts by the LAC until farmers were convinced of the new crop. Sunflower established itself in Laela for a number of reasons: Firstly, farmers could directly see that higher profits could be made with sunflower compared to traditional crops while the labour intensity of sunflower cultivation was lower. Secondly, multiple buyers from Laela and outside are available. Finally, sunflower seeds could - at least partly – be consumed directly by the farmers. As a result, sunflower has become the second important crop in Laela after maize.
A negative experience has been made in regards to chili in Laela in the 1990s. Chili was successfully promoted as a high-paying cash crop in the Iringa region and the success story was to be transferred to Laela. An agro-processing company was willing to enter a long-term contract with the LAC paying an attractive price compared to other crops cultivated in Laela. Transport would have been initially organized by the LAC and later transferred to a farmer´s group. However, the dependence on one single buyer and the fact that chilis were not consumed by the farmers discouraged farmers from the beginning to start cultivating the new crop so that the promotion by the LAC was soon stopped.

The promotion of Jatropha as a new cash crop would in particular be difficult as it takes at least three years until significant yields can be achieved (Fact Foundation, 2010: 4). Additionally, the seeds cannot be consumed by the producer and only one buyer (the MFP) would be available as the distance to potential alternative buyers are most likely too far away which would create dependencies and a suboptimal bargaining positions for the farmers.

On the positive side, is the price farmers can reach for the Jatropha seeds (or oil) directly visible as they are aware of the current price of fossil diesel as the product to be substituted in the village. This gives the farmers a potentially better negotiating position as compared to crops where market prices are mostly unknown to small farmers. Additionally, if Jatropha would be cultivated in hedges, after the initial effort of planting the hedge, labour intensity in maintaining the hedge and harvesting the seeds would be relatively low.

Due to the difficulties associated with Jatropha implementation, the LAC staff emphasized that the promotion of the currently more or less unknown crop would require an effective extension service convincing the farmers of the benefits of Jatropha cultivation.[97] Even if an extension officer would instruct and convince farmers on a regular and long-term basis it would take several years until first significant amounts of seeds could be harvested, as the majority of the farmers would be convinced of the potential benefits of Jatropha cultivation only after some years of successful cultivation by the first farmers growing the new crop.

[97] A full-time extension officer employed by the LAC promoting Jatropha cultivation in Laela would be paid the following monthly wages:

- TZS 500.000-600.000 for a university graduate
- TZS 400.000-450.000 for an agricultural school graduate.

Thus, it would be rather unlikely that considerable amounts of seeds would be produced in the near future.

To implement Jatropha in Laela effectively, the most progressive and venturous farmers in the village (that have mostly been trained by the LAC) could be given a training course in Jatropha cultivation and processing. Additionally, Jatropha cuttings and plants could be provided and the farmers assisted in planting the first hedges. The cultivation of Jatropha could also be integrated in the teaching curriculum of the agricultural school of the LAC. If a small number of farmers successfully grew Jatropha and generated an attractive income as compared to the labour input, a larger number of other farmers would follow their example. To give the first farmers an additional incentive, outgrower contracts guaranteeing stable prices at least in the first years could be offered.

6.6 Establishment of a demonstration plantation in the LAC

As the LAC has already participated in the introduction of new (cash) crops it would be an ideal promoter for the establishment of Jatropha in Laela. Although some approaches did not succeed, valuable lessons could be learnt from these projects to optimise future implementation.

The LAC represented itself to the author as a valuable and trustworthy partner for research and implementation in Laela and would be very interested in promoting Jatropha if financial support was provided. Sufficient land resources would be available to establish a Jatropha nursery and plantation as about 370 acres of its 650 hectares of land are currently used only very extensively as pasture land. As the grazing cattle are not eating Jatropha (Van Peer, 2010: 32), the plants could be cultivated at large planting distance on the pasture land without completely clearing the existing trees and shrubs. To establish a Jatropha nursery, a former tree nursery in the LAC that is currently lying fallow could be used.

Figure 14: Former tree nursery in the LAC

Figure 15: Overview of LAC[98]

[98] Source of satellite image: http://maps.google.de/

6.6.1 Establishment of a Jatropha nursery

A large number of Jatropha seedlings could be produced in a nursery to quickly establish a first plantation. After the plants have developed well in the plantation, Jatropha cuttings would be cut and initially planted as hedges around the plots of the Centre and successively distributed to farmers in the village who plant their own Jatropha hedges (see below). Through this approach a rapid implementation of the crop could be achieved.

The cultivation of Jatropha in nurseries has two major advantages: first, seedlings can grow under controlled and potentially optimised circumstances (such as irrigation and fertilizer). Secondly, slow growing or abnormally performing plants can easily be removed leaving only robust and resistant plants for the transfer to the plantation. Stronger plants have a higher survival rate under sub-optimal conditions such as in Laela (e.g. extended dry seasons, weeds, presence of browsing cattle (young plants have low levels of toxins) and insects) (Fact Foundation, 2010: 36).

There are, however, disadvantages of nursery plants. The root development of seedlings is hampered due to the growth in small plastic containers (the germinated seeds are planted and irrigated in polypropylene bags filled with top soil). This is especially disadvantageous when the seedlings are not planted timely in the fields (less than one month) as the roots are restricted by the plastic bag. In addition, extra labour and capital is required and a risk exists of spreading pests and diseases to all seedlings and the field during the planting period.

The LAC staff estimated the production costs of Jatropha seedlings at TZS 500-1,000 per seedling which is in line with the costs of other tree seedlings available in Laela (TZS 250-1,000 per seedling).

6.6.2 Propagation through cuttings

Cuttings are a fast and cheap way of propagating Jatropha as they are clones with the same genetic characteristics as the mother plant, and in case a high yielding mother plant is selected the cuttings have the same properties (Fact Foundation, 2010: 16). When establishing a plantation for the production of cuttings, in the first years all suitable plants would be used to produce cuttings. In the mid-term - after the plants in the plantation are bearing the first fruits – the best yielding plants could be selected to be reproduced through cuttings and are distributed in the village. A disadvantage of using cuttings is that these develop only lateral roots and cannot access nutrients and water in deeper soil layers, making them more vulnerable to droughts and extended dry seasons. However, the Jatropha handbook recommends the use of cuttings especially to establish hedges and living fences.

According to FAO (2010: 33) when planting Jatropha as a living hedge, cuttings of 60–120 cm length should be inserted between 5 and 25 cm apart and 20 cm into the ground. This should be done two to three months before the onset of the rainy season.

In the LAC a Jatropha nursery would be best located on the main compound of the Centre as the area is fenced and no grazing animals are roaming around inside the fenced area and would feed on the young plants.[99] Additionally, water supplies for irrigating the young

[99] The compound of the LAC has a size of about three acres. In the past tree nurseries have been established on the compound. According to Mr. Mahenge, currently, the areas used for tree nurseries are not in use and will most likely not be used in the mid-term as sufficient trees have been planted on the compound. In the woodlands of the LAC aforestation is taking place naturally.

seedlings could be made available in the Centre[100]. This is of high importance as the use of irrigation would allow the production of seedlings during the last months of the dry season when abundant labour is available and little other work on the fields needs to be done.

The seedlings would be planted in the plantation after about one month (with the beginning of the rain season), allowing the young cuttings to develop in a favourable climate. Plant losses after the rains have finished would therefore be limited as the plants have developed sufficiently.

As many subsistence farmers have hardly any income during the dry season creating additional demand for labour might have positive socio-economic impacts on the village. On the other hand, if parts of the available workforce would be used during the rain season for the establishment of a nursery and plantation, this could lead to negative impacts on food security as the labour would not be available for food production.

6.6.3 Potential site for plantation

A suitable site for a Jatropha plantation was identified to the East of the LAC compound. The plot has previously been used as pasture area for the LAC´s cattle and is therefore fenced with barbed wire protecting the young plants against grazing animals. Currently the plot lies fallow and only occasionally grass is cut as cattle fodder. As can be seen in Figure 16 a handful of shrubs and trees are growing on the plot.

[100] However, investments would have to be made in the water system to improve the water supply in the LAC. Currently, a photovoltaic powered water pump provides water from a deep well which is about 17 years old and partly dysfunctional. By replacing some of the older photovoltaic panels, sufficient water could be made available for both the requirements of the LAC and the Jatropha nursery and plantation.

Figure 16: Potential site for Jatropha plantation in LAC[101]

The plot could be planted extensively with Jatropha plants after clearing some of the shrubs, whereby the few larger trees would remain on the plot. If the Jatropha plants would be planted at very wide spacing of at least four meters enough area would remain for the cultivation of fodder plants and as pasture land as the cattle would not feed on the (more mature) Jatropha plants.

If the plants in the LAC would be planted at four by four meters[102] each plant would require an area of 16 m². As the plot has a total size of about 29,000 m² a total number of 1,812 plants could be planted on the plot.

[101] Source of satellite image: http://maps.google.de/

[102] Common plant spacing in Jatropha plantations is in a rectangular pattern of 3 x 2.5 meters. When permanently intercropped, the plants should be planted about 4 meters between rows and 2.5 or 3 meters between plants (Fact Foundation, 2010: 11).

6.6.4 Agricultural potential for Jatropha hedges in Laela

As calculated above, Laela has a total arable land of 7,403 acres divided into 2,047 plots with an average plot size of 3.6 acres (9,000 m²). Assuming that the plots are of quadratic size, every plot is sized 94.86 x 94.86 m and thus has a perimeter of about 379 m. In addition to that the LAC cultivates a total of 105.5 acres of land (plus another 540 acres of pasture and woodlands). Each of their nine plots has an average size of 11.7 acres adding another 6,000 m of hedge potential.

Thus, theoretically a potential of up to 781,813 m of field demarcations exists in Laela that could be used for growing Jatropha hedges.

6.6.5 Substitution of diesel consumption

According to TaTEDO (2008b: 38) and GTZ (2009: 45), about 4 kg of seeds are required to produce one litre of Jatropha SVO. As about 1.14 litres of Jatropha SVO are equivalent to one litre of diesel (FNR, 2009: 64), roughly 33,000 litres of SVO would be required to substitute the diesel consumption of the MFP which would require approximately 13.5 tons of Jatropha seeds.

Table 20: Requirements of Jatropha SVO to substitute MFP diesel consumption

Diesel consumption of MFP per year (l)	28.616,00
Jatropha oil consumption per year (l)	32.622,24
Jatropha seeds required (kg)	130.488,96
Number of bags (at 55 kg per bag)	2.372,53

6.6.6 Yield estimations in hedges

Van Peer (2010: 26) states that Jatropha hedges in Mali may produce up to 0.8 kg per meter of hedge and year. These yields will however, only be reached on fertile soils with a good moisture supply. On poor soils it will be much less (Fact Foundation (2010: 21).

Jatropha plants in hedges are planted 25 to 50 cm apart whereas a spacing of 50 cm is most commonly used by farmers in Mozambique (Fact Foundation, 2008). Here it is also assumed that an average two plants are grown per meter of hedge.

Based on a sample of 180 mostly small-scale farmers growing Jatropha in hedges in different regions of Kenya, GTZ (2009) observed the following actual yields per plant and year (column 2). In column 3 and 4 a minimum and maximum scenario for expected future yields are depicted.

Table 21. Observed and projected Jatropha yields in fence plantation in Kenya (kg per plant and year)[103]

	Fence		
	Actual	**Low**	**High**
Year 0	0		
Year 1	0.002		
Year 2	0.036		
Year 3	0.059	0.066	0.050
Year 4	0.100	0.095	0.100
Year 5	0.535	0.125	0.200
Year 6		0.155	0.251
Year 7		0.184	0.301
Year 8+		0.214	0.361

Thus, the yields stated by Hennings (2007) of 0.27 to 0.4 kg per plant and year can be confirmed by the sample taken in Kenya. However, yields of 0.5 kg per plant have only been reached after five years of cultivation and with significant labour and agricultural inputs.

As the agricultural conditions in Laela are much less optimal, Jatropha yields are very likely much lower. Here average yields of 0.15 kg per plant and year are assumed. As a theoretical potential of about 780,000 m of field demarcations exists in Laela A, up to 1,560,000 Jatropha plants could be grown without using land for food production. To produce the 131 tons of Jatropha seeds required to substitute the annual diesel consumption of the MFP, roughly 56% of this theoretical agricultural potential would have to be used and planted with Jatropha hedges. If each plant would produce an average amount of 0.15 kg per year, 870,000 Jatropha plants would produce enough Jatropha oil to fully substitute the diesel consumption of the MFP (see Table 22).

Table 22: Requirements of hedges plantations to produce Jatropha SVO

Jatropha seeds required (kg)	130.488,96
Number of Jatropha plants required (0.15 kg of seeds per year)	869.926,40
Meters of hedge required (two plants per metre)	434.963,20
Theoretical agricultural potential for hedge plantations in Laela A (meters)	781.813,00
Percentage of agricultural potential required	55,64%

6.6.7 Economic analysis

[103] GTZ, 2009: 78

Table 23 and

Figure 17 show the results of an economic analysis of Jatropha SVO production in Laela. Most parameters in the analysis are identical to scenario II of the economic analysis of sunflower processing (centralised production during the dry season; see section 0).

The analysis is based on the following assumptions:

- As no experience currently exists in Laela with Jatropha cultivation, market or production costs for one kg of Jatropha seeds could not be estimated. The German company Prokon that is producing Jatropha SVO in Mpanda (the nearest known cultivation area of Jatropha) is paying TZS 300 per kg of Jatropha seeds to their outgrowing farmers.[104] Thus, this figure is used here.
- Processing takes place when the sunflower press is not used during the dry season (due to the toxicity of Jatropha, the expeller cannot be used at the same time to process sunflower or other seeds).
- Labour costs are thus at a minimum.
- The value of the seed cake was difficult to estimate as it is currently not sold in Laela. As its only use would be as an organic fertilizer (see above) it could potentially replace chemical fertilizers[105]. For a conservative estimation TZS 100 per kg of seed cake were assumed.

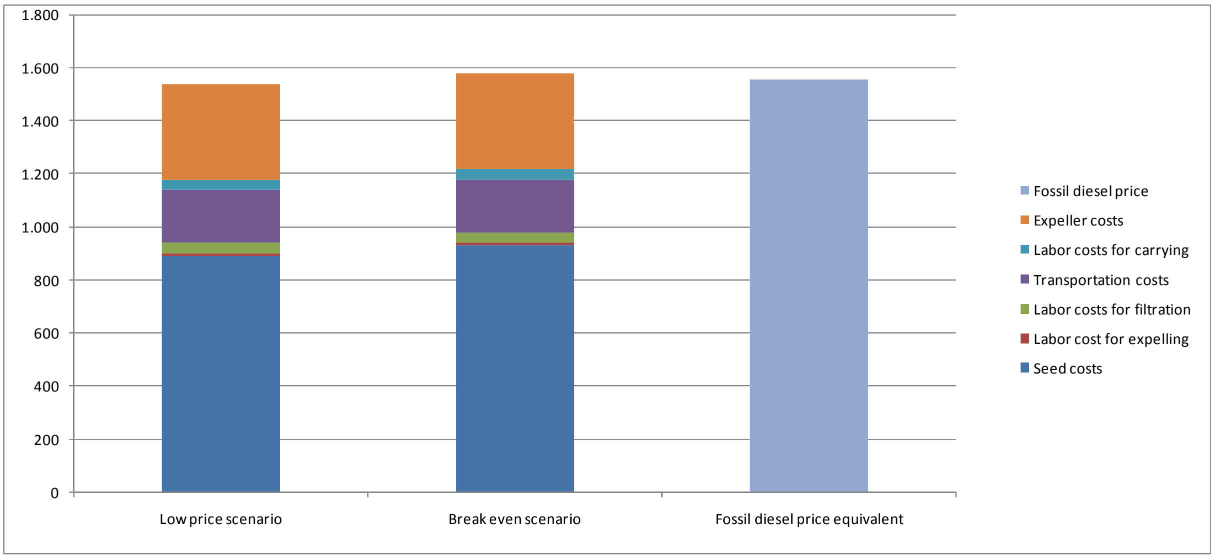
[104] Based on an expert interview with Prokon staff by Dr. Götz Uckert in November 2010.

[105] The most common chemical fertilizers used in Laela are diammonium phosphate (DAP) and urea available at prizes of TZS 1,400 and 1,040 per kg.

Table 23: Economic analysis of the production costs of Jatropha SVO in Laela (scenario III: decentralised small-scale production)

Parameters	Low price scenario	Break even scenario
Diesel consumption MFP l / y	28.616,00	28.616,00
Diesel price TZS/l	1.800,00	1.800,00
Oil extraction rate kg/l	4,00	4,00
Price of Jatropha seeds TZS/kg	300,00	310,00
Oil pressed per working day in l/day	228,57	228,57
Wages in TZS/hour	125,00	125,00
Expeller costs in TZS/kg	90,00	90,00
Labor costs for expelling seeds TZS/kg	1,70	1,70
Labor costs for filtration TZS/kg	10,00	10,00
Transportation costs TZS/kg	50,00	50,00
Labor costs for carrying TZS/kg	10,00	10,00
Income from press cake TZS/kg seed cake	100,00	100,00
Crude plant oil output in kg per kg seeds	0,23	0,23
Seed cake output kg per kg seeds	0,77	0,77
Heating value Jatropha oil MJ/kg	36,80	36,80
Heating value diesel MJ/kg	42,60	42,60
Heating value sunflower oil to diesel %	86,38%	86,38%
Jatropha oil equivalent to one litre of diesel	1,14	1,14
Production costs for one liter of crude sunflower oil		
Seed costs	1.200,00	1.240,00
Labor cost for expelling	6,80	6,80
Labor costs for filtration	40,00	40,00
Transportation costs	200,00	200,00
Labor costs for carrying	40,00	40,00
Expeller costs	360,00	360,00
Income from press cake	-308,00	-308,00
One litre of Jatropha oil	**1.538,80**	**1.578,80**
Jatropha oil equivalent to one litre of diesel	**1.748,31**	**1.793,75**

Figure 17: Production costs (in TZS) of one litre of Jatropha SVO[106]



The economic analysis shows that Jatropha oil production to be used as a substitute for diesel would only be economical at a seed price of up to TZS 310 per kg. However, as the value of the presscake has only been estimated very conservatively, oil production might even be feasible at a higher seed price. Further, real production costs for Jatropha seeds could not be calculated here. If labour and agricultural inputs for Jatropha hedge plantations are as low as it is assumed here, production costs could in fact be much lower than used here.

[106] The income from the selling of the presscake (TZS 308 per litre) is deducted from the seed costs.

7. Conclusions

The economic analyses show that the local production of both sunflower and Jatropha SVO to be used as a diesel substitute in the MFP is theoretically economically feasible if sunflower seeds can be purchased in the village for a farm-gate price lower than TZS 350 per kg[107] (TZS 320 when processing is done by small-scale farmers) and Jatropha seeds at a price lower than TZS 310 per kg. Theoretically, agricultural potentials in the village are sufficient as at a conservative estimation a maximum of 6.8% of all arable land cultivated with sunflower would be sufficient to substitute the total diesel demand. Agricultural potential for Jatropha hedges – which is considered the only economically feasible option for pro-poor development (cf. GTZ, 2009a) - are even higher as only about 50% of the theoretically available potential for hedges would be required to produce sufficient amounts of SVO to substitute the diesel demand.

The establishment of a local value-chain for sunflower SVO could relatively easy be implemented as the crop is widely cultivated in Laela, idle processing capacities exist and labour costs are very low.

However, as the largest share (73%) of the current sunflower seed production would be required to fully substitute the diesel consumption of the MFP, local and regional agricultural markets could potentially be distorted at least in the short-term. The additional demand for sunflower seeds would very likely lead to rising farm-gate prices and hence to an increase of sunflower cultivation in the following years. This in turn could potentially threaten food production if sunflower would be produced at the expense of staple foods[108].

Based on the collected data it can however be assumed that overall agricultural production could significantly be increased in the village so that the additional demand of sunflower seeds used in the MFP would be compensated without reducing local consumption and export of staple and cash crops.

This hypothesis is based on two assumptions:

a) Overall agricultural productivity in Laela is comparably low due to a lack of income to invest in agricultural inputs; furthermore the available agricultural land is not used entirely due to a lack of attractive market opportunities;
b) The additional local processing of sunflower seeds could entail significant local value-addition and potentially generate additional income for the farmers allowing investments in agricultural inputs. This would lead to higher agricultural productivity and overall yield increases. As a result, the amount of locally consumed sunflower seeds for electrification would be compensated by higher overall yields. However, further intensification of the agriculture in the village would most likely lead to further environmental degradation if soil-protecting measures are not consequently promoted.

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[107] Which is more than twice the minimum price of TZS 170 available during harvesting season in Laela.

[108] As the largest share of staple crops is currently exported, food security in Laela is not regarded as directly threatened as a result of biofuel production. However, food security in other regions could potentially be endangered hence the national legislation banning use of food crops for non-food purposes in regions with high food production.

The hypothesis would however have to be examined in detail and validated on a quantitative basis, estimating the increases in yields to be expected through higher input application and the development of seed prices and thus incomes for the farmers.

Jatropha on the other hand is currently not cultivated in Laela, so that the establishment of a local value-chain for Jatropha SVO would require significant promotion efforts. However, widespread Jatropha cultivation in hedges surrounding the farmer´s plots could potentially have positive impacts on environmental degradation and declining yields as a result of erosion which is a major problem in the village. Thus, in terms of socio-economic impacts a Jatropha value-chain would very likely be the more beneficial option, justifying significant promotion efforts, potentially financed by external donors.

Additionally, the lower-cost option of sunflower SVO as a diesel substitute is currently legally banned in the Laela region due to national legislation.

Another factor potentially constraining the feasibility of the establishment of a local biofuel value-chain are the market developments expected after the finalization of the road constructions. Laela will most likely lose much of its remoteness and local SVO production as a diesel substitute could become less feasible On the other hand however, diesel prices can be expected to increase in the mid- to long-term, potentially making SVO competitive again.

8. Literature

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9. Appendices

9.1 Annex I: Minutes of workshops and interviews

Results focus group interview No. 1 – Village Scoping

23.11.2010

Laela, Teacher´s Centre

Participants:

- Better-iS team (Dr. Götz Uckert, Harry Hoffmann, Jan Rordorf (all ZALF), Ewald Gervas Emil, Theresia Gawile, Julius Edward, Geoffrey Rwabagabo (all ICRAF))
- Ibrahim Njelekela, Agricultural Officer
- Henry Haule, Division Officer (D.O.); Community Development Officer
- Emanuel Iluway, Livestock Ward Officer
- Leonard James, Ward Education Officer
- James Michael, Ward Executive Officer

General information:

- Laela A+B: 11.000 inhabitants
- Laela A consists of seven subvillages
- Average members per household: 4 people
- Average acres per household: 4
- Average plots per household: 2-6
- High immigration rate from surrounding areas
- Birth rate: 0.7%
- Environment protection committee is currently not active in the village
- No forest management
- No areas for expansion are available

According to Mr. Haule (8.12.):

- Inhabitants Laela Ward: 19.000
- Laela A+B: 9.000
- Laela A: 4.800

According to TaTEDO (2008):

- 1,486 households
- 9,052 people
  - o 3,921 men
  - o 5,131 women

Village and sub-villages:

- Kamnyatili?
  - o Many farmers
  - o 3-4 businesses
- Kasakalawe
- Kivuko-Mteta

    - Only farmers
- Kiwanda
- Laela Kati:
    - Highest population
    - Highest share of business activities:
        - Bars/bottle stores
        - Shop keepers
        - Butchers
        - Markets
        - Selling of agricultural products
        - Traders
        - Small stalls
        - Milling machine
    - Few farmers
    - High education levels compared to other subvillages
- Maporomoro
    - Few businesses
    - Many farmers
- Mtindi?
    - Small subvillage with low incomes
    - Low education level
- High differences in terms of size and education levels among sub-villages
- In some villages no Kisuaheli is spoken

Energy use:

- Majority of people use firewood (from woodlands about to 2km away from Laela Kati) and few use charcoal
- Some people are involved in charcoal production
- Majority of charcoal is consumed locally
- Trees for charcoal production are derived from Kisarara (8km from Laela Kati) and Kivuko Mteta
- Charcoal production leads to environmental degradation
- Petrol and kerosene is imported from Sumbawanga
    - Petrol: TZS 2.000 – 2.200
    - Kerosene: TZS 1.800
- 10-15 local vendors sell petroleum products
- In Laela Kati approximately 50 houses own generators; few households in other sub-villages (approximately 60 households in total)
- Charging of mobile phones is TZS 500 using generators

Agricultural activities:

- Main cash crops cultivated are (in order of area cultivated)
    - Maize
    - Finger millet
    - Sunflower
    - Ground nuts

    - Beans
    - Sorghum
- 75% of the farmers use oxen
- Agricultural output per acre maize:
    - No fertilizers: 3-5 bags
    - Fertilizer (including manure, crop residues): 20-25 bags
- Laela A: 4604 hectare
- 85% private land, 15% common land (including forests, schools, health centers, rivers etc.)
- Animals (in order of numbers):
    - Cows
    - Chicken
    - Pigs
    - Goats
    - Horse
    - Sheep

Processing and trade activities:

- Farmers rarely own processing machines
- Dehulling machines for ground nut production owned by external traders are only temporarily available in the village during harvesting season
- Traders from the Democratic Republic of Congo buy groundnuts for exporting
- Sunflower oil is sold by farmers directly at about TZS 2.500 – 3.000 per litre
- Two pressing machines for sunflower seeds exist in the village
- Seven people own trucks to transport agricultural products to other regions
- one tractor exists in the village by a farmer owing 30 acres
- Maize is sold in the village at 25.000-30.000 per bag (100kg)
- It is expected that after the completion of the road the price for maize will increase due to better accessability of the village for outside traders

Income groups:

- Very low income:
    - can only afford to feed themselves for about 3-4 months on own agricultural production
    - in the rest of the year they work as agricultural laborers on other farms
    - large families
    - depend on casual labour
    - people with disabilities
    - old people
    - many of this group makes charcoal
- low income (subsistence farmers)
    - enough production for own food consumption
    - no surplus
- group with little surplus
- group with high surplus

Results focus group interview No. 2 – Natural Resource Mapping

24.11.2010

Laela, Teacher´s Centre

Participants:

- Better-iS team
- Sabas Ndalama, Teacher
- Ibrahim Njelekela, Agricultural Officer
- Herman Mkandi, member of Mtindiro (?)
- Linus Kasunga
- Henry Haule, Division Officer (D.O.), Ward executive officer
- Emanuel Iluway, Livestock Ward Officer
- Clement Sangear (?)
- Maria Nga-Iamise, from Laela Kati
- Sebastian Sikaciyo (?),Subvillage chairman Mtindiro
- Athanaeli Dodozi, Subvillage chairman Kivuko Mteta
- Adamuson And (?)
- Herman Mwanisary (?)
- Efren Masumbko, Subvillage chairman Kamnyanile
- Leonard James, Ward Education Officer
- Longino Kizinga, Subvillage chairman Maporamoko
- James Michael, Ward Executive Officer
- Maria Wazina, deputy mayor small town (?)
- Joseph, farmer, former member of environmental committee (not included in list of participants)

Not present:

- Datus Kisunga, Subvillage chairman Laela Kati

- Three people were aware of Jatropha

Available resources in the village:

- Land (for agriculture and settlement)
- Human resources
- Rivers
- Forests
- Minerals/gemstones
- Animals (livestock)
- Low lands
- Catchment

Resources in Laela:

Land:

- 75% of land is used for agriculture
- 5% of land is used for settlement
- 20% of land is forest
- 10-15% of land is fertile and can be used without application of fertilizers

- 85-90% of land use fertilizers, manure and crop rotation or changing of crops

Rivers:

- All rivers in Laela are seasonal
- Three main large rivers exist:
  - Kanteza
  - Nyianatuzi
  - Kantoto
- Seven small rivers exist:
  - Mtungu
  - Namisurguti
  - Sinde
  - Kanatondwe
  - Pepe
  - Chisakagu
  - Kalale

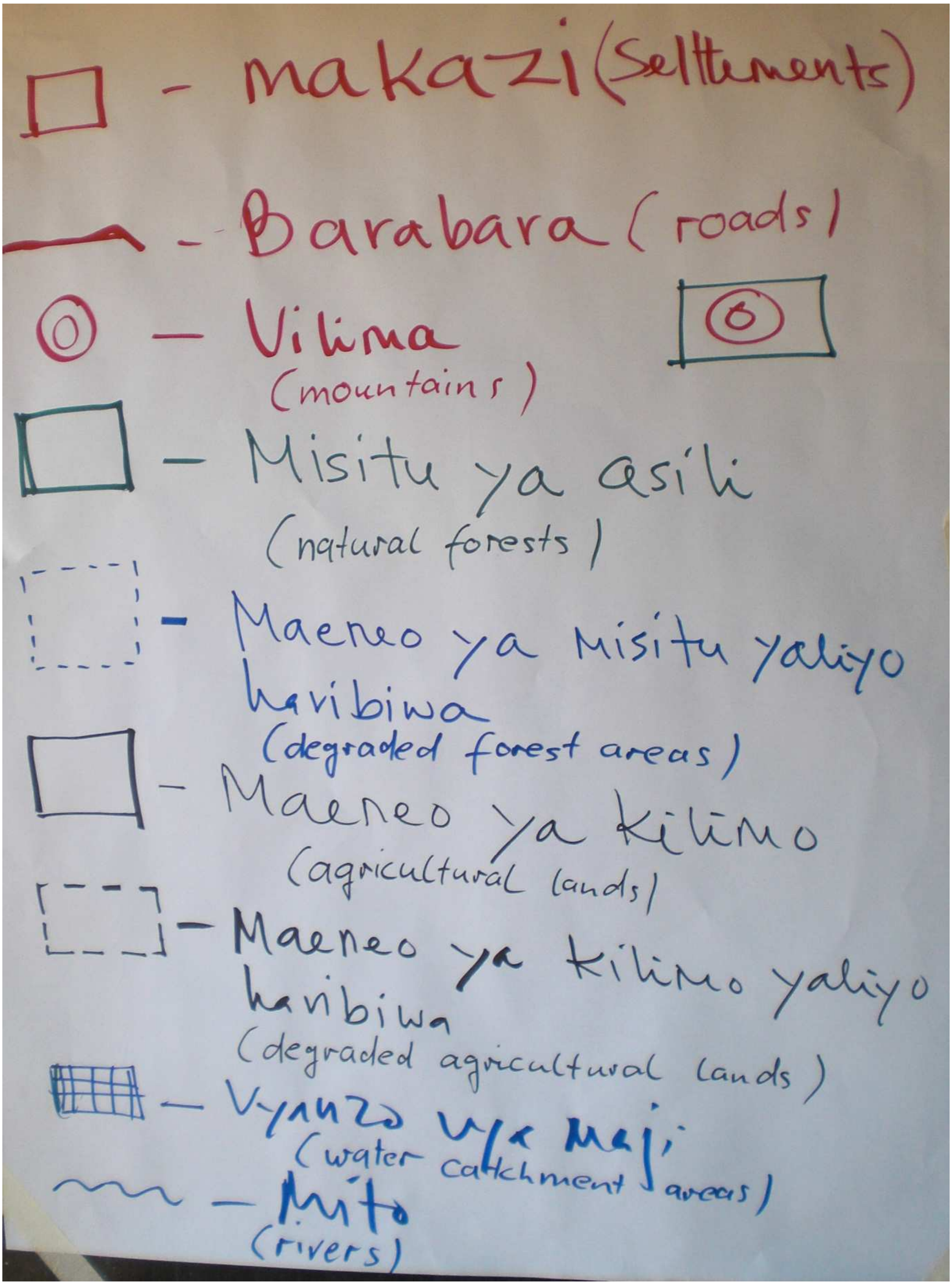
Forests:

- No forest management plant exists
- No reserve forest exists
- An environment committee exists, however, its members have not been trained on forest management issues
- Existing forests (all found in surrounding hills):
  - Nayula
  - Kachewike
  - Tundingomo
  - Mulilandondo
- Wild animals found in forest areas:
  - Antelope
  - Sungura
  - Dikdik
  - Pakaporis
  - Ndezi panya
  - Monkeys
  - Nbenjele (local name in Fipo language)
- Birds found in the area:
  - Kanga
  - Kurale (all following in local language - Kigspa)
  - Tutu
  - Namume
  - Pempe
  - Chipungu
- Birds that used to be in the area but have not been spotted in recent years:
  - Iiumba (local name)
  - Nkwazi
  - Ingoli/Korongo (crested crane)
- Wild animals:
  - Tandala – not seen
  - Elephant – not seen

- Buffalo – can rarely be seen
- Kongoni – not seen
- Lions – not seen
- Warthog (Ngiri) – not seen
- Leopard – not seen
- Cheeter (Duma) – not seen
- Pogu – not seen
- Antelope – can rarely be seen
- Inzowe – not seen
- Mbuzi mawe – can rarely be seen

- Reasons why these mammels cannot be seen anymore:
  - Deforestation
  - Illegal hunting
  - Population increase (lead to disturbances in the wildlife habitats e.g. through forest fires)
  - Decline in rainfall in the last 10-15 years has affected the grasslands and availability of water for wild animals; as a result wild animals moved to other areas
- Ten privately owned forests exist in Laela, owned by and acres owned:
  - H.J. Mwarisawa – 15
  - Clement R. Sangu – 2
  - S.M. Sikazwe – 4
  - Everist Muizaliste – 5
  - Noel Z. Nkawe - 50
  - Agriculture Centre Laela – 50
  - Laela “A” primary school – 1
  - Salvatory Mzee – 4
  - Wilbroad Longino – 6
  - Kannyatile primary school – 2
- No traditional (sacred) lands exist in Laela due to conversion to Christianity

Ressource Mappings:



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Results focus group interview No. 3 – Meeting with local authorities

24.11.2010

Laela, Teacher´s Centre

Participants:

- Better-iS team
- Sabas Ndalama, Teacher
- Ibrahim Njelekela, Agricultural Officer
- Henry Haule, Division Officer (D.O.)
- Emanuel Iluway, Livestock Ward Officer
- Sebastian Sikaciyo (?),Subvillage chairman Mtindiro
- Athanaeli Dodozi, Subvillage chairman Kivuko Mteta
- Efren Masumbko, Subvillage chairman Kamnyanile
- Leonard James, Ward Education Officer
- Longino Kizinga, Subvillage chairman Maporamoko
- James Michael, Ward Executive Officer

Not present:

- Datus Kisunga, Subvillage chairman Laela Kati

Discussion with village chairmen and government officials:

Survey

- Assistance from subvillage heads was requested
- (updated) lists of all inhabitants will be provided until Friday
- A first selection of households will be done by the subvillage chiefs covering each of the four income groups identified (2 per income group)
- A further random selection of 160 households will be done by the research team on the basis of the lists provided by the subvillage chiefs
- The percentage of households selected from each subvillage will be done according to the population size of each subvillage (in descending order):
  - Laela Kati
  - Kamnyalile
  - Mapomoko
  - Mtindio
  - Kivuko Mteta
- Pretest interviews will be conducted in Mapomoko on Thursday
- First interviews will be conducted in Laela Kati on Saturday afternoon

<u>To do</u>

- Subvillages chiefs provide lists of inhabitants of each subvillage including information on
  - Gender
  - Income group
  - Profession
  - ?

- Calculation of population shares of each subvillage of total population in Laela “A”; calculation of households to be interviewed per subvillage
- Random selection of households per subvillage
- Discuss and confirm with subvillage heads whether selection was representative of respective village

Results focus group interview No. 4 – Environment, Environmental Degradation and Development

02.12.2010

Laela, Teacher´s Centre

Participants:

- Dr. Götz Uckert, ZALF
- Jan Rordorf, ZALF
- Ewald Gervas Emil
- Abel S. Suwi, Kapele subvillage in Mnolola village; member of Environmental committee
  Remarks in participant list: community needs to be sensitized so that it can participate actively in conservation of forest resources and environment; capacity building that communities are capacitated; access to credits and agricultural implements (ploughs)
- Gabri Sumbu, Mkusa (sub-)sub-village; member of the Environmental Commmittee
  Remarks: requesting for facilities like bicycles, motorcycles, uniforms
- Maria Wazima, Mayor of Laela Kati; from Maporomoko sub-village
  Remarks: prices for agricultural inputs are high; government should improve access for poor small farmers to agricultural inputs at lower prices
- Exavery Mlowezi, farmer of Katapulo sub-village
  Remarks: requesting frequent trainings for farmers on agricultural practices
- Sangu Clement, councelour from Laela Kati
  Remarks: all topics discussed in focus group interview should really be addressed and send to the authorities (especially natural resource management)

Part-time participation:

- Emanuel Iluway, Livestock Ward Officer
- Godueli Kisanga
- Jerita Filipo

Deforestation:

- Is seen as a major problem in Laela as it closely related to
  - The amount of rain in the village
  - Wildlife migration (most of the wildlife in the region has migrated to Katari game reserve, Lake Rukwa or other regions which still have forests)
    - Wildlife is also reduced through forest fires due to the following causes:
      - Illegal hunting (fires started to chase animals out of the forests)
      - Fires from fields or grasslands may spread to forests
- Main reasons for deforestation (in descending order):
  - Charcoal production
  - Brick production
  - Firewood
  - Wildfires
  - Livestock (including grazing animals from other areas)
  - Timber

- Underlying causes:
  - Lack of awareness
  - Poverty
- How could deforestation be reduced:
  1. Education and awareness raising
     a. Villagers have to understand benefits from utilizing forest resources in a sustainable way
  2. Encouragement of tree planting
  3. Enforcement of bylaws protecting environment and forests
  4. Availability of forest experts (forest extension officers) to advice villagers on tree planting (forest officers exist in Sumbawanga but are not active in Laela)
  5. "Availability of electricity would reduce or even eliminate deforestation"
  6. Areas should be set aside for tree nurseries owned by the village where villagers could buy timber and firewood
- Two private nurseries exist (no participant has heard of a nursery implemented by TaTEDO)
  - Average price for trees: 500 (250-1000 per seedling)
- According to the forest owners in the group forests are difficult to maintain due to
  - Termites
  - Livestock grazing
  - Water consumption
  - Theft of fuelwood
- In Sumbawanga a NGO/CBO is running a tree nursery (KAESO, Kaingesa Environmental Society); tree seedlings are sold at about 500

Environmental committee

- It is active in the village
- Challenge: the village community is not supportive of the committee (even "hates" it) as its members can charge fees for cutting trees even on own fields
  - Fines depend on the level of environmental impact: 10.000 – 15.000
  - Fines are part of the local budget of the village authorities
- Committee members are appointed by the village council
- No salaries are paid but allowances (about half of the fines collected)
- The committee is not very effective in many cases as they patrol only on foot and are not enough present in sensitive areas

Bylaws

- Exist in the village
- Fines the environment committee can charge are regulated in the bylaws
- In August there was a large fire in the forest owned by the school destroying 5 acres and killing some trees; after that the culprit has left the village

Participatory approaches in forest management (PFM):

- The following approaches exist in general: Existence of participatory approaches
  - CBFM (Community-based Forest Management): forest is owned and managed by community
  - JFM (Joint Forest Management): forest is owned by the government and managed by communities
- In Laela no such approach is in place

- In Nokolo village which is close to the largest areas of natural forests a JFM is in place:
    - Forests are owned by the local authorities and managed by the village community
    - However, the village is not well involved in the management
    - Still deforestation is taking place but not at the same extent as it used to (rate of deforestation is decreasing)
- The village councilor expressed his concern about TaTEDO and the MFP project:
    - Villagers were expecting a lot from the project and the introduction of electricity
    - Now disappointment is high with TaTEDO and the project

Soil erosion:

- Situation is bad and alarming and causes declining soil fertility and yields
- 45% of lands are effected
- Generally, soil quality is poor as many farmers are not following proper ways of cultivating fields
- Farrows (drenches) are seen in many areas
- Infrastructures are destroyed due to erosion (roads and bridges)
- Efforts against soil erosion:
    - Tree planting as farmland boundaries
    - Using of contour measures, terraces (practiced by some farmers only)
    - Planting of leguminous crops
    - Planting of soil-covering crops
        - Pumpkins
        - cucumbers
- Jatropha is not known by the participants as a soil protecting plant
- Extension officers and trainings are not sufficient to improve awareness and knowledge for proper agricultural practice among many farmers
    - Many farmers are thus not reached by the extension officers as they live to remote
- Soil fertility is also reduced because farmers are not applying crop rotation
- Crops cultivated (percentage of agricultural land):
    - Maize: 55%
    - Sunflower: 15%
    - Groundnuts: 15%
    - Finger millet: 10%
    - Beans: 5%

Kilimo Kwanza initiative:

- The initiative is considered as very good by the participants however,
    - Available inputs are limited (seeds are not available in planting time)
    - Bureaucracy level is seen as too high
        - Every household has to register
        - Not all households can participate
            - In one village from 300 households that applied only 30 were randomly selected and received vouchers to purchase inputs such as:
                - DAP (diamoniumphospate?)

        - Seeds
        - Urea and Cam?
        - Phospate
      - Each voucher entitles farmers to buy a certain amount of agricultural inputs at a reduced price
- The governmental budget is fixed from July to July of each year
  - The prices for the subsidized inputs are set for the whole time-span of the budget
  - Of this fixed market price the government is paying 50%
  - Due to inflation the share the farmer is paying may increase
    - 50kg of DAP:
      - Market price July: 88.000
        - Government (50%): 44.000
        - Farmer (50%): 44.000
      - Current price (due to inflation): 92.000
        - Government (48%): 44.000
        - Farmer (52%): 48.000
- (private) distributors designated by the government give out subsidized inputs
- The participants further complained about the following aspects:
  - The distribution of vouchers is poorly supervised
  - Too little attention is being paid to linking the farmers to the market
    - Through subsidized inputs farmers will be able to produce more but are not able to sell it at a better price due to poor infrastructure
    - In some cases production costs are higher than the market price covers (especially if inputs are used)
- It is expected that the finishing of the road construction will lead to higher market prices as more traders and buyers come to the village and price will increase due to higher competition
- During harvesting season, the following market prices are reached:
  - 1 bag of maize (100-120kg): TZS 10.000-15.000
    - Preferred price: TZS 30.000-40.000
  - 1bag of sunflower (50-60kg): TZS 10.000-15.000
    - Preferred price: TZS 30.000-40.000
  - Many farmers are not happy to sell at this price but they need money (especially for school expenses in the same period
  - Intermediaries earn most as they are able to buy cheap and sell at a better price after the prices increased (as they have storage capacities most farmers do not have)
  -

Availability of credits:

- The participants were very angry as the subject of Saccos was mentioned ("please don´t talk about credit and savings associations")
- A Saccos was founded in town in 2005 and worked quite well for the first years
- A Saccos (abbreviation?) is a cooperative organized by villagers
  - Not directly financially supported by the government
  - Regulated and audited by the Ministry of ?
- In Laela 400 villagers are members of the Saccos

    - 5.000 member fee
    - 25.000 share
- In 2009 the Saccos started business relations to a commercial bank to access a large credit so that loans could be given to its members (TZS 800 Mio.)
- Two problems were associated with the Saccos:

1. Access to credit:

- Small farmers were only able to access credits of TZS 50.000-100.000
- A small number of larger farmers or businesspeople (such as intermediaries) were able to access large loans (about four people)

2. Voucher system (Stakadadhi Gholani):

- The farmers sells a share of his harvest directly to the Saccos (i.e. 100 bags)
- The Saccoss pays the farmer a share (50%) of the price at current (low) market prices (for immediate expenses of the farmer); the farmer also receives a voucher for the rest of his money
- The Saccos stores the harvest until a better market price can be achieved and sometimes sells directly to end consumers (cutting the intermediaries)
- In some cases farmers were not paid the other part of their harvest
- According to the participants the leaders of the Saccos colluded with bank officials, district authorities regulating the Saccos to access the credit for themselves and not pay it back
- As the Saccoss did not run its activities properly the bank did not pay for the remaining 50% of the harvest that were due to be paid to the farmers
- One chairman of the Saccos is Mahamud Mohamed, chairman of the MFP operating company
- The participants estimated that due to the fraud about 400 tons of maize were not being paid in 2010 (about 4000 bags)
- The leaders withheld information regarding the credit to their members
- Not only harvests were lost but also fees and shares as well as savings of some of the members they put in the Saccos
- currently the Saccos is not active anymore
- According to Mr. Masebe from the Laela Agricultural Centre [in a different meeting], a second Saccos has prior been initiated by the LAC
    - As the district authorities only wanted one (strong) Saccos to exist in Laela they did not grant it permanent status but only preliminary status
    - Some members joined the new Saccos others (including Mr. Masebe) were skeptical to join as some important questions were not answered in a satisfactory way

Floods:

- In 2009 severe floods destroyed houses, lifestock and significant amount of the harvest mostly on fields in the river bassin
- No evaluation on the financial impact of the flooding was conducted by the government
- In 2006 a similar flooding happened

General comments by the participants:

- The government should increase the number of agricultural extension staff

- Facilities for the extension staff should be provided (bikes and motorbikes)
- Farmers should receive more frequent training and capacity building in agriculture
- Access to credit for farmers needs to be improved
- Kilimo Kwanza initiative should also provide large tractors, ploughs and agro-chemicals
- Power tillers prove difficult to use and an emphasis should be put n oxen and ploughs
- Land should be distributed more evenly among farmers as some farmers have large areas they are not able to cultivate by themselves and others have so little land that they are only able to feed their families for a limited amount of months from their own land
- Especially some institutions (namely the LAC and the schools) own large share of land
- Generally, in Laela abundant land is available but as market prices are too low due to infrastructural constraints labor is often not profitable enough, especially for owners of large amounts of lands to pay for labor to cultivate cash crops (→ hypothesis to be)

Results Focus Group Interview No. 5

Structure of value chains - maize, sunflower

10.12.2010

Laela, Primary School

Participants:

- Philipo Masebe - resident of Laela, chairman of Saccos
- Ulimboko – resident of Laela, chairman of the market businessmen
- Osca – resident of Laela, farmer
- Theresia – farmer
- Mimo Hussein – business woman (milling machine)
- Ephren Masumboko – chairman Kamyalile
- Henry Haule – ward officer
- Francisca Mbella (Mama Rehema) – business woman, main supplier of soft drinks in town, milling machine, generator, pressing machine
- Mahmoud Mohamed – businessman (trader, chairman MFP), member of the development committee

1. General discussion concerning the following topics:

   1.1 What are the most important value chains with respect to cash crops (maize, sunflower)

Maize:

- Producers:
  - Farm preparation
  - Farm inputs
  - Cultivation
  - Sowing
  - Weeding
  - Fertilizer application
  - Harvesting
  - Threshing
  - Storage (includes application of insecticides to minimizes losses)
- Before selling a farmer should look for a middleman to find a market for the harvest
- Middlemen receive payment from both the farmers and the buyer
- Buyers need to pay for insecticides while storing and for transport costs
- The buyer can sell directly to wholesellers
- Wholeseller can again store the crop, sell to retailers or process the crop to sell maize flour and husks or sell directly to retailers without processing

- Wholesellers also pack the processed maize and sell to other companies or retailers

Sunflower:

- Value chains are similar to maize but insecticides and fertilizer cost do not apply

Groundnuts:

- many buyers unshelled groundnuts and process themselves

1.2 Have there been other crops in history (more/less valuable?) What are the reasons of change? When did the change occur?

- More valuable:
  - o Millet
  - o Beans
- Less valuable:
  - o Groundnuts
- Reasons for change:
  - o Due to production costs; millet uses lots of capital or money in production
  - o Also people are afraid of cultivating beans due to weather variations
  - o Prices for beans and millet is higher than for other crops
  - o Groundnuts: less valuable because the output price was low which makes many farmers not cultivate it

1.3 Are there different ways of producing/marketing? Experiences with cooperatives, bigger plantations, higher mechanisation. Existing approaches to outgrower schemes, marketing education, etc.

- Cultivation of beans in lowlands during dry season (high price for crop)

1.4 Do you think there are any difficulties in the value chain e.g. prices, distribution of power (who is making the prices? quantities, too many producers, product quality?)

- Prices are made by buyers: producers have no influence on the prices which are proposed by buyers
- Also a large number of producers exist who produce large quantities of crops
- Transportation costs are very high which makes buyers plan for a price that is favourable for them (to cover their transportation costs); Laela and Sumbawanga are considered to be too far to buy
- Lack of competitors and increase of producers lower prices
- Quality of the crops is an issue:

- o Buyers regard quality to be highly fluctuating thus they pay an even lower price

1.5 Distinct support for enhancing the chain (more/deeper steps) or raising the productivity

Maize:

- Government could plan for a fixed price for crops so that farmers could be motivated and increase their production
- Also, the government could buy more maize and allow free market to neighbouring countries (at the moment farmers are not allowed to sell to foreign markets)

Sunflower:

- Increasing the number of pressing machines in town
- Government could incentivize the development of processing factories in the region (pressing and refining of high quality sunflower oil) so that farmers could sell directly to the factory and get a better price
- The government could enable importers to import machines which can use sunflower oil as fuel; as a result sunflower farmers could get a good price and more farmers would grow sunflower

0. Introduction in group work
   - I. Maize
   - II. Sunflower
   - III. Groundnuts

Each group should discuss about:

2.1 Agents in value chains and define whether they are residents of Laela, or not

Maize: agent of cash crops are from outside Laela

2.2 Trading and processing

Maize: trading and processing is done inside and also outside Laela

2.3 Structure of value chains (graphical)

Maize:

- Middlemen benefit from both sides (buyer and processor) if prices for crops is good
- Producer does not benefit because price is planned by the buyer

- Losses:
    - Destructive insect
    - Theft in farms
    - Theft in the weight balance
- Residues:
    - Up to 5-20 bags depending on the size of the family
    - For food and other needs
    - 1 bag of maize with cobs yields about half a bag of cobs
    - 1 bag of six buckets produces 4 bags of maize corns and 2 bags of husks

Sunflower:

- Pressing machines exist in Laela at Mama Rehema, Mama Nimo and at the Mission; outside Laela in Tunduma,Mbeya, Sumbawanga
- Prices:
    - During harvest: 15,000 per bag for the farmer
    - Buying: 15,000
    - Weighting: 200
    - Bag: 600
    - Storing: 500
    - Transportation: 1,200
    - Carrying: 500

    Total: 20,000 (?)
    - Selling price after storage: 35,000
    - Profit: 15,000

2.4 Prices and margins in the value chains including the respective agent/step/position (producer, middlemen, buyer)

2.5 Losses like e.g. theft, storage losses and diseases including the respective agent/step/position in the value chain

Sunflower:

- Average losses (one acre):
    - Farming: 20,000
    - Weeding: 14,000
    - Seeds: 5,000 (local seeds; hybrid seeds 9,500)
    - Harvesting: 10,000

- o Removing seeds from the head: 10,000
- o Transportation: 10,000

  Total: 69,000

- o Yield of one acre: 3 bags @ 15,000 = 45,000 (?)
- o Loss: 14,000 (?)

2.6 Amount of residues and their usage

Sunflower:

- 1 bag of six buckets of sunflower seeds yields about two bags of press cake
- Press cake is used as fodder for pigs, poultry and cattle

Discussion in big group about validity

Desired outcomes

- Graphical designs of value chains
- Definition of agents in the trading process
- Roles of mills and pressing stations as processing step in value chains
- Validation of results in big group

3. Specific questions on sunflower value chain

3.1 What share of the locally produced sunflower seeds is sold directly at the market and which share is processed to sunflower oil in Laela?

- Most of sunflower seeds is sold outside Laela and few inside
- About ¾ is sold in Mbeya, Tunduma and Sumbawanga; ¼ in Laela

3.2 Of the locally produced sunflower oil, which share is

3.2.1 Consumed directly by the producer of the seeds

- ¼ of the sunflower seeds are processed to sunflower oil directly by the farmers
- Very little is consumed by the producers directly, most seeds are sold
- Very few farmers are producing oil for selling

3.2.2 Sold at the market for consumption in Laela

- Mostly during harvesting season no more than five people in Laela are selling their oil after pressing
- They sell about 10-20 litres per day for cooking
- Prices:

- During harvesting season: 2,000-2,100
- Currently: 2,500-2,700

3.2.3 Sold outside Laela

- No one who produces sunflower oil is selling it outside Laela

3.3 Who is buying the sunflower seeds?

- Most buyers are middlemen from Laela who know where to sell sunflower seeds (in Mbeya, Tunduma, Sumbawanga etc.)
- Outside traders are currently not active in Laela; this might change after completion of the road

3.4 Could the production of sunflower be increased in the village without reducing lands for food production (staple crops)?

- Yes, enough land exists for cultivating sunflower and it would not affect food crops

4. Specific questions on Jatropha

4.1. Have you heard of Jatropha? What do you know about Jatropha?

- Seeds were used for lighting purposes (put on a stick and burned)
- All participants know it, it is used as a fence or hedge
- It is only grown as a hedge by Mr. Mwanisawa

4.2. Is Jatropha grown in the area?

- In general, it is not grown in Laela

2. Specific questions on electricity use in Laela

6.1 How many people in Laela sell electricity to other people?

- For the moment no one, for a short period a mini grid was running (TaTEDO) but currently it is not working

6.2 How much do they charge?

- 3,500 per week

6.3 How much lights / appliances can be connected?

- Only four light bulbs and 1 TV
- Refrigerator and ironing was not allowed to use

Results expert interview No. 2 – MFP

26.11.2010

Laela

Participants:

- Jan Rordorf, ZALF
- Ewald Gervas Emil, ICRAF
- Balton Mwakitalima, District Agricultural and Livestock Development Officer, Chairperson of the District Sustainable Energy Cluster, contact person of TaTEDO in Laela[109]
- Datus Kisunga, Subvillage chairman Laela Kati
- Mahamud Mohamed, chairman MFP operating company
- Alfred Msumeno, secretary MFP operating company
- Fred John, Treasury MFP operating company
- Desdery Ismail, local businessman (owner of haircutting shop and mobile phone recharging, owner of a PV system and generator set)

Not present:

- Abel Kauzeni, member (partner) MFP operating company (does not live in Laela anymore?)

General information:

- According to Ewald Gervas Emil harvesting season in Laela is around April/May
- Most agricultural lands only allow for one harvest per year as the second rain season is short only (from October to December; long rains (Masika) from March to May); only in river basins two harvests can be reached

Visit of the MFP:

General aspects:

- Construction of the MFP was finalized in November 2009
- The MFP was installed by a team of TaTEDO including Shukuru Meena and a technician from Dar es Salaam
- In total, the MFP was running three weeks only due to technical failures elaborated below

Technical aspects:

- The MFP consists of the following assets:
    - Chinese diesel engine (Feidong, 26Hp)[110]. The diesel engine is already technically modified to run on pure plant oil (equipped with a two-tank-system)
    - Alternator (24kW)[111]

[109] Based on personal communication on behalf of the author conducted by Ewald Gervas Emil, ICRAF with Shukuru Meena, TaTEDO project manager of MFP implementation in Laela
[110] Source: Shukuru Meena, TaTEDO

    - Battery charging machine
    - Originally a milling machine was directly connected to the MFP, however, the operating company decided to sell the machine (sold at 450.000) due to below discussed technical problems and invest in a dehulling machine. The dehulling machine is installed in a separate building nearby the MFP building and powered by an electric motor. Originally, it was planned to power the dehulling machine with electricity produced by the MFP. Since the MFP is not running, the dehulling machine and an additional machine owned privately by the chairman of the operating company are not working.
- Some major technical problems led to the decommissioning of the MFP:
    - Difficulties were experienced with the size of the flywheels of both the engine and the alternator which are connected by transmission belts. As fuel consumption was higher than expected the flywheels were changed.
    - Unstable electrical current levels in the mini-grid led to light bulbs and television sets being destroyed in some households; also, the electric motor of the dehulling machines was damaged (during the visit the motor was not installed in the machine (currently in Sumbawanga for repair?)).

Organizational and financial aspects:

- Overall **investment costs** of the MFP (including generator, alternator, battery charger, milling machine) amounted to **TZS 3.400.000** financed by TaTEDO
- The building accompanying the MFP is rented for TZS 20.000 per month by the operating company
- Ownership of the MFP was transferred to a group of four local entrepreneurs that own and operated the MFP on equal terms. Each partner holds a different position in the operating company (see list of participants above).
- The four partners of the operating company also form the village energy board
- The chairman of the operating company previously owned a small energy service company supplying electricity from small 7kW and 20kW generators to about 20 households through a mini-grid. After becoming a partner in the MFP operating company he sold the generators.
- TaTEDO financed the initial installation costs which were due to be repaid by the operating company
- according to a contract and MoU between TaTEDO and the operating company the initial investment costs were to be paid back during 12 months of operation at a zero interest rate
- The group of entrepreneurs made the following additional investments:
    - Establishment of a mini-grid connecting 32 households[112], in the mid-term a total number of 200 households was planned to be connected. Investment costs include:
        - Poles: TZS 1.000.000
        - Electric cables: TZS 2.000.000 (including additional cabling already purchased to extend the mini-grid (how many additional households can be connected?))

[111] Source: Shukuru Meena, TaTEDO
[112] Source: Shukuru Meena, TaTEDO

- Energy services planned to be provided by the MFP:
  - o Grid-based electricity
  - o Recharging of car batteries to be used for lighting in households: about 10 clients
    - ▪ TaTEDO provided the batteries plus a basic electric system in each participating household including 3 light bulbs and a connection for a radio
    - ▪ an up-front payment of TZS 10.000 had to be made by each costumer plus down payments of TZS 40.000 in total to be repaid during the following three months
    - ▪ however, the batteries were faulty as they could not be recharged properly (this had been tested without success at a battery charging station in Sumbawanga)
- Both services are not provided by currently existing systems[113]

Plans for cultivation and running the MFP on Jatropha:

- TaTEDO is planning to run the MFP on pure Jatropha plant oil[114] and therefore installed a modified diesel engine capable of running on pure plant oil.
- On request of the MFP operating company in late 2009 TaTEDO sent 30kg of Jatropha seeds to Laela. The members of the operating company own land nearby the village (mostly cultivated by rural laborers) and were planning to cultivate Jatropha seeds to produce Jatropha plant oil for running the diesel engine. Each member of the operating company was planning to establish a Jatropha plantation of about 2 acres. When the first significant harvest would have been reached it was planned to procure a mechanical oil press from TaTEDO to be connected to the MFP to locally produce Jatropha plant oil. However, the germination rate of the seeds was less than 10% thus, the establishment of Jatropha plantations failed
- The chairman of the operating company expressed his interest in establishing business relations with Jatropha producers such as PROKON in Mpanda to source Jatropha seeds or oil. He was aware of Jatropha cultivation activities in Mpanda. If they would get the MFP running again they would be very much interested in sourcing Jatropha seeds and oil. They expect it to be less costly even considering the transportation costs from Mpanda.

Criticism:

- The operators of the company as well as Mr. Mwakitalima claimed that TaTEDO did not provide enough technical training to the operating company
- In May 2008 a scoping study was conducted by TaTEDO in Laela to assess the installation of the MFP (see document)
- In 2009 TaTEDO installed the MFP during a four-day-visit
- Also, the electrical set-up of the MFP and the mini-grid was insufficiently done.
- Generally, the members of the operating company claimed that TaTEDO did not follow-up sufficiently after the installation of the MFP and make sure that the

[113] Source: Shukuru Meena, TaTEDO
[114] Source: Shukuru Meena, TaTEDO

operation of the MFP in technical and entrepreneurial terms worked smoothly. Since the installation of the MFP the members of the group have not heard of TaTEDO again.

- Mr. Mwakitalima promised to contact TaTEDO as soon as possible to communicate the technical problems associated with the installation.
- The chairman of the operating company has relatives in Lengaruka (?) where TaTEDO has installed another MFP. In Lengaruka about 200 households are connected to the mini-grid which (after some initial technical complications) works without problems. The chairman thus expects TaTEDO to make sure the MFP in Laela was technically operating the same way.

Plans to put back the MFP into operation:

- The operating company would be very much willing to restart the MFP if technical and financial capacity would allow for it
  - It would however, be more suitable to move the installation and the mini-grid to a new site in the centre of Laela (along the main road) as consumption levels, current and future demand and willingness-to-pay for electricity is higher in that area than in the current site (in the centre most individually operated small-scale generators exist).
  - For this purpose the following investments would be required:
    - Acquisition of a new building (cost estimation TZS 1.000.000)
    - Installation of a new mini-grid: about TZS 1.000.000)
- According to the chairman, a major bottleneck of putting the MFP back in operation is the lack of technical capability in the region to adequately configure the electrical set-up of the mini-grid so that the electrical current levels permit a safe use of electric appliances.
- In nearby cities such as Sumbawanga only electricians of questionable capabilities are available.
- If the MFP is not being put into operation again the operating company plans to alternatively invest in two 20hp diesel generators to power a mini-grid in the centre of Laela. The set-up of the mini-grid for this new system however, was not discussed.

Processing of groundnuts:

- Investment costs of dehulling machines:
  - TZS 2.800.000
  - TZS 1.600.000
- Both machines were ordered directly in Dar (through a dealer in Sumbawanga) and transported by the importing company to Laela
- The dehulling machines were operational for about one month only between May and June of 2010
- One bag of groundnuts yields 27kg of dehulled peanuts sold at TZS 12.000 to 18.000
- Traders from Uganda buy peanuts to be transported to Uganda by own trucks

(further information on MFP see Baseline Study Electricity)

Results expert interview No. 3 – Jatropha production Prokon Renewable Energy Ltd.

26.11.2010

Prokon Renewable Energy Ltd., Mpanda

Participants:

- Dr. Götz Uckert, ZALF
- Hary Hoffmann, ZALF
- Jessica Parzik (?), Prokon Renewable Energy Ltd.

- Prokon pays TZS 300 per kg of Jatropha seeds to their outgrowing farmers
- 3kg of Jatropha seeds yield 1l of straight Jatropha oil
  [according to TaTEDO, 2008 ("Bio-fuel powered energy service platforms for rural energy services") an "average of 4 kg of good quality Jatropha seeds produce one liter of Jatropha oil"]
- Pressing costs: TZS 80 per l
  Calculated by Dr. Uckert (based on production costs of small-scale cold pressed rape seed oil in Germany of 40 € / t using a press from Maschinenfabrik Reinartz GmbH)
  [according to TaTEDO, 2008 Jatropha oil production :
    - 4kg of seeds at 300/kg: 1.200
    - Labor for oil expelling per kg of seeds: 70
    - Labor filtering per kg: 30
    - Depreciation and maintenance of the machine Sundaya oil expeller: 30
    - Price of one liter of jatropha oil: 1.720
    - ➔ Price of jatropha oil equivalent to one liter of diesel (+15%): 1.978
    - ➔ Average diesel price in rural areas (according to TaTEDO, 2008): 2.200
    - ➔ Current diesel price Sumbawanga: 1.850
    - ➔ Current diesel price Laela (according to Mr. Hassan): 1.700

- Prokon currently uses two presses (both imported from Maschinenfabrik Reinartz GmbH?):
    - Small: 35kg/h yielding aprox. 11l
    - Large: 180kg/h yielding aprox. 60l
- Investment costs:
    - Small: 14.000 €
    - Large: 34.000 €
- Calculated depreciation time: 10 years
- Operation of press: approx. 7 hours per 8h working shift
- Jatropha oil content (based on laboratory tests by Indian Sisal farmer in Morogoro):
    - Seeds with pods: 31%
    - Kernels: 54%

Results expert interview No. 4 – Sunflower processing

27.11.2010

Laela

Participants:

- Jan Rordorf, ZALF
- Ewald Gervas Emil, ICRAF
- Balton Mwakitalima, District Agricultural and Livestock Development Officer, Chairperson of the District Sustainable Energy Cluster, contact person of TaTEDO in Laela[115]
- Datus Kisunga, Subvillage chairman Laela Kati
- Abdillahi Hassan, local businessman Laela, owner of several milling machines, dehuller, oil press
- Rashid Hassan, son of Hassan Tukale, local businessman Laela, owner of a store and diesel engine

Potentials for Jatropha cultivation:

- According to Mr. Mwakitalima the natural conditions in the Laela region are highly suitable for Jatropha cultivation
- Also, unused land or low productivity land is largely available thus Jatropha could be cultivated without producing less food crops
- Competition with food production is
- Another option would include the planting of Jatropha plants at river banks to prevent erosion
- In some areas sisal is planted as hedges as demarcations between field plots; sisal is being used to make ropes etc.; Jatropha plants could be planted in the same manner
- Currently, in the village only two farmers have been growing Jatropha hedges around their farm premises from cuttings obtained from ; Jatropha trees are up to ten metres high and bear very little and small seeds; according to Mr. Mwakitalima seeds are currently not used
- In ten villages in the Sumbawanga region Jatropha has been introduced by the district council (check!) in 2008 as an additional cash crop; first harvests are expected next year
- Mr. Mwakitalima conducted trials with Jatropha seeds provided by TaTEDO in petri glasses yielding the following germination rate:
    - 8/100
    - 11/100
- Due to disappointing results the remaining seeds have not been further used
- TaTEDO has established three tree nurseries in Laela village to promote agroforestry
- In his annual report to TaTEDO to be compiled beginning of next year Mr. Mwakitalima will suggest to establish a Jatropha nursery in the existing tree nurseries

[115] Based on personal communication on behalf of the author conducted by Ewald Gervas Emil, ICRAF with Shukuru Meena, TaTEDO project manager of MFP implementation in Laela

  - In Laela a village energy committee exists that has worked closely with TaTEDO; its field of activities include the following (assisted by TaTEDO):
    - Training on efficient charcoal production
    - Planting of trees
    - Improved cooking stoves

Local diesel engine + generator:

- A local businessman (owner of a store) was visited who owns a 13hp diesel engine coupled with a 5kW alternator
- The system is used to generate electricity for about four hours every day for own consumption only
- Consumption of 2-3 l/day
- Installation costs:
  - Engine: TZS 400.000 in 2000 (current price was estimated at TZS 1.2000.000)
  - Alternator: TZS 400.000 in 2000 (current price was estimated at TZS 800.000)
- The store also uses a refrigerator running on kerosene:
  - Kerosene consumption: 1,5l in 24 hours

Milling / oil processing:

- Abdillahi Hassan was visited, owner of a processing facility for maize and sunflower
- The facility includes the following assets:
  - Maize mill
  - 2 sunflower dehulling machine
  - Oil press
  - Four diesel powered motors (3x20hp, 1x18hp)
  - Alternator (used for private purposes only when the other machines are not running)
- Up to 20 bags of sunflower seeds can be processed every day
- 1 bag of approximately 60kg of sunflower seeds yields between 17 and 20l of crude sunflower oil depending on seed quality
  - 17l: 3,53kg = 1l
  - 20l: 3kg = 1l
- Price for pressing service: TZS 1.000 for 10kg sunflower seeds
- The crude oil is refined by cooking at sold at the local market at TZS 1.200 (during harvesting time) and TSZ 2.000 at current prices
- Outside traders only buy sunflower seeds in the village, refined oil is only locally consumed
- Mr. Hassan is only providing the processing services and is not directly involved in commodity trading
- 10 kg of press cake are sold for TZS 1.000

Results expert interview No. 5 – Sunflower processing

29.11.2010

Laela

Participants:

- Dr. Götz Uckert, ZALF
- Jan Rordorf, ZALF
- Ewald Gervas Emil, ICRAF
- Abdillahi Hassan, local businessman Laela, owner of several milling machines, dehuller, oil press

Milling machine:

1 large bucket (20l – about 16-20kg) of maize dehulling: TZS 750

1 large bucket of maize milling: TZS 750

According to Mr. Hassan, 1 bucket of maize corns yields 16kg of dehulled corns

- The residues (husks) are mixed with sunflower presscake and fish mill to feed chicken

After dehulling three fractions are produced from the maize corns:

- Dehulled corns
- Husks (maize skin): sold at TZS 1.000 per big bucket
- Seedling: sold at TZS 2.000 per big bucket

According to Mr. Hassan, 10 big bags (120l) of maize corns yield the following:

- 8 bag bags of dehulled corn
- 1 big bag of husks
- 3 big bags of seedling husks

Sunflower:

- Harvesting season starts in April
- Pressing mill is about six months in operation
- Daily processing capacity 10-20 big bags
- This year very low production

Fuel consumption:

- 10l diesel per day
- About 20l per day if all machines are running during high season

Results expert interview No. 6 – Agricultural Potential in Laela / Potential for Jatropha production

30.11.2010

Laela

Participants:

- Jan Rordorf, ZALF
- Gaudens Athanas Masebe, teacher for crops, Laela Agricultural Centre (LAC)

Maize production:

- Harvesting period: June to August
- Threshing by small-scale farmers is done by drying cobs in the sun and breaking out seeds by beating them with a stick on the ground
    - Some famers use a elevated wooden platform to beat cobs so that the seeds fall on the ground
- A diesel powered threshing machine is available in the Laela Agricultural Centre (LAC) which can be used by the local population during harvesting time (currently cobs are hardly available as most are being threshed right after harvesting)
- The LAC first dries the cobs in an indoor- drying floor
- Various Chinese-made hand-shelling machines have been distributed to farmers since the early 1990s by the Agricultural Centre

Groundnuts:

- During harvesting season buyers of groundnuts come to town to buy groundnuts to dehull them with a dehulling machine that has been brought with them
- The machine is also rented out for use for the local population
- Oil production from groundnuts is not taking place in Laela (to do: cost calculation)
- One big bag (120l) of non-dehulled peanuts is currently sold at TZS 13.000-15.000
    - (according to Mr. Hassan, owner of the mill in town one big bag consists of 6 big buckets (about 96-108kg))
- After dehulling one big bag of peanuts yields only one tin of peanuts (?)

Sunflower:

- Sunflower was introduced as a new (food and cash) crop in the region in the beginning of the 1990s, also promoted by the LAC
- After some initial years of low production rates it has now become the second most important crop in Laela (after maize, followed by finger millet)
- Sunflower seeds are sold at the market or have it pressed in local pressing mills to use it as cooking oil, thus replacing imported cooking oil that would have been bought on the market
- Farmers have also been convinced to grow sunflower because cultivation is less labor-intensive in comparison to finger millet (weeding is only required once before harvest) and especially maize where weeding is required 2-3 times before harvesting
- The LAC used to own the first diesel-powered pressing machine for sunflower oil production in town (from about 1994-2000 after which it was sold as various privately owned machines were purchased in the village)

- The pressing machine could be used by farmers from the village for own plant oil production
- Sunflower oil is currently sold at TZS 2.000 per litre
- One medium bag of sunflower seeds contains six buckets ("tins") of each 8-10kg, totaling to 48-60kg
    - o 1 medium bag is currently sold at TZS 40.000
        - ▪ Price for 1kg: TZS 666-833 (depending on the weight of the bag)
            - Price for 1l oil[116]: TZS 2.611-3.195
    - o During harvesting season: TZS 25.000
        - ▪ 1kg: TZS 416-520
            - 1l oil: TZS 1.736-2.100
    - o In 2009: TZS 15.000-25.000 (as a result this year many farmers were discouraged from planting sunflower)
        - ▪ Lowest price (TZS 15.000) per kg: TZS 250-312
            - 1l oil: TZS 1.155-1.372
        - ▪ Highest price (TZS 25.000) per kg: TZS 416-520
            - 1l oil: TZS 1.736-2.100
- Currently the following pressing machines exist in Laela (bought during the last ten years):
    - o Mama Rehema
    - o Mr. Hassan
    - o Secondary school

Weights and measures:

- One medium bag (of 50kg) equals 6 tins
    - o according to Mr. Masebes estimations one tin equals:
        - ▪ Maize: 18-20kg
        - ▪ Sunflower: 8-10kg
        - ▪ groundnuts (not dehulled): 8-10kg
        - ▪ groundnuts (dehulled): 15-18kg

Potential for Jatropha cultivation:

- Mr. Masebe is aware of Jatropha and some of the first approaches of Jatropha promotion by TaTEDO (he has heard of the meeting with TaTEDO in May 2008 and of the seeds they send here that did not germinate)
- Enough land for additional cultivation of Jatropha would be available in the village as many plots are under-utilized or cultivated with low productivity
- If farmers would be able to gain additional income from a new cash crop grown on a small portion of their land (hedges or intercropped with other plants) with little input of work and fertilizers etc. overall productivity of small-scale agriculture might be increased as farmers could invest the additional income in the purchase of

[116] Assumption for sunflower oil production (based on an expert interview with Dr. Uckert, 2010):

- 3,5kg seeds yields 1l of oil
- TZS 80 / kg processing costs (based on figures for rape seed pressing using a small Rheinhard press (processing capacity of about 180kg/h): 40 € per ton)

agricultural inputs. As a result higher overall yields could be achieved from the same land (Jatropha, cash and food crops)

- However, convincing farmers in cultivating a new crop has been proven difficult in the past
- the experience of sunflower promotion in the last two decades has shown that it takes a long time until farmers are convinced of the advantages and income opportunities of a new cash crop
- profits and opportunities have to be immediate and visible to the farmers for them to be cultivate the crop otherwise cultivation does not take place
- the same experience has been made in regards
    - to the promotion of sunflower which succeeded as profits and lower labor-intensity were clearly visible to farmers and
    - in regards to the introduction of spicy paprika (“Chilis ”) which was promoted by the Diocese in Iringa and was also tried to be promoted in Laela. Transport would have been organized directly by the producers to a buyer in Iringa (Diocese?) which would have acted as the sole buyer. This dependence on only one buyer and the fact that the paprika could not be consumed in the households discouraged farmers to cultivate the fruit.

General information:

- the general use of agricultural inputs is very low in the village
- Mr. Masebe expects prices for agricultural products to increase significantly after the road construction is finalized which will lead to raised income levels and consequently a higher use of fertilizer and other inputs

Results expert interviews No. 7 – Laela Agricultural Centre

04.12.2010

(also includes results of prior discussions with Mr. Masebe)

Laela Agricultural Centre

Participants:

- Jan Rordorf, ZALF
- Andrew Mahenge, teacher for cross-cutting issues, manager of LAC
- Gaudens Athanas Masebe, teacher for crops, acting manger Laela Agricultural Centre (LAC)

Contact details:

LAELA AGRICULTURAL CENTRE (LAC)

P.O. Box 21

Laela – Rukwa

laelalac@yahoo.com

Manager, teacher for crosscutting issues:

Mr. Andrew Mahenge

0767-074946

0786-074946

mahenge@yahoo.com

Acting manager, teacher for crops:

Mr. Gaudens Masebe:

gaudensmasebe@yahoo.com

+255787284585

Teacher for livestock:

Mr. Ray Mtetewaunga

0752550797

- LAC is the only agricultural extension centre in the Rukwa region
- LAC is involved in the Kilimo Kwanza initiative and received a total of seven power tillers
    - Also in their agricultural input store subsidized implements are sold for vouchers given out by the government
    - Mr. Mahenge is not convinced of the subsidy component of Kilimo Kwanza:

        - Due to high bureaucratic costs he estimates the percentage of government spending that is directly reaching the farmer in the form of a subsidy to agricultural inputs at 5% of total government spending on subsidies
        - He is rather suggesting to invest the money in capacity building and trainings on market access, on infrastructure development and the establishment of processing industries in rural areas
        - Educated farmers would not need subsidized inputs as they could invest in inputs at market prices if they know which crop to grow and how to sell it with high profit
- Power tillers are difficult to use under some conditions and costly in maintenance so that mostly oxen are used in the LAC; power tillers are not necessarily more effective (in terms of labor and time) as oxen
- During a visit the Prime Minister of Tanzania considered it as a best practice example in the Rukwa region
- The centre is involved in three activities:
    1. Agricultural school
    2. Outreach programme for external farmers (LAC staff going to villages to educate farmers)
    3. Income generation activities (crop and livestock production)
- Total area owned by the centre: 650 acres
    - Fields: 60
    - Woods: about 220 acres
    - Grasslands: about 370 acres (woodlands and grasslands are not easy to separate)
    - Compound: 3 acres
- If additional opportunities for the cultivation of income generating crops would come up the agricultural land could be increased without replacing (dense) forest areas
- The LAC is part of the Catholic Diocese of Sumbawanga and was funded by the Catholic church of the Netherlands for its extension service program between 1990 and 2008
    - About € 100.000 per year
    - Due to the long-term funding the donor pulled out leaving the LAC to find new financing
    - Currently, the LAC receives no external funding and is financing its operation through the sale of agricultural products (and to a limited extent by giving extension trainings for the District of Sumbawanga
    - The Catholic Diocese of Sumbawanga only paid for the buildings but is not financing any running costs
- The government or local authorities are not directly supporting the LAC
    - The district government pays LAC to train farmers in agriculture and extension services (about one week course)
- The manager Mr. Mahenge used to be a teacher for Maths and Physics, then studied agricultural science in the SUA, worked in different positions in private companies and for the government

Agricultural school:

- Capacity of 60 students

- Currently 31 students enrolled, 15 females
- One year course from September 1 to August 31
- School fees: TZS 100.000 for one year course including full accommodation is in some cases paid back by the students from the earnings they generate during their stay in the LAC
- Age: 18-20 up to 35
- Student come from surrounding villages
- Staff:
  - Three teachers:
    - Crops, agroforestry, tree nursing
      - Currently no tree nursery exists due to shortages of seeds and water but is planned to be established in September for new students
    - Livestock production
    - Crosscutting issues:
      - Marketing
      - Gender
      - Environment
      - HIV
- 75% of the classes are practical
  - Each student cultivates ½ acres of land; five students together cultivate 1 hectare
    - Inputs are provided by the LAC but are deducted from the earnings of the students
  - When the students leave the school they are provided with a starting capital to become farmers (agricultural inputs, ploughs, livestock; no financial capital) which they do not have to pay back

Staff:

- Three teachers
- 11 permanent support staff:
  - Office
  - Kitchen
  - Crop assistant
  - Livestock assistant
  - 2 machine operators/mechanics:
    - Milling machine
    - Shelling machine
  - Livestock grazing (shepherd)
  - Night watchman
  - Day watchman in forest areas
  - Driver/mechanic
  - Shopkeeper (agricultural inputs store)
- The LAC has problems with wood theft from their forests; a guard is patrolling the forests every day at daytime
- Nevertheless, the forest area and wood store has slightly increased in the last five years since Mr. Mahenge has been working in the LAC

- Regularly fires are set in the forest (for hunting animals out of the woods); the local authorities are not very cooperative; however, one person was caught, turned in to the police and sentenced to one year in jail
- The centre is fully covering its own consumption of firewood from its own forest; only dry dead wood is collected, wood is neither sold nor bought on the market nor is it processed into charcoal
- Additionally, fire wood is obtained from regularly clearing fire breaks in the forest
- The forest is not intensively managed, as no additional trees are planted; tree nurseries have been used to plant trees on the compounds (for instance plantation north of the teacher house)
    - It takes up to ten years for a planted tree to grow high enough to use it as timber wood
    - Termites are a major problem in nursing trees
- very few poor people from the village are permitted to collect dry wood in the forest for their own use
- the forests in the mountains are owned by the government and not managed properly (environmental committee is not powerful enough)
- According to Mr. Masebe parts of the centre´s forest areas are protected and not used for firewood collection
- Mr. Haule (now Division Officer) used to work at the LAC (organizing farmers in cooperatives etc.)
- The LAC is running an input shop (Duka la Kilimo) in the new market area:
    - Agricultural implements (seeds, herbicides, pesticides, fertilizers, ploughs) are sold at prices that are lower than market prices
    - costs of the store (transportation, rent, staff) are covered and only a small profit is generated
    - also subsidized inputs from the Kilimo Kwanza initiative are sold (farmers can buy implements at lower price and turn in voucher which LAC changes for cash in Sumbawanga)
    - main function of the shop is to secure availability of agricultural inputs for farmers at relatively stable prices (price are highly fluctuating)

Cost estimations for one full-time extension officer to promote Jatropha in Laela area:

- Based in the LAC
- Costs for housing paid by officer: 15% of the wages (all costs included)
- University graduate: 500.000-600.000 per month
- Diploma: 400.000-450.000
- Transportation costs (by motorcycle including fuel, maintenance, cost depreciation): 500 per km
- According to Mr. Mahenge the most important task of the extension officer would be to explain farmers the agronomics of the new crop and convince them that their crops can be sold
- If farmers are convinced that they could reach high prices for the seeds they would make sure the plants would grow well and yield high amounts of seeds
- especially the famers trained at the center which received classes in access-to-market-strategies and thus are very aware to produce only crops that sell at high prices in the market would be interested in cultivating (new) cash crops if high prices can be achieved
- if they would be convinced in the viability of Jatropha they would turn to the LAC for assistance in cultivating the new crop
- the best option to work with such farmers are outgrower contracts

Establishment of a Jatropha nursery on the LAC compounds:

- Mr. Mahenge confirms the hypothesis that enough land is clearly available in Laela but due to low market prices for agricultural products as a result of poor infrastructure and market access land is used in a suboptimal way:
    - Agricultural productivity is low (especially for owners of large lands)
    - The use of implements is low
    - (paid) labor at a low price is widely available but not invested for productive use
- Therefore, in its farmer trainings the LAC emphasizes the importance of market access strategies:
    - Farmers need to be aware of current market prices and only cultivate crops that can be sold at a good price (currently beans are more profitable than maize or sunflower)
    - For instance the LAC is cultivating about 40 acres of maize seeds for a seed company in Mbeya
        - Yield: 8 bags (100kg)
        - 1 bag is sold at 60.000 (compared to about 20.000 for milling maize)
        - According to Mr. Mahenge this is an example of producing more directly for the market
        - If crops can be sold at such high prices directly to the end consumer high transport costs are not as prohibitive
        - Ironically the seeds are further processed in Mbeya (basically cleaning and packaging) and shipped back to Laela where they are sold in the input store the LAC is running. However, the LAC is not allowed to plant the seeds directly.

- Some part of the extensively used land (currently only for occasional grazing) owned by the centre north (?) of the compound could be cleared and fenced in (with a Jatropha hedge for instance) to protect the seedlings from grazing animals
- The establishment of a nursery would be associated with relatively high initial fixed costs:
    - Clearing the land (currently covered with shrubs and small trees)
    - Fencing
    - polythene tubes
    - seeds
    - fertilizer
    - soil preparation
- (running) labor costs would be relatively low:
    - The cultivation of Jatropha could also be integrated in the teaching curriculum of the agricultural school
    - The students would learn from working in the nursery (in cooperation with the extension officer) and from pruning grown plants
    - for this purpose Jatropha plants could be planted in different forms (intercropped with other shrubs in the woodlands , as hedges to protect fields from grazing cattle) on the currently only extensively used areas north of to the LAC compounds
        - [Jatropha Handbook Fact Foundation, 2006 (?): "In case of permanent intercropping, the plants should be planted in rows with a larger distance in between for other crops. The distance between the rows depends on the space needed for intercropping, usually about 4 meters. The distance between Jatropha plants within a row is 2.5 or 3 meters."]
    - On the other hand casual labor is available at very low costs in the village (the centre hires casual labor on a regular basis during planting and harvesting season etc.):
        - During dry season: 1.000-1.500 per day
        - During high demand periods: 2.000-3.000 per day
        - In terms of higher efficiency Mr. Mahenge advised to pay a fixed amount for certain agreed upon tasks
- Mr. Mahenge estimates the production costs of Jatropha seedlings at TZS 500-1000 [in line with costs of tree seedlings as sold by the tree nurseries in Laela: according to focus group interview 4 average price for trees: 500 (250-1000 per seedling)]
- However, if farmers could be convinced of cultivating Jatropha because their harvests are bought at a good (fixed) price, nurseries would not be necessary in the mid-term as farmers would plant seeds directly [as it is also promoted by Prokon]
- One limiting factor is the shortage of water in Laela and the LAC during the dry season (seedlings could be produced during the rain season, however, during that time availability of (cheap) labor both on the market and in the LAC is limited):
    - The capacity of the PV-powered water pump could be increased (see below)
    - A dam and water reservoir could be constructed at the foot of the mountain storing water from the rain season
        - If funding or access to credit would be available the LAC would be very interested in constructing a dam to start irrigation agriculture cultivating vegetables (which are hardly available (at affordable prices) in Laela

during the dry season, thus potentially improving nourishment and health in the village)

Feasability of Jatropha cultivation in Laela:

- According to Mr. Mahenge the promotion of Jatropha in Laela is problematic:
    - Farmers are very hesitant in cultivating new crops, especially considering that
        - Jatropha is a non-food crop
        - The MFP would be the only available buyer for the Jatropha seeds

Water situation in Laela:

- Mr. Mahenge confirmed that water shortages during the dry season is a severe problem
- Even if people use their own wells the water is often polluted as latrines are often in close proximity to the wells
- As a result regular deaths occur from diarrhea etc.
- Only a handful of public wells exist that are often far away from the vilage
- People are mainly dependent on rain water as drinking water

Water availability in the LAC:

- Compared to the situation in the village the availability of water in the centre is very good
- The water tower of the centre (capacity of 10.000l) is filled during daytime by a PV powered electric pump (20 panels of 25Wp equals 500Wp)
- However, due to the limited capacity of the system (about 17 years old) running water is limited to about one hour in the evening
- Between May and July water is supplied for a longer period as the pumping capacity is higher due to higher water tables in the ground
- Additionally, during the rain season a well is used which is fed through pipes from the mountain area

PV system:

- Total costs: 14.8 Mio Shilling (about € 7.380, € 9.460 pro kW), including transportation, installation
- Installed in 2008
- Installed capacity:
    - Panels: 12 x 65W: 0,78kW
    - Inverter/transformer: 3kW
    - Battery charger: 100 Amps
    - Battery system: four batteries (12v. 210Ah/100h) = 840Ah
- Installed by BP Solar

18.02.2011:

Solar Now: Information booklet. Sales information - Installation - Maintenance – Marketing

21: The battery size can be calculated approximately by the panel wattage times 2. Battery size Ah = panel wattage x 2

d.light solar lighting products:

- Mr. Mahenge is selling solar lighting products (small PV panel plus LED light) by the company d.light based in Dar es Salaam (which is partly financed from carbon credits)
- He is directly importing the lights from Dar to Laela
- Types :
    - Nova S 100: 70.000 (retail price); 65.000
    - Nova S 200: 75.000; 69.000, includes mobile phone charging which takes about 1:45 hours)
    - Solata: 22.500 (20.000)
    - Kiran: 22.500 (20.000)
- He has sold about 60 pieces of Nova S 200 since June 2008 and 48 of Solata
- He is importing the lights as he is very convinced of solar energy and wants to replace kerosene lamps
- One kerosene lamps roughly consumes about 200-300 worth of kerosene per night

Energy prices:

- Headload of firewood: 3.000-4.000 (depending on the season, higher during rainseason)
- Bag (up to 50kg) of charcoal: 4.000-6.000

Input prices:

- DAP:
    - 50kg: 65.000-75.000 (currently: high price due to planting season)
    - Government subsidy: 26.000 (farmer (with voucher) currently pays 49.000
- Phospate is hardly used in Laela
- Urea:
    - 50kg: 52.000
    - Subsidy: 22.000
- Seeds
    - Maize (hybrid): 3.500 per kg
        - Up to 10kg the government pays a subsidy of 2.000 per kg:
            - 10kg (subsidized): 15.000
    - Sunflower: 6.000 per kg
        - No subsidy

Harvest prices

- Sunflower: sold at: 30.000-40.000 per bag (60kg)
    - 60kg of sunflower seeds yield 20l of oil (3kg / l)
- Peanuts (dehulled): sold at 15.000-20.000 per bag of 50kg

National Food Reserve Agency

(information based on a discussion with an employee of the storing place in Laela (05.12.) and as confirmed by Mr. Masenge and Mr. Masebe):

- In Laela a storage for maize exist of the National Food Reserve Agency (large building on right side of main road leading to Tunduma)
- The agency buys a limited amount of maize at 300 per kg (30.000 per bag) which is much higher than what farmers are paid by the intermediaries (see below)
- The maize is sometimes stored for up to one year or further transported to Mbozi for distribution to areas with poor nutrition
- According to Mr. Mahenge very few farmers are able to sell directly to the Agency as intermediaries sell large amounts of maize directly so that the Agency has lower transaction costs
- A standard bag of the agency is exactly 90kg
- Mr. Masebe explained the mechanisms of the Agency:
  - During harvesting season many traders want to sell to the Agency as they pay a good price; long lines of trucks are waiting in front of the Agency
  - intermediaries buy a bag of maize at 18.000-20.000; a bag may be up to 20kg more weight thus giving the intermediaries an even higher price when selling for 300 per kg to the Agency
  - the Agency buys only a limited amount of maize and during a limited time
  - therefore, intermediaries bribe the officials of the Agency (for example with the extra 2kg of maize they get per bag when buying from the farmers); the official in charge of the gate and weighting instrument of the Agency receives the bribes but shares it with higher officials in the district authority
  - small-scale farmers have very little chance to sell to the Agency directly and prefer to sell to the intermediaries as they do not have to transport to the Agency, deal with the officials, wait for a long time etc.
  - thus, the Agency effectively supports the position of intermediaries

Lunch with Mr. Mahmoud Mohamed (chairman MFP operating company, secretary Saccos, maize trader, owner of bus):

- One of Mr. Mohamed´s businesses is maize trading:
- He rents one of the trucks in towns and buys maize directly from small farmers in the surrounding villages for 10.000-15.000 per bag (confirmed by Mr. Mahenge)
- He then sells to the National Food Reserve Agency, to other traders from Sambia, Congo or Dar and delivers to Tunduma mostly
- He is not shipping directly to other places as the risks are too high for him
- Last year the Saccos (Mr. Mohamed is the secretary) had a contract with the World Food Program on delivery of maize to Dodoma
- Due to “some problems” this year they did not receive a follow-up contract (no further information were given)

Loan dependency (“loan sharks”):

- According to both Mr. Ndalama (teacher) and Mr. Njelekela (extension officer crops) intermediaries in Laela offer loans to poor farmers during the dry season when they are have little income
- For a loan of TZS 10.000 one bag of maize has to be paid back after harvesting
- As a result, many farmers are taking a loan of up to TZS 100.000 so that they have to give as much as the their complete harvest to the creditor

Saccos:

- According o Mr. Masebe on December 5th a meeting of the Saccos was scheduled to elect a new leadership
- Since the bank pulled out of the contract with the Saccos a committee has been put in place to prepare the election of the new leadership
- The meeting yesterday could not take place and was postponed for next Sunday as many members did not show up
- especially those members who received a loan from the Saccos were afraid to have to pay back the loan

According to Mr. Masebe Laela is a business town as it is the first stop for business people and traders from Mbeya.

Talk with Mr. Mahenge, 11.12.

- at the moment farmers are in a supply chain, not in a value chain
- as part of the extension programme LAC conducted for the District Government LAC was planning to establish contacts between selected farmers and a processing company in Mbeya or Sumbawanga to allow farmers to sell directly to a processor at a fixed price (but without the obligation to sell of market prices increase above the agreed level)
- financing for the extension programme by the district was stopped in October 2010 so that these plans were not realized
- in the extension program the LAC encouraged farmers to diversify their crops (gardening, livestock) to have a steady supply all around the year instead of relying on only one cash crop per year, thus reducing dependence on loan sharks
- in the access-to-market component of the program they trained the farmers to conduct simple gross margin analysis to decide on which crops to cultivate to gain a profit
-

Climate data LAC:

- temperatures:
  - min (June/July): 20°C
  - max (September): 28°C
- average rainfall Laela: 786,5 mm (1994-2000 + 2007)
  - 1994: 848
  - 1995: 684
  - 1996: 888
  - 1997: 805
  - 1998: 1126
  - 1999: 739
  - 2000: 511
  - 2007: 691
    - J: 222
    - F: 63
    - M: 95
    - A: 26
    - M: 8
    - J: 0
    - J: 0
    - A: 0
    - S: 0
    - O: 0
    - N: 125
    - D: 152

TaTEDO, 2008a [Laela village workshop], 8:

3.5 Year calendar for Laela 'A' village

- January-April: rain season
- [May: BLANK]
- June-November: dry season
- December Rain season

Based on villager´s statements in a village workshop organized by TaTEDO in May 2008 (23 participants including 5 women).

TaTEDO, 2008b, 38:

Jatropha can grow in areas with rainfall range between 250 and 2400mm

best yields with 500-800mm

grows well in temperatures between 20 and 32 degree Celsius)

Result Baseline study electricity generation (fuel-based)

Number of generators in Laela:

From Focus group interview 1:

- In Laela Kati approximately 50 houses own generators; few households in other sub-villages (approximately 60 households in total)
- ➔ Share of total population:

Known owners of generators from personal communication (Laela Kati):

Name	Status	Questionnaire?
Mahmoud Mohamed	chairman MFP operating company, secretary Saccos, maize trader, owner of bus, owner of generator	?
Desdery Ismail	local businessman (owner of haircutting shop and mobile phone recharging in main road, owner of a PV system and generator set)	?
Abdillahi Hassan	local businessman Laela, owner of several milling machines, dehuller, oil press, generator	?
Hassan Tukale	local businessman Laela, owner of a store, kerosene refrigerator and diesel engine	?

Results survey:

Maporomoko:

Laela Kati:

Result inter views:

Mr. Yustus Thomas Landula, Designation Environmental Health Officer

- Planning to engage in sunflower production and trading
- Uses small generator (220 W)
- 3h daily, 1l petrol at 2,200 per litre (buys twice ties per week 2-3l – 4-6 litre/week
    - o TV
    - o Radio
    - o Two light (regular) bulbs

Mr. Rashid Hassan (son of Hassan Tukale):

- A local businessman (owner of a store) was visited who owns a 13hp diesel engine coupled with a 5kW alternator
- The system is used to generate electricity for about four hours every day for own consumption only
- Consumption of 2-3 l/day
- Installation costs:
    - Engine: TZS 400.000 in 2000 (current price was estimated at TZS 1.2000.000)
    - Alternator: TZS 400.000 in 2000 (current price was estimated at TZS 800.000)

Interview with Mr. Mahmoud Mohammed, chairman of MFP (10.12.2010)

First electricity generation business:

- Operating time 2007-2008 (about one year) – mini grid was integrated in MFP mini grid
- 45 houses were connected
- 7,5 kW
- Mr. Mohamed invested in the generator and the mini grid up to the house connection, the wiring had to be provided by the costumers
- No installation fees were taken
- User fees:
    - Households: 4,000 per week
    - Businesses: 15,000 per week
- Restriction on consumption:
    - No restriction of amount
    - No ironing
    - no electric cattles
    - no electric cooking
- allowed were:
    - lighting
    - TV
    - Radio
    - Phone charging
- Mr. Mohamed sent around some kids to his costumers to control that the restrictions were adhered to
- One costumer was taken from the grid as he did not adhere to the restrictions in spite of repeated requests
- Fuel consumption:
    - 5l diesel for six hours operating time

MFP

- The operating company of the MFP is planning to move the MFP to a new site in Laela Kati as one of the partners owns an empty plot in Kati; here a house for the MFP is planned to be constructed
- If TaTEDO will not support them they will find a capable electrician in Sumbawanga, Tunduma or Mbeya
- They are planning to eventually connect 500 households
- The mini grid of the MFP originally went up to Laela Kati (beyond Mama Remesas store)
- The MFP supplied a 25kV system
- Household wiring had to be paid by the costumer
- User fees:
    - Households: 3,000 per week
    - Businesses: 10,000 per week
- No fees were charged as the system only worked for three weeks and led to many problems for the costumers (burned bulbs and appliances)
- The same restrictions as in the first electricity generation business of Mr. Mohamed applied

- The operating company invested about 3,000,000 in wiring, poles and rent
- Fuel consumption:
  - 10l of diesel for 8 hours in daytime
  - 8l of diesel for 6 hours at nighttime
  - The fuel consumption was much higher than in the first business, due to the flying wheels and the electric installation
- Use of plant oil:
  - TaTEDO had plans to run the MFP on plant oil, also the entrepreneurs were willing to cultivate Jatropha on their own lands but they felt left alone by TaTEDO
  - Mr. Mohamed was not aware that the MFP could also be run on sunflower oil
  - However, prices for sunflower oil are currently too high to run it economically:
    - Market price during harvesting season: 2,000-2,100
    - Currently: 2,500-2,700
    - Diesel price: 1,800
  - Enough land would be available to grow Jatropha and farmers would have an additional form of (good) income as the crop would be directly used in the village

Investment costs MFP:

According to an interview with Mr. Mohamed the overall investment costs of the MFP (including engine, alternator, battery charger, milling machine) amounted to TZS 3.400.000 financed by TaTEDO. The operating company invested an additional 3,000,000 in wiring, poles and rent for the building.

In TaTEDO´s MFP publication (2008) the following figures are given:

p. 11: costs for the platforms ranges from TZS 5,000,000 for a basic system to TZS 20,000,000 for large systems with oil seed press and a minigrid which connects 50 to 100 costumers. Costs for the ESP with minigrid is high due to additional costs for electricity distribution and connection.

p. 67: example of capital costs for an ESP enterprise with minigrid:

- generator set, energy platform: 2,500,000
- cables […]: 5,800,000
- pole top hardware […]: 1,700,000
- other hardware […]: 800,000
- house wiring materials: 6,800,000

TOTAL: 17,600,000

Other generators in Laela:

Mr. Rashid Hassan (son of Hassan Tukale):

- 13hp diesel engine coupled with a 5kW alternator
- Consumption of 2-3 l/day
- Installation costs
    - Engine: TZS 400.000 in 2000 (current price was estimated at TZS 1.2000.000)
    - Alternator: TZS 400.000 in 2000 (current price was estimated at TZS 800.000)

Francisca Clement, Laela Kati

- Bought in 2004
- Motor: 350,000
- Generator:500,000

- Generator was installed along a milling machine and sunflower press opposite her store; due to the road construction it was demolished in October 2010; She is planning to start constructing a new house for the generator and a minigrid supplying people in Laela Kati in the next months; However, originally she connected other households to the grid because she used the electricity to run four refrigerators for her store but the power (voltage?) was too high for her store alone. Therefore, she connected other households to the grid and charged them. Supposedly, she did not make any profit from selling.

PV system LAC:

- Total costs: 14.8 Mio Shilling (about € 7.380, € 9.460 pro kW), including transportation, installation
- Installed in 2008
- Installed capacity:
  - Panels: 12 x 65W: 0,78kW
  - Inverter/transformer: 3kW
  - Battery charger: 100 Amps
  - Battery system: four batteries (12v. 210Ah/100h) = 840Ah
- Installed by BP Solar, Dar es Salaam

Questionnaire Electricity Production and Consumption in Laela

December 2010 - Better-iS project

Name (owner of generator) / subvillage:	Francisca Clement, Laela Kati
How much horsepower / capacity does your generator have?	? (to do: take picture, data)
When did you buy it and how much did you invest?	Bought in 2004 Motor: 350,000 Generator:500,000 Generator was installed along a milling machine and sunflower press opposite her store; due to the road construction it was demolished in October 2010; She is planning to start constructing a new house for the generator and a minigrid supplying people in Laela Kati in the next months; However, originally she connected other households to the grid because she used the electricity to run four refrigerators for her store but the power (voltage?) was too high for her store alone. Therefore, she connected other households to the grid and charged them. Supposedly, she did not make any profit from selling. The minigrid of the MFP ran up to her store but she was not connected.
Which appliances are connected to the generator?	
- Number of households/businesses:	Originally, 10 households were connected, in the end only 5 as payments were not made
- Lighting:	No restrictions on the amount of lighting and appliances were made

- Other:	TV, radio, lighting, refrigerator
Which fuel does it use?	Diesel
- If diesel: could you also use vegetable oil in the generator (mixed with diesel)?	She heard of it and asked for detailed information as she owns a sunflower farm and a pressing machine. She will be contacting Mr. Mohamed for information on the MFP and a contact to TaTEDO so that she might buy an engine running on plant oil or modify the existing engine.
How much fuel does your generator consume on average:	
- Per day:	2,5l
- Per week:	
- Per year:	
Do you consume the same amount all year around?	Yes
At what time of day do you run the generator?	From 7 to 12 pm
How many days per week do you run it?	Every day
Where do you buy fuel at what price?	Directly in Sumbawanga (at 1,680 per litre) as she used it also for the milling and pressing machines. In Laela one litre is sold at 1,800
How do you use the electricity?	Refrigerator, mini grid
Do you earn money with your generator (charging batteries, phones, haircutting, etc.)?	Selling of cold drinks; supposedly no profit was made from selling electricity
Do you sell electricity to other people?	Yes, until October 2010
- If yes, how much do you charge?	5,000 per month for unlimited consumption

How many generators in Laela (Laela A and subvillages) do you know of?	
- Please name further people that own a generator?	
Does anybody in Laela sell electricity (batteries, grid)?	Grid: only aware of TaTEDO project
Was electricity sold in the past?	Yes, from TaTEDO
- How much was charged?	?
If electricity would be sold in Laela (privately, not by TANESCO): how much would you pay for it?	
- Per month:	
- Per kilowatthour:	

According to questionnaire:

- Diesel: each day 2,5 litres for 6 hours
- Petrol: each day 2 litres for 4 hours

From focus group interview 5 – value chain analysis:

1. **Specific questions on electricity use in Laela**

6.4 How many people in Laela sell electricity to other people?

- For the moment no one, for a short period a mini grid was running (TaTEDO) but currently it is not working

6.5 How much do they charge?

- 3,500 per week

6.6 How much lights / appliances can be connected?

- Only four light bulbs and 1 TV
- Refrigerator and ironing was not allowed to use

Results Field Trip Tandai

14.12.2010

Tandai

Energy prices:

- Diesel: 2,000
- Kerosene: 1,600
- Charcoal: 500 per piled up tin (paint tin of 4l; estimated by Geoffrey at 1kg)
    - Not produced in village as forests are protected in the area (water catchment area for Dar, protected and enforced by government)
    - Imported from other areas
- Headloads: 2,000 in town
    - Only sold in the village
    - Transportation about three hours (after cultivating outside plots always one headload is transported to the village regardless if it is needed for cooking)
    - One headload is enough for three days of cooking
    - Weight (kg):
        - 33
        - 34
        - 23
        - 26
        - 45
        - 44,5
        - 35
        - 31
        - Average: 33,9375

Local electricity system:

- Family owned, integrated in milling station
- 15-16 houses are supplied
- The capacity is up to 50 households
- Running time: 6am-12pm
- Costs for electric connection are paid for by the costumers (connection to next household)
- User fees:
    - 500 for households
    - 1,500 to 2,500 for businesses depending on appliances connected (currently about three connected); up to 4,000 according to participants of workshop
- User fees are daily collected
- Diesel is bought in Morogro (about three gallons every week)
- Once a week the machine is maintained and oil is changed (the mechanic is paid 5,000; 4l oils are changed at 2,500 per litre)
- Consumption: 22 litres per day
- Investment costs:
    - Generator: 2,500,000
    - Engine: 988,000

9.2 Annex II: List of interviews

#	Date	Type	Location
1	22.11.2010	Expert interview 1	Sumbawanga, Rukwa Regional Office
2	23.11.2010	Focus group interview 1 - Village scoping	Laela, Teacher´s Centre
3	24.11.2010	Focus group interview 2 - Ressource mapping	Laela, Teacher´s Centre
4	24.11.2010	Focus group interview 3 - local authorities and sub-village	Laela, Teacher´s Centre
5	26.11.2010	Expert interview 2 - MFP	Laela
6	26.11.2010	Expert interview 3 - Prokon	Mpanda
7	27.11.2010	Expert interview 4 - Sunflower processing A	Laela
8	29.11.2010	Expert interview 5 - Sunflower processing B	Laela
9	30.11.2010	Expert interview 6 - Agricultural Potential in Laela / Potential for Jatropha production	Laela Agricultural centre
10	02.12.2010	Focus group interview 4 - Environment, Environmental Degradation, Development	Laela, Teacher´s Centre
11	04.12.2010	Expert interview 7 - Laela Agricultural Centre	Laela Agricultural centre
12	10.12.2010	Focus group interview 5 - Value chain analysis	Laela Primary School
13	14.12.2010	Field trip Tandai	Tandai
14	17.12.2010	Expert interview 8 - TaTEDO	Dar

9.3 Annex III: Daily activities of men and women in Laela (TaTEDO, 2008b)

Daily activities distribution in the village

Time	Activity (Mother)	Activity(Father)
5:00 A.M	Waking up	Waking up (sharpening the axe)
6:00 A.M	-Cleaning -Preparing food for the children -Making pots(dry season)	-Checking if the animals are safe -Going to the farms -Farming by using oxen
7:00 A.M	Going to the farm	
8:00 A.M	-Cooking (when they are on farms) -Farming	
9:00 A.M	Planting	Sawing
10:00 A.M	Sawing	Harvesting groundnuts
11:00 A.M	Harvesting	Taking care of cattle
12:00 Noon	Eating	Eating
13:00 P.M	Cleaning utensils	
14:00 P.M	-Firewood collection -Preparation of dinner	Helping in firewood collection
15:00 P.M		
16:00 P.M	-Washing clothes -Other small activities -Finishing cooking food	-Eating and taking shower -Resting -Leaving home
17:00 P.M		
18:00 P.M	Resting	Resting
19:00 P.M	-Mothers and children eating	Resting
20:00 P.M	Sleeping	Resting

9.4 Annex IV: Component prices in the project region

1 €	=	2.019,26	TZS	13.12.2010					
component	**location**	**date**	**W(p)**	**Ah**	**price (TZS)**	**price (€)**	**price per W(p)/Ah**	**source**	**comments**
battery	Sumbawanga, Sunrys Enterprises	22.11.2010	50		135.000,00	66,86	1,34		
battery	Sumbawanga, Sunrys Enterprises	22.11.2010	75	100	170.000,00	84,19	0,84		
battery	Laela	26.11.2010	200W?		260.000,00	128,76		Desdery Ismail	bought in Sumbawanga in late 2009
battery N100	Sumbawanga market (shop 1)	21.11.2010		100	200.000,00	99,05	0,99		
battery N50	Sumbawanga market (shop 1)	21.11.2010		50	95.000,00	47,05	0,94		
battery N70	Sumbawanga market (shop 1)	21.11.2010		70	115.000,00	56,95	0,81		
charger controller	Laela	26.11.2010			130.000,00	64,38		Desdery Ismail	bought in Sumbawanga in mid 2010
electric motor for oil press	Sumbawanga, Sunrys Enterprises	22.11.2010			650.000,00	321,90			
generator	Sumbawanga market (shop 1)	21.11.2010	500		155.000,00	76,76	0,15		according to Geoffrey much higher than in Dar
generator	Sumbawanga market (shop 1)	21.11.2010	2500		350.000,00	173,33	0,07		according to Geoffrey much higher than in Dar
inverter	Laela	26.11.2010			300.000,00	148,57		Desdery Ismail	bought in Sumbawanga in late 2008
oil press	Sumbawanga, Sunrys Enterprises	22.11.2010			2.700.000,00	1.337,13			
PV system (including inverters, batteries, transport, installation)	Laela	04.12.2010	780		14.800.000,00	7.329,43	9,40	Mr Mahenge	- Total costs: 14.8 Mio Shilling (about € 7.380, € 9.460 pro kW), including transportation, installation - Installed in 2008 by BP Solar - Installed capacity: o Panels: 12 x 65W: 0,78kW o Inverter/transformer: 3kW o Battery charger: 100 Amps o Battery system: four batteries (12v. 210Ah/100h) = 840Ah
solar PV panel	Sumbawanga market (shop 1)	21.11.2010	50		280.000,00	138,66	2,77		no cabling included
solar PV panel	Sumbawanga market (shop 1)	21.11.2010	60		400.000,00	198,09	3,30		no cabling included
solar PV panel	Sumbawanga, Sunrys Enterprises	22.11.2010	15		130.000,00	64,38	4,29		
solar PV panel	Sumbawanga, Sunrys Enterprises	22.11.2010	30		300.000,00	148,57	4,95		
solar PV panel	Sumbawanga, Sunrys Enterprises	22.11.2010	45		480.000,00	237,71	5,28		
solar PV panel	Sumbawanga, Sunrys Enterprises	22.11.2010	60		700.000,00	346,66	5,78		
solar PV panel	Sumbawanga market (shop 2)	22.11.2010	50		300.000,00	148,57	2,97		
solar PV panel	Sumbawanga market (shop 2)	22.11.2010	100		500.000,00	247,62	2,48		
solar PV panel	Dar	20.11.2010	50		200.000,00	99,05	1,98	Ewald	
solar PV panel	Laela	26.11.2010	30		350.000,00	173,33	5,78	Desdery Ismail	bought in Sumbawanga in late 2009
solar PV panel	Laela	26.11.2010	80		600.000,00	297,14	3,71	Desdery Ismail	bought in Sumbawanga in late 2008
solar PV panel	Laela	26.11.2010	120		900.000,00	445,71	3,71	Desdery Ismail	bought in Sumbawanga in late 2009
solar PV panel	free delivery in Arusha/Dar	30.09.2010	15		120.000,00	59,43	3,96	Helvetic Solar	Panasonic
solar PV panel	free delivery in Arusha/Dar	30.09.2010	50		380.000,00	188,19	3,76	Helvetic Solar	Panasonic
solar PV panel	free delivery in Arusha/Dar	30.09.2010	80		580.000,00	287,23	3,59	Helvetic Solar	Panasonic
solar PV panel	free delivery in Arusha/Dar	30.09.2010	100		780.000,00	386,28	3,86	Helvetic Solar	Panasonic
solar PV panel	free delivery in Arusha/Dar	30.09.2010	120		880.000,00	435,80	3,63	Helvetic Solar	Panasonic
solar PV panel	free delivery in Arusha/Dar	30.09.2010	165		1.180.000,00	584,37	3,54	Helvetic Solar	Panasonic

9.5 Annex V: Energy prices in the project region

1 €	=	2.019,26	TZS					
commodity	**location**	**date**	**amount**	**price (TZS)**	**price (€)**	**price (TZS) per quantity**	**price (€) per quantity**	**source**
charcoal	Sumbawanga	21.11.2010	bucket	3.500,00	1,73			wholesesale trader
charcoal	Sumbawanga	21.11.2010	small pile	300,00	0,15			
charcoal	Sumbawanga	21.11.2010	large bag	16.000,00	7,92			
charcoal	Dar	21.11.2010	small pile	1.000,00	0,50			Theresia
charcoal	Tandai	14.12.2010	1kg	500,00				
charcoal (high price)	Laela	03.12.2010	1 big bag (about 20kg?)	5.000,00	2,48	250,00	0,12	Mr. Masebe
charcoal (low price)	Laela	03.12.2010	1 big bag (about 20kg?)	3.000,00	1,49	150,00	0,07	Mr. Masebe
Charcoal (max)	Laela	04.12.2010	bag (50kg)	6.000,00	2,97	120,00	0,06	Mr. Mahenge
Charcoal (min)	Laela	04.12.2010	bag (50kg)	4.000,00	1,98	80,00	0,04	Mr. Mahenge
cooking gas	Sumbawanga	21.11.2010	15kg	45.000,00	22,29	3.000,00	1,49	
cooking gas	Sumbawanga	21.11.2010	6kg	20.000,00	9,90	3.333,33	1,65	
Diesel	Morogoro	17.11.2010	1l	1.650,00	0,82			
Diesel	Morogoro	17.11.2010	1l	1.630,00	0,81			
Diesel	Morogoro	19.11.2010	1l	1.665,00	0,82			
Diesel	Tunduma	20.11.2010	1l	1.870,00	0,93			
Diesel	Sumbawanga	21.11.2010	1l	1.850,00	0,92			
Diesel	Dar?	end 2008	1l	1.430,00	0,71			GTZ, 2009: Regional Report Renewable Energies in East Africa
Diesel	Kaufland, Osterode am Harz	23.11.2010	1l	2.360,51	1,17			
Diesel	Berlin	25.11.2010	1l	2.538,20	1,26			
Diesel (Laela average)	**Laela**			**1.820,00**				
Diesel	Laela	27.11.2010	1l	1.700,00	0,84			Mr. Abdillahi Hassan
Diesel	average in rural areas	30.06.1905	1l	2.200,00	1,09			TaTEDO, 2008
Diesel	Laela	05.12.2010	1l	1.800,00	0,89			
diesel	Sumbawanga	09.12.2010	1l	1.680,00				Mrs. Clement
diesel	Laela	09.12.2010	1l	1.800,00				Mrs. Clement
diesel	Tandai	14.12.2010	1l	2.000,00				
diesel	Laela	12.12.2010	1l	2.000,00				
diesel	Laela	10.12.2010	1l	1.800,00				Mr. Mohamed
diesel	Iringa	12.12.2010	1l	1.730,00				
diesel	Mbeya	12.12.2010	1l	1.910,00				
diesel	Sumbawanga	12.12.2010	1l	1.870,00				
Diesel (max)	Dar es Salaam	12.12.2010	1l	1.854,00	0,92			The Guardian, 13.12.2010
Diesel (min)	Dar es Salaam	12.12.2010	1l	1.650,00	0,82			The Guardian, 13.12.2010

1 €	=	2.019,26	TZS					
commodity	location	date	amount	price (TZS)	price (€)	price (TZS) per quantity	price (€) per quantity	source
electricity (households)	nation-wide	end 2008	kWh	129,03	0,06			GTZ, 2009: Regional Report Renewable Energies in East Africa
electricity (industry)	nation-wide	end 2008	kWh	70,00	0,03			GTZ, 2009: Regional Report Renewable Energies in East Africa
firewood	Laela	02.12.2010	1 oxen cart	3.000,00	1,49			Julius
Firewood (max)	Laela	04.12.2010	headload	4.000,00	1,98			Mr. Mahenge
Firewood (min)	Laela	04.12.2010	headload	3.000,00	1,49			Mr. Mahenge
Jatropha oil production costs (including seeds and pressing costs)	Mpanda	26.11.2010	l	980,00	0,49			calculation by Dr. Uckert
Jatropha oil	GTZ, 2009: 45		l	about four kg				
Jatropha seeds	Tandai	14.12.2010	10kg	3.500,00		350,00	0,17	
Jatropha seeds	Mpanda	26.11.2010	kg	300,00	0,15			Mrs. Parzik, Prokon
kerosene	Dar?	end 2008	1l	1.000,00	0,50			GTZ, 2009: Regional Report Renewable Energies in East Africa
kerosene	Tandai	14.12.2010	1l	1.600,00				
Kerosene (max)	Dar es Salaam	12.12.2010	1l	1.190,00	0,59			The Guardian, 13.12.2010
Kerosene (min)	Dar es Salaam	12.12.2010	1l	1.120,00	0,55			The Guardian, 13.12.2010
Kerosine	Dar es Salaam		1l					
Kerosine	Dar es Salaam		1l					
Kerosine	Morogoro	17.11.2010	1l	1.130,00	0,56			
Kerosine	Morogoro	17.11.2010	1l	1.090,00	0,54			
Kerosine	Morogoro	19.11.2010	1l	1.140,00	0,56			
Kerosine	Sumbawanga	21.11.2010	1l	1.250,00	0,62			
Kerosine	Laela	23.11.2010	1l	1.800,00	0,89			focus group interview 1
Maize	Laela - National Food Reserve Agency	05.12.2010	kg	300,00	0,15			
maize (max price; max weight)	Laela	02.12.2010	1 bag (100-120kg)	15.000,00	7,43	125,00	0,06	participants focus group interview 4
maize (max price; min weight)	Laela	02.12.2010	1 bag (100-120kg)	15.000,00	7,43	150,00	0,07	participants focus group interview 4
Maize (max)	Laela - National Food Reserve Agency	05.12.2010	1bag (100kg)	25.000,00	12,38	250,00	0,12	
Maize (max) - paid to farmer by middleman	Laela	04.12.2010	1bag (100kg)	15.000,00	7,43	150,00	0,07	Mr. Mohamed, confirmed by Mr. Mahenge
maize (min price; max weight)	Laela	02.12.2010	1 bag (100-120kg)	10.000,00	4,95	83,33	0,04	participants focus group interview 4
maize (min price; min weight)	Laela	02.12.2010	1 bag (100-120kg)	10.000,00	4,95	100,00	0,05	participants focus group interview 4
Maize (min)	Laela - National Food Reserve Agency	05.12.2010	1bag (100kg)	22.000,00	10,90	220,00	0,11	
Maize (min) - paid to farmer by middleman	Laela	04.12.2010	1bag (100kg)	10.000,00	4,95	100,00	0,05	Mr. Mohamed, confirmed by Mr. Mahenge

1 €	=	2.019,26	TZS					
commodity	location	date	amount	price (TZS)	price (€)	price (TZS) per quantity	price (€) per quantity	source
Peanuts (dehulled) - max	Laela	04.12.2010	bag (50kg)	20.000,00	9,90	400,00	0,20	Mr. Mahenge
Peanuts (dehulled) - min	Laela	04.12.2010	bag (50kg)	15.000,00	7,43	300,00	0,15	Mr. Mahenge
Petrol	Tunduma	20.11.2010	1l	1.875,00	0,93			
petrol	Dar?	end 2008	1l	1.340,00	0,66			GTZ, 2009: Regional Report Renewable Energies in East Africa
Petrol (Laela average)	**Laela**			**2.160,00**				
Petrol	Laela	25.11.2010	1l	2.200,00	1,09			
Petrol	Laela	05.12.2010	1l	2.200,00	1,09			
petrol	Laela	09.12.2010	1l	2.200,00				
petrol	Iringa	12.12.2010	1l	1.800,00				
Petrol (max)	Dar es Salaam	12.12.2010	1l	1.801,00	0,89			The Guardian, 13.12.2010
Petrol (max)	Laela	23.11.2010	1l	2.200,00	1,09			focus group interview 1
Petrol (min)	Dar es Salaam	12.12.2010	1l	1.720,00	0,85			The Guardian, 13.12.2010
Petrol (min)	Laela	23.11.2010	1l	2.000,00	0,99			focus group interview 1
plastic container	Sumbawanga market	21.11.2010	1	1.500,00	0,74			
pressing of sunflower seeds	Sumbawanga pressing station	21.11.2010	90 kg	4.000,00	1,98	44,44	0,02	
pressing of sunflower seeds	Laela (Mr. Hassan)	27.11.2010	10kg	1.000,00	0,50	100,00		
sunflower oil (Laela current average)	Laela		1l	2.450,00				
sunflower oil (Laela harvest time average)	Laela		1l					
sunflower oil (currently, min)	Laela	10.12.2010	1l	2.500,00	1,24			Mr. Mohamed
sunflower oil (currently, max)	Laela	10.12.2010	1l	2.700,00	1,34			Mr. Mohamed
sunflower oil (during harvesting time, min)	Laela	10.12.2010	1l	2.000,00	0,99			Mr. Mohamed
sunflower oil (during harvesting time, max)	Laela	10.12.2010	1l	2.100,00	1,04			Mr. Mohamed
sunflower oil	Sumbawanga market	21.11.2010	5l	14.000,00	6,93	2.800,00	1,39	
sunflower oil	Sumbawanga market	21.11.2010	1,5l	4.200,00	2,08	2.800,00	1,39	
sunflower oil	Sumbawanga pressing station	21.11.2010	0,5l	1.400,00	0,69	2.800,00	1,39	
sunflower oil	Sumbawanga pressing station	21.11.2010	1l	2.800,00	1,39	2.800,00		
sunflower oil	Sumbawanga pressing station	21.11.2010	20l	51.000,00	25,26	2.550,00	1,26	
sunflower oil	Sumbawanga pressing station	21.11.2010	22l	53.000,00	26,25	2.409,09	1,19	
sunflower oil	Kaufland, Osterode am Harz	23.11.2010	1l	3.230,81	1,60	3.230,81		
sunflower oil	Aldi, Berlin	25.11.2010	1l	2.200,99	1,09	2.200,99		
sunflower oil	Laela	30.11.2010	1l	2.000,00				Mr. Masebe
sunflower oil	Laela	04.12.2010	1l	3kg of sunflower seeds				Mr. Mahenge
sunflower oil (assumption during harvesting season based on seed price)	Sumbawanga pressing station	21.11.2010	1l	2.177,78	1,08			
sunflower oil (max)	Laela	23.11.2010	1l	3.000,00	1,49			focus group interview 1
sunflower oil (min)	Laela	23.11.2010	1l	2.500,00	1,24			focus group interview 1
sunflower oil (not filtered/cooked)	Sumbawanga pressing station	21.11.2010	20l	50.000,00	24,76	2.500,00	1,24	
sunflower oil current price	Laela	27.11.2010	1l	2.000,00	0,99			Mr. Abdillahi Hassan

1 €	=	2.019,26	TZS					
commodity	**location**	**date**	**amount**	**price (TZS)**	**price (€)**	**price (TZS) per quantity**	**price (€) per quantity**	**source**
sunflower oil during harvesting time	Laela	27.11.2010	1l	1.200,00	0,59			Mr. Abdillahi Hassan
sunflower press cake	Sumbawanga pressing station	21.11.2010	1kg	250,00	0,12			
sunflower press cake	Laela	27.11.2010	1kg	100,00	0,05			Mr. Abdillahi Hassan
sunflower seeds (currently)	Laela	30.11.2010	1 bag (48kg)	40.000,00	19,81	833,33	0,41	Mr. Masebe
sunflower seeds (currently)	Laela	30.11.2010	1 bag (60kg)	40.000,00	19,81	666,67	0,33	Mr. Masebe
Sunflower seeds (max)	Laela	04.12.2010	bag (60kg)	40.000,00	19,81	666,67	0,33	Mr. Mahenge
Sunflower seeds (min)	Laela	04.12.2010	bag (60kg)	30.000,00	14,86	500,00	0,25	Mr. Mahenge
sunflower seeds (harvesting season; min price; max weight)	Laela	02.12.2010	1 bag (48-60kg)	10.000,00	4,95	166,67	0,08	participants focus group interview 4
sunflower seeds (harvesting season; min price; min weight)	Laela	02.12.2010	1 bag (48-60kg)	10.000,00	4,95	208,33	0,10	participants focus group interview 4
sunflower seeds (harvesting season; max price; max weight)	Laela	02.12.2010	1 bag (48-60kg)	15.000,00	7,43	250,00	0,12	participants focus group interview 4
sunflower seeds (harvesting season; max price; min weight)	Laela	02.12.2010	1 bag (48-60kg)	15.000,00	7,43	312,50	0,15	participants focus group interview 4
sunflower seeds (harvesting season 2010)	Laela	30.11.2010	1 bag (48kg)	25.000,00	12,38	416,67	0,21	Mr. Masebe
sunflower seeds (harvesting season 2010)	Laela	30.11.2010	1 bag (60kg)	25.000,00	12,38	416,67	0,21	Mr. Masebe
sunflower seeds (max in 2009)	Laela	30.11.2010	1 bag (60kg)	25.000,00	12,38	416,67	0,21	Mr. Masebe
sunflower seeds (max in 2009)	Laela	30.11.2010	1 bag (48kg)	25.000,00	12,38	416,67	0,21	Mr. Masebe
sunflower seeds (min in 2009)	Laela	30.11.2010	1 bag (48kg)	15.000,00	7,43	250,00	0,12	Mr. Masebe
sunflower seeds (min in 2009)	Laela	30.11.2010	1 bag (60kg)	15.000,00	7,43	250,00	0,12	Mr. Masebe
sunflower seeds (currently)	Sumbawanga pressing station	21.11.2010	60kg	45.000,00	22,29	750,00	0,37	
sunflower seeds (during harvesting season)	Sumbawanga pressing station	21.11.2010	60kg	10.000,00	4,95	166,67	0,08	
Super	Dar es Salaam		1l					
Super	Dar es Salaam		1l					
Super	Morogoro	17.11.2010	1l	1.780,00	0,88			
Super	Morogoro	17.11.2010	1l	1.699,00	0,84			
Super	Morogoro	19.11.2010	1l	1.780,00	0,88			
Super	Sumbawanga	21.11.2010	1l	1.900,00	0,94			
wood	Tandai	14.12.2010	34kg	2.000,00	0,99	58,82	0,03	Sample

9.6 Annex VI: Further information on the Laela Agricultural Centre

The Laela Agricultural Centre is a church based organization whose objective is to contribute to the improvement of agricultural production and income through farmers' increased access to markets. Operations are limited to Laela Parish covering approximately 25 villages.

LAC also provided training services to communities in agricultural production.

LAC ran a seed intervention activity where they operated a seed production program as an agro-enterprise. They had a farm, where part of the land was devoted to seed production of different seed crops.

The seed multiplied from their on–station farm was sold directly to farmers through Laela farm inputs shop (Garforth, 2005).

The Laela Agricultural Centre has been providing extension services to small farmers mainly targeted at improving their farming methods. Also, durable cattle and oxen breeds suitable to be used for farming are bred and promoted to the local villagers.

A one year course is given to youths of the region whose main job is expected to be farming.

The LAC used to run the Access to Market programme (ATM) in order to channel agricultural products from small-scale farmers to the market by establishing contacts between farmers and agro-processing companies.

Apart from those activities, cross cutting issues are addressed such as HIV/AIDS prevention and environmental conservation.

Farmers are trained in the use of improved cooking stoves to reduce excess use of fire wood.

Moreover education on groups and groups dynamics is being provided so as to enable them produce and collectively as this increases the bargaining power. [117]

LAC (2007: 11):

Laela Agricultural Centre (LAC) is a non profit making semi – autonomous organization established by and under the jurisdiction of the Catholic Diocese of Sumbawanga. Thus this Centre operates under legal recognition of the Catholic Diocese of Sumbawanga through the governing board.

The Laela Agricultural Centre was started in September 1990 by the Diocesan Authorities, the Parish of Laela and the benefactors in the Netherlands.

The Project was initially planned to run in two phases: the Pilot Phase from September 1990 to August 1995 and the Operational Phase from September 1995 to August 1998. An external evaluation of 1995 observed among others that the project had reached a stage in its development when there was an overriding need for consolidation of the initiated activities so as to provide a solid and realistic basis for its future operation.

Vision statement

A community that lives a good life with its basic needs met. This community believes in human rights and lives in a conducive environment.

Mission statement

[117] Information from http://kilimoajira.blogspot.com/2009/06/laela-agricultural-centre-fighting.html

LAC provides training, extension, marketing support and other services to smallholders in view of promoting sustainable agriculture and livestock keeping. The Centre hereby promotes cooperation in groups, gender sensitivity and awareness on HIV-AIDS. The Centre itself strives at becoming a strong organization that is sustainable in financial and organizational terms.

Main activities

1.2.1 Training:

Long course training for youths (girls and boys) The number of youths trained up to August 2005 is 412 (118 girls). More than 90% of them are in the villages and have taken agriculture as their main occupation. However, only about 60% of them are practicing improved agriculture.

Short course training for adults; the number of adult farmers trained up to August 2005 is 8586 (2216 women). The course duration ranges from one day to two weeks and most of these courses are run in the villages.

For both courses the training is practically oriented and is tuned to the needs of the target population.

1.2.2 Animation and extension:

The animation in the villages aims at strengthening farmers groups as a way of managing their own livelihood. It is also anticipated that through strong groups farmer networks can be formed which can at a later stage be a farmer's voice in marketing and other important issues. Currently we can speak of only 6 groups as being strong while many others are very weak mainly because of lacking own objectives. However we have learnt a lot about group problems particularly in this area and our weaknesses too, that will help us perform better in future.

The extension work supports the training of both youths and adults in terms of follow up, training needs assessment, advisory services to group members etc. However there are recommendations for the Centre to put more weight on extension work particularly to ex trainees.

1.2.3 Production activities

The Centre run farm activities that serve dual purposes of contributing to financial self sufficiency of the Centre while at the same time keeping within the Centre objective of promoting sustainable agricultural practices in Laela mandate area. These activities include crop and livestock production. Generally the percentage of own contribution has continued to rise especially when market price of farm produce are good. However the Centre needs to workout an improved costing system of every unit so as to come up with real production costs.

Other activities

1.2.4 Farm input shop:

This shop supplies input and implements to farmers at a reasonable price. Moreover customers get a wide range of advice from the shopkeeper because he has skills in agriculture and livestock keeping. The shop serves farmers within and outside Laela

mandate area because it is the only shop with wide varieties of agricultural input in a radius of about 100 km. At the time of compiling this report the average number of customers per day is 23 (one woman).

1.2.5 Workshop services:

The Centre operates a small workshop for the repair and maintenance of farmers' equipment and implements such as ploughs carts, mills, bicycles, hand tools etc. Moreover Centers equipment and implements are also repaired here at reasonable costs. On average the workshop serves 4 (men only) customers per day. Currently this activity has been stopped for some time because it was a loss making venture. Considerations are being worked out for the possibility of reopening the services because they are being asked by target group.

1.2.6 Demonstration and trials:

The Centre tries and demonstrates new technologies that are environmentally friendly and cost efficiently in crop and livestock husbandry. Currently the Centre collabourates with Uyole Agriculture Research Centre in conducting beans and maize trials together with farmers.

1.2.7 Environmental protection:

The Centre continues to raise tree nursery each year in an effort to maintain good environment at the Center and surrounding villages. In most cases the nursery is maintained by trainees as part of their practical lessons.

1.2.8 Construction of market centres

A market Centre was constructed in Kalambazite village that is being used by producers for selling small products. Another has been constructed in Lusaka.

1.2.9 Cross cutting issues

The Center has efforts in sensitizing the community in cross cutting issues such as Gender Relations and HIV/AIDS, since without emphasis on this the community won't produce and move from poverty since suffering due inequalities in social relations between men and men as well as suffering from diseases like HIV/AIDS would make the community keep on sailing in the boat of poverty and other problems.

9.7 Annex VII: Agricultural properties of Jatropha curcas

9.7.1 Description

Jatropha curcas (*Jatropha*) is a multi-purpose, shrubby, tree belonging to the *Euphorbiaceae* family. It is native to Mexico or Central America, but now thrives in many parts of the tropics and sub-tropics in sub-Saharan Africa and Asia. *Jatropha* has received tremendous attention around the world over the past several years due to its potential as a biofuel crop. However, many of the claims made regarding *Jatropha* — including wide adaptability to diverse climatic zones and soil types, short gestation period, easy multiplication, drought tolerance, not competing with food production, and pest and disease resistance — have proven highly exaggerated. The fundamental purpose of this study was to test these and other claims against the reality of *Jatropha* being grown in Kenya (GTZ, 2009: 5):

9.7.2 Yields

Fact Foundation, 2010 (2010-11_ICJC-2010_FN_Presentation)

- Currently expecting 800 kg/ha.
- Theoretical potential around 4000 kg/ha (methodology: Openshaw 2000)

Fact Foundation (2010: 22-23)

Yield per plant in hedges are estimated at 0.2-0.4 kg (based on Henning). “On fertile soils with a good moisture supply yields are about 0.8 kg per meter of hedge. On poor soils this will be much less”).

Prokon Renewable Energy Ltd.:

- yield expectations Prokon: 0.2 kg/plant in year ?[118]

Sumagro Ltd. (based on Segerstedt et al., 2010):

- according to our yield assessment, seed yields in the range of 1 to 2.52 kg per plant are possible [from year six on], where the upper boundary would only be reached with high levels of fertilization
- manure and single super phosphate in the first year (0.5 and 2 kg/plant)
- NPK is applied annually depending on the nitrogen withdrawel
- Pesticides (Thionex) are applied three times a year
- Irrigation is applied once a week using buckets in the dryer months between June and October [five months]
- The plantation uses about 600 m³ irrigation water in the drier months [0,24 m³ (240 litre) per plant]

TaTEDO, 2008a: 39:

[118] Based on expert interview with Jessica Parzik, Prokon Renewable Energy Ltd. by Dr. Götz Uckert, 26.11.2010, Mpanda

A single jatropha tree can give yield of 300 gm to 9 kg of seed per season from 2-10 years of harvesting.

Observed & Projected Jatropha Yields by Plantation Type and Age (kilograms per tree):

	Monoculture		
	Actual	Low	High
Year 0	0		
Year 1	0.004		
Year 2	0.085		
Year 3	0.063	0.115	0.119
Year 4	0.016	0.144	0.238
Year 5	0.800	0.174	0.476
Year 6		0.204	0.595
Year 7		0.234	0.714
Year 8+		0.263	0.857

	Intercrop		
	Actual	Low	High
Year 0	0		
Year 1	0.002		
Year 2	0.079		
Year 3	0.015	0.106	0.110
Year 4	0.428	0.133	0.220
Year 5	0.202	0.160	0.440
Year 6		0.187	0.440
Year 7		0.214	0.660
Year 8+		0.241	0.793

9.7.3 Processing of Jatropha seeds

Fact Foundation: Business plan for the BBC in Bilibiza_ES:

The price is calculated at the basic that 4 to 5 kg of seeds give 1 litre of bio oil. In the calculations is used 4.5 kg per l.

9.7.4 Filtration

If pure plant oil is to be used in diesel engines it needs to filtered after pressing so that small particles do not block the fuel filter of the engine. Before using it in a diesel engine the oil should be free of all particles larger than 5 µm (Fact Foundation, 2010: 47).

For the purpose of a small-scale local biofuels production Fact Foundation (2010) recommends

“Sedimentation is the simplest and cheapest way of cleaning by using the earth’s gravity: the solids settle at the bottom of the tank. Sedimentation is only recommended for small processes. For production rates of < 50 litres/hr sedimentation is a preferred low-cost solution. It requires little technology and efficiency losses are less important when producing small volumes. It is a cheap cleaning method because little hardware needs to be purchased… only a storage tank large enough to keep the oil for about a week with little or no flow. If necessary, the process can be completed in multiple stages […].

One disadvantage of a sedimentation system is that it depends on optimal conditions to remove particles with sizes of 8 μm and less [2]. Therefore a security filter (bag filter or candle filter) is required. Sedimentation alone is not enough to produce good fuel quality. Additionally the relatively high amount of oil that remains in the sediment (50-55%) is lost if no further steps are included. Both available alternatives, filtration and centrifugation, have higher oil yield, assuming the input product meets the filter’s requirements.” (Fact Foundation, 2010: 47)

According to TaTEDO (2008: 41) Jatropha oil needs approximately one week for decantation (sedimentation) to obtain 20-25% of the sediments to be settled.

9.8 Annex VII: Electricity prices in Tanzania[119]

Electricity prices in Tanzania as charged by the state utility Tanesco depend on the amount of electricity consumed and on the voltage level required.

Four different electricity tariffs exist:

1. **Domestic Low Usage Tariff (DI)**: a subsidized tariff for consumers with an annual consumption of less than 283 kilowatt hours. Tariffs are only charged per kilowatt hour and no fixed monthly service charge has to be paid.
2. **General Usage Tariff (T1)**: consumption of more than 283 kWh per year (230-400V)
3. **Low Voltage Usage Tariff (T2)**: consumption of more than 7,500 kWh per year (400V)
4. **High Voltage Usage Tariff (T3)**: voltage level of 11kV

Tariff category	Monthly service charge	Demand charge per kVA	Tariff per kWh
Domestic Low Usage Tariff (DI)			
Low energy charge (0-50 kWh)	-	-	40
High energy charge (>50 kWh)	-	-	128
General Usage Tariff (T1)			
	1,892	-	106
Low Voltage Usage Tariff (T2)			
	7,012	7,680	60
High Voltage Usage Tariff (T3)			
	7,012	7,123	65

[119] Based on GTZ, 2009a: 30

9.9 Annex VIII: Further electrification options for Laela

In this section the most common renewable energy options are briefly discussed to evaluate which other technological options could be feasible for rural electrification in Laela.

9.9.1 Hydro power

The use of hydro power is virtually impossible in Laela as the only larger river leading through the village ("Kanteza") has been falling dry during the six-months dry season since the year 1974.[120] It can be expected that the availability of hydro power resources will be further deteriorating in the future as on-going deforestation and the impacts of climate change will lead to even lower availability of water.

9.9.2 Wind power

Small wind turbines with electrical capacities between 10 and 20 kW are available on the market and have been installed worldwide (see BWE, 2011 for a market overview).

Wind turbines must be located where wind resource are good which is usually on ridges and hilltops, while communities are usually found lower down the slopes or in the valleys (NRECA, 2000: 21). In Laela this is also the case as the main settlement area is on flat lands. Some hills are surrounding the village that might provide enough wind to generate electricity. Of the eight small wind turbine types mentioned above most require wind speeds between 2.5 to 3.5 m/s to start operating (only one turbine was capable of starting at a wind speed of 1.5 m/s).

According to NRECA (2000: 21) in the case with hydropower, a knowledgeable individual is needed, but this time to ensure proper measurement of the wind resource. This usually requires the collection of data for at least one year before making a decision. Data already gathered in the immediate vicinity should give some indication of this resource but care must be exercised in extrapolating the results because windpower is sensitive to the local topography.

However, maintenance and spare parts might be difficult to

According to NRECA (2000: 21) a small-scale wind power system including turbine, tower, battery bank, and electronics costs in the range of $6,000/kW (€6,509[121]) for units in the 5 to 10 kW range. However, it can be expected that this price has significantly fallen since the year 2000 due to technological and market developments.

9.9.3 Solar energy

Small solar-home-systems are being used widely in rural areas of many developing countries. These systems use single or multiple solar panels between 14 and 250 Watt peak, a regulator and charge controller and a battery to store electricity for the night time. Solar home systems typically generate 12 V or 24 V direct current and can power small electric appliances compact fluorescent lights, radios, TV sets and mobile phone rechargers and small refrigerators.

Prices for PV system have fallen significantly in the last years. NRECA (2000: 21) states that a complete PV-based power supply, with batteries, electronic controls, inverters, etc., costs at least $10,000 per peak kilowatt (€ 10,850).

120

121 Based on year 2000 exchange rates: $1 = DM2.12208 = €1.085

As calculated in chapter X the generator of the MFP powering the mini-grid is providing an electrical output of about 12 kW and was running for 14 hours every day. The electrical output of a photovoltaic system providing the same electricity supply would have to be sized larger as the electricity production is limited to sunny daytime hours:

“A PV solar system rated at 1 kW (peak) would yield roughly 4 kWh daily. However, a hydropower plant or diesel genset rated at 1 kW could yield 24 kWh daily. For a community to get access to the equivalent amount of energy (i.e., 24 kWh), the PV option would have about six times the capacity noted above or 6 kW. Consequently, in terms of "real" energy generated, the solar option would cost six times its cost per kW (peak). (NRECA, 2000: 22)

If the existing diesel generator-set in Laela would be replaced by a PV and battery system providing the same electrical output of 12 kW over 14 hours the system would have to be 3.5 times the capacity of the generator (42 kW peak). A PV system of that size would cover an area of about 310 m² on a roof top or installed on mounting systems in an open space.[122]

In Laela three buildings exist that are large enough to install a PV system of that size on the roofs and that are close enough to the existing mini-grid:

- Elementary School Laela Kati: three tin-roofed buildings with a total of about 600 m² of roof area and about 300 meter distance to the main street[123]
- Health Centre: two tin-roofed buildings with a total of 730 m² roof area and about 480 meters distance to the main street
- Warehouse of the National Food Reserve Agency: one tin-roofed building with about 3,400 m² of roof area at about 640 meters distance to the current powerhouse (site of the MFP generator).

Solar Now: Information booklet. Sales information - Installation - Maintenance – Marketing:

21: The battery size can be calculated approximately by the panel wattage times 2. Battery size Ah = panel wattage x 2.

In 2008 the Laela Agricultural Centre installed a small off-grid PV system using 12 PV panels with 65 Watt peak electrical capacity (0.78 kWp), a 3kW inverter and transformer to provide an alternating current 230 V electricity supply, four batteries with each 210 Ah capacity and a 100 Amp battery charger. The Centre powers about 15 compact fluorescent lights, a TV set, a copy machine, a printer, four Laptop computers and a satellite-based internet connection with the PV system. On sunny days the system provides enough electricity to satisfy the demand of all electrical appliances at daytime and nighttime.

However, it can be expected that the installation of such a large system would be much more economical on a per kWp basis.

The system was installed by BP Solar from Dar es Salaam at a total price of 14.8 Mio Shilling (about € 7.380, € 9.460 pro kW) including transportation, installation

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[122] A standard 180 Wp PV module (BP 4180T manufactured by BP Solar) has a size of 1,25 m². If a clearance spacing of one cm is taken into account in between the modules one kWp of PV capacity requires 7,41 m² of area. For module specifications see https://na3.salesforce.com/sfc/p/3000000001pzfo5tIeSiklHM0I1M3OspsFhkS6A.

[123] Both measured from the crossing of the main street and the street leading to the stadium and elementary school.

Eidesstattliche Erklärung

Hiermit versichere ich, dass ich die Arbeit in allen Teilen selbständig verfasst und keine anderen als die angegebenen Hilfsmittel benutzt habe. Die Arbeit ist auch an keiner weiteren Stelle zur Prüfung vorgelegt worden.

Berlin, 31. März 2011

Jan Rordorf