UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Economic Analysis on Electrification of Rural Villages in Eastern Zambia

Jesper Eriksson and Johan Tiselius

Bachelor thesis
Spring term 2013

Mentor: Per-Åke Andersson

Abstract

A large proportion of Zambia's population lives in rural areas and only 3 percent of them have access to electricity. This means that they have to cook over open fire that requires firewood, and with a growing population this usage will increase deforestation. The absence of proper lighting possibilities make life hard during the nights and also increase unwanted encounters with dangerous animals. The government of Zambia has began to realize that the electrification issue needs to be solved and has therefore initiated the development of a national power grid. But other alternatives are required to provide the vast majority of rural villages due to slow progress and high costs associated with the power grid. Generator powered electricity is an option but the question is whether it is sustainable or not? Jatropha Curcas is a multipurpose crop and its seeds can be used for oil extraction. This oil can then be used to produce biodiesel in a transesterification process, which can be conducted in the villages. This integrated biodiesel production lets villagers take control over their own electricity supply since they would grow it on their own land, and is a good alternative until the power grid is available.

This paper deals with issues regarding what type of fuel that should be used and how to conduct a process towards electrification in order for villages in the area to be financially and environmentally sustainable. Interviews were conducted in the project village Kakoma, Lundazi District area, and used for data and information collection. In the general case, aiming at providing a general model for electrification in the area, a comparison between fossil diesel import and Jatropha based biodiesel was made, where a part of each farmer's cultivation area is used for growing Jatropha instead of cash crops. In a case study, growing Jatropha on a new land area in order to produce biodiesel is compared with diesel import. Using a Cost-Benefit Analysis it can be shown that Jatropha based biodiesel is more financially viable in both cases. However, large investment costs that are excluded from the calculations would decrease its feasibility. To make a transition from cash crops to Jatropha possible there are certain identified socioeconomic factors that need to be fulfilled. External knowledge, villagers propensity to cooperate for the common good, woman involvement, leadership and increased education levels are important for a transition to be successful. In order for Jatropha cultivation to be sustainable, deforestation in favour for plantations cannot be allowed and also efficient use of byproducts to complete the lifecycle of the plant needs to be applied. A general case transition towards Jatropha based biodiesel is not recommended at the moment due to high risks, mainly due to short-term thinking by villagers, absence of NGOs and insufficient financial resources. The presence of an NGO in the Kakoma case, that is monitoring projects along with strong leadership make this case more likely to succeed. However, more research regarding seed yields in the area and the social dynamics of villages is required in order to make a informed decision whether a transition should be conducted or not.

Acknowledgement

After a two-year process that started on a previous journey through east Africa and a meeting on a dull Tuesday evening, we finally have come to an end.
After some long nights of blood, sweat and tears we have reached the finish line. Before we are done there are some acknowledgements that has to be declared.

We would like to thank ZASP for letting us visit your beautiful project, and giving us support to perform our study. The work you do with such limited resources deserves all credit.

There are some people who deserve some extra acknowledgement for believing in us when nobody else do, our beloved parents, who did there very best to give us all the opportunities in the world. Without you, this never would have been possible.

A special thanks to the crop we now a days eat, shit and sleep, the crop of all crops, Jatropha Curcas.

We are also grateful to the University of Gothenburg and SIDA for giving us the opportunity to perform a Minor field study. The experiences we have gained from our journey and studies will remain in our hearts and minds for the rest of our lives.

Last but not least, our mentor, Per-Åke Andersson.

Finally our journey through southern Africa has made us realize one thing: “Equality” is a word that the world does not know…

GHG – Greenhouse Gas

SVO – Straight vegetable oil

NGO – Non-governmental organisation

OECD – Organisation for cooperation and economic development

CIA – Central Intelligence agency

USD – United state dollars

UN – United Nations

CBA – Cost Benefit analysis

NPV_J – Net present value for Jatropha based biodiesel production

NPV_D – Net present value for diesel import

I_{CC} – Income from cash crops on a third of the cultivation area

i – Income from cash crops on residual area

C_D – Cost of Diesel import

C_P – Cost of Biodiesel production

1. Intro

1.1 Introduction

Zambia is experiencing strong economic development with a GDP growth averaging 6,9 percent over the past three years though 64 percent of the population live below the margin of poverty according to the World bank (2013). Predictions show that approximately 85 percent have agriculture as their main livelihood (CIA 2012).

Electrification in Zambia reaches only 3 percent of the rural population, and 19 percent of the total population in Zambia, according to the World bank (2013). This percentage is low considering the fact that 8 out of 14 million people (61 %) live in rural areas. The Zambian government has recognized electrification to be one of the key factors to reduce poverty in rural areas. The long-term target is to electrify 66 percent of the country, 90 percent in urban areas and 50 percent in rural areas. To achieve this goal the government founded a new department in 2003, the REA-Zambia, Rural Electrification Authority. So far the department has focused on an electric grid, which is costly and slow process (World bank 2013). The electricity that flows in the grid contains of 99 percent electricity from renewable energy sources, mainly hydropower but also a small amount of solar and the remaining 0,4 percent comes from imported fossil fuel. The transport sector contains almost solely of road carried transports, trucks and cars running on fossil fuel, since there is now coastline and the train network is severely under developed. The import of crude oil is 10 790 barrels a day and is mainly for the transport sector (CIA 2009).

In rural areas firewood and charcoal is still the main fuel source. The reason for this kind of usage is the log fires that are used for cooking. Lack of clay-stoves drastically increases the consumption of firewood. The high consumption of firewood in a combination with increasing population is the main reason for increased deforestation in many areas. Women who gather firewood say that it is becoming more difficult since the walking distances are increasing (Interview 030413). Total amount of forest in Zambia is approximately 50 million hectares and the UN predicts deforestation of 250.000 to 300.000 hectares per year (UN-Redd 2012). According to a manager at a local NGO the Zambian government has slowly began to realize the issues of deforestation and are planning to take countermeasures in terms of a national tree planting project (Interview 070411).

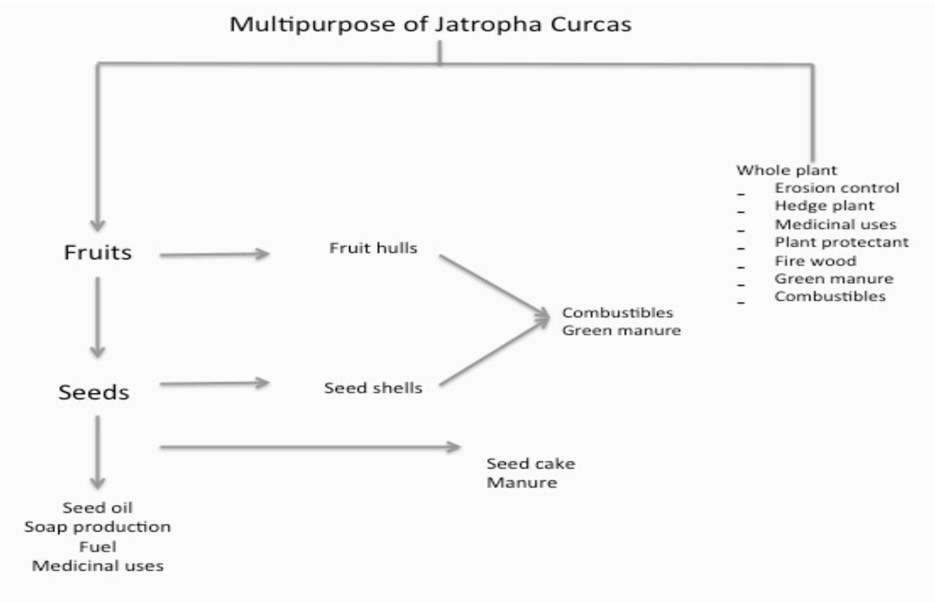
Zambia's CO_2 emissions are 0,2 tons per capita (CIA 2012) compared with 10 tons per capita on average in OECD countries (OECD 2013). At first sight this might sound low, though with rising population, growing economy and higher demand for welfare these figures are about to increase. There are also rising issues in other areas not directly related to GHG emissions, such as deforestation, soil erosion, water quality and indoor smoke. All these are directly related to a large proportion of the population living on agriculture as its only livelihood. Deforestation due to soil preparation and soil depletion along with more irrigation leads to salination. Salination causes poor water quality and lowers or completely eliminate yields for farmers. Indoor smoke is not only an environmental hazard but also a health issue. Especially for women, since they do all the cooking, and the children who spend most of their time with the mother (Cunningham & Cunningham 2008). The Environmental protection agency in United States reports that passive smoking, which is considered similar to spend time cooking food indoor with firewood, to cause over 3000 cases of lung cancer each year in United States. Studies have also showed that indoor air pollutant levels are increasing and is a serious concern since people spend up to 90 percent of their time in-door (EPA 1993).

1.2 Project village

The village where the case study is conducted is located in the Eastern province in Zambia. It is a part of the Lundazi district area, which inhabits approximately 320 000 people. The Lundazi district area contains several chiefdoms. This report puts focus on two of these chiefdoms, Phikamalaza and Magodi, see appendix 1. None of the villages in the area are connected to the electric grid. Unemployment rate is close to 90 percent and individuals survives on small-scale farming. Questions regarding land ownership are controversial and therefore not often discussed among villagers.

1.3 Jatropha Curcas a Biofuel

The Jatropha Curcas is a bush/tree that origins from the Central America and is mainly used as a hedge or fence planting to keep animals away. The poisonous bush is non-edible and therefore suitable for such purpose. The Jatropha bush is a succulent that sheds its leaves during dry season. It has been proven successful to grow in areas with an annual average rainfall from 300 mm up to 1000 mm. It grows mainly on lower altitudes from sea level up to 500 meters. The plant is well adapted to high temperatures, however the origin species of the plant was found in areas with temperature from 20 degrees up to approximately 28 degrees Celsius, where it also has proven to give the highest yield. The Jatropha needs well-drained soils and adapts well on soils with low levels of nutrition. In some cases origin species has been found on rocky slopes. The strong and well-adapted root system of the plant has given it an ability to grow on poor, dry sites, wastelands. Because of its special characteristics it does not compete with any other crops on fertile soils, which is an important factor for biofuel crops. Competition with food crops is neither acceptable nor desirable. The roots are widely spread and are great preventers of soil erosion. It is a multipurpose crop, figure 1, and suits well for intercropping scenarios during the first years before the thick leaves create too much shade if planted to dense. The seeds contains between two to three nuts that can be pressed for oil and contain up to 35 percent oil. The seedcake is rich in nitrogen and suits perfect for soil nutrient after being pressed. There are many different facts and figures on how much Jatropha yields per year, but figures say between 0,4-12 tonnes of seeds per hectare annually (Heller 1996).



Figur 1. Scheme that shows the multipurpose of Jatropha curcas.

Jatropha was first introduced from Angola and Mozambique where it is widespread. Abundance of Jatropha can today be found in the Eastern, Western and Northwestern parts of Zambia where framers use it as a hedge to keep roaming animals away from their fields. Projects are trying to make Jatropha cultivation an integrated part of rural village development. The possibility to produce biodiesel due to the characteristics of the plant could be a way to provide rural villages with generator-powered electricity. The characteristics of the plant also makes it well suited for production of soap, which can help promote the status of women in the villages (Henning 2000). Jatropha grows seeds that can be pressed for crude oil, which contains a free fatty acid, water, sterols, and some other small substances. The straight vegetable oil (SVO) could be used directly in engines if the engine is modified. However, SVO is not the best choice considering its negative impact on engine endurance. The combination of substances in the crude oil makes it hard to use directly in combustion engines, so it needs some chemical modification. The oil can be refined and mixed with an alcohol to produce biodiesel in a transesterification process (Parawira 2010). Biofuel is in some parts of the world considered to be a solution to huge environmental problems, primarily greenhouse gas (GHG) emissions. The invention of biodiesel is old and goes back to the invention of the diesel engine, by Rudolf Diesel who used Peanut oil as fuel for his first diesel engine. When petroleum products later became cheaper, fuels made by vegetables could not compete on a global market. Electrification by Jatropha based biodiesel is a controversial question since it might compete with food sources. What also has to be taken under consideration is that the Jatropha seeds might be a source of income for the local villagers. This source of income could lead to sustainable economic development (Achten et al. 2007). The question regarding biofuel is very controversial and the opinions regarding biofuel are divided between those who argue for and those who argue against. India has decided to grow biofuel on 14 million hectares to become self-sufficient and cover its constantly increasing demand for fuel in the future. This decision was made after its minister of finance called the transition from food crops in to fuel crops “a crime against humanity” (The Economist 2008). In the meanwhile food prices are the highest in history. Oxfam (2011) shows that three-quarters of southern part of Asia’s population live in rural areas. Their budget consists to 50 percent of food. While the same figure is only 17 percent in United states. Food price inflation and shortage of food hit poor people hard. Most countries in southern parts of Asia barely produce enough food to be self-sustainable. Inappropriate subsidises and tax breaks in favour for biofuel lead to land grabbing and also a distortion in the food production (Oxfam 2011).

2. Purpose and Research questions

2.1 Purpose of study

The purpose of our study is to emphasize the possibilities and obstacles of growing Jatropha in the close area around the project village (Kakoma). What the costs and benefits of growing Jatropha might be. If it is possible for small-scale farmers to grow Jatropha as a side crop and/or as a complement to their main crop, which normally is maize, in order to generate electricity. Can this create other opportunities that can lead to rural development and economic growth in a sustainable way? Through a case study we look at one village. Further, the study assesses the possibility for other villages to implement a transition where other cash crops are swapped for Jatropha. The purpose of the transition is to serve a common good, in this case a generator, to provide electricity for the entire village.

2.2 Research questions

- General case - Cost-Benefit analysis on implementing Jatropha based biodiesel instead of imported fossil diesel as fuel for generators to generate electricity in rural villages, Lundazi district, Eastern province, Zambia. What fuel is the best option?
- Case study - Cost-Benefit analysis on implementing Jatropha based biodiesel by using a new cultivation area instead of imported fossil diesel to supply generators for electricity production in Kakoma village, Lundazi district, Eastern province, Zambia. What fuel is the best option?
- What socioeconomic factors are important to enable a transition towards Jatropha based biodiesel?
- What socioeconomic benefits can come from such a transition?

3. Methodology and Previous studies

3.1 Methodology

The report contains theories and resources from two different disciplines, economics and environmental science. First a Cost benefit analysis is used to analyse the profitability/feasibility from growing Jatropha in the Lundazi district area. Secondly a Cost benefit analysis is used to analyse the profitability/feasibility from growing Jatropha on a new area in the project village, Kakoma. Common pool resource management theory is used for socioeconomic analysis to assess externalities but also to study the opportunities and required factors for implementation of Jatropha based biodiesel. The environmental science handles the issue regarding sustainable development through biofuel plantation and cost effective implementation of rural electricity. The site of the field study is chosen according to the author's relationship to the village. Qualitative interviews have been used to collect data from the project village. This data collection has been compare with previous studies conducted within the same area of research. Most interviews are made through focus groups were people from different villages in the surroundings were gathered to get a diversified data sample. Group one was mainly men, group two was women, group three was a youth group and group four was mixed gender and age. Finally a former municipal council advisor, now considered a village elder, was interviewed to get an outside perspective on the issue. All together thirty-two interviewed persons. This is considered a diverse and large enough sample in order to give a good image of the situation in this area. In most cases, English as language to perform interviews worked very well. Though some of the interviews were performed with a translator since none of the authors neither speak nor understand the local language Tumbuka. This is considered a source of error in the result. However, there are no reasons for the translators to manipulate neither the questions nor the answers since all the translators lives in the villages and are a part of the local community. Hence they have no personal or economic interest in the current situation regarding Jatropha cultivation or the direct result of the study. The data is also based on previous studies, which is compared with the primary data collection. All data is analysed using theories chosen, and summarized in a final conclusion.
The fact that Jatropha is a multipurpose crop is touched briefly. Even though it is an interesting factor it is difficult to calculate a monetary value for the different purposes since they differ widely from each other. Hence, the multipurpose factor is left out of this paper. Many of the highly relevant externalities that are difficult to value in strict monetary terms are not valued but cared for and discussed in both the result as well as the analysis.

3.2 Previous studies

There are a limited amounts of research related to our questions regarding small-scale cultivation of Jatropha for self-sustainable electricity production in rural areas. Most studies found show results from larger commercial plantations.

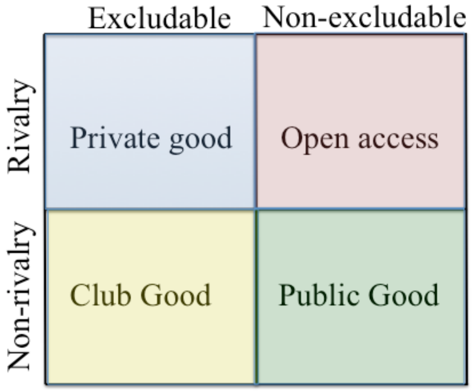
A previous study in Honduras proved that the current price for diesel, USD/litre 0,7 in 2009, was to low since the price of producing Jatropha biodiesel was USD/litre 1,5. The net profit of USD -0,7 was an incentive not to proceed with biodiesel production on large industrial scale. The study also emphasise that if other value adding activities can not be added, there is now profit in production if crude oil price do not increase above USD/litre 1,7 (De Jongh, Nielsen 2011). Several studies, among those a Kenyan, a Tanzanian and a Zambian showed that farmers make a profit during the first years while they can apply intercropping on their Jatropha plantation. Such intercropping is not possible after five years. In Zambia many farmers are encouraged to conduct intercropping during the first years to increase profitability. After approximately five years it is impossible to continue intercropping, which significantly lowers the income. Studies from India have calculated the income from plantations with intercropping during the first five years to USD 2833 over a lifespan of 27 years (Van Eijck et al. 2010). Since most farmers sell their seeds to refining companies under uncertain conditions, trust issues have occurred and affected profit for both buyers and sellers. The additive multipurpose products are essential to create profit for small-scale farmers. Plants need more care than previous studies have shown in order to give higher yields and therefore increase profit (Mogaka et al. 2012)(Andreasson, Richard 2011)(Wahl et al. 2009). Lack of markets has also affected the profit of growing Jatropha. Hence biodiesel from Jatropha is non profitable besides from a few niched markets. The current price in India is USD 0,58 per litre according to government directions, though producers claim they can only make profit if price increase to over USD 1,1 per litre (Van Eijck et al. 2010). Studies emphasize problems in profitability on larger commercial scale since then lack of market decreases the price of the good. Though the margins are tight in comparison with fossil fuel, greater price volatility and uncertain demand on fossil fuel are to expect in the future. This prediction is the reason why most previous studies hope for a paradigm shift within the global market. The study will test the concept of rural biodiesel production for own consumption within production areas and this type of studies is enlightened to be able to be profitable, but more studies are needed (Goswami et al. 2011)(Van Eijck et al. 2010). One other study showed effects on small-scale farmers in India who performed a transition not different from ours. The households tend to have a diversified livelihood. Food crops are self-grown in a combination with market crops. The labour tends to differ during the season from field labour to wage labour. 82 percent of households in one province substituted food crops for Jatropha. 44 percent had performed intercropping. 42 percent experienced shortage in edible oil, 53 percent experienced shortage in food and 20 percent experienced shortage in firewood (Ariza-Montobbio & Lele 2010).

Common for most previous studies is that they assume to high yields. Due to this overstatement, calculations are misleading and promote bad investments (Van Eijck et al. 2010).

4. Theory Common goods

4.1 Private and Public goods

A private good is generally owned by a single individual and is therefore excludable. Only one person can consume a hamburger. There is rivalry and excludability of a private good. The opposite of a private good is a public good. The Public good as common property is for example the streetlights or the national defence. The different goods and what defines them are presented in figure 2. There are different solutions to pay for public goods though the most common is by tax. The definition of a public good is “a commodity or a service whose consumption by one person does not preclude others from also consuming it.” (Perloff, 584, 2011)



Figur 2. Matrix showing the different economic goods.

A Club good is when a player can be excluded. It has clear borders everybody can take part it of as long as they chose to do so due to non-rivalry. An example of a club good is cable TV since everybody can get it as long as they pay the fee. The fourth scenario is the open access scenario where it is impossible to exclude consumers but rivalry exists. An example of this is fishery or hunting. This scenario is often referred to as: “tragedy of the commons” (Hardin 1968), because it is always over utilized and this will in the long run impair the system and the livelihood of the people that lives of it. Solutions to an open access scenario are to either privatize or nationalize. Only then will individuals care for the resource, otherwise the free-rider problem will occur. The free-rider issue describes an individual who exercise the right to consume a public good without paying for it. An example is to use the public transport without buying a ticket. Individuals take benefit from the actions of other individuals (Perloff 2011)(Frank 2010).

4.2 Game Theory

Normal game theory has two competitors. The strategic actions will decide the outcome of the game. The normal game theory is generally presented through a payoff matrix. This matrix describes a scenario with two individuals facing two options. The choice of option will affect both players economic outcome. Since one individual’s option also affects the other player’s choice and payoff there is incentives for strategic reasoning.

The payoff matrix is modified for our specific case but the general theory concerning game theory is according to Perloff (2011) and Frank (2010). Farmer A has different choices, either he chose to contribute, or he can chose not to. The same rules holds for farmer B. One farmer’s choices will affect both his own and the other farmer’s outcome. If farmer A and B decides to contribute, the village will experience electricity. If farmer A contributes and B does not, or if B contributes and A does not, no electricity will be generated. If neither farmer A nor farmer B contributes, there will be no electricity.

5. Theory Cost Benefit Analysis (CBA)

To investigate whether this project will yield a better outcome than the current situation, a cost-benefit analysis (CBA) will be applied. The structure of CBA rests on several basic steps that must to be met for the method to be complete:

- Definition of the project
- Identifying impacts which are economically relevant
- Physically quantifying impacts
- Calculating a monetary valuation
- Discounting
- Weighting
- Sensitive analysis

5.1 Definition of the project

This step is divided into two parts, where the first part aims to map the reallocation of resources being proposed. The second part includes consideration of gainers and losers within the affected population due to the proposed project. This is the basis of the analysis, since a project cannot be appraised unless what is to be appraised is known. Implementation of this step also makes it easier to determine the boundaries of the project.

5.2 Identifying impacts which are economically relevant

Additionality and displacement are the two main concepts in this stage of the analysis. The net impact of the project is referred to as additionality. If displacement occurs in any other region due to the proposed project it is to be taken under consideration.
This stage will identify and list all the impacts resulting from the implementation of the project, for example: resources used in the project, effects on local and regional employment, effects on surrounding property etc. When defining the economically relevant impacts, there is one crucial assumption that has to be made: Society strives to maximize the weighted sum of utilities across its members. Utilities are measured primarily by the level of consumption of different goods that can be achieved. Goods can be divided into market goods and non-market goods. The difference between them is that some can be traded on a market, while some give rise to market failure that makes the latter category of goods more difficult to value. The benefit is calculated by adding the values of all the positive contributions, and consequently the cost is obtained by adding the value of all the contributions that have a negative impact on the total utility of society. CBA is thus used as a tool in order to select those projects that increase the total utility of society.

5.3 Physically quantifying impacts

The benefit and cost flows are determined and also when these flows will occur.

5.4 Calculating a monetary valuation

For the comparing and valuation of the physical metrics to be accurate they have to be co-measurable. The common unit used in CBA is money.

5.5 Discounting

When the metrics have been expressed in monetary values, converting future cash flows to present value is necessary to make a good analysis. This is due to the time value of money, which means that money today is worth more than money tomorrow.

$$NPV(i, N) = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

5.6 Weighting
Since some metrics might count as more important than others, a weight has to be connected to each metric in order for the Net Present Value (NPV) calculation to be precise. This type of calculation is not easy to conduct and is therefore not always applied in practice.

5.7 Sensitive Analysis
CBA is based on forecasts that create projections of the future. These projections are used when calculating the NPV and it is therefore crucial that these projections are as accurate as possible to minimize risk for bad investments. In order to be accurate, a sensitivity analysis of what metric that has the largest impact on the NPV is made. For example the discount rate could give rise to major differences in NPV. So, to investigate how large this difference could be, calculations with a number of different discount rates are made. This sensitivity analysis should be made with all the key metrics. When the analysis is completed, it is easier to create a projection of the future that also takes possible changes in key metrics into account. (Hanley et al. 1993) (Wahl et al. 2009) (Mattsson 1988) (Gaaf & Reinhard 2012)

6. Results

Farmer and Household are regarded as equal since each household has its own cultivation area. Benefits of electricity are not accounted for since they are the same not matter what source is used to produce it.
The main purpose of electrification in rural villages is to make cooking more efficient and safe. Villagers express great concern regarding the use of firewood for cooking and specify that as the primary reason for electrification. Due to long nights without light life is difficult after dark. By gaining access to light a few hours every night, activities such as reading that is important for the continuous development of education in the village would be made possible. Hence, safe cooking and light are the two factors most crucial to villagers when evaluating their life situation. In an average household one stove and four lamps is considered enough to meet their most critical needs (Interview 020413). The one stove and four lamps will from now on be referred to as devices. Net Present Value calculations will be based on the use of these devices over a 25-year period using a discount rate of 12 percent derived from a 20 percent nominal rate of interest and an 8 percent inflation rate (IndexMundi 2012).

6.1 General Case
In the general case, the cost of growing Jatropha on a part of existing land areas is compared to the cost of diesel import. The Net Present Value (NPV) is calculated over the 25-year period. In current situation, one farmer has about 3,6 hectares of agricultural land on average. Approximately 40 percent of this land is used to grow maize for food consumption. The rest is used for cash crops, most commonly soybeans, sunflower and groundnut, that are either consumed within the household or sold on the local market generating income that is mainly used for purchasing hygiene products (Interview 020413). In the general case two *Scenarios*

are analyzed. The first *Scenario* requires farmers to import diesel to supply a generator in order to get electricity. In the second *Scenario* one third of the total cultivation area, 1,2 hectares, is used for growing Jatropha resulting in a decreased area used for cash crops, 0,9 hectares. The devices have a total effect of 1,7 Watts that require 769 liters of fuel to supply a generator that runs for five hours a day over one year (generatorsales 2013)(advfn 2013). However, assuming a conservative yield of 586 liters/ha the average farmer can only produce 699 liters of biodiesel on his 1,2 hectares of Jatropha fields, hence the production capacity is not sufficient to cover the required 769 liters of fuel. This yield was obtained using a South African Jatropha plantation as a proxy where yields of 502 liters/ha was observed, and since conditions in Zambia are preferable to those in South Africa a larger yield was assumed (Van Eijck et al. 2010). So for one farmer to produce 769 liters of biodiesel, yields must increase to the breakeven yield of 646 liters/ha. The yield is difficult to determine in advance due to dependence on several different factors such as location, management and seed quality. In this case Jatropha yields are assumed to be sufficient in order to make comparison with imported fossil diesel interesting. In reality yields might be higher or lower than the breakeven yield, which is discussed in the analysis. In each of the two *Scenarios* income is only used to cover cost of electricity production, which in reality would pose a risk to food security due to the use of cash crops for own consumption mentioned above. The food security risk is discussed further in the analysis. The compared *Scenarios* in the general case are presented below:

- *Scenario 1, current situation: Electricity by diesel import. Figure 3*
  $NPV_D = I - C_D$
  Income, $I = I_{cc} + i$, to cover the required diesel import, C_D, in order to generate electricity. Financing of diesel import rely solely on the level of income.

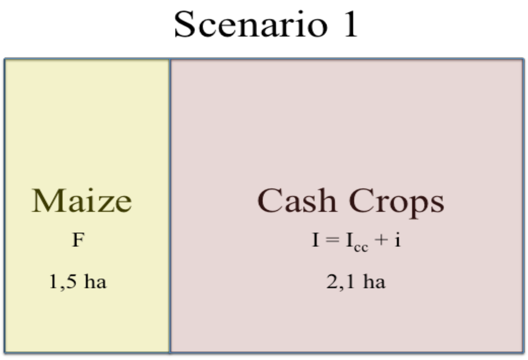


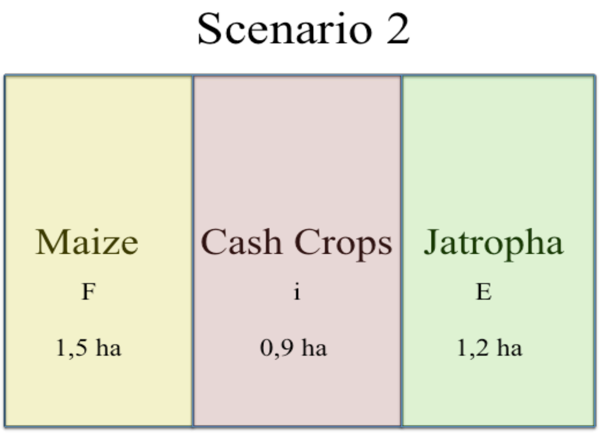
Figure 3. Image of the cultivation area and the value of each part.

Commodity Data			
	Yield (kg/ha)	*Price (USD/kg)*	*Area (ha)*
Soybean	1000	0.6	0.70
Sunflower	600	0.3	0.70
Groundnut	700	0.7	0.70
Diesel			
	USD/L		
Price	1.53		

Table 1. Price and yield information for cash crops and diesel.

Using existing price and yield data on cash crops from Table 1 the total income for year one equals: 0,7 ha * (1000 kg/ha * USD 0,6 + 600 kg/ha * USD 0,3 + 700 kg/ha * USD 0,7) = USD 889. The required amount of diesel is 769 liters and the current price is USD/liter 1,5, hence the total cost of diesel import year one equals: USD/ liter 1.5 * 769 liters = USD 1154. In a scenario where farmers have to import diesel they end up with 889 – 1154 = - USD 265 on their account after the first year. Over a 25-year period, using historical prices on cash crops and diesel to get an annual price change, the NPV_D equals - USD 2700 per farmer, see Appendix 2. Hence it is not possible for one farmer to produce electricity through diesel import without gaining access to external financial resources.

- *Scenario 2: Electricity by Jatropha. Figure 4*
  $NPV_J = i + B_{EX} - C_P$
  The cash crop area generating I_{cc} is transformed into generating Jatropha seeds for biodiesel production, C_P. Hence, the income will decrease to i. The income has to cover the production costs of biodiesel, which is assumed to be only the cost of input factors for the transesterification process. These input factors are Methanol and Potassium Hydroxide (PH). The cost of maintaining the Jatropha field is the same as for the cash crops field and therefore it cancels out when comparing the diesel import *Scenario* (Interview 020313).



Figur 4. Scenario 2, Image of the cultivation area and the value of each part.

Commodity Data			
	Yield (kg/ha)	*Price (USD/kg)*	*Area (ha)*
Soybean	1000	0.6	0.3
Sunflower	600	0.3	0.3
Groundnut	700	0.7	0.3
Diesel			
	USD/L		
Price	1.5		
Input Factors per hectare Jatropha			
	Methanol (L)	*Potassium Hydroxide*	
Amount	115.4	2.9	
Price	0.4	22.1	

Table 2. Price and yield data for cash crops. Diesel price per liter. The amount of input factors needed to produce an equivalent of one hectare of biodiesel and their price.

To generate electricity in *Scenario 2* Jatropha is planted on a third of the total area of cultivation to get oil from the seeds in order to produce biodiesel through a transesterification process. Using price and yield data from Table 2 the lower income, i, for the first year will be 0,3 ha * (1000 kg/ha * USD 0,6 + 600 kg/ha * USD 0,3 + 700 kg/ha * USD 0,7) = USD 381. When calculating the cost item an incremental increase in the use of biodiesel is applied. This means that an additional cost of diesel import has to be accounted for during the first 5-year period. The price of Methanol and PH is USD 0,4 per liter and USD 22 per kilogram respectively. To produce 769 liters of biodiesel, 115 liters of Methanol and 3 kilograms of PH are required according to Table 2. The first five-year cost development is presented in Table 3. The use of historical prices on diesel and the input factors to create a price development over time makes the biodiesel production more expensive in year five than in year one.

	Cost (Cd)	**Cost (Cp)**	
Year	*Diesel*	*Methanol*	*Potassium hydroxide*
1	$ (1,175.31)	$ -	$ -
2	$ (1,190.18)	$ -	$ -
3	$ (723.14)	$ (19.71)	$ (26.09)
4	$ (366.15)	$ (34.66)	$ (45.88)
5	$ -	$ (49.76)	$ (65.87)

Table 3. Shows the incremental increase of biodiesel production during the first 5-year period.

By applying this price change over a 25-year period a NPV_J of USD 19 per farmer is obtained, see Appendix 3. This indicates that it could be possible for one farmer to produce electricity through Jatropha cultivation. When taking the investment cost of a generator into account this number will turn negative, which makes implementation of Jatropha based biodiesel electrification impossible.
By subtracting NPV_D from NPV_J the best scenario can be observed: NPV_J - NPV_D = 19 – (-2698) = USD 2700 per farmer. So, for one farmer to produce electricity through Jatropha based biodiesel it is USD 2700 better than importing fossil diesel. Even though *Scenario 2* is the better option that does not imply it being feasible. The assumptions made take away important costs such as pressing oil and labor required to produce biodiesel. If these costs are added, the NPV_J will most probably turn negative. Yields per farmer using conservative measures (586 liters/ha) are also insufficient, which is another factor that make implementation impossible.
When checking for small and large deviations in variables to determine what variable that has the greatest impact on the difference NPV_J-NPV_D, the inflation rate and the nominal rate are the most important variables, see Appendix 3. Hence, the discount rate is the calculation factor that has the greatest impact on the difference between NPV_J and NPV_D. Diesel prices are the second most important factor both for small and large deviations in price. Cash crop and input factor prices have a very small impact on the result. The difference does not turn negative even with large deviations, which gives strong reason to believe that *Scenario 2* will be better than *Scenario 1* even with higher future price volatility.

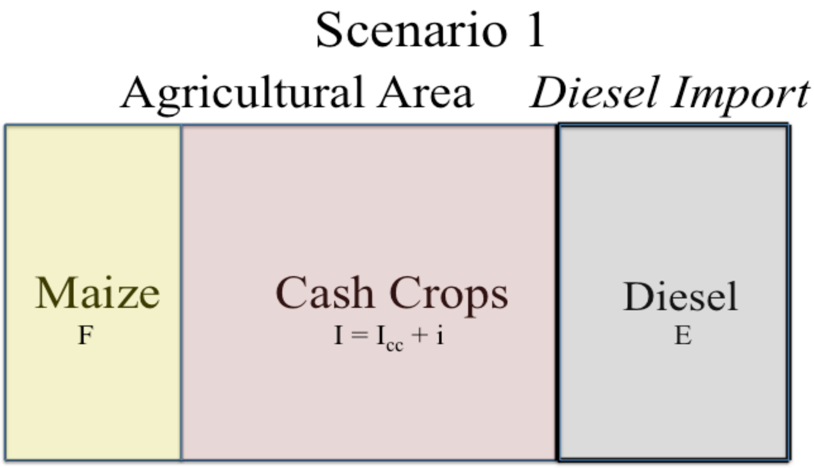
By looking at the financial result it is clear that an implementation of either *Scenario* is not possible without external funding. However, Jatropha based biodiesel is a better option than diesel import. If a transition towards integrated Jatropha biodiesel production is to be successful, socioeconomic factors are important. Common for all the people we interviewed in the Phikamalaza and Magodi district is that they had farming as their main livelihood. Common for all responders is also that electricity is considered important and that it could contribute to the well being of all individuals in the area. The farmers currently have between two and five hectares of arable land, depending on the size of their family. Most households have between six and twelve family members. The average income per farmer/household is approximately USD 300 and average level of education is six years of primary school. Almost all our responders claimed that their arable land was used in the following way, around 40 percent was used to grow maize, and 60 percent was used for other cash crops such as soybean, cotton, sunflower and groundnuts. Cash crops are not an entirely true name for its purpose. Some responders claim to be able to sell some of their cash crops but some say that it is used for relish (side dish) to their staple food maize. Those who had the opportunity to sell some of their cash crop could do so in some of the local markets.
Many of the responders answered positively on the question regarding common pool resource management. They thought that a village could be able to cooperate and work to achieve a common goal. The positive answers were followed by comments saying that similar situations already exist. There were different examples but mainly concerning fieldwork, weeding, harvesting etc. Many examples explained the case of women groups that had come together to discuss and give financial support to each other. For example they could come together and lend money to somebody who wanted to start a business, or if someone had a hard time buying seeds or seedlings in the fall. These types of groups only consist of women. However, most responders thought that a scenario where households in villages join together for a common good could work. Uncertainty regarding how the common good is supposed to be

shared among the villagers was expressed as a concern. One responder claimed that it once was a “Native Tumbuka council” that argued and pushed for more widespread cooperation. It did work for a while, but many villagers did not see the long-term perspective and when it came to the issue of sharing the harvest, it fell apart. However, there are scenarios were this could work, for example if the villager’s get some kind of production going were they actually see results. Such a production could work if it creates self-employment, self-income and were they are able to divide the workload depending on previous experience.
Regarding strong leadership in village communities, most responders claimed it exists. Not solely in the form of village elders, who are mainly males, but also in the form of elected individuals who are most suitable for the task. There are no doubts concerning the legitimacy of the election process and no obvious corruption issues. Such issues are not present as long as it is concerning the villager’s own home village. Hence, everybody will do what is best for the village. If the elective process on the other hand would concern several villages problems may occur since the ties in the village remain strong and family is important. Since no social security network exists villagers need to take care of their family. “Long-term is not a state of mind if you do not know if you live tomorrow.” (Interview 040413)
The knowledge of environmental issues is lacking. Not a single one of the responders in our focus groups were familiar with the scientific term global warming. Most responders claim to throw their waste in the nature or burn it in a garbage pit. Very few are familiar with deforestation but some, most of them women, have noticed that they have to walk longer distances to find firewood. Some, only women, say that log fires creates inside smoke. Clearly there is a lack of knowledge regarding negative health effects and the environmental issues of log burning.

6.2 Case: Kakoma

In the Kakoma case an additional cultivation area is available for growing Jatropha outside the Kakoma village. Using this area in order to produce biodiesel has only reached testing stage where a few Jatropha plants have been planted. To see if using this new area to supply the village with electricity is a better option then importing diesel the 2-scenario model is applied: One where a new area is used for Jatropha cultivation and the other where fossil diesel is imported. This analysis does not consider income since no change is made regarding cash crop cultivation. Since Jatropha does not compete with cash crops in this case food security is not an issue.
The new area used for Jatropha in Kakoma is 3,6 hectares. Cost data have been collected and transformed to a per hectare basis. 586 liters/ha of biodiesel can be produced using the South African proxy, which is the amount used when comparing Scenario 1 and 2. Since there are no obvious benefits except for the benefits from electricity calculations are focusing on cost flows.

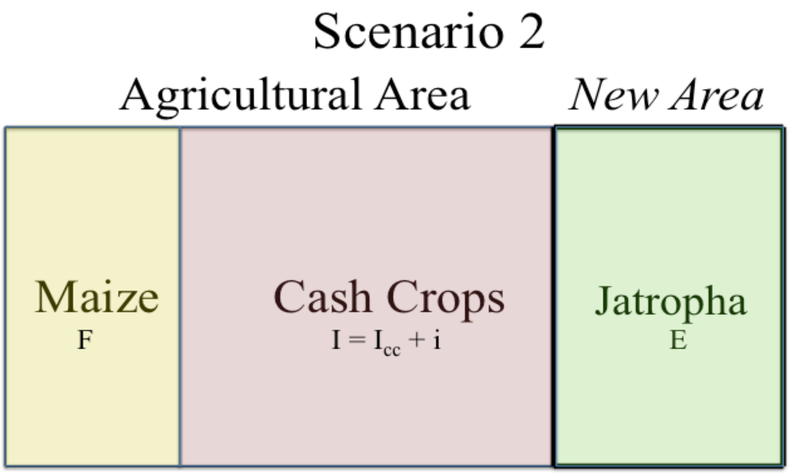
- *Scenario 1, current situation: Electricity by diesel import. Figure 3*
  Imported Diesel, C_D, to generate electricity. The only cost is to import diesel.



Figur 3. Scenario 1, shows diesel import needed to cover electricity demand.

Since the only cost in this Scenario is diesel import the total cost for the first year equals 586L * USD/L1,5 = USD 895 using the diesel price from Table 1 and 2. Using the same annual diesel price change as earlier results in a NPV_D of - USD 8856 per hectare. This number does not explain anything, except that an implementation process is not possible without sufficient external funding, until it is compared with the NPV_J of Scenario 2.

- *Scenario 2: Electricity by Jatropha. Figure 4*
  A new area is used for growing Jatropha to produce biodiesel, C_P.



Figur 4. Scenario 2, shows the new area used for Jatropha cultivation in order to produce biodiesel.

Interviews and focus group discussions with the local NGO management group provided cost data regarding Jatropha cultivation on new areas, see appendix 5. First year cost consists of both fixed costs and average cost. All costs items are specified in a per hectare basis. The fixed cost of digging holes and planting seeds is USD 48 and USD 11 respectively and are completed during the first year. Pest control, pesticides, weeding, clearing bushes and

FC		*AVC*					*Input factors*		*Diesel*		
Digging holes	Planting seeds	Pestcontrol	Pesticides	Weeding	Clearing bushes	Harvesting	Methanol	PH	Cd		**SUM**
$ (47.99)	$ (11.09)	$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ -	$ -	$ (894.82)		$ (1,147.48)
		$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ -	$ -	$ (906.14)		$ (1,099.71)
		$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$(15.00)	$ (19.86)	$ (550.56)		$ (779.00)
		$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$(26.39)	$ (34.93)	$ (278.76)		$ (533.65)
		$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$(37.88)	$ (50.15)	$ -		$ (281.61)

Table 4. Five-year cost flows and the total sum. Shows how the incremental increase of biodiesel production affects the annual sum.

harvesting are yearly average costs amounting to USD 194. The average costs will be held constant over time due to lack of historical price data. Since electricity will be provided from the first year an incremental increase of biodiesel usage is applied. Full capacity of biodiesel production will apply from the fifth year, which requires an annually determined amount of imported fossil diesel during the first five years. The first five-year cost flows are presented in Table 4.
Over the 25-year period using a 12 percent discount rate, NPV_J equals - USD 4744 per hectare, see Appendix 5.
Subtracting NPV_D from NPV_J gives a difference of -4744 – (-8856) = USD 4112 per hectare. Hence, the NPV_J of Scenario 2 is preferable to Scenario 1, which implies that growing Jatropha on a new area in order to supply Kakoma Village with electricity is a better option than importing fossil diesel. The NPV results show that none of the scenarios are feasible without sufficient external funding, which was already known and not the purpose of the analysis.
The only variables controlled for in the analysis are the nominal rate of interest and the inflation. This implies deviations in the discount rate, which is calculated based on the two variables. Checking for small and large deviations in these variables show that the difference: NPV_D-NPV_J, never turns negative. This indicates that even with large deviations in the discount rate Scenario 2 will be preferable to Scenario 1, see Appendix 6.

Depending on the efficiency of Jatropha byproduct usage benefits of externalities can arise if Scenario 2 is used in both the general and the Kakoma case (Interview 020413). Eliminating use of fossil diesel could reduce GHG emissions and ecological footprint, depending on the life cycle of the Jatropha plant. If forest is removed in favour for Jatropha the emission reduction could turn negative, resulting in a situation that is worse than with fossil diesel import (Jatropha asses). Regarding environmental benefits it is therefore important that Jatropha is cultivated on wasteland areas or areas already used for crops. The cost of investing in a generator will appear in both Scenario 1 and 2 in both cases and is therefore neglected in calculations. Even if this cost item is omitted from calculations, the investment is a major obstacle for electrification and should be cared for in a possible implementation process. This issue will be discussed further in the analysis.

7. Analysis

7.1 General case

As the result indicates, supplying a rural village in the Lundazi district area with Jatropha based biodiesel is preferred to fossil diesel import. However, this does not make it a feasible option due to assumptions used in the calculations. Financial resources to buy a generator are not present in these poor areas, which make the electrification process impossible without sufficient external funding. The only reasonable solution is that NGOs active in the area have to raise money to buy a generator before any further field transitions are made. Such transitions need to be well conducted to minimize the food security risk due to the heavy reliance on food crops. It is of great concern that transitions from cash crops to Jatropha cultivation do not put food production at risk. The interest in electricity is high among villagers, dangerously high the way we see it. A transition process needs to be assessed carefully before implemented and the eager to gain electricity can lead to a compromised assessment. Such compromise is a great risk and could lead to decreased food supply. The transition where arable land with edible cash crops is swapped for non-edible Jatropha significantly reduces the total amount of accessible food. This affects the households' vulnerability against unmanageable external effects, such as climate change or seasonal changes in yields. If food surplus is low, one low yield could easily cause famine with fatal consequences. As observed in the Indian study by Ariza-Montobbio & Lele (2010), households changing to Jatropha experienced shortage of essential products such as edible crops. This cannot be tolerated since it puts the survival of villagers at risk.

Concerning the Jatropha yield it is hard to estimate an exact number from year to year since it depends on many different factors. As stated by Heller (1996) yields can vary from 0,4-12 tonnes of seeds per hectare and year. In this report a conservative yield of 1,5 tonnes of seeds per hectare is used in order to minimize the risk of misleading results. Calculations show that in order to supply a farmer with electricity over one year, 769 litre of biodiesel is required. With a yield of 1,5 tonnes of seeds per hectare one farmer can only produce 586 litres of biodiesel, which make it impossible to provide enough electricity. In order for electrification through Jatropha cultivation to be possible yields need to be at least 646 litres per hectare. It might be so that the yield in reality is either higher or lower than the one used in calculations, but it is difficult to determine the real yield without further field studies.

Managing a Jatropha field is according to the local management not much different from managing a cash crop field. This strengthens the assumption that additional maintenance costs will not arise from a transition from cash crop to Jatropha cultivation. Even if additional costs were to appear, they would have to be large in order for it to make Jatropha a less preferred option.

The weakest assumption concerns the transportation cost of diesel and the cost of extracting oil from Jatropha seeds. The extraction process could be seen as a part of managing the field, which would make Jatropha cultivation even more desirable. But since no information regarding the cost of pressing oil in rural village could be found it was considered to offset the transportation cost of diesel for simplification purposes.

Externalities, positive or negative, are always difficult to measure, which is why they are not a part of calculations. However, external effects are of great importance when evaluating a project since they will affect villagers in other ways than financially. The environmental benefits from Jatropha could be many. Increased amount of biofuel can reduce GHG emissions. This is due to decreased use fossil fuel but also in decreased burning of firewood. Burning firewood leads to deforestation, which leads to depletion of biomass accumulated for centuries. Less soil erosion keep the soil arable and less in the risk zone of desertification. From a general environmental perspective a transition process is good. The generator would we describe as a club good. Each household can chose if they want to be connected to the generator and benefit from the electricity. In exchange the household must perform a transition where they give some part of their arable land to the greater good for the village and start to grow Jatropha. This will work up to a certain limit where the size of the generator cannot provide more households with electricity since the capacity limit is reached. The incentives to contribute are strong since it would make life easier in many perspectives. The possibility to do quick and emission free cooking and in the same time extend waking hours due to electric light are strong incentives to participate in a transition in to a common good resource scenario.

According to the theory of common pool resource management, and for an implementation scenario where electricity becomes possible, all villagers must contribute. If any household decides to sell their seeds no one will benefit from electricity. The incentives to sell the seeds to generate any income are high since all sources of income are gone. Then the contributors would end up in a trust issue or a prisoner dilemma. Since they cannot trust their fellow villagers to contribute, each and everyone will do what is least bad for them and in that case it would be to sell off their seeds and get income. This scenario would make the transition process fail because of trust issues. The long-term perspective is impending. Five years until maximum yield will occur requires high endurance of its invertors, in this case the investors are poor and the income will decrease during the whole transition period even though intercropping is conducted. It will never return to previous levels if the land is not expanded or the Jatropha is not sold.

To avoid such a scenario strong communication is needed. That creates a high demand for strong leadership within each village to form a cooperatively mentality and that every contributor feels they benefits equally from the common good. The fact that groups who work together have existed and exists currently among women is positive. If a similar group could be democratically elected in the village to manage the common good that would drastically increase the chances of success. However, village elders, who are mainly men, are considered natural group leaders. Since our interpretation is that it would affect the outcome of the elections. Hence a woman cannot be elected as leader or as a part of a managing group, which according to our interpretations would lower the success rate of the transition process and of the resource management. Our analysis is that women are a key factor.

Awareness on environmental issues is low, which we believe is related to lack of education. Since the average person attends school for approximately six years there are limitations in basic knowledge. Lack of information sources, such as television also contributes to the low level of knowledge. We also interpret it as a hazard that low knowledge level could lead to innocent but serious decisions with severe consequences for daily life. The personal interest for the single individual with no long-term analyse could lead to inadequate basic needs and therefore grave situations. Higher standards of education are a key factor for making rational decisions.

Regarding health standards among women and children we believe it would increase since the expose for in-door smoke associated to cooking would decrease. We do not have figures on monetary value for the healthcare sector on similar issues hence our argumentation weakens though our interpretation is that life quality would increase and premature death cause, like passive smoking diseases, would decrease.

7.2 Case: Kakoma

The difference compared with the general case is that new area is taken in to consideration. A generator is already in place and a management are handling the issues that occur. These are three factors that separate case Kakoma from the general case. Such factors will, according to what we know about the requirements for a successful electrification process, increase the success rate. That is why we think that case Kakoma could be more successful in providing a village with electricity. The presence of an NGO in Kakoma that is contributing to the development and monitoring new projects in the village is another important factor for an increased success rate. Without this external knowledge regarding project management and control, electrification of a rural village would be difficult to conduct.

The food security issue is not as big in this scenario as in the previous since new area is taken in to consideration. Though the question regarding new arable land is highly infected, due to this our only interpretation is a difficulty in solving land issues and until that problem is solved we see no solutions in the near future. Since policy questions regarding land issues are beyond the topic of this paper. Hence no further analysis regarding previous topic is done.

8. Conclusion

The general case is feasible by only looking at the NPV_J. However, the initial investment cost of a generator is not incorporated in the NPV calculations. If that cost were taken into account NPV_J would turn negative and make the general case unfeasible. To make a complete feasibility assessment the socioeconomic factors required for a transition process need to be taken into consideration. Food security, level of education, trust issues that leads to prisoners dilemma are some of the discussed issues that could lead to a failed transition. This leaves us with a final conclusion where we cannot recommend conducting a transition. Key factors we recognize as the most important to make the transition feasible in the future are stated below.

- External funds – External funds are essential to buy generators and to create economic space for a transition.
- External assistance – Presence of an NGO or a governmental agency providing experience and knowledge to villages. This is in some sense similar to education since the purpose of this external entity is to increase villager's ability to manage a transition and follow up with controls. By monitoring a transition, an external entity could help ensure a well-conducted process.
- Women involvement – Women have the ability to cooperate and take care of the common good. Since scenarios with common goods already exist among women, the possibility that it could work in this case increases. Empowered women need to be involved in managing the common good for the greater good of the village.
- Education – Education is a key factor to strengthen the human resources and provide opportunities for empowerment and democratic development in villages. It would lead to better knowledge of agriculture, which would make yields more sufficient.

A transition in Kakoma could be feasible since external funds can come from the present NGO and a functional management exist which gives legitimacy to the transition process. Even though these important factors exist, more research regarding yields, villager's propensity to cooperate and the NGO's ability to provide sustained financial funding are required.

9. References:

Achten, Wouter. Mathijs, Erik. Louis Verchot. Virendra Singh. Raf Aerts. Bart Muys. 2007. *Jatropha biodiesel fueling sustainability?.* Wiley InterScience (www.interscience.wiley.com); DOI: 10.1002/bbb.39; *Biofuels, Bioprod. Bioref.* 1:283–291 (2007).

Andreasson, Karl. Maria Richard. 2011. A sustainable miracle?, Determining the socio-economic sustainability of small scale Jatropha cultivation in the Eastern Province of Zambia. ARBETSRAPPORTER Kulturgeografiska institutionen Nr. 783.

ADVFN – Share News, Available (online) http://www.advfn.com/nyse/StockNews.asp?stocknews=TOT&article=46431335, 2013-05-06

CIA, World factbook, Zambia. Avaliable (online) https://www.cia.gov/library/publications/the-world-factbook/geos/za.html 2013-05-07

Cunningham, William P. & Cunningham, Mary Ann (2008). *Environmental science: a global concern* . 10. ed. Boston: McGraw-Hill Higher Education

De Jongh, Nielsen, 2011, Lessons learned Jatropha.

The Economist. 18 sept. 2008.

EPA. January 1993. Fact Sheet: Respiratory Health Effects of Passive Smoking. 2013-05-15. Avaliable (online) http://www.epa.gov/smokefre/pubs/etsfs.html.

Frank, Robert H. (2010). *Microeconomics and behavior* . 8. ed., International student ed. New York: McGraw-Hill Higher Education

Gaaff, Aris. Stijn Reinhard. 2012. Incorporating the value of ecological networks into cost–benefit analysis to improve spatially explicit land-use planning. Science Direct. Ecological Economics 73, pp 66-74, 2012.

Generator Sales, Available (online) http://www.generatorsales.com/order/JD1PH50.asp?page=JD1PH50, 2013-05-06

Hanley, N. Spash, C. 1993. *Cost Benefit Analysis and the environment.* Available (Online) http://www.ima.kth.se/utb/mj2694/pdf/CBA.pdf

Hardin, Garrett. 1968, Tragedy of the commons. Science vol. 162. December 1968.

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

Henning, Reinhard. 2000. *The Jatropha Manual.* http://www.betuco.be/agroforestry/Jatropha%20-%20Manual%20Zambia.pdf

Indexmundi.com, World market commodity prices. Available (online) http://www.indexmundi.com, 2013-05-09

Janske van Eijck, Edward Smeets, Henny Romijn, Anne lies Balkema, Raymond Jongschaap. 2010. Jatropha Assessment Agronomy, socioeconomic issues, andecology.

Kishor Goswami, Jitu Saikia, and Hari Kanta Choudhury. Economic Benefits and Costs of Jatropha Plantation in North-East India. Agricultural Economics Research Review, Vol. 24, January-June 201, pp 99-108.

Mattsson, Bengt (1988). *Cost-benefit kalkyler* . Göteborg: Esselte studium/Akademiförl.

Narayan, Swati. 2011. Oxfam, "*Nourish South Asia - Grow a better future for food justice".* Oxfam International September 2011.

Parawira, Wilson. 2010. *Biodiesel production from Jatropha Curcas: A review*. Scientific Research and Essays Vol. 5(14), pp. 1796-1808, 18 July, 2010. Available (Online) http://www.academicjournals.org/SRE

Pere Ariza-Montobbio, Sharachchandra Lele. 2010. "*Jatropha plantations for biodiesel in Tamil Nadu, India: Viability, livelihood trade-offs, and latent conflict"*. Ecological Economics. Science Direct.

Perloff, Jeffrey M. (2011). *Microeconomics with calculus* . 2., [updated and rev.] ed., int. ed. Harlow: Pearson

United Nations, article on deforestation, Zambia. Available (online) http://www.un-redd.org/UNREDDProgramme/CountryActions/zambia/tabid/1029/language/en-US/Newsletter31/Zambia_Deforestation_Management/tabid/102684/Default.aspx 2013-05-07

Violet Moraa Mogaka, O.L.E Mbatia and Nzuma Jonathan, 2012, Feasibility of Biofuel Production in Kenya: The Case of Jatropha. University of Nairobi

Wahl N, Jamnadass R, Baur H, Munster C and Iiyama M. 2009. Economic viability of Jatropha curcas L. plantations in Northern Tanzania – Assessing farmers‟ prospects via cost-benefit analysis. ICRAF Working Paper no. 97. Nairobi. World Agroforestry Centre.

World Bank, Article on rural electricity, Zambia. Available (online) http://wbi.worldbank.org/sske/case/improving-zambia's-rural-electrification 2013-05-07

Zambian Commercial Bank, Bank Lending Rate Zambia. Available (online) http://www.indexmundi.com/zambia/commercial_bank_prime_lending_rate.html, 2013-05-06

10. Appendix

10.1 Appendix 1

2010 CENSUS OF POPULATION AND HOUSING - POPULATION					
			TOTAL POPULATION		
	PROVICE DISTRICT CONSTITUENCY WARD	NUMBER OF HOUSEHOLDS	TOTAL	MALE	FEMALE
	LUNDAZI DISTRICT	**62069**	**323870**	**158379**	**165491**
CHIEF	**WARDS /TOTALS**	**16603**	**86262**	**42145**	**44117**
Magodi	Manda Hill	805	4371	2159	2212
	Magodi	3375	17762	8682	9080
	Susa	1936	10576	5177	5399
	Luwerezi	929	4961	2453	2508
	Kajilime	3526	18363	9035	9328
	Kapilisanga	2085	10169	4890	5279
	Nkhanga	3947	20060	9749	10311
CHIEF	**WARDS**	**2686**	**13566**	**6665**	**6901**
Phikamalaza	Membe	986	5044	2464	2580
	Chamboli	1700	8522	4201	4321
CHIEF	**WARDS**	**5987**	**31325**	**15269**	**16056**
Kapichila	Ndonda	1815	9606	4667	4939
	Msuzi	3184	16622	8082	8540
	Mkomba	988	5097	2520	2577
CHIEF	**WARDS**	**8520**	**35582**	**21653**	**22929**
Mwase	Chilola	2045	1195	4972	5223
	Chimaliro	2017	10180	4969	5211
	Nthintimila	1482	8241	4029	4212
	Lunevwa	2976	15966	7683	8283
CHIEF	**WARDS**	**10468**	**54418**	**25940**	**27758**
Mphamba	Vuu	3815	19976	9854	10122
	Mnyamazi	6653	34442	16086	17636
CHIEF	**WARDS**	**5790**	**30002**	**14789**	**15213**
Zumwanda	Chamtowa	2546	12923	6390	6533
	Kachama	1709	9119	4547	4572
	Wachitangachi	1535	7960	3852	4108
CHIEF	**WARDS**				
Chikomeni	Kamimba	**2153**	**11306**	**5460**	**5846**
CHIEF	**WARDS**	**6046**	**32795**	**16269**	**16526**
Mwase Mphangwe	Diwa	4143	23410	11675	11735
	Chibande	1903	9385	4594	4791
CHIEF	**WARDS**	**3816**	**19614**	**9469**	**10150**
Kazembe	Kazembe	1724	8780	4209	4571
	Lumimba	1654	8679	4197	4487
	Lukusuzi	438	2155	1063	1092

10.2 Appendix 2.

Per Farmer over a 25 year period							
	NPV = I - Cd =	$ (2,698.44)	Discount Rate 12%			Periods 24	
	Income (I=Icc+i), I depends on Yields and CC prices				*Cost (Cd), Cd depends on Diesel prices*		
Year	Soybean +	Sunflower +	Groundnut +		Diesel Price -	=	**SUM**
1	$ 394.68	$ 105.18	$ 320.69		$ (1,175.31)		$ (354.76)
2	$ 404.04	$ 105.28	$ 331.54		$ (1,190.18)		$ (349.33)
3	$ 413.61	$ 105.38	$ 342.75		$ (1,205.24)		$ (343.49)
4	$ 423.42	$ 105.49	$ 354.34		$ (1,220.49)		$ (337.24)
5	$ 433.46	$ 105.59	$ 366.32		$ (1,235.93)		$ (330.56)
6	$ 443.73	$ 105.69	$ 378.71		$ (1,251.57)		$ (323.43)
7	$ 454.25	$ 105.80	$ 391.51		$ (1,267.40)		$ (315.84)
8	$ 465.02	$ 105.90	$ 404.75		$ (1,283.43)		$ (307.76)
9	$ 476.04	$ 106.00	$ 418.44		$ (1,299.67)		$ (299.19)
10	$ 487.33	$ 106.11	$ 432.59		$ (1,316.12)		$ (290.09)
11	$ 498.88	$ 106.21	$ 447.22		$ (1,332.77)		$ (280.46)
12	$ 510.71	$ 106.32	$ 462.34		$ (1,349.63)		$ (270.27)
13	$ 522.81	$ 106.42	$ 477.97		$ (1,366.70)		$ (259.50)
14	$ 535.21	$ 106.52	$ 494.14		$ (1,384.00)		$ (248.13)
15	$ 547.90	$ 106.63	$ 510.84		$ (1,401.51)		$ (236.14)
16	$ 560.88	$ 106.73	$ 528.12		$ (1,419.24)		$ (223.50)
17	$ 574.18	$ 106.84	$ 545.98		$ (1,437.19)		$ (210.20)
18	$ 587.79	$ 106.94	$ 564.44		$ (1,455.38)		$ (196.20)
19	$ 601.73	$ 107.05	$ 583.53		$ (1,473.79)		$ (181.49)
20	$ 615.99	$ 107.15	$ 603.26		$ (1,492.44)		$ (166.04)
21	$ 630.59	$ 107.26	$ 623.66		$ (1,511.32)		$ (149.81)
22	$ 645.54	$ 107.36	$ 644.75		$ (1,530.44)		$ (132.79)
23	$ 660.84	$ 107.47	$ 666.55		$ (1,549.80)		$ (114.94)
24	$ 676.51	$ 107.57	$ 689.09		$ (1,569.41)		$ (96.24)
25	$ 692.55	$ 107.68	$ 712.39		$ (1,589.27)		$ (76.65)

10.3 Appendix 3.

Per Farmer over a 25 year period

NPV = i - Cp + Bex =	**$ 18.69**		**Discount Rate (r)**	12%	**Periods (n)**	24				
			Income (i)			*Cost (Cd)*	*Cost (Cp)*		*Benefit Externalities*	
% Biodiesel	**% Diesel**	**Year**	Soybean +	Sunflower +	Groundnut +	Diesel -	Methanol -	Potassium hydroxide -	Efficient use of biproducts +	**SUM**
0%	100%	1	$ 171.09	$ 45.59	$ 139.02	$ (1,175.31)	$ -	$ -	$ -	$ (819.61)
0%	100%	2	$ 175.15	$ 45.64	$ 143.72	$ (1,190.18)	$ -	$ -	$ -	$ (825.68)
40%	60%	3	$ 179.30	$ 45.68	$ 148.58	$ (723.14)	$ (19.71)	$ (26.09)	$ -	$ (395.37)
70%	30%	4	$ 183.55	$ 45.73	$ 153.60	$ (366.15)	$ (34.66)	$ (45.88)	$ -	$ (63.80)
100%	0%	5	$ 187.90	$ 45.77	$ 158.80	$ -	$ (49.76)	$ (65.87)	$ -	$ 276.84
100%	0%	6	$ 192.35	$ 45.82	$ 164.17	$ -	$ (50.01)	$ (66.20)	$ -	$ 286.13
100%	0%	7	$ 196.91	$ 45.86	$ 169.72	$ -	$ (50.26)	$ (66.53)	$ -	$ 295.71
100%	0%	8	$ 201.58	$ 45.91	$ 175.46	$ -	$ (50.51)	$ (66.86)	$ -	$ 305.58
100%	0%	9	$ 206.36	$ 45.95	$ 181.39	$ -	$ (50.76)	$ (67.19)	$ -	$ 315.75
100%	0%	10	$ 211.25	$ 46.00	$ 187.52	$ -	$ (51.01)	$ (67.53)	$ -	$ 326.23
100%	0%	11	$ 216.26	$ 46.04	$ 193.86	$ -	$ (51.27)	$ (67.87)	$ -	$ 337.03
100%	0%	12	$ 221.39	$ 46.09	$ 200.42	$ -	$ (51.53)	$ (68.21)	$ -	$ 348.16
100%	0%	13	$ 226.64	$ 46.13	$ 207.20	$ -	$ (51.78)	$ (68.55)	$ -	$ 359.63
100%	0%	14	$ 232.01	$ 46.18	$ 214.20	$ -	$ (52.04)	$ (68.89)	$ -	$ 371.46
100%	0%	15	$ 237.51	$ 46.22	$ 221.45	$ -	$ (52.30)	$ (69.24)	$ -	$ 383.64
100%	0%	16	$ 243.14	$ 46.27	$ 228.94	$ -	$ (52.56)	$ (69.58)	$ -	$ 396.20
100%	0%	17	$ 248.90	$ 46.31	$ 236.68	$ -	$ (52.83)	$ (69.93)	$ -	$ 409.13
100%	0%	18	$ 254.80	$ 46.36	$ 244.68	$ -	$ (53.09)	$ (70.28)	$ -	$ 422.47
100%	0%	19	$ 260.84	$ 46.40	$ 252.95	$ -	$ (53.36)	$ (70.63)	$ -	$ 436.21
100%	0%	20	$ 267.03	$ 46.45	$ 261.51	$ -	$ (53.62)	$ (70.98)	$ -	$ 450.38
100%	0%	21	$ 273.36	$ 46.49	$ 270.35	$ -	$ (53.89)	$ (71.34)	$ -	$ 464.97
100%	0%	22	$ 279.84	$ 46.54	$ 279.49	$ -	$ (54.16)	$ (71.70)	$ -	$ 480.01
100%	0%	23	$ 286.47	$ 46.59	$ 288.94	$ -	$ (54.43)	$ (72.05)	$ -	$ 495.51
100%	0%	24	$ 293.26	$ 46.63	$ 298.71	$ -	$ (54.70)	$ (72.41)	$ -	$ 511.49
100%	0%	25	$ 300.21	$ 46.68	$ 308.82	$ -	$ (54.98)	$ (72.78)	$ -	$ 527.95

10.4 Appendix 4.

Sensitivity Analysis (Small Deviation)

Sammanfattningsrapport Jatropha

	Aktuella värden:	*Nominal Rate = 22%*	*Nominal Rate = 18%*	*Inflation = 9.6%*	*Inflation = 5.6%*	*Diesel Price + 2%*	*Diesel Price -2%*	*Cash Crop Prices + 2%*	*Cash Crop Prices -2%*	*Input Factors Prices + 2%*	*Input Factor Prices -2%*
Justerbara celler:											
NR	20%	22%	18%	20%	20%	20%	20%	20%	20%	20%	20%
INFL.	8%	8%	8%	10%	6%	8%	8%	8%	8%	8%	8%
DP	$ (1.53)	$ (1.53)	$ (1.53)	$ (1.53)	$ (1.53)	$ (1.56)	$ (1.50)	$ (1.53)	$ (1.53)	$ (1.53)	$ (1.53)
CCP Soy	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.57	$ 0.55	$ 0.56	$ 0.56
CCP Sun	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.26	$ 0.25	$ 0.25	$ 0.25
CCP Ground	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.67	$ 0.64	$ 0.65	$ 0.65
IF Me	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.42)	$ (0.43)	$ (0.41)
IF PH	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.09)	$ (22.53)	$ (21.64)
Resultatceller:											
NPVj	$ 18.69	$ (280.61)	$ 410.17	$ 453.25	$ (315.71)	$ (43.07)	$ 80.45	$ 96.14	$ (58.76)	$ 5.95	$ 31.43

Sammanfattningsrapport Diesel

	Aktuella värden:	*Nominal Rate = 22%*	*Nominal Rate = 18%*	*Inflation = 9.6%*	*Inflation = 5.6%*	*Diesel price + 2%*	*Diesel price -2%*	*Crop prices + 2%*	*Crop prices -2%*	*Aktuella värden:*	*Aktuella värden:*
Justerbara celler:											
NR	20%	22%	18%	20%	20%	20%	20%	20%	20%	20%	20%
INFL.	8%	8%	8%	10%	6%	8%	8%	8%	8%	8%	8%
DP	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.56	-$ 1.50	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53
CCP Soy	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.57	$ 0.55	$ 0.56	$ 0.56
CCP Sun	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.26	$ 0.25	$ 0.25	$ 0.25
CCP Ground	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.67	$ 0.64	$ 0.65	$ 0.65
Resultatceller:											
NPVd	$(2,698.44)	$(2,465.62)	$(2,980.27)	$(3,010.05)	$(2,437.04)	$(2,931.07)	$(2,465.80)	$(2,519.77)	$(2,877.11)	$(2,698.44)	$(2,698.44)
NPVj-NPVd	$2,717.13	$2,185.01	$3,390.44	**$3,463.30**	**$2,121.33**	$2,888.01	$2,546.24	$2,615.91	$2,818.34	$2,704.38	$2,729.87

Sensitivity Analysis (Large Deviation)

Sammanfattningsrapport Jatropha

	Aktuella värden:	Nominal Rate 30%	Nominal Rate 10%	Inflation 15%	Inflation 2%	Diesel Price +10%	Diesel Price -10%	Crop Price +10%	Crop Price -10%	Input Factors +10%	Input Factors -10%
Justerbara celler:											
NR	20%	30%	10%	20%	20%	20%	20%	20%	20%	20%	20%
INFL.	8%	8%	8%	15%	2%	8%	8%	8%	8%	8%	8%
DP	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.68	-$ 1.37	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53
CCP Soy	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.62	$ 0.51	$ 0.56	$ 0.56
CCP Sun	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.28	$ 0.23	$ 0.25	$ 0.25
CCP Ground	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.72	$ 0.59	$ 0.65	$ 0.65
IF Me	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.42	-$ 0.46	-$ 0.38
IF PH	-$ 22.09	-$ 22.09	-$ 22.09	-$ 22.09	-$ 22.09	-$ 22.09	-$ 22.09	-$ 22.09	-$ 22.09	-$ 24.29	-$ 19.88
Resultatceller:											
NPVj	$ 18.69	$ (946.54)	$ 3,854.31	$ 2,412.74	$ (737.45)	$ (290.10)	$ 327.48	$ 405.95	$ (368.57)	$ (45.03)	$ 82.41

Sammanfattningsrapport Diesel

	Aktuella värden:	Nominal Rate = 30%	Nominal Rate = 10%	Inflation = 15%	Inflation = 2%	Diesel Price +10%	Diesel Price -10%	Crop Price +10%	Crop Price -10%	Aktuella värden:	Aktuella värden:
Justerbara celler:											
NR	20%	30%	10%	20%	20%	20%	20%	20%	20%	20%	20%
INFL.	8%	8%	8%	15%	2%	8%	8%	8%	8%	8%	8%
DP	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.68	-$ 1.37	-$ 1.53	-$ 1.53	-$ 1.53	-$ 1.53
CCP Soy	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.56	$ 0.62	$ 0.51	$ 0.56	$ 0.56
CCP Sun	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.25	$ 0.28	$ 0.23	$ 0.25	$ 0.25
CCP Ground	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.65	$ 0.72	$ 0.59	$ 0.65	$ 0.65
Resultatceller:											
NPVd	$(2,698.44)	$(1,845.88)	$(4,985.95)	$(4,211.90)	$(2,063.22)	$(3,861.63)	$(1,535.24)	$(1,804.75)	$(3,591.83)	$(2,698.44)	$(2,698.44)
NPVj-NPVd	$ 2,717.13	**$ 899.34**	**$ 8,840.26**	$ 6,624.64	$ 1,325.77	$ 3,571.53	$ 1,862.72	$ 2,210.70	$ 3,223.26	$2,653.40	$2,780.85

10.4 Appendix 4.

Per hectar over a 25-year period

NPV = B - FC - AVC - Input Factors - Diesel Cost = $ (4,743.97) — **Discount Rate** 12%

			FC		*AVC*					*Input factors*		*Diesel*	
%Biodiesel	**%Diesel**	**Year**	Digging holes	Planting seeds	Pestcontrol	Pesticides	Weeding	Clearing bushes	Harvesting	Methanol	PH	Cd	**SUM**
0%	100%	1	$ (47.99)	$ (11.09)	$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ -	$ -	$ (894.82)	$ (1,147.48)
0%	100%	2			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ -	$ -	$ (906.14)	$ (1,099.71)
40%	60%	3			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (15.00)	$ (19.86)	$ (550.56)	$ (779.00)
70%	30%	4			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (26.39)	$ (34.93)	$ (278.76)	$ (533.65)
100%	0%	5			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (37.88)	$ (50.15)	$ -	$ (281.61)
100%	0%	6			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (38.07)	$ (50.40)	$ -	$ (282.05)
100%	0%	7			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (38.26)	$ (50.65)	$ -	$ (282.49)
100%	0%	8			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (38.45)	$ (50.90)	$ -	$ (282.93)
100%	0%	9			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (38.65)	$ (51.16)	$ -	$ (283.38)
100%	0%	10			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (38.84)	$ (51.41)	$ -	$ (283.83)
100%	0%	11			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (39.03)	$ (51.67)	$ -	$ (284.28)
100%	0%	12			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (39.23)	$ (51.93)	$ -	$ (284.73)
100%	0%	13			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (39.43)	$ (52.19)	$ -	$ (285.19)
100%	0%	14			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (39.62)	$ (52.45)	$ -	$ (285.65)
100%	0%	15			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (39.82)	$ (52.71)	$ -	$ (286.11)
100%	0%	16			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (40.02)	$ (52.98)	$ -	$ (286.57)
100%	0%	17			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (40.22)	$ (53.24)	$ -	$ (287.03)
100%	0%	18			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (40.42)	$ (53.51)	$ -	$ (287.50)
100%	0%	19			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (40.62)	$ (53.77)	$ -	$ (287.97)
100%	0%	20			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (40.83)	$ (54.04)	$ -	$ (288.44)
100%	0%	21			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (41.03)	$ (54.31)	$ -	$ (288.92)
100%	0%	22			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (41.24)	$ (54.58)	$ -	$ (289.39)
100%	0%	23			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (41.44)	$ (54.86)	$ -	$ (289.87)
100%	0%	24			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (41.65)	$ (55.13)	$ -	$ (290.36)
100%	0%	25			$ (26.66)	$ (14.93)	$ (133.32)	$ (8.00)	$ (10.67)	$ (41.86)	$ (55.41)	$ -	$ (290.84)

10.5 Appendix 5.

	Per hectar over a 25-year period					
	NPV = -Cost of Diesel import =		**$ (8,855.91)**		Discount Rate	12%
Year	Cost of Diesel		SUM			
1	$ (894.82)		$ (894.82)			
2	$ (906.14)		$ (906.14)			
3	$ (917.60)		$ (917.60)			
4	$ (929.21)		$ (929.21)			
5	$ (940.97)		$ (940.97)			
6	$ (952.87)		$ (952.87)			
7	$ (964.93)		$ (964.93)			
8	$ (977.13)		$ (977.13)			
9	$ (989.50)		$ (989.50)			
10	$ (1,002.02)		$ (1,002.02)			
11	$ (1,014.69)		$ (1,014.69)			
12	$ (1,027.53)		$ (1,027.53)			
13	$ (1,040.53)		$ (1,040.53)			
14	$ (1,053.70)		$ (1,053.70)			
15	$ (1,067.03)		$ (1,067.03)			
16	$ (1,080.53)		$ (1,080.53)			
17	$ (1,094.20)		$ (1,094.20)			
18	$ (1,108.04)		$ (1,108.04)			
19	$ (1,122.06)		$ (1,122.06)			
20	$ (1,136.26)		$ (1,136.26)			
21	$ (1,150.63)		$ (1,150.63)			
22	$ (1,165.19)		$ (1,165.19)			
23	$ (1,179.93)		$ (1,179.93)			
24	$ (1,194.86)		$ (1,194.86)			
25	$ (1,209.98)		$ (1,209.98)			

10.6 Appendix 6.

Sensitivity Analysis (Small Deviation)

Sammanfattningsrapport Jatropha

	Aktuella värden:	*Nominal Rate 22%*	*Nominal Rate 18%*	*Inflation 9.6%*	*Inflation 5.6%*
Justerbara celler:					
NR	20%	22%	18%	20%	20%
Infl	8%	8%	8%	10%	6%
Resultatceller:					
NPVj	$ (4,743.97)	$ (4,442.35)	$ (5,114.12)	$ (5,153.57)	$ (4,405.56)

Sammanfattningsrapport Diesel

	Aktuella värden:	*Nominal Rate 22%*	*Nominal Rate 18%*	*Inflation 9.6%*	*Inflation 5.6%*
Justerbara celler:					
NR	20%	22%	18%	20%	20%
Infl	8%	8%	8%	10%	6%
Resultatceller:					
NPVd	$ (8,855.91)	$ (7,876.38)	$ (10,088.64)	$ (10,221.72)	$ (7,758.70)
NPVj-NPVd	$ 4,111.94	$ 3,434.03	$ 4,974.52	**$ 5,068.15**	**$ 3,353.14**

Sensitivity Analysis (Large Deviation)

Sammanfattningsrapport Jatropha

	Aktuella värden:	*Nominal Rate 30%*	*Nominal Rate 10%*	*Inflation 15%*	*Inflation 2%*
Justerbara celler:					
NR	20%	30%	10%	20%	20%
Infl	8%	8%	8%	15%	2%
Resultatceller:					
NPVj	$ (4,743.97)	$ (3,651.82)	$ (7,914.25)	$ (6,800.71)	$(3,927.99)

Sammanfattningsrapport Diesel

	Aktuella värden:	*Nominal Rate 30%*	*Nominal Rate 10%*	*Inflation 15%*	*Inflation 2%*
Justerbara celler:					
NR	20%	30%	10%	20%	20%
Infl	8%	8%	8%	15%	2%
Resultatceller:					
NPVd	$ (8,855.91)	$ (5,462.18)	$ (20,009.96)	$(15,977.21)	$(6,274.82)
NPVj-NPVd	$ 4,111.94	**$ 1,810.37**	**$ 12,095.71**	$ 9,176.50	$ 2,346.83