Annex 5: Economic feasibility of Jatropha production and processing

A calculation model for business case development by small producer organizations (SPO)

2013
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Supported by the Global Sustainable Biomass Fund of NL Agency
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Acknowledgements

This report has benefited from the inputs and comments from the following people, for which the author is extremely grateful:

- Current and former members of the project team for the Feasibility Study Fairtrade Certification Jatropha: Fenny Eshuis (Max Havelaar Netherlands), Silvan de Boer (Eneco), Suzanne Kagchelland (formerly Eneco), Gert de Gans (ICCO), Anne Marieke Schwencke (formerly ICCO) and Ab van Peer (independent consultant).
- Martha Djourdjin (Bridge Builders, Germany) for providing valuable input to the calculation model.
- Marg Leijdens for the literature review of socio-economic studies on Jatropha.
- Gerald Msilanga of KNCU in Moshi, Dunstan Ndamugoba of KCU in Bukoba, Philip Mwakipesile of Kilicafé in Mbinga, as well as Christopher Ndangala, independent consultant from Dar es Salaam, for their support in the economic data collection in Tanzania.
- Janske van Eijck (Copernicus Institute, University of Utrecht) for providing comments on earlier versions of this report.
1. Introduction

This report is part of the feasibility study on Fairtrade certification of Jatropha, carried out by Max Havelaar Netherlands, ICCO and Eneco. The objective of this report is to analyse the value chain of Jatropha seeds and oil, and to provide a calculation model to assess the economic feasibility of Jatropha oil production and processing by Small Producer Organisations (SPOs).

In this report, a number of key premises have been used that should be kept in mind when reading:

- The business model for Jatropha is set up around Fairtrade certified Small Producer Organisations (SPOs), as the assumed initiators and owners of Jatropha related business activities along the supply chain, in function of benefit maximisation for their members.
- In this model, organized smallholder farmers that are planting Jatropha have a unique trade relationship with these SPOs and do not sell through other market channels.
- In this model, it is assumed that there will be an integration of Jatropha production, transport and processing in existing logistical and export chains for other Fairtrade certified products. For this feasibility study, we have used the coffee chain as an example, but one could also think of cotton, bananas, tea etc.

The report covers the following topics:

- Analysis of the different steps of the value chain for the different products derived from Jatropha (Pure Plant Oil, biodiesel, seedcake, shells/husks) (Ch.2)
- Literature review of economic assessment studies of the costs and benefits of Jatropha production for small producer organisations (Ch.3)
- Description of a calculation model to assess the economic feasibility of Jatropha oil production and processing, based on four different business cases of the use of Jatropha oil (Ch.4)
- In the last chapter, a number of final remarks and recommendations are made (Ch.5).

The calculation model will support SPOs in their decision making process before getting involved in Jatropha production and processing, by making a rough estimate of the financial costs and benefits of various business cases for smallholders. In this report, the case of organized smallholder farmers in Tanzania is used to illustrate the cost-benefit model, but the calculation model is applicable worldwide if appropriate context-specific data are used to feed the model. The data used have been obtained through extensive literature review as well as field data collected in Tanzania.

For technical details on the various energy applications of Jatropha, please refer to another report produced for this project, entitled Local energy utilization from Jatropha curcas: state of the art and practical applications (November 2013).
2. Value chain of Jatropha products

In this chapter, the value chain of Jatropha products is described. The major products of the Jatropha value chain that we will focus on in this study are oil (also referred to as Pure Plant Oil), biodiesel and seedcake.

2.1 Value chain of Jatropha oil

In the model as proposed in this feasibility study, Jatropha fruits are produced at smallholder farmer level by means of intercropping and as hedges. After the fruits are harvested, collected and dehulled on the farm, the seeds are transported to the Primary Cooperative Society (PCS). Next, the seeds are pressed into Pure Plant Oil (PPO).

In the value chain charts below, the different steps are given for both local oil pressing (figure 1a) and for central oil pressing (figure 1b). While the steps in the value chain are similar in both cases, the processing takes place at different locations. There are basically two options for the pressing of Jatropha seeds into oil:
1) Pressing at local level (Primary Cooperative Society level) or
2) Pressing at central level (Small Producer Organisation level).

The choice between local and central pressing will to a large extent be determined by the geographical distance to the final destination at which the oil and seedcake will be used or sold.

Another important choice is whether or not to process the Pure Plant Oil into biodiesel by a process called transesterification. Biodiesel production requires more advanced technical skills and higher capital investments, leading to a different cost benefit analysis compared to the sales of Pure Plant Oil. In our calculation model, biodiesel production is included as well to be able to compare the economic perspectives. However, it is recommended to SPOs to start with pure plant oil production, as biodiesel demands more specialization and higher investments, which may make it less suitable for small producer organisations.

Jatropha oil can be used directly, sold on local markets, or exported. Currently, local demand for Jatropha oil is still limited, but it is expected that demand will increase when it becomes more competitive compared to fossil fuels such as diesel or kerosene. This includes Jatropha oil as fuel for transport, energy generation, cooking or lighting, or as an ingredient for soap making. For Jatropha biodiesel, local demand potentially exists as fuel for transport or energy generation. Regarding exports, there has been increasing demand for Jatropha oil from the transport sector (especially aviation), although this is still a volatile and uncertain market. Demand for other purposes, e.g. large-scale electricity

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1 The details of the planting model can be found in the Jatropha Growing Manual by Ab van Peer.
2 The Primary Cooperative Society is the smallest cooperative structure unit in Tanzania, often at the village level.
3 Demand for aviation fuel is expected to increase by approximately 1.5 to 3% per year. Most non-food promising feedstocks to be considered are short rotation coppice, woody residues,
generation, has not taken off as expected earlier on. This is mainly caused by uncertain supply levels combined with high feedstock cost.

![Value Chain of Jatropha oil: local oil pressing](image)

**Figure 1a: Value chain of Jatropha oil: local oil pressing**

In the case of local processing, the biodiesel option is not a very logical choice. It has only been included to show the full range of options in theory.

jatropha, camelina; for the longer term biojetfuels could include algae, and halophytes; IEA Bioenergy, 2012.

* In the case of local processing, the biodiesel option is not a very logical choice. It has only been included to show the full range of options in theory.
Looking at the value chain from a user’s perspective, the most important types of local use of Jatropha oil are given in the figure below. It should be noted that in our calculation model, we have only incorporated those options that are based on the use of Jatropha oil for energy purposes. This means that soap production is not dealt with in the economic feasibility study. Nevertheless, given the fact that many groups are working on Jatropha soap production, it has been included in these figures.

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5 For a more detailed description, see the report Local energy utilization from Jatropha curcas: state of the art and practical applications (November 2013)
Figure 2: Local use applications of Jatropha oil

**Local use of Jatropha oil**

- **Use by SPO**
  - Oil as fuel for transport of coffee and other cash crops
  - Biodiesel as fuel for transport of coffee and other crops
  - Oil or biodiesel to power engine (e.g. for coffee processing or jatropha seed pressing)

- **Use by Farmers/Households**
  - Oil as fuel for cooking (improved stove) or lighting
  - Oil or biodiesel for power generation at village level (e.g. MFP/generator)

- **Sales at Local markets**
  - Oil or biodiesel (e.g. as fuel for transport of safari companies or others)
  - Power generation to supply national grid
2.2 Value chain of Jatropha seedcake

Jatropha seedcake provides a valuable by-product from the production of Jatropha oil. It consists of the remaining biomass after pressing the oil from the Jatropha seeds, and represents 65-75% of the total weight of the seed. The value chain of Jatropha seedcake is given in the figure below, both in the case of local (figure 3a) and central oil pressing (figure 3b).

An important consideration is how to use the seedcake. Either the seedcake can be returned to the farm as an organic fertilizer, or it can be used as a fuel feedstock, e.g. for briquette making or production of biogas. In the frame of this feasibility study, it is assumed that seedcake will be used as fertilizer to increase food crop productivity. In the context of Tanzania (and large parts of rural Africa), most smallholder farmers do not use agro-chemicals while at the same time they are facing depleted soils. When an intercrop model is used for Jatropha, it is recommended to use Jatropha seedcake as a fertilizer on food crops to ensure that the productivity of food crops is not threatened, while at the same time improving soil conditions with limited use of agro-chemicals.

Another option is to use the seedcake for the production of biogas, after which the remaining slurry can be used as fertilizer. The slurry is a good fertilizer, especially if combined with cow dung. However, as the press cake is usually centrally available at the press and the cow dung is usually distributed at people’s homes, it may be difficult to bring the two substrates together. In our calculation model, we have not included the biogas option because of the following reasons:

- It is the preferred option to use the seedcake as fertilizer directly on-farm, so it is normally not available for biogas.
- The other residual parts of the Jatropha fruit, the fruit shells and seed husks, could theoretically be used for biogas production. However, in practice, this is not very realistic, as the shells and husks cannot be used for biogas as they are too dry and woody. They do not decompose, not sufficiently fast anyway.
  - Fruit shells: The jatropha fruits are shelled on the farm, which makes it logistically complex to collect and transport to a central location.
  - Seed husks: Usually, farmers do not de-husk the seeds before pressing them, which means that the husks remain part of the seedcake after processing the Jatropha seeds into oil.
- Therefore, in our model it is assumed that the shells and husks do not have any economic value to the farmers or to the SPOs.

An important factor that determines whether it is economically feasible to return the seedcake to the farm is the distance between the processing facility and the smallholder farm. It is expected that Jatropha produced by organised

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6 Diligent Tanzania is producing biogas from Jatropha seedcake, among others. This biogas is used in kitchens as a fuel and the remaining slurry is used as fertilizer (Farioli & Portale 2009).
smallholders that are already involved in another value chain like coffee, would be able to reduce transport costs significantly by integrating the transport of seedcake to farmers in their logistical coffee chain. This basically means that they could use their transport fleet to transport coffee cherries and Jatropha seeds from the farm to the central processing level. During the same visit, the seedcake that was pressed earlier on in the process - as a byproduct during the oil pressing of the Jatropha seeds - could be transported to the farmers.\(^7\).

\(^7\) For more information on the different studies on the use of seedcake as fertilizer, see the report *Local energy utilization from Jatropha curcas: state of the art and practical applications* (November 2013).
Figure 3a: Value chain of Jatropha seedcake: local oil pressing

Value Chain of Jatropha seedcake: local oil pressing

Smallholder farmer → Jatropha production → Collecting and Transporting seeds → Oil extraction with local press → Seedcake → Seedcake as fertilizer → PPO

Primary Cooperative Society

Producing & Consuming country

SPO (Smallholder Producer Organisation)

Eco-Briquette production → Slurry as fertilizer

Biogas production

Eco-Charcoal → Fuel for cooking/heating
Figure 3b: Value chain of Jatropha seedcake: central oil pressing

Value Chain of Jatropha seedcake: central oil pressing

Smallholder farmer

Primary Cooperative Society

SPO (Smallholder Producer Organisation)

Producing & Consuming country

Jatropha production

Collecting and Transporting seeds

Oil extraction with central press

Seedcake as fertilizer

Seedcake

Eco-Briquette production

Biogas production

Eco-Charcoal

Fuel for cooking/heating

Long distance from factory to farm -> use coffee transport chain
The different local use options of Jatropha seedcake are given below.

**Figure 4: Local use options of Jatropha seedcake**

- **Jatropha seedcake**
  - Use by SPO
    - Biogas for heat and/or power generation
  - Use by SPO members
    - Fertilizer to be used on farm
  - Sales at Local markets
    - Selling fertilizer to other farmers/agri-businesses
  - Use of seedcake briquettes or charcoal for cooking
  - Sales of seedcake briquettes or charcoal to consumers for cooking
  - Biogas for heat and/or power generation
  - Slurry to be used as fertilizer on farm
3. Literature review of economic feasibility studies on Jatropha production and processing

This chapter provides a review of the literature on the economic feasibility of Jatropha production (3.1) and processing (3.2). The focus will be on studies related to smallholders. The chapter ends with a number of conclusions (3.3).

3.1 Review of economic feasibility studies on Jatropha production

*Jatropha Assessment, Van Eijck et al. (2010)*

A comprehensive assessment of economic feasibility studies for Jatropha, carried out by Van Eijck et al. (2010), reports that most studies focus on East and Southern Africa as well as India. CBAs (Cost-Benefit Analyses) have been undertaken for smallholders, mostly for small-scale Jatropha plantations, while some studies were done on intercropping and hedges. However, these studies have no specific reference to business organisation and sizes of production. Van Eick et al. found that there are still many gaps in the economic data. The reliability of the CBA technique highly depends on accurate estimations of the expected cash flows.

In the assessment, two types of problems appeared to be prevalent that were found to have major effects on the results of the CBA. First, seed yield estimates were either too low or too high, leading to overly optimistic or overly pessimistic CBA outcomes. Secondly, often there was no valuation of resources, especially land and labour, according to their opportunity costs, i.e. their productive value in case the project would not take place. CBAs often take a limited time horizon (10 years or less). Also, economic data about the cost of Pure Plant Oil and biodiesel production in facilities of different scales are scarce, especially in Africa where commercial oil production is only just beginning.

Some of the main conclusions of the assessment by Van Eijck et al. are:

- The Jatropha value chain as a whole needs to become more profitable, especially through finding higher-value uses for by-products, further increasing oil processing efficiency, developing seed varieties with higher and more reliable seed yields under semi-arid conditions, and optimizing cultivation practices. These challenges are, however, unlikely to be resolved within a few years.

- Currently, the only possibly feasible scenario for Jatropha cultivation that emerges from the studies is resource-extensive Jatropha hedge cultivation. This is so because it has very low opportunity costs and can yet be undertaken on fertile lands with good water access. The studies seem to agree that Jatropha cultivation in any scenario other than hedge plantings should not be recommended for the time being.

- Local projects that link seed production closely to local processing and oil use – like the FACT project in Mozambique – appear to have better
potential for achieving financial viability than larger, non-local ones. The reasons are: the ability to return the seedcake to farmers, thereby aiding higher long term yields; low transport costs; and the use of Pure Plant Oil rather than more expensive biodiesel produced through transesterification.

- Seed or oil production for export to the EU is unlikely to be profitable due to stiff competition from highly subsidized US bio-oils, except in some niche markets.

In the table below, an overview of Jatropha prices worldwide is given, as reported by Van Eijck et al (2010). It can be seen that prices range from USD 0.07 to 0.20 per kilogram of seed.

Table 1: Prices of Jatropha seed worldwide (Source: Van Eijck et al. 2010, p.46)

<table>
<thead>
<tr>
<th>Country</th>
<th>Type of project</th>
<th>Price per kg ($)</th>
<th>Transaction details</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Small scale</td>
<td>0.20 (and 0.01 hulls or leaves)</td>
<td>Guaranteed fixed price to farmer</td>
<td>(Practical Action Consulting 2009)</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Outgrowers, Diligent in May 2008</td>
<td>0.07 (80 Tzs)</td>
<td>Guaranteed price to farmer</td>
<td>(Struijs 2008)</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Outgrowers, Diligent in 2009</td>
<td>0.08-0.17 (100-200 Tzs)</td>
<td>0.08 $ is guaranteed</td>
<td>(Van Eijck 2009)</td>
</tr>
<tr>
<td>India</td>
<td>Government centered</td>
<td>0.06 and 0.14 (6.5 or 3 Rs)</td>
<td>Guaranteed minimum support price</td>
<td>(Altenburg et al. 2009)</td>
</tr>
<tr>
<td>Mozambique</td>
<td>FACT-ADPP</td>
<td>0.08-0.18 (2.5-5 MZN)</td>
<td>5 MZN is paid to participating farmers, 2.5 MZN to other farmers</td>
<td>(Nielsen and de Jongh 2009)</td>
</tr>
</tbody>
</table>

Jatropha, retrospective and future development, FACT Foundation (2010)

In this report, a number of economic studies on Jatropha are analysed and compared. Based on the outcomes of studies in Mali, Mozambique, Honduras, India and Kenya, it is concluded that Jatropha cultivation is not profitable in a low-input scenario, basically because yields are too low because very small quantities of fertilizer are applied. In a high-input scenario, the revenues are not high enough to cover the costs, and losses occur especially in the first years. On the basis of a 10-year investment, no or very low earnings can be obtained. The main problem observed by FACT Foundation in these studies is that most projections were based on a combination of assumptions (including yields, growth on marginal soils, low inputs), some of which were individually right, but they were wrongfully assumed to be true in combination. Estimated average Jatropha yields from monoculture plantations in the FACT studies ranged from 400 kg to 1.4 ton/ha/year, which is significantly lower than earlier estimates by others. This has led some farmers to convert their fields back from Jatropha to food crops, as they are more profitable. Many initiatives have failed and stopped, and existing Jatropha business is still highly dependent on subsidies. The only profitable business case is where farmers are planting Jatropha as hedges (which is in line with the conclusion by Van Eijck et al. 2010, see above). Requirements
that could make Jatropha feasible include low wages, a lack of profitable alternative crops, relatively fertile land and high market prices for seeds or oil.

**Meta-evaluation of 6 Hivos Biofuel projects, Prakash (undated)**

In an evaluation of six biofuel projects funded by Dutch NGO Hivos, there are some interesting conclusions on the feasibility of Jatropha for smallholders. Some of the most relevant outcomes for our study are as follows:

- The labour requirements for Jatropha production are substantial, and lead to competition for labour with other crops. At least in the initial years Jatropha seems to need more investment in terms of labour to income ratio than other crops.
- Jatropha also has a long gestation period of up to seven or eight years after planting before it reaches optimal yields.
- The yields attainable, even under favourable conditions have been lower than the estimates made at the height of the Jatropha hype when most of these projects were initiated.
- Finally, Jatropha production for oilseed was a completely new venture in most places, and involved many uncertainties relating to crop production and processing.

**Jatropha sustainability assessment, data from Tanzania, Mali & Mozambique, Van Eijck et al. (2013)**

In a recently published Jatropha sustainability study, commissioned by NL Agency, it is concluded that the prospects for smallholders are not very bright. Until better plant varieties will become available, the value of Jatropha for smallholders is limited to its use in environmentally and economically disadvantaged areas, where people do not have alternative income earning opportunities that are more attractive than Jatropha. Even in those circumstances smallholders only value the crop in a hedge set up, because yields are currently too low and unreliable for it to be a viable field crop. The average income received from seed sales by Jatropha hedge growers in the survey ranged between US$ 23.00 and US$ 0.48 per 100 metres of hedge.

### 3.2 Review of economic feasibility studies on Jatropha processing

In this section a review is presented of earlier studies on the costs and benefits of processing of Jatropha seeds into Pure Plant Oil or biodiesel.

**Jatropha Assessment, Van Eijck et al. (2010)**

The authors conclude that data about the cost of Jatropha oil and biodiesel production are scarce, especially in Africa where commercial oil production is only just beginning.

Modelled on inside information about the business plans and practices of two Jatropha investors in Tanzania, Van Eijck et al. presented some best estimates for the expected financial profitability of a large centralized plantation setup and a decentralized outgrower model with one (or a few) central oil processor(s). For the outgrower model, two different input scenarios were estimated: “low input”,...
meaning no fertilizers and no irrigation, and “intermediate input”, which assumes some weeding, fertilizer and pesticide application and pruning. The assumed yields between the two scenarios differ by about one tonne dry seeds per ha per year. The assumed yields of respectively 1002 and 1981 kg/ha/y are compatible with the realistic yield range reported by other studies.

For the outgrower scenarios, the main observation is that the estimated profitability of the activities is bad, especially for the seed growers. For these smallholder farmers (who receive a relatively ‘good’ market price of US$ 0.14/kg seed), pay back periods of 16 to over 20 years, and real IRRs of 5.3% to 8.9% (compared with a real discount rate of 6.5%) essentially imply zero profitability over a 20 year period. The intermediate input scenario performs even worse than the low input scenario because the extra costs of fertilizers are not made good by sufficient extra revenues from higher yields.

The results for the processing company (in this case producing and selling SVO rather than biodiesel, in view of the latter’s lower profitability) are only marginally better than for the smallholders. Payback periods of 12-13 years are long. The best IRR for the processor is 17.2% obtained in the intermediate scenario, but in that scenario the supplier farmers are expected to make a loss, so this scenario is infeasible. In the low input system, expected returns for the smallholders are marginal, and with an IRR of 13.4% they are also very modest for the processing company. The NPV for the processor looks high in absolute terms, but is poor when seen in relation to the amount of required investment.

**Cost/benefit analysis of biomass energy supply options for rural smallholders in the semi-arid eastern part of Shinyanga Region in Tanzania, Wiskerke et al. (2010)**

This study consists of a cost-benefit analysis in Tanzania of biomass energy supply options, including Jatropha. It was concluded that Jatropha oil can be utilized economically as a diesel substitute at observed diesel cost of USD 1.49 per litre, which is higher than the cost price estimated by Van Eijck et al (2012) (see below). Based on a cost price of mechanical expellers of USD 2,000 (excluding fuel and maintenance costs), it is concluded that this is unlikely to be affordable for smallholders, but that it would be possible under a cooperative structure.

**Jatropha, retrospective and future development, FACT Foundation (2010)**

In this paper, data are presented on the production costs of Jatropha oil (see Table 2 below). A reference fossil fuel diesel price is used of USD 1.17/litre (excluding taxes). Based on this price, it is concluded that Jatropha oil production would be competitive with fossil fuel. An interesting observation is that a carbon credit project would give additional benefits of USD 0.02 per kg. of seeds, based on the use of the seedcake for biogas production under a CDM scheme. Biogas production itself would give additional benefits of USD 0.04 per kg of seeds.
Table 2: Production cost of Jatropha oil Mozambique
Source: FACT Foundation (2010)

<table>
<thead>
<tr>
<th>Cost item</th>
<th>USD/lt</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressing</td>
<td>0.36</td>
<td>31</td>
</tr>
<tr>
<td>Transport</td>
<td>0.22</td>
<td>19</td>
</tr>
<tr>
<td>Seeds (at seed price of USD 0.09/kg)</td>
<td>0.38</td>
<td>32</td>
</tr>
<tr>
<td>Profits</td>
<td>0.21</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.17</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The economic performance of jatropha, cassava and Eucalyptus production systems for energy in an East African smallholder setting, Van Eijck et al. (2012). A more recent study by Van Eijck et al. (2012) looks at the economic viability of the use of Jatropha for the production of liquid biofuels, in comparison to conventional diesel, for the case of Tanzania. It is concluded that Jatropha biodiesel has higher costs than conventional diesel, while Jatropha PPO (Pure Plant Oil) is competitive with conventional diesel, but only in a family labour system (i.e. in case no hired labour is needed\footnote{This implies that the opportunity costs for labour are not taken into account in Van Eijck’s study. In our calculation model, these opportunity costs are priced at the value of the daily labour rate under the assumption that paid work could have been found elsewhere.}). Van Eijck et al. found that the feedstock cost of Jatropha seeds varies between USD 0.15 and 0.58 per litre, the total costs for Pure plant Oil (or Straight Vegetable Oil) vary from USD 0.61-1.04 per litre, and for biodiesel varies from USD 0.88-1.32 per litre.

Government taxes are not taken into account, since there is no biofuel policy in place in Tanzania (as in most parts of Sub-Saharan Africa). As taxes add up to 35% to the fossil fuel price at gas stations, this could lead to a substantial price increase for biofuels as well. When biofuels have to be competitive with fossil energy, this could lead to a downward pressure on the price farmers receive for Jatropha seeds. In Table 3 below, a cost breakdown is given for the conversion of Jatropha seeds into PPO and into biodiesel in case of a cost price of USD 0.88 (Van Eijck et al. 2012).

At the moment of Van Eijck’s study, conventional diesel had a CIF price (price at point of import to Tanzania) of 0.80 USD. This means that Jatropha PPO was competitive with conventional diesel, while Jatropha biodiesel was not. The diesel consumption in Tanzania was almost 1 M ton in 2010, which means that the local market for Jatropha oil or biodiesel is potentially substantial.

It is noted by Van Eijck et al. (2012) that the cost of transport could be reduced when more efficient transport systems are in place; similarly, the cost of transesterification could reduce when economies of scale are applied.

\[^{8}\text{This implies that the opportunity costs for labour are not taken into account in Van Eijck's study. In our calculation model, these opportunity costs are priced at the value of the daily labour rate under the assumption that paid work could have been found elsewhere.}\]
Table 3: Feedstock cost of Jatropha SVO (Straight Vegetable Oil) production and transesterification

Source: Adapted from Van Eijck et al. (2012)
Based on prices in Tanzania in 2008

<table>
<thead>
<tr>
<th>Cost item</th>
<th>TZS/Lt</th>
<th>US$/lt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm gate price Jatropha seeds</td>
<td>144</td>
<td>0.13</td>
</tr>
<tr>
<td>Transport seeds to refinery</td>
<td>278</td>
<td>0.25</td>
</tr>
<tr>
<td>Seedpress conversion to SVO (Straight Vegetable Oil)</td>
<td>222</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Subtotal conversion of Jatropha seeds into oil</strong></td>
<td>644</td>
<td>0.58</td>
</tr>
<tr>
<td>Depreciation equipment per liter SVO</td>
<td>33</td>
<td>0.03</td>
</tr>
<tr>
<td>Cost of electricity consumption</td>
<td>0</td>
<td>0.0001</td>
</tr>
<tr>
<td>Cost of methanol for biodiesel production (20 ml added/Lt)</td>
<td>211</td>
<td>0.19</td>
</tr>
<tr>
<td>Water needed for production</td>
<td>11</td>
<td>0.01</td>
</tr>
<tr>
<td>Cost of caustic soda for production (4 gr per L)</td>
<td>11</td>
<td>0.01</td>
</tr>
<tr>
<td>Labour</td>
<td>56</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Subtotal conversion into biodiesel (transesterification)</strong></td>
<td>322</td>
<td>0.29</td>
</tr>
<tr>
<td>Distribution of SVO or biodiesel</td>
<td>11</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Total feedstock cost of Jatropha biodiesel - off factory</strong></td>
<td>978</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Exchange rate Tanzania Shilling to 1 USD 1111

_Jatropha sustainability assessment, data from Tanzania, Mali & Mozambique, Van Eijck et al. (2013)_

In this study, it is concluded that the “business case” for processors who source from outgrowers also remains largely unproven, as most projects are still in an early stage of establishment and some distance removed from sufficient scale in their operations. At a cost of roughly US$ 1.20 per litre, Jatropha oil is still expensive. The authors also conclude that efforts and ambitions to export to western markets have been abandoned. After 2008, these markets shrank as buyers scaled down their ambitions to source sustainably produced bioenergy. Companies now concentrate on local market development.

3.3 Conclusions

Based on a limited number of studies on the economic feasibility of Jatropha production for smallholders (mainly focusing on East Africa), it is clear that Jatropha production is not a very profitable business case. The only business case that has clear economic potential is the planting of Jatropha as hedges. However, as concluded in a literature review by Van Eijck et al. (2010), some of these studies have serious shortcomings and the conclusions on economic feasibility are very much dependent on local circumstances, including the level of wages, availability of profitable alternative crops, land fertility and market prices for seeds or oil. Also, the conclusions of studies that are very context-specific cannot be extrapolated to other situations, and a more tailor made calculation model is needed.

As for Jatropha processing, it can be concluded that the economic feasibility of Jatropha oil or biodiesel is directly related to the price of conventional diesel. Jatropha oil production becomes feasible under the condition that its production
cost is lower than the diesel price. If the price of Jatropha oil or biodiesel is higher than the price of diesel, there will be no market for Jatropha because it cannot compete with diesel. Overall, the studies provide a not too rosy picture: in one case, it was found that Jatropha oil is not competitive unless labour is provided at no cost (i.e. as family labour). The question is whether this is a realistic assumption. Family labour has an opportunity cost that should be taken into account, as is done in most economic studies on farming systems,
4. Economic calculation model for different business cases of Jatropha production and processing

This chapter starts with the objective of the calculation model developed for a number of business cases of Jatropha production and processing, to be applicable worldwide (4.1), then briefly describes the concept of cost-benefit analysis of jatropha production and processing (4.2). This is followed by an explanation of the calculation model (4.3). The chapter ends with the case of a fictitious SPO in Tanzania as an example to demonstrate the calculation model (4.4).

4.1 Objective

The objective of the economic calculation model is to assess the profitability of Jatropha curcas for Small Producer Organisations (SPOs) by evaluating the economic value of Jatropha trees planted by means of intercropping with food crops and as fences, as explained in the agronomic part of the feasibility study. The model is built around the SPO-business cases for 4 different use options of Jatropha oil: 1) use of oil for transport, 2) use of oil to run a generator, 3) use of oil for lighting purposes, and 4) export of oil. The purpose is to provide an interactive tool for SPOs that allows them to:

- input up-to-date data from their own context
- update the data whenever new information is available
- model different project sizes, based on the number of participating farmers, or hectares of land included in the project over the years
- vary a range of relevant variables simultaneously to model different project scenarios

In this way, SPOs can compare a much wider range of scenarios, based on more relevant data, than are available in any of the existing literature. This is especially relevant for the evaluation of the potential impact of significant developments in key variables, such as new seed varieties, developments in the price of diesel, or increasing demand for exports, as suggested in the literature.

Nevertheless, the model allows only an initial, rough cost-benefit analysis. For a more concrete and reliable model, the assumed values and dynamics need to be refined further according the local context and expectations for the future market developments, with the help of a business development expert.

4.2. The concept of cost-benefit analysis

In this section, the basic features of cost-benefit analysis are explained in relation to our calculation model for Jatropha production.

Economic feasibility is determined by evaluating the financial net benefits of the production of a certain agricultural crop. A financial analysis or cost-benefit analysis is used to look at the costs and returns from the perspective of individual farmers or the small producer organisation as a whole. As indicated
before, for this study we have taken the perspective of the small producer organisation.

Below are the key tools used in our cost-benefit analysis:

- **Net present value (NPV):** The difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment or project. NPV compares the value of a dollar today to the value of that same dollar in the future, taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected because cash flows will also be negative.

- **Free cash flow (FCF):** A measure of financial performance calculated as operating cash flow minus capital expenditures. Free cash flow (FCF) represents the cash that a company is able to generate after laying out the money required to maintain or expand its asset base. Free cash flow is important because it allows a company to pursue opportunities that enhance shareholder value. Without cash, it's tough to develop new products, make acquisitions, pay dividends and reduce debt.

- **Internal rate of return (IRR):** The discount rate often used in capital budgeting that makes the net present value of all cash flows from a particular project equal to zero. Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project. As such, IRR can be used to rank several prospective projects a firm is considering. Assuming all other factors are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first.

With the help of cost-benefit analysis, it is possible to calculate the break-even price of producing Jatropha seeds, which is a key input in the calculation model. The **break-even price** is the cost price at which expenses and revenues are equal: there is no net loss or gain, and one has "broken even".

In our model, costs and benefits of Jatropha production and processing are assessed over a 15-year period. It is assumed that Jatropha starts to produce substantial amounts of fruits around the third year, with maximum yields after 9 years. Even though Jatropha trees continue producing seeds for a period of 30 to 50 years, an economic lifetime of 15 years is considered realistic, because benefits made in the far-away future will only make a small difference in the net present value. The discount rate is an important variable in cost-benefit analysis, as it adjusts financial values over time. The discount rate is effectively a desired return, or the return that an investor would expect to receive on some other comparable proposal of equal risk. The discount rate reflects two issues: 1) the fact that a dollar available now is more highly valued than one received later, and 2) the degree of uncertainty as to whether a future dollar will actually be received.

---


10 The discount rate is effectively a desired return, or the return that an investor would expect to receive on some other comparable proposal of equal risk. The discount rate reflects two issues: 1) the fact that a dollar available now is more highly valued than one received later, and 2) the degree of uncertainty as to whether a future dollar will actually be received (source: [http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/primer/15.htm](http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/primer/15.htm)).
projects vary between 5-15%. In our calculation model, the discount rate can be adjusted to see the different outcomes.

In economic analysis, it is common practice to carry out a sensitivity analysis. Such an analysis shows how the results respond to parameter changes, for instance seedling cost, labour price, labour time, and discount rate. Our calculation model is set up in such a way that anyone using the model can calculate the profitability for different parameters by entering different values to test for sensitivity to changes in these parameters, e.g. the price of diesel, the cost of labour, the value of carbon credits etc.

### 4.3 Economic calculation model for Jatropha production and processing by small producer organisations

In this section, a calculation model is presented for a number of business cases that could be developed by small producer organisations. The business cases are focused on the following use options of Jatropha oil:

1. **The use of oil or biodiesel for transport:**
   In this case, the main assumption is that the diesel that is currently used by the SPO for transport (in trucks or other vehicles), will be replaced by Jatropha oil or biodiesel.

2. **The use of Jatropha oil or biodiesel to power generators:**
   In this case, the main assumption is that the diesel that is currently used by the SPO for electric power generation will be replaced by Jatropha oil or biodiesel.

3. **The use of oil for lighting purposes:**
   In this case, the main assumption is that the kerosene that is currently used by households for lighting purposes will be replaced by Jatropha oil.

4. **The export of oil:**
   The main assumption is that the majority of the Jatropha oil produced will be exported and traded in the international market, for instance for use by the aviation industry.

A key feature of the calculation model is the way in which the potential income for farmers and SPOs of Jatropha production and processing is calculated. The following assumptions have been made:

- We have assumed that the [economic value of Jatropha oil or biodiesel](#) can be measured by taking the price of conventional fuel (diesel, kerosene, jet fuel) as a proxy for the value of Jatropha oil or biodiesel.
- For the first two business cases (Transport and Power generation), the Jatropha oil is actually replacing diesel that would otherwise have to be bought by the SPO or the farmer, for instance by using Jatropha biodiesel to fuel a truck for coffee transport, or to power a stationary engine in a coffee curing factory. In these cases, we have used the [price of diesel as a proxy](#) for the value of Jatropha oil or biodiesel.

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11 These options have been chosen based on an assessment of local energy utilizations from Jatropha. See the report *Local energy utilization from Jatropha curcas* (November 2013).
proxy for the value of Jatropha oil. The savings on fuel expenses are then considered as income from Jatropha production, as the SPO can use the money for other purposes instead of buying diesel.

- For the business case of lighting, we have used the price of kerosene as a proxy for the value of Jatropha oil, as most people in rural areas in developing countries use kerosene to light lanterns. The use of Jatropha oil by farmers for lighting leads to savings on kerosene expenses as they can now use Jatropha oil to fuel their lamps. These savings are considered as income from Jatropha production.

- The remaining oil that is not used by the SPO is assumed to be sold on the local market at the market price of Jatropha oil or biodiesel (where the price of biodiesel is assumed to be equal to the price of conventional diesel).

- For the case of export, we have assumed that the Jatropha oil can be sold at the market price of jet fuel, given the high demand for biofuels in the aviation industry.

In addition, we have taken into account the economic value generated by channelling back the Jatropha seedcake to farmers for use as fertilizer. Even though we assume that the farmers will receive the seedcake at zero cost, the replacement value of organic fertilizer can be monetized, as in our business case farmers can use the organic fertilizer (e.g. cow manure) for other purposes. The value attached to the seedcake is currently put at 50% of the market price of Jatropha seedcake. This lower value is justified by the fact that the value of the seedcake as fertilizer is necessarily less than what Jatropha takes out of the ground, as some of the nutrients become part of the tree and some of them are left with the oil.

Finally, we calculated the income flows from carbon credit generation, based on the calculation model developed by Bridge Builders.12

Summarizing, for each business case, the following assumptions have been made with regards to the cost savings and income flows made as a result of the use of Jatropha (see Table 4).

Table 4: Overview of income flows from Jatropha for 4 business cases

<table>
<thead>
<tr>
<th>Business case:</th>
<th>1: Use of oil or biodiesel for transport</th>
<th>2: Use of oil or biodiesel to power stationary engines</th>
<th>3: Use of oil for lighting</th>
<th>4: Export of oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proxy used for the value of Jatropha oil:</td>
<td>Market price of conventional diesel as a proxy for the value of Jatropha oil or biodiesel</td>
<td>Market price of conventional diesel as a proxy for the value of Jatropha oil or biodiesel</td>
<td>Market price of kerosene as a proxy for the value of Jatropha oil</td>
<td>Income from sales of Jatropha oil on export market (e.g. aviation industry)</td>
</tr>
<tr>
<td>Estimated monetary value of seedcake to farmers:</td>
<td>50% of market price of Jatropha seedcake</td>
<td>50% of market price of Jatropha seedcake</td>
<td>50% of market price of Jatropha seedcake</td>
<td>50% of market price of Jatropha seedcake</td>
</tr>
</tbody>
</table>

12 Please refer to the report *Carbon Credits from Planting and Utilizing Jatropha Curcas, Introduction for Small Producer Organizations* (Bridge Builders, 2013).
Potential income from carbon credits | Sequestration and emission reductions from plant oil use for transport | Sequestration and emission reductions from plant oil in stationary engines | Sequestration | Sequestration
---|---|---|---|---

The presented calculation model enables SPOs to make a first assessment of the feasibility of Jatropha production and processing.

The model is built up in such a way that the financial consequences of these different options can be easily assessed, to facilitate the decision making process.

In our model, the different project designs envisaged by the SPO can be represented through the following variables that need to be filled in by the user:

- The number of farmers participating in the Jatropha intercropping scheme within the organizational setting of an SPO. For this variable, it needs to be determined how many farmers will be involved in each year. It is recommended to start with a limited number of farmers participating in the beginning, with increasing numbers in consecutive years. This will allow the SPO to train the farmers at a realistic pace and create a revolving seed distribution system, in which farmers that have planted in the beginning will deliver seeds to farmers that are adopting later in the process. For inspiration purposes, three examples are given in the table below, which includes scenarios for 3,000, 10,000 and 30,000 farmers.

- The total land area used for Jatropha intercropping. SPOs need to fill in the area planted in each year of the project. This can also be used to calculate the average plot size and length of the Jatropha hedges. For example, if 10,000 farmers plant on average 0.5 ha. of Jatropha intercropping, with 300 m. of Jatropha fences around their plots (assuming an average plot size of 50x100 m.), this means that they have planted approximately 1.500 km. of Jatropha fences.\(^{13}\)

- The expected yield per hectare for Jatropha, which depends on the climatic conditions (rainfall and temperature), ecological zone, and altitude of the area. In our model, for Jatropha intercropping, a choice can be made from 1 to 4 tonne of Jatropha seeds per hectare. For Jatropha hedges, a choice can be made ranging from 0.10 to 1.00 kg of Jatropha seeds per tree.

- Is the SPO planning to use pure plant oil or process it into biodiesel (only for the 1st and 2nd business case)?

- Is the SPO planning to incorporate a carbon credit component as an additional income generating activity?

\(^{13}\) 5,000 ha times 300 metres of fence
Table 5: Examples of farmer participation scenarios of Jatropha production

<table>
<thead>
<tr>
<th>Year</th>
<th>Low scenario</th>
<th>Middle scenario</th>
<th>High scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of new farmers</td>
<td>No. of ha planted</td>
<td>No. of new farmers</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>62.5</td>
<td>250</td>
</tr>
<tr>
<td>1</td>
<td>250</td>
<td>125</td>
<td>500</td>
</tr>
<tr>
<td>2</td>
<td>500</td>
<td>125</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>1000</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>3000</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3000</td>
<td>1500</td>
<td>10000</td>
</tr>
</tbody>
</table>

Furthermore, the SPO is encouraged to fill context-specific variables relevant to the cost-benefit analysis, such as:

- the expected development of the diesel, kerosene or jet fuel price throughout the timeframe of the project
- the local opportunity cost of labour
- the exchange rate between local currency and the USD and EUR
- the local inflation rate
- the local applicable tax rate
- the relevant discount rate

The calculation model is based on a number of assumptions around the economic value of Jatropha production. These values are based upon data that were collected in two ways:

1. Literature review of economic studies on Jatropha (see Chapter 3)
2. Field data collected during the pilot carried out with three SPOs in Tanzania between 2010 and 2012.

Assumptions for the costs and benefit analysis of Jatropha production

- The introduction of Jatropha as an intercropping system does not lead to decreased food crop production, based on a planting ratio of 40% Jatropha and 60% food crops. This assumption is based on higher agricultural yields due to the introduction of best agricultural practices and the use of Jatropha seedcake as fertilizer for the food crops. For this assumption to hold true it is assumed that before introducing Jatropha, no or very little amounts of fertilizer are used.
- The Jatropha yield figures are expected to increase over the years at the following rate:

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14 For a full explanation of the Jatropha planting model, please refer to the Jatropha growing manual by Ab van Peer.
Table 6: Estimated growth rate of Jatropha seeds in the first 9 years of production
Source: based on various studies and estimates by Ab van Peer

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield in year X in % of maximum yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>4</td>
<td>40%</td>
</tr>
<tr>
<td>5</td>
<td>50%</td>
</tr>
<tr>
<td>6</td>
<td>65%</td>
</tr>
<tr>
<td>7</td>
<td>80%</td>
</tr>
<tr>
<td>8</td>
<td>90%</td>
</tr>
<tr>
<td>9</td>
<td>100%</td>
</tr>
</tbody>
</table>

- Labour requirements for Jatropha production are estimated by combining the average labour input from three cases, see table below.

Table 7: Labour requirements for Jatropha production
Sources: Van Eijck et al. 2012, Wiggins 2008 and GTZ 2009 (adapted where appropriate):

<table>
<thead>
<tr>
<th>Activity</th>
<th>year 0</th>
<th>year 1</th>
<th>year 2</th>
<th>year 3</th>
<th>year 4</th>
<th>year 5 onwards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land preparation</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuring/Fertilization</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Pest and disease control</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Planting</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-planting</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weeding/pruning</td>
<td>12</td>
<td>16</td>
<td>16</td>
<td>10</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total labour days</td>
<td>43</td>
<td>25</td>
<td>23</td>
<td>17</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

- Labour requirements for harvesting are based on the assumption that 40 kg seeds can be harvested per person per day, 25 man days are needed to harvest 1 ton of Jatropha seeds. Post-harvest activities (dehulling) are assumed to require 10% of the labour demand for harvesting.

Assumptions for the costs and benefit analysis of Jatropha processing

- It is assumed that 1.05 litre of Jatropha oil is needed to replace 1 litre of diesel for power generation or transport purposes, because of the lower energy content. The same goes for biodiesel.
- It is assumed that the Jatropha seeds are dehusked on the farm, and that the volumes produced are net volumes after dehusking.
- Conversion rates for oil and seedcake content and shells/husks volumes for local mechanical expelling are assumed as follows:
  - Oil content of 25% (4 kg of seeds needed to produce 1 lt oil)

---

15 The sources of the data mentioned can be found in the calculation model in Excel (provided as an annex to this report).
Seedcake content of 75% (1 kg of seeds gives 0.75 kg of seedcake). This includes the shells, which are assumed to be pressed as well during the processing into oil.

- Farmer extension services are estimated at US$ 70 per farmer for 3 training cycles. This is based on the average costs of 4 Farmer Field School programs in West-Africa.
- The SPO buys the seeds from the farmer at cost price, which may differ per location and which is calculated in the model. Worldwide, the prices vary between USD 0.07 to 0.20 per kilogram of seed.
- For the transport cost of seeds to the oil extraction unit, we have used an average cost price of US$ 0.04 per kg. of Jatropha seeds (based on data provided in Van Eijck et al. 2012).
- For the oil extraction cost, we have used an average cost price of US$ 0.14 per liter, including labour, fuel cost and material cost (also based on Van Eijck et al. 2012)
- Management cost of oil extraction unit is estimated at 7% of oil extraction cost
- Taxes: no taxes are applicable when the oil is used directly by the SPO or by farmers; in case the oil is sold on the local market or exported, the local income tax rate is applicable.

4.4 The case of Tanzania: application of the calculation model for a fictitious SPO

To illustrate the use of the calculation model, the model has been filled out for the fictitious case of an SPO in Tanzania. While reading this chapter, it is recommended to open the calculation model Excel sheet (provided as an annex to this report). A user’s guide to the calculation model is provided in the Annex to this report. All important inputs and outputs are found in the Cockpit of the Excel sheet, and this is where the values below should be entered. The other tabs are only for reference purpose, for instance if a user would like to know in detail which costs and benefits are involved in the production or processing of Jatropha, or in the generation of carbon credits.

For this case, the following project design inputs have been entered in the model (same values for all 4 business cases):

- A total of 1,000 jatropha plants per hectare of field is planted
- The fraction of the field covered with jatropha plants is 40%
- There are 3 trees per meter of hedge/fence planted around each plot
- A total of 10,000 farmers is participating in the project, who are increasingly participating during the first 8 years of the project
- The average planting area covered with Jatropha intercropping is 0.5 ha, amounting to a total area of 5,000 ha. for the SPO as a whole
- An average of 5 kg of Nitrogen is applied per hectare as fertilizer for the Jatropha trees
- Daily labour wage = 3500 TZS (Tanzania shilling)
- Local price of diesel (per lt) = 2000 TZS
- Local jatropha oil price (per lt) = 1500 TZS
- Local jatropha seedcake price (per kg) = 100 TZS
- Discount rate = 15%
- Inflation rate = 3%
- Applicable tax rate = 30%

In addition, the following project design inputs have been entered specifically (same values for all business case):

**Business case 1: Transport**

<table>
<thead>
<tr>
<th>Truck conversion cost for plant oil</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment cost for modifying engine of 1 truck for using Jatropha plant oil (in local currency)</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Additional maintenance cost for 1 truck per year (in local currency)</td>
<td>500,000</td>
</tr>
<tr>
<td>Number of trucks modified</td>
<td>10</td>
</tr>
<tr>
<td>Amount of diesel use expected without the project (in tons)</td>
<td>5,000</td>
</tr>
<tr>
<td>Local price of Diesel (local currency per liter)</td>
<td>2,000</td>
</tr>
</tbody>
</table>

**Business case 2: Generator**

<table>
<thead>
<tr>
<th>Generator conversion cost for plant oil</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment cost for modifying 1 generator for using Jatropha plant oil (in local currency)</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Additional maintenance cost per year for 1 generator (in local currency)</td>
<td>500,000</td>
</tr>
<tr>
<td>Number of generators modified</td>
<td>25</td>
</tr>
<tr>
<td>Maximum capacity per generator (kW)</td>
<td>100</td>
</tr>
<tr>
<td>Amount of diesel use expected without the project (in tons)</td>
<td>5,000</td>
</tr>
<tr>
<td>Local price of Diesel (local currency per liter)</td>
<td>2,000</td>
</tr>
</tbody>
</table>

**Business case 3: Lighting**

<table>
<thead>
<tr>
<th>Oil use planning</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Local price of kerosene (local currency per lt)</td>
<td>2000,00</td>
</tr>
</tbody>
</table>
Total number of households using jatropha oil for lighting: 15,000

**Business case 4: Export**

<table>
<thead>
<tr>
<th>Export costs - Jatropha (in US$/ tonne)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage cost (SPO level)</td>
<td>25,00</td>
</tr>
<tr>
<td>Transport cost (from SPO to port)</td>
<td>60,00</td>
</tr>
<tr>
<td>Insurance cost</td>
<td>300,00</td>
</tr>
<tr>
<td>Storage cost (before exporting from port)</td>
<td>50,00</td>
</tr>
<tr>
<td>Shipping cost (to country of destination)</td>
<td>500,00</td>
</tr>
<tr>
<td>Freight charges</td>
<td>50,00</td>
</tr>
</tbody>
</table>

**International market price - Jatropha**

<table>
<thead>
<tr>
<th>International market price for jet fuel (US$ per gallon)</th>
<th>2,78</th>
</tr>
</thead>
<tbody>
<tr>
<td>International market price for jet fuel (US$ per liter)</td>
<td>0,73</td>
</tr>
</tbody>
</table>

Finally, for all four business cases we have selected the same scenarios to make the outcomes comparable:

<table>
<thead>
<tr>
<th>Key project design elements scenario selection</th>
<th>Seed yield scenarios</th>
<th>Intercropping - yield in tonne/hectare</th>
<th>Hedge/Fence - yield in kg/metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of plant oil or biodiesel</td>
<td>Plant Oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of diesel substituted</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon credits for biofuel use</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon credits for jatropha planting</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diesel price scenario (how the price of diesel changes over the years, ranging from -5% to +10%)</th>
<th>Carbon credit price scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Price Scenario 1%</td>
<td>Conservative $ 5,00</td>
</tr>
<tr>
<td></td>
<td>Average $ 7,00</td>
</tr>
<tr>
<td></td>
<td>Optimistic $ 9,00</td>
</tr>
<tr>
<td></td>
<td>Maximum $ 15,00</td>
</tr>
<tr>
<td></td>
<td>Select Price Scenario 7,00</td>
</tr>
</tbody>
</table>
After filling in the above values, the results are summarized in a number of tables and graphs in the Cockpit of the excel sheet (illustrated below for business case 1: Oil for Transport):

<table>
<thead>
<tr>
<th></th>
<th>Total 15 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total project seed production (tons)</td>
<td>98.952</td>
</tr>
<tr>
<td>Total project seedcake production (tons)</td>
<td>74.214</td>
</tr>
<tr>
<td>Total biofuel production (plant oil or biodiesel, in tons)</td>
<td>24.738</td>
</tr>
<tr>
<td>% of targeted diesel use replaced by jatropha biofuel</td>
<td>94%</td>
</tr>
<tr>
<td>Biofuel remaining for sale (plant oil or biodiesel, in tons)</td>
<td>19.810</td>
</tr>
</tbody>
</table>

**Figure 3.1.1: Plant oil and seedcake production (in tons)**

**Figure 3.1.2: Biofuel or biodiesel production for own use and for sale (in tons)**
Figure 3.2.1: Annual cost of seed production divided in labor and cash costs

Figure 3.3.1: Breakdown of revenues

Figure 3.3.2: Breakdown of costs
Figure 3.3.3: Net profit before tax

Figure 3.5.1: Total volume of carbon credits generated
As a final output to the model, the internal rate of return and net present value of the different business cases are calculated. For our fictitious case, this leads to the following results:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IRR 5 years</td>
<td>-46% negative value*</td>
<td>5% negative value*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR 10 years</td>
<td>18%</td>
<td>17%</td>
<td>48%</td>
<td>negative value*</td>
</tr>
<tr>
<td>IRR 15 years</td>
<td>26%</td>
<td>25%</td>
<td>50%</td>
<td>negative value*</td>
</tr>
<tr>
<td>Total Net Present Value (over 15 years)</td>
<td>$ 505.841</td>
<td>$ 466.355</td>
<td>$ 766.008</td>
<td>$ -4.739.895</td>
</tr>
<tr>
<td>Total cashflow for business case (not discounted)</td>
<td>$ 3.756.675</td>
<td>$ 3.657.014</td>
<td>$ 3.274.373</td>
<td>$ -22.894.519</td>
</tr>
<tr>
<td>NPV per hectare (over 15 years)</td>
<td>$ 101</td>
<td>$ 93</td>
<td>$ 153</td>
<td>$ -948</td>
</tr>
<tr>
<td>NPV per hectare (per year)</td>
<td>$ 7</td>
<td>$ 6</td>
<td>$ 10</td>
<td>$ -63</td>
</tr>
</tbody>
</table>

*: No result given in Excel model because values are too extreme.

For this fictitious case, the following preliminary conclusions can be drawn16:

- The Internal Rate of Return is highest for the case of Lighting (50% after 15 years), compared to 26% for Transport and 25% for Power generation.
- The net present value over 15 years is also highest for the case of Lighting, amounting to a total of around US$ 766,000, followed by Transport and Power generation.
- Interestingly, the total cash flow (not discounted) is highest in the case of Transport, which is caused by the fact that towards the end of the project,

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16 N.B. these results should not be interpreted as general conclusions about Jatropha production but serve as an example only.
revenues are much higher than in the case of Lighting. Due to the discounting method used for cost-benefit analysis, these revenues are worth less than revenues earned earlier in the lifetime of a project.

- The case of Export yields a negative IRR and NPV so should be disregarded in terms of economic feasibility. The main reason for this negative outcome is the low market price for jet fuel compared to diesel, as well as the high transport cost for shipping Jatropha oil to export markets.

The model allows users to compare investment levels of the different business cases, for instance how much upfront capital is needed for setting up a Jatropha processing capacity or for adaptation of engines.

When looking specifically at the potential revenues from carbon credit projects, the following can be concluded:

- The IRR from carbon sequestration is positive in all four business cases. IRR amounts to 42% after 15 years, while NPV is around US$ 300,000.
- For carbon credits from emission reductions, the IRR is negative (-6%)\textsuperscript{17}. This is caused by the fact that emission reductions only start to generate revenues very late in the project cycle, while the expenses made earlier on for registration are significant.

The results presented above offer only a first glimpse of the full range of possibilities of the model. By changing the switches that determine a number of key variables, specifically the use of plant oil or biodiesel, the % of diesel substituted and the inclusion of a carbon credit generation project, users can see which case provides the best economic perspective. The same goes for the following variables that can be adapted: expected change in diesel price, expected Jatropha seed yield and expected carbon credit price. This is best demonstrated by using the model and “playing around” with it by changing the key variables.

\textsuperscript{17} Only applicable in the cases of Transport and Power generation.
5. Final remarks and recommendations

On the basis of a number of earlier economic studies and own field data collection, an economic calculation model was designed for Small Producer Organisations (SPOs) that are considering Jatropha production and processing. The model can be used to assess the feasibility of Jatropha production and processing based on specific inputs provided by SPOs that are considering to start Jatropha farming. The added value of this model lies in the fact that it can be used in the early stages of deciding on whether or not the use of Jatropha in an intercropping model would make an interesting business case. This should always be followed by a more rigorous exercise with the help of a business development consultant, providing a more tailor made business plan.

The calculation model is based on the most recent academic insights as well as the results of the Jatropha planting pilot in Tanzania. However, it is important to realize that the model has not yet been field tested. After sharing the calculation model for use by small producer organizations, it would be useful to incorporate the feedback from the first generation of users, not only to improve the model but also to find out whether the model is actually responding to the needs of SPOs.
List of Literature

- Beerens, P. (2007). Screw-pressing of Jatropha seeds for fuelling purposes in less developed countries. Eindhoven University of Technology
- Bridge Builders (2013) Carbon Credits from Planting and Utilizing Jatropha Curcas, Introduction for Small Producer Organizations
- Dorp, M. van (2011). Local energy utilization from Jatropha curcas: state of the art and practical applications. Interim report for the Jatropha Fairtrade Feasibility study
- Eijck, J. van et al. (2013). Jatropha sustainability assessment, data from Tanzania, Mali & Mozambique. Commissioned by NL Agency
- GTZ (2009). Jatropha Reality Check – A field assessment of the agronomic and economic viability of Jatropha and other oilseed crops
- Vyahumu Trust (undated). Production of the Sayari oil expeller. www.jatropha.de (accessed on 03/10/2011)

In this annex, a short guide to the use of the calculation model is provided\textsuperscript{18}.

Introduction to the calculation model
This calculation model is specifically designed for Small Producer Organisations to enable them to assess the feasibility of Jatropha production and processing, including the use of carbon credits. There are 4 different business cases under this calculation model:

1) **The use of oil or biodiesel for transport:**
   In this case, the main assumption is that the diesel that is currently used by the SPO for transport (in trucks or other vehicles), will be replaced by Jatropha oil or biodiesel.

2) **The use of Jatropha oil or biodiesel to power generators:**
   In this case, the main assumption is that the diesel that is currently used by the SPO for electric power generation, will be replaced by Jatropha oil or biodiesel.

3) **The use of oil for lighting purposes:**
   In this case, the main assumption is that the kerosene that is currently used by households for lighting purposes will be replaced by Jatropha oil.

4) **The export of oil:**
   The main assumption is that the majority of the Jatropha oil produced will be exported and traded in the international market, for instance for use by the aviation industry.

Choices to be made before using the model
In the calculation model, two important choices should be made:

1. Is the SPO planning to use Jatropha for the production of pure plant oil (PPO) or will it be processed into biodiesel?
2. Is the SPO planning to incorporate a carbon credit component as an additional income generating activity?

The model is built up in such a way that the financial consequences of these different options can be easily assessed, to facilitate the decision making process. The calculation model is meant to fit all circumstances and is therefore very general. Hence, it helps with an initial cost-benefit analysis of a project. A more customized model, developed with a business development expert, will be needed for a more precise financial model of your particular project.

Using different scenarios
It is important to try out different scenarios, in order to understand how each of the factors in your project affects the final result. For example, an increase in the diesel price of 5% per year could have an enormous positive effect, but the same decrease may make the project completely unviable. This type of projects involve large fixed costs, and increasing the scale of the project (number of hectares planted) may sometimes increase the profitability of the project.

\textsuperscript{18} The calculation model is provided as an Excel sheet, which should be opened when reading these instructions.
**Key assumptions**
The project also assumes that you are able to replace your own diesel consumption with Jatropha oil or biodiesel, and sell the remaining Jatropha oil or biodiesel at the price of conventional diesel. This may not be possible in all circumstances. It is very important to assess the market for plant oil and biodiesel and ensure you can sell these products before you undertake a project of this type.

**How is the model built up?**
The calculation model consists of two parts, one part that allows users to enter the key information about the project, and the remaining tabs allowing users to get more detailed insight in the calculations. The different tabs are explained here:

<table>
<thead>
<tr>
<th>Tab</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockpit</td>
<td>This tab allows you to enter key information about your project and summarizes the main outcomes. In this tab, you can do three things: 1. You can enter the main project design inputs, 2. You can indicate which scenario you want to calculate and 3. You can find the results of the calculation model. The financial outcomes will change automatically if you change the input variables and scenarios, allowing you to play with the model.</td>
</tr>
<tr>
<td>Cashflow</td>
<td>In this tab, you can see the cashflow that the business case generates under the inputs and scenarios that you selected.</td>
</tr>
<tr>
<td>Values</td>
<td>This tab includes the fixed values used for financial projections of Jatropha production and processing</td>
</tr>
<tr>
<td>Oil</td>
<td>Here you will find the volumes of Jatropha seeds and oil produced and the volumes of diesel that will be replaced</td>
</tr>
<tr>
<td>Seed cost price</td>
<td>In this tab, you will see the break-even price of Jatropha seeds that will be used in the calculation model</td>
</tr>
<tr>
<td>Plant oil</td>
<td>This tab provides a breakdown of the revenues, expenses and financial results in case of plant oil production</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>This tab is similar to the &quot;Plant oil&quot; tab, but then in the case of further processing into biodiesel</td>
</tr>
<tr>
<td>Carbon Credits intro</td>
<td>Here you will find the basic assumptions and conditions that you need to fulfill to become eligible for a carbon credit project</td>
</tr>
<tr>
<td>Carbon credits ER</td>
<td>Here you will see a breakdown of the revenues, expenses and financial results in case of carbon credits generation through emissions reduction (reduced carbon emissions by replacing fossil fuels by Jatropha oil or biodiesel)</td>
</tr>
<tr>
<td>Carbon credits SEQ</td>
<td>This tab is similar to the &quot;Carbon credits ER&quot; tab, but then in the case of sequestration (storing carbon through the planting of Jatropha trees)</td>
</tr>
<tr>
<td>References</td>
<td>This tab includes a list of references that are used in the calculation model</td>
</tr>
</tbody>
</table>