End report FACT pilot project "Jatropha oil for local development in Mozambique" 2007-2010

Prepared for FACT Foundation

BBC workshop with generator house(left)

FACT Project no:

Authors: Flemming Nielsen, Bananahil & Jan de Jongh, FACT-Arrakis,

With contributions from Henderson Maposa ADPP, Jacob Zulu ADPP, Erik Schurmann ADPP, Niels Ansø Dajolka, Christian Fenger GAIA Movement, Krishna Raghavan-Arrakis

Date: 20 February -2011

TABLE OF CONTENTS

1 PREFACE

1.1 Foreword

This report is the End-report of the project Jatropha oil for local development in Mozambique, which was executed from January 2007 until December 2010. It was written by Flemming Nielsen, Bananahil & Jan de Jongh, FACT-Arrakis, with contributions from Henderson Maposa ADPP, Jacob Zulu ADPP, Erik Schurmann ADPP, Niels Ansø Dajolka, Christian Fenger GAIA-Movement, Krishna Raghavan Arrakis. It narrates the results achieved compared to the activities planned, the lessons learned from it and recommendations for future activities after the project end. It is the own internal view of the executors of the project, while an external view of the project is given in the Evaluation report of Annie Sugrue.

All relevant reports made in the course of the project have been placed on a special project website: https://sites.google.com/site/mozambiquejatropha/

For more information or comments please contact us at FACT via our website or send an e-mail:

internet: www.fact-foundation.com

email: info@fact-foundation.com

1.2 Acknowledgements

We would like to thank our donors which have provided the funds to make this project possible, namely: Stichting Doen, Hivos Foundation, Solidaridad and Stichting Het Groene Woudt.

We would like to thank all people involved in the execution of the project; The project leaders directly involved: Felicity Dennis, Ernesto, Henderson Maposa, Bachir Afonso, Itai Chikanya, The extension workers, The ADPP staff at Headquarters, Birgit Holm, Erik Schurmann, Jacob M. Zulu, Anne Fisker; The volunteers: Guiseppe Berlingeri, Janio J. Flechas. The subcontracted parties providing Technical Assistance: Niels Ansø, Ger Groeneveld, Krishna Raghavan, Brendon Evans, Janske van Eijck, Hayo de Feiter, Peter Beerens and those providing business and administrative support: Remi Rijs, Peter Moers, Mathilda. The partners in the project, Christian Fenger (GAIA-Movement), Flemming Nielsen (IIAM, presently Bananahil). External supporters; Anna Lerner GTZ-ProBEC, the local government authorities of Cabo Delgado. Danida and Wageningen University provided logistic support for the research program. Thank you to all the researchers and students from institutions in Mozambique, the Netherlands and Mozambique that spent countless hours and resources on the research program. The project evaluators, Ruaraidh Petre & Annie Sugrue provided constructive and refreshing views on the project. And thank you to all those people at ADPP in Bilibiza and Chimoio that provided basic services in providing accommodation and transport.

For FACT Foundation,

Jan de Jongh

2 BACKGROUND

2.1 History

Introduction

Mozambique's climate and soils are very suitable for Jatropha production. The plant originates from Central America but was introduced to Africa centuries ago by the Portuguese. In Mozambique it is known as a medicinal plant but since mid-2005 it has been planted with the goal of producing oil from its seeds.

The project reported here was implemented in Mozambique from 2007 till 2010 by FACT and the local organisation *Ajuda de Desenvolvimento de Povo para Povo (ADPP*).

The goal was to explore the suitability of using Jatropha for local development. Small farmers integrate Jatropha in their farming systems and the oil is extracted locally for local use.

Apart from good agro-climatic conditions Mozambique also has enough land to avoid conflict over land use and the political system was fully behind the Jatropha production effort with president Guebusa promoting it strongly.

Before the start of this project there had been limited experience with Jatropha cultivation in Mozambique: The international non-governmental organisation *Caritas* had started Jatropha nurseries and small estates, in co-operation with ADPP's programme for teacher-training colleges (EPF) and with small farmers. All these activities took place in Manica Province. The estimated area planted with Jatropha during 2006 was approx. 150 hectares. Due to the presidential push for planting Jatropha the government extension workers also distributed seeds to many farmers throughout the country. Unfortunately no information about Jatropha production was provided through the government system. The initial activities with Jatropha cultivation by small farmers have come to a standstill through a combination of poor selection of planting sites, lack of knowledge and lack of markets. The FACT/ADPP project remains the only significant Jatropha project in Mozambique focused on small farmers that has managed to sustain momentum. One reason is that the project has focused on developing the complete value chain from nurseries to processing and consumption in converted diesel engines.

The limited experience with Jatropha cultivation was assessed before the start of the FACT/ADPP project and it was found that Manica Province did not appear suitable for Jatropha production due to high pest pressure and problems with water logging. Eventually the project focused all activities in Cabo Delgado. Research carried out later has shown that this was a wise choice.

After the FACT/ADPP project started several commercial Jatropha plantations have been established throughout Mozambique. They focus on export of Jatropha oil or seeds.

The government has over the last years developed a much more comprehensive approach to Jatropha and other bio-fuels. Rules have been established for where biofuels can be produced and under what conditions. When this project started no legislative framework was in place.

There is presently no formal or in-formal market for biodiesel, but one should mention an initiative by the local farmer Brendon Evans (originally from Zimbabwe), who has produced biodiesel from cotton seed for propelling his own tractor. This project has worked with Brendon on testing of converted diesel engines running on plant oil.

2.2 The Project Area: Quirimbas National Park

The project area is within the Quirimbas National Park (QNP) that was established Norh-West of Pemba in 2002.

QNP is located in Cabo Delgado between 12°00'00" and 12°55'04" S and 39°10'00" E and 40°39'44" E. and has an area of 7500 square kilometer. It has a coastline between the cities Pemba and Palma in the North. Although it has been designated as a National park, it is populated with some 300.000 people in small villages. These people from mainly Makua, and Makonde tribes, have a harsh existence, living from crops such as maize, sorghum and cassava grown in shifting cultivation systems that requires new land to opened up every three to four years.

Farmers have to constant scare and fight elephants, wild pigs, monkeys and other animals which still manage to steal about 50% of their harvest even though everybody is living in the fields day and night throughout the rainy season. Starvation occurs regularly during the dry season. The infrastructure is poor, poverty high, literacy level low, and there are few opportunities to improve their lives.

	
Deforestation caused by slash and burn practice in the QNP.	*People collecting water form an open well at the end of dry period.*

Due to shifting cultivation deforestation is going on at a very high rate. This fact, combined with lack of measures in water conservation, like dams in rivers, etc, is making water scarcity a severe problem, which will worsen over the years. The government considers the project area as unsuitable for drilling wells, because the ground water is saline at most locations. This could mean that complete villages have to move to other places, making the pressure on water resources even higher. This problem could greatly reduce results of development efforts. Sim Aqua no Futuro!

2.3 Biofuel in Mozambique

As mentioned in the introduction the Mozambican government has since the start of the FACT/ADPP project developed a comprehensive bio-fuel strategy because it sees biofuel as having a great potential in Mozambique.

It wants to promote biofuel production to stimulate:

1. Socio-economic development; especially in rural areas (PARPA)
2. Diversification of the energy mix (reduce dependency on fossil fuel imports)

To achieve this the Mozambique's National Biofuel Strategy prescribes the:

- Establishment of a national biofuel market;
  - Compulsory national blending targets for E10 and B5;

- Promote local processing capacity to add value;
- Increase biofuel tax to support the build up of the domestic sector;

- Sustainability
  - Promote feedstock according to the agro-ecological zoning exercise;
  - Avoid use of basic food crops and monocultures/ enhance biodiversity;
  - Certification of biofuel production;
  - Sugarcane, sweet sorghum/ Jatropha and coconut
- Socio-economic development.

Analysis shows positive macroeconomic benefits and that approximately 150.000 new jobs will be created based on modest expansion to 450.000 ha (direct and indirect employment)

An assessment of Mozambique's biophysical potential carried out between October 2007 and May 2008 by an inter-ministerial working group found that of the identified 7 million ha, 3.780.933 ha (54%) was suitable for agriculture (including biofuel developments), the other 3.185.097 ha (46%) was suitable for other purposes, such as forestry and grazing (Government of Mozambique, 2008).

Biofuels are envisioned as a means of promoting development in remote areas. However, most of the present bio-fuel developments are in areas with good infrastructure: Roads, facilities, health care and relaxation services, goods, (tele-) communication, (skilled) labor availability.

Only few projects are located in remote, rural areas. The FACT/ADPP is one of them. Moreover, job creation as proposed by investors seems lower than expected by the government

Most of the projects are commercial projects focusing on premium markets in EU in absence of domestic and regional market, very few projects are aimed at local market development and involvement of rural smallholders.

3 PROJECT DESCRIPTION

3.1 Objectives

FACT's long-term goal is to make a tangible contribution to the development of biofuels in developing countries, enabling local communities to benefit from this renewable energy source.

The objective of this pilot project is to develop a local market for pure plant oil (PPO) derived from Jatropha seeds produced by subsistent farmers in remote rural areas in Mozambique. The infrastructure, technical and human capacity has to be established to enable autonomous up-scaling of the activities after termination of the project.

Outputs:

The project target was to grow 250-500 hectares-equivalent of Jatropha in hedges; to build up a viable oil processing workshop and; to adapt 20 diesel engines in use by small enterprises and schools for operation on PPO. Organization and training of farmers and technicians is an important component of the project.

3.2 Strategy

FACTs' strategy is to work with experienced partners, who have been working for a long term in the area with the target groups. To obtain knowledge of potential partners, a workshop was

organized by FACT in Chimoio in 2006, where stakeholders in Jatropha were invited. The experience so far with Jatropha was discussed and the participants were requested to draft proposals at the same workshop. The best partners were selected to join the final project proposal which was then written by FACT and GAIA Movement, with inputs of Flemming Nielsen, at that time working for IIAM in Mozambique. The partners involved, besides FACT were ADPP, GAIA-Movement, and IIAM.

The anticipated project location in Chimoio, Manica Province was changed to Bilibiza, in Cabo Delgado Province, since ADPP's and GAIA's experiences with Jatropha were not so positive in Manica; the plants did not grow well and were attacked by pests. ADPP in Bilibiza liked the project and knew existing old Jatropha plants in the area that were growing well.

The major activities were staggered in three phases: The first phase focused on the introduction of Jatropha to the Farmers Clubs established by ADPP, and simultaneously starting research on Jatropha. The second phase focused on market aspects, technology development and research. The last phase (2009-2010) focused on developing a training centre, and organizing courses to enable sharing of the generated knowledge, improve the regional knowledge base provide revenue for the centre. The plan was to set up an oil producing factory that would be able to operate on purely commercial terms.

Five seminars for the project partners and other interested organizations were organized by FACT-ADPP, 4 in Chimoio and 1 in Maputo (2010).

3.3 Project elements; original targets and results

Four major project elements with specific targets were formulated:

1 The project will create between 250 to 500 ha of land cultivated with Jatropha;
2 knowledge of the most efficient variety will be obtained;
3 a local market for the oil will be developed; and
4 a training centre on Bio-fuels in Mozambique will be established

In the following description, the original target will be described first, followed by an explanation of the achieved results.

3.3.1. The project will create between 250 to 500 ha of land cultivated with Jatropha

3.3.1.1 The original target

The original target was to plant between 250 and 500 ha of land with Jatropha within three years. The sites would be located in 5 different areas spread over Mozambique (from North to South), in which the local counterpart ADPP has had a long-lasting presence.
The production of Jatropha would be done by small farmers united in 25 farmer organisations called "Farmers Clubs" (FCs), supported by ADPP and will be coordinated by FACT.

It was soon realised that it would not be practical spreading such a pilot project throughout Mozambique, and a decision was therefore reached at first to have it implemented in Chimoio. However, due to poor performance of Jatropha in Chimoio it was soone decided to move it further north to Cabo Delgado where Jatropha grows well.

3.3.1.2 Achievements & problems encountered.

The main project area is inside Quirimbas national Park (QNP)in Cabo Delgado, with its main base at the ADPP Teacher Training college in Bilibiza. When the project was launched, ADPP had just started with 25 FC's to produce horticulture and trees, funded by EU and USDA. The Jatropha was basically added as an extra component. Later on in the project, when more knowledge about Jatropha cultivation was obtained, the project was expanded to 3 other provinces.

The project came off to a slow start due to a number of problems described in the first project report from the ADPP project leader Felicity Dennis.

"The first six months of the project, January – July 2007, were relatively quiet given the stage of the agricultural calendar. The main activities laid out involved sensitising farmers about Jatropha and the project, planning nurseries, starting the construction of wells and rope pumps for the nurseries, purchasing basic equipment for commencing the project and starting to improve the condition of the Bilibiza centre.

All of the scheduled activities were begun, but due to considerations or various issues at the time, a number will not really take off until the next 6 month period. As most of activities were scheduled to occur over the space of several months anyway, this should in no way affect the functioning of the project – instead, they are practical changes responding to real issues in the field.

Many of the problems to date have been related to power, communication and transport issues at the Bilibiza EPF centre. Most have come to resolve themselves or are improving with time thus they are unlikely to be as much of an issue in the future as they have been. We are attempting to take action where possible, such as find alternative power sources to the current generator until a new one is purchased to minimise the negative impacts on the project.

Overall, things are looking positive for the next 6 month period and many of the farmers club members are excited about the prospects of really beginning cultivating Jatropha from the commencement of the rainy season later this year."

Unfortunately, the project leader became overburdened after one year, with 3 projects on her back and difficulties with communication with the local Mozambicans (she is Australian and did not speak Portuguese yet). Also the technical project leader Ernesto was transferred after one year.

Felicity Dennsi was replaced by a new project leader, Henderson Maposa from Malawi, while Bachir Afonso from Bilibiza became the technical project leader. This team worked together very well until the end of the project. The agricultural background of Henderson and the fact that the technical PL Bachir spoke the local languages, Macua, Makonde, Swahili and Kimuani and his capability to motivate people, resulted in 36 strong clubs in active participation until the end of the project funding period. Over 600.000 Jatropha plants are currently growing (an equivalent of 600 ha).

"*Transport for staff is in general problematic. At the moment it appears that a replacement for the light truck is a priority as well as one or two high quality motorcycles if possible. As an indication of the amount of travel – in the past 1 year the Nissan pick up has covered around 100,000 km, which is equivalent to driving continuously for 30 work weeks (i.e. 40 hours a week). In effect this means that the amount of time to actually carry out work in villages has been severely limited*."

Also the quality of motorbikes for the extension workers was quite poor; constant breakdowns and difficulties in finding good spare parts meant that extension workers had to spend some time off the field, resulting in low performance of the FC's in some districts. Therefore the Nissan kept on being used extensively by the project leaders.

The developing of the FC committees in the right format took also some time. The first attempts by giving money to village leaders and FC committees did not work and was abandoned.

It was actually towards the end of the first year that the project started operating normally, with all the planning and deadlines well in place. All the budgeting and reporting came into place, with monitoring and evaluation taking place as originally planned.

At present 36 well trained FCs are increasing their income from horticulture and Jatropha, and at the same time the number of new FCs is fast increasing. All FCs are equipped with a lined well and a hand rope pump, and 10 hand-held water cans. One bicycle for the FC head to bring products to local markets was also provided.

10 FCs have been legally registered as associations, giving scope for further development, including potential access to credit.

The expansion to three other provinces in Mozambique, Niassa, Itoculu and Macuse, was scheduled to start in 2008. The selected provinces have been chosen because FCs are being created there by ADPP with the aid of an USDA program.

The status at july 2010 as reported by Jacob Zulu was:

“Although in all three provinces the cultivation of Jatropha had started, and project leaders from the locations participated in the first training course on Jatropha cultivation in Bilibzia, in fact only Sofala, Gorongoza is likely to continue. In Itoculu plants died (3 times) and in Macuse, there is no continuation of FC’s and thus no leaders, although 4000 plants are growing.”

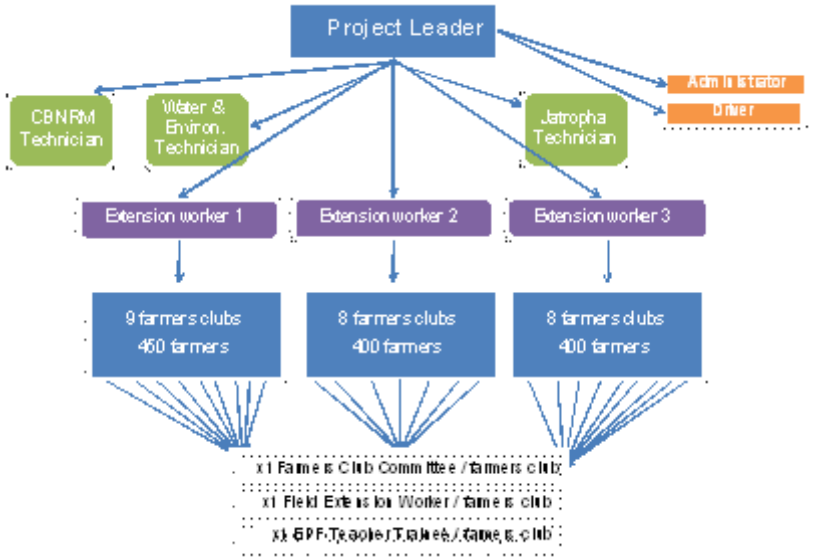
3.3.1.3. The Farmers Club (FC) approach

The Farmers Club’s concept as described here, was developed over 15 years, by Humana related organizations in Zimbabwe, and later on extended to Zambia, Mozambique, Malawi, Congo, Angola, and Guinea Bissau.

The concept of a Farmers Club is that a group of farmers, man and women, between 20 to 50 members, volunteer to work together, on one common demonstration plot where each farmer has a small plot where he/she is applying new methods which they are learning from extension workers and project leaders from ADPP.

The farmers’ clubs are being taught low input conservation farming, whereby waste from agriculture and other natural resources are used in a clever ways to increase the yield without using chemical fertilizer. They are taught horticulture, like cultivation of tomato’s, cabbages, beans, salad, etc, part for own use, to raise nutritious food, a part for storing and a part for sales.

The Organisation of ADPP in relation to the Farmers Clubs, Cabo Delgado



After having learned these new methods, he/she can apply them at his/her own private plot elsewhere. The inputs are knowledge and some investments, like improved stable wells, equipped with hand rope pumps, better seeds and watering cans for irrigation.

The provision of secure water points is crucial. They consist of a stabilized, lined (with concrete rings) wells, a well rim and cover and a hand rope pump, which is locally made at the workshop of ADPP and can be maintained by the farmers. This makes a trusted water source over the dry season possible, allowing farmers to build nurseries where they can grow seedlings at the end of the dry season that can be planted directly at the start of the rainy season, giving them a head start. It provides also water to some extend for irrigation. Herewith they are also better equipped to overcome the dry periods caused by irregular rain patterns which are becoming increasingly more irregular because of climate change.

	
Farmers Club of 25 de Junio C.D. Salad is being washed in water from the hand rope pump and sold for 5MT/piece (ca 18 $ct). The Jatropha plant is 0.5 m high after 4 months.	*Farmers of the Farmers Club of Petolia C.D. working at their common demonstration plot.*

Where there are customers for the vegetables, like the EPF and other schools, a local market emerges, and they start to earn some cash income. This results in enthusiasm about the new knowledge they have acquired and they become eager to learn more. This is also the point where a new concept is introduced, a FC committee, that controls a fund to be used for the members. If this works well, as is the case in most of the FC's in Cabo Delgado, the FC has already reached an organizational level which is the basis for a growth to a legally registered organization, which is the real step up to further development. This makes it namely possible to borrow money from some Banks that are focusing on agriculture, like GAPI and also the Dutch Rabobank. At Nov 2009, there were 36 FC's operational of which 10 had been officially registered.

From another project Arrakis was involved in 2006-2007 with Farmers Clubs in Chimoio, it was found that it is possible to earn enough money from vegetables, like onions, tomato's, etc to pay back the money borrowed from a bank for a hand rope pump, within 1 or two years.

The FACT project in Cabo Delgado, is introducing Jatropha as an energy crop in combination with food crops with the Farmers Clubs. Instead of planting Jatropha in plantations like large commercial companies are doing, these farmers are planting Jatropha in hedges around their crop fields.

This is also done for several reasons: It is important to keep smaller animals away from the fields. Farmers tend to group their fields together, to make it easier to protect them against theft and damage by animals like monkeys, wild pigs and elephants as well. There are proofs from neighbouring countries, like Zimbabwe and Zambia, where this concept was developed already 15 years ago, that because of the investments made by the projects and the farmers themselves, in areas with FC's the shifting cultivation is being reduced. Also in Mozambique, this trend was found; it is attractive to continue cultivating a field protected by a Jatropoha hedge instead of cutting more forest down.

One outstanding example is a woman president of a FC in Pemba Metuge, who has raised US$ 3000 in one year, selling vegetables on contract basis to a luxury hotel in Pemba.

Concluding; the FC concept is a really valuable and proven concept, in the countries where it has been introduced now, like Zimbabwe, Zambia and Mozambique by partner organizations from Humana People to People, like DAPP and ADPP.

3.3.2 Knowledge of the most efficient variety will be obtained

3.3.2.1 The original target was:
Knowledge of

a) most efficient Jatropha varieties, cultivation of these,
b) the possibility of Jatropha acting as host for various agricultural pest organism, and
c) combat of these with natural pesticides known

The national **research institutes IIAM and ICRAF will carry out "on farm research"** to investigate different varieties, pests, diseases, and the use of biological pesticides with the aim to achieve a balanced production of the Jatropha crop.

3.3.2.2 **Achievements & problems encountered.**

Agricultural and socio-economic research was from the beginning undertaken in collaboration with several national and international institutions. In Mozambique University Eduardo Mondlane (UEM), The National Agricultural Research Institute (IIAM) and ICRAF-Mozambique were major partners. Unfortunately ICRAF had to close down due to funding shortage before

any field activities had started. In Europe the Universities of Wageninge and Copenhagen were major partners.

Jatropha curcas is a non-domesticated plant and it is therefore expected that simple variety selection can have significant impact on yield and other factors like plant shape, seed size, and resistance to pests.

In practice there are several obstacles. Timing is a major issue because it takes years to reach firm conclusions. However, the project had to start producing seedlings immediately. Results from the variety selection would therefore mainly of benefit to future projects and to farmers in the project area planting at a later stage. However, since this is a pilot project aimed at generating knowledge for wider use and the potential benefit is so large it was deemed justified to undertake this research. Until the results from the trials are available it was decided to use local Jatropha trees as the main seed source. The logic is that Jatropha was likely introduced to the area a long time ago and adaptations to the local conditions have taken place. The local plants were all found to grow and yield well.

Another obstacle was the absence of knowledge about what varieties exist. The situation has improved slightly after DNA fingerprinting has been done by a few universities since the start of this project. The FACT/ADPP project participated in one of these projects, namely the *Jatropha curcas* Evaluation Program (JEP) project of Wageningen University. Samples of the local Jatropha "mother trees" that were the main seed source for the project were submitted to JEEP. It was found that the genetic variation of Jatropha sampled within Africa is limited. Therefore there is probably little to be gained from including several African Jatropha provenances in trials.

Due to the lack of knowledge about varieties the approach was to import Jatropha seeds from different countries and continents with the expectation that it would be genetically diverse.

Requests for seeds were made to more than fifty organizations, companies and individuals. However, many were not able to deliver or took a very long time which led to another bottleneck: The viability of Jatropha seeds drops sharply after about one year. Whenever we managed to import seeds from a new location other seeds imported earlier were no longer viable.

Figuur 1 Seed pre-treatment trial, Sussundenga.

The first seed batches we obtained had a low germination rate and before starting large variety trials it was tested if pre-treatment of Jatropha seeds could increase the germination rate.

Three varieties were submitted to three different pre-treatments. It was found that none of the pre-treatments had any effect. Seed batches received after the trial had much higher

germination rate and it was therefore concluded that the initial problems were due to age and/or handling of the first seed batches.

Figuur 2 Poorly maintained Jatropha variety trial, Mandonge.

In the Mandonge research forest outside Sussundenga town a 0.43 ha Jatropha variety trial was established by the national agricultural research organizations, IIAM and the FACT/ADPP project. The trial was well planned and implemented at first. However, the follow up was not up to standard and after two seasons without weeding many plants were lost. Eventually FACT decided to pull out of the trial and soon after IIAM effectively abandoned the trial.

In Cabo Delgado variety trials were established at four locations. They were well laid out and performed very well compared to the trial at Sussundenga. Every month seeds were collected from each trial plot and put is sealed pre-labeled envelopes. The project managers past experience from a research station in Malawi initially ensured that data collection was

Figuur 3 Jatropha variety trial being established at Bilibiza.

punctual and of a high standard. However, when there had been no visits to the project by FACT staff for some time the quality of the data collection deteriorated. Short reliable data series have been obtained but none that covers 12 month which makes it impossible to assess accurately the annual yield which is one of the parameters everybody is looking for. However, the relative performance of the varieties can still be assessed.

Globally only two reliable long-term data series on Jatropha yield are known and they indicate that maturity is first reached after about seven years. The variety trials in Cabo Delgado are therefore only half way to maturity. To reach firm conclusions they should be monitored for about four years more. Discussions are under way with universities that are interested in continuing this work.

Figuur 4 Jatropha plant in farmers field marked for montly yield sampling.

Due to the lack of reliable yield data world-wide it was necessary to start from scratch. Two approaches were followed. One was to develop a yield prediction model based on the best available information. Another was to initiate measurements of yield in five farmer managed Jatropha plots and eight hedges every month. This was undertaken by the same people that monitored the provenance trials and consequently suffered from similar problems.

Most farmers preferred hedges to plots of Jatropha. In West-Africa and elsewhere Jatropha hedges are common and typically uses a planting distance of 5-15 cm. It the project area farmers opted for a planting distance of 1-3 m instead. A trial was designed to test the yield of different combinations of planting material and distances in hedges. The trial was repeated at four FCs. Seed collection was scheduled monthly and ran into similar problems as the two previously mentioned trials.

Figuur 5 Trial of improved hedges being established.

The problems of consistent and reliable data collection are understandable. The project had no staff whose main task was research and the research tasks therefore tended to get low priority when other pressing issues emerged. Even within IIMA where the only objective for the staff is research similar problems occur.

Figuur 6 Yellow flee-beetles - the main pest in Jatropha in Manica Province.

When the project started there was a widespread belief that Jatropha did not suffer from pests problems. However, we became aware of problems at an early stage by observing the Jatropha planted under Caritas' supervision and the trial plantings by ADPP in Chimoio. A survey found that in particular the yellow flee beetle was so common and devastating that it was not worth pursuing Jatropha production in Manica Province under small scale farming conditions. In Cabo Delgado the picture was the opposite and it was at times very hard to find any pests in Jatropha.

Figuur 7 Sampling insects from Jatropha plant.

The initial survey was followed up by a major survey of insects in Jatropha in collaboration with University Eduardo Mondlane. Logistics was paid for by Danida. The study had almost national coverage and drew on experts in Mozambique, South Africa and Italy. To our knowledge there exists no other study worldwide of a similar scope. The results have been published in a thesis and presented at scientific conferences internationally.

One important finding was that the time of sowing affects the levels pests in the field even many years later.

Some of the insects found in Jatropha are pest in other crops but they did not appear at alarming levels in Jatropha. The study was carried out over two months and to substantiate the conclusions it should be repeated one or two times at other seasons. This was unfortunately not possible to do under this project.

With a good understanding of insects in Jatropha the next step was to test cheap locally available organic methods for pest control. In collaboration with UEM a trial of three bio-pesticide extracts from Tephrosia (*Tephrosia* spp.), Tobacco (*Nicotiana* spp.) and Neem (*Azadirachta indica*) respectively were tested for their efficacy. The results of this study are not available yet.

It was observed that young Jatropha plants suffer more from pests than older plants. It is known that the concentration of poison is higher in the older plants so a trial was planned to test if press cake could be efficient as a pesticide in young Jatropha plants. 200 kg of seeds were pressed but due to logistic problems the press cake was not applied in time.

Figuur 8 Sampling of Jatropha plants and soil in farmers' fields.

The relationship between Jatropha plant development and soil nutrients was studied in collaboration with Wageningen University. It was found that soil nitrogen and potassium variation could not explain the differences in plant development. However, higher phosphorous levels lead to more branching and higher plants. In general the availability of N, P and K are not the main determinant of plant development. Other factors are not well researched but pruning, planting distance and weeding are likely to be important factors. For the Cabo Delgado project it is unfortunate that P and not N is of some importance for plant growth because there are few options for manipulating P levels within the constraints of the current farming systems.

At the beginning of the project a small observation trial with manure application was carried out in Manica Province. It showed a significant response to manure. This research is not directly comparable to the research described in the previous paragraph.

When the project was designed there was little knowledge about the energy- and carbon balance of Jatropha but it was generally assumed to be very positive and did therefore not received much consideration.

However, after the project had started a number of scientific studies indicated that the energy- and carbon-balance of biofuels may not be as positive as assumed. In particular the study by

Searchinger in 2008 was influential. The carbon and energy balance suddenly became big issues and we had no data.

A study was therefore undertaken with University of Copenhagen and it concluded that the carbon balance depends on where farmers plant Jatropha. If they clear forest to plant Jatropha it will take 1900 years to pay back the carbon debt. If they plant in already cultivated or fallow fields the carbon balance is good.

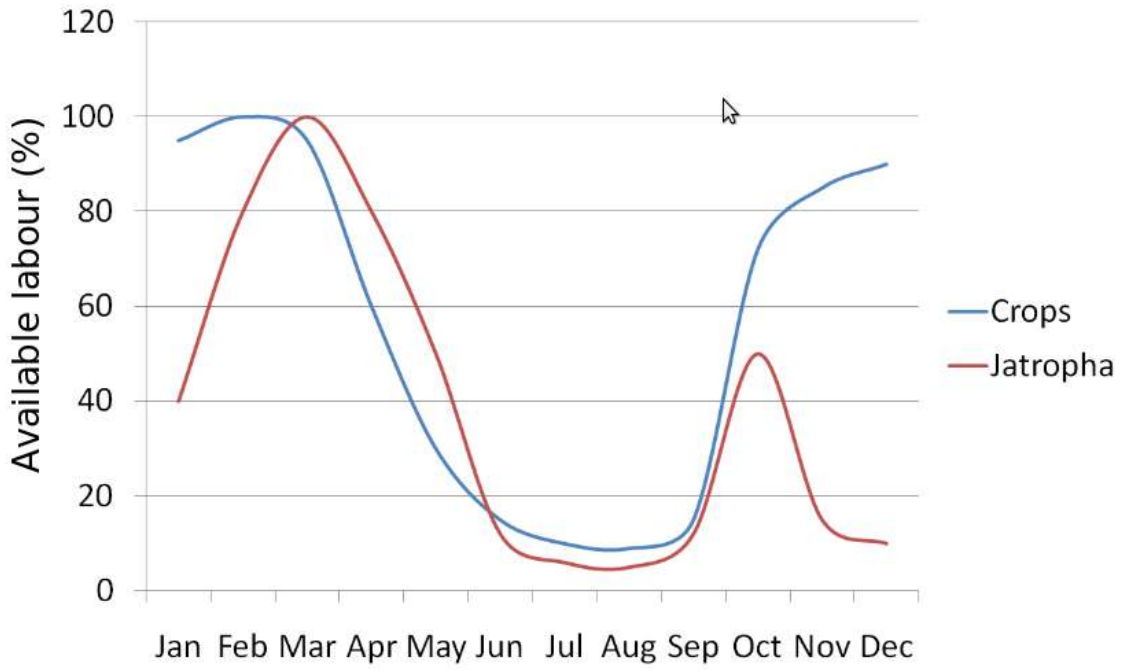
The same study also looked at socio-economic issues and found no gender bias in Jatropha cultivation and no technical obstacles to expansion.

Discussions with farmers showed that harvesting and de-shelling of seeds counts for about 90% of the labour required in Jatropha production.

Figuur 9 Measuring labour required for harvesting.

Harvest trials were conducted to assess the labour requirements and the profitability of Jatropha production. It was found that Jatropha production gives a better return on labour than alternative crops and paid employment.

Observations at the start of the project indicated that the Jatropha seeds matured after the food crops. However, as more data has become available this appears not to be the case. In all FCs the main harvest coincide with the major food crop harvest, i.e. the end of the rainy season. At some locations there is a second smaller harvest just before the start of the growing season.



Figuur 10 Labour requirement by season.

I was proposed to farmers that the labour bottle neck could be avoided by leaving the Jatropha seeds on the bushes and harvest them after the food crops. Some seeds will be lost but not many. At first the farmers welcomed the idea but towards the end of the project most farmers appeared to prefer harvesting food crops and Jatropha simultaneously. During a work day in the fields they mix different tasks. Picking Jatropha is considered an easy task and can therefore be alternated with heavier physical work. Most farmers appears to now to postpone the de-shelling till the evening when they sit around the fire.

Data from Honduras that became available during the project showed that bigger seeds result in a higher oil fraction. It was also known from experience that small seeds often have low germination rate. Selection of large seeds for planting is therefore beneficial. It was tested if simply shaking of Jatropha seeds in a container till the largest seeds appeared on top was feasible. Unfortunately this was not successful. Visual sorting of seeds is also not efficient. Visual selection can eliminate unusually small seeds but it is too difficult to spot the largest seeds as they are only marginally bigger than the average.

Selection and breeding of larger seeds is a promising way forward. In India interesting work is going on with Jatropha hybrids that produce seeds of double the normal size. It is expected that seeds of twice the current size can almost double the labour productivity.

Figuur 11 Pruned Jatropha.

Observations of the effect of different pruning times were made at the project and elsewhere in Mozambique. Problems were only found when pruning was done during the wet season and it was subsequently decided to recommend pruning only during the dry season. This is the opposite of what some of the commercial plantations have concluded: They prune during the wet season because wound healing is much faster then.

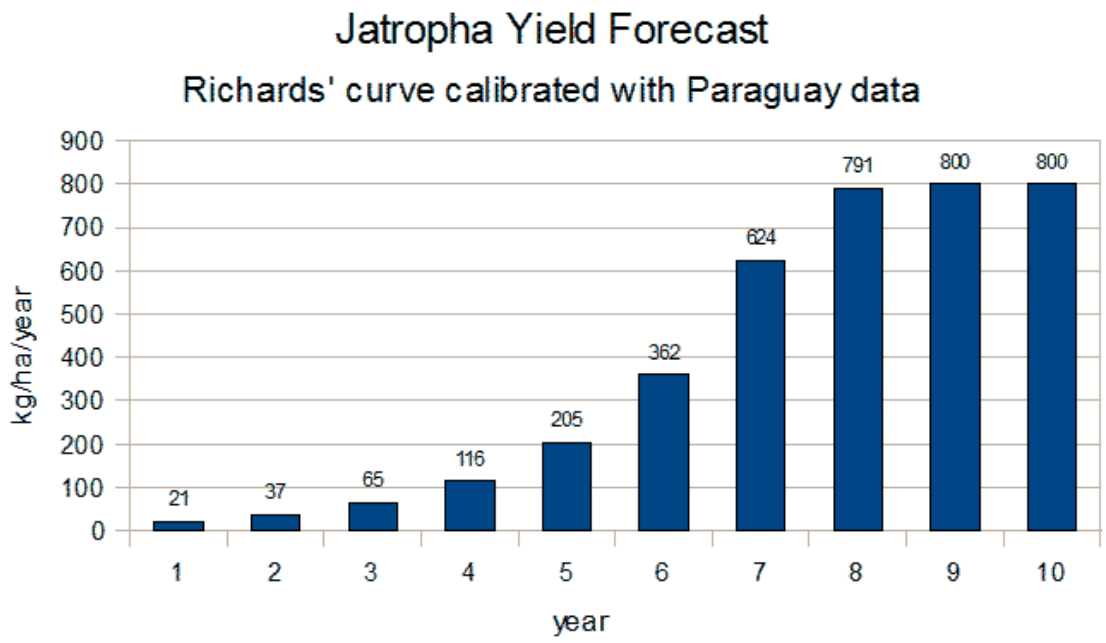
Nurseries were established with shade roofs made from bamboo and grass because that is common in tree nurseries. However, observations indicated that Jatropha nurseries do not require shade. The plants can do well without the shade but require more frequent watering.

Direct seeding and bare root seedlings were observed to work well but no systematic research was undertaken. Farmers have a preference for using cuttings for propagation because they grow into a dense hedge faster than other planting materials. Through the training received from the project they are generally aware of the problems with using cuttings.

Due to the long distances between the FCs and the relatively small amounts produced the transport costs can significantly affect the profitability Jatropha production. To minimize transport costs a transport planner was programmed. It is based on data from a GIS that was developed with information about all transport routes and their conditions.

1 YIELDS

The yield forecast on a per hectare basis is shown in the figure below. With our current knowledge from the trials, observations and data on seeds purchased by the BBC we assess that they still look realistic.



In 2010 the tonnage delivered to the BBC was only a fraction of the predicted yield. This is mainly explained by two factors.

First of all buyers from Tanzania purchased seeds directly from the farmers for a price several times higher than what BBC offered. Consequently farmers preferred to sell to Tanzania.

Secondly the high price paid by the Tanzania buyers made farmers discontent with the price offered by BBC and many farmers appeared to have left seeds un-harvested. During field visits at the end of 2010 this was confirmed. The external evaluation also confirmed this scenario

Actual achieved in the project:

Date	**Nr of living Jatropha plants**
November 2008	95375
December 2009	413988
May 2010	608148

3.3.3 A local market for the oil will be developed

3.3.3.1 The original target was:

The development of a local market for the oil, which can be used to operate diesel generators for schools, to run corn mills and as a fuel for (a few) vehicles equipped with a diesel engine.

Project target was: a market created for 25 diesel engines distributed over 25 villages.
Local technicians will receive training on how to convert diesel systems for plant oil operation, which involves the assistance of experts from abroad.
The oil will be pressed at 10 different sites (within 5 schools and 5 small enterprises) to create an guaranteed initial market for the farmers to sell the seeds and the oil.
Other options for the oil:
use as lamp oil for lighting in the villages and for soap production.

The knowledge acquired will be disseminated and the experiences and local revenues will generate new, comparable projects.

3.3.3.2 Demand for products:

Interviews with Erik Schurmann, head of ADPP in Bilibiza (for 12 years) and survey of diesels in the project area revealed the potential for PPO to replace fossil diesel in the project area:

The diesel generator set supplying the EPF school (of ca 200 students) uses about 10.000 liter fuel/year. The Nissan project car uses about 10.000 liter/year (driving 1:10 and 100.000 km.).

The diesel engines of the maize mills use about 1000 liter per year (in the season only). In total about 20 diesel engines give a total potential of 20.000 liters/year.

The overall potential market for PPO is thus about 40.000 liters-year.

Research was conducted in other areas by Jacob Zulu to asses the market potential for the Jatropha oil as well as soap and press cake for use as fertilizer, in three different areas, namely Quissanga, Mocuba and Gorongosa. The report reveals big potential market for Jatropha products such as oil for lamps, oil for soap and press cake for fertilizing the soil.

The area in and around the Quirimbas National Park has roughly a population of 316,000, Mocuba has a population of 306,543, while Gorongosa has 116,912 bringing a total of 740,196 people of which 90% has no access to electricity. With this background it means therefore that there is a big potential for oil for lamps for about 133,000 families. If 90 families can consume 60 liters per week as indicated by the surveys, it means that 133,000 families consume about 88,000 liters per week and in a year they consume roughly 4,000,000 liters of oil for light. There is an equally available market for Jatropha soap.

In Quisanga, where Bilibiza is located, 29 families out of the 30 interviewed use soap and together they spend a total of 568MZN to buy this soap per week, while they use another 120MZN in transport for all the families together that need transport to buy the commodity per week. All these families indicated the need of having more soap for various use e.g. bathing, clothes washing, dish washing, washing hands after using the toilets etc, which could not be met due to prices and distance to the market in some cases. As in the case of oil, if the market was close to the people, consumption would increase by one third, besides, there is more demand for soap than for lamp oil. The price of the cheapest soap in the surveyed area is above 60 MZN per kilo.

In Quisanga, a total of 49.5 hectare of land is cultivated by the 30 families, of which 38 hectare is for cereal crops, 8.5 for cassava crops, 2 hectare for groundnuts and 1 hectare for sesame.

On average maize costs 5 MZN/kg (with a varience in price of + or – 3 MZN), 3 MZN/kg for cassava and 20 MZN/kg for groundnuts and they get 50 MZN/kg for sesame.

On average, each farmer has about 1.5 hectare of land under cultivation, which in it self does not give the family enough harvest for home consumption as the yields are low. There is enough land for expansion but with only manual labour available it is not physically possible to tend larger areas.

There was clear indication that all the farmers were looking forward to increased production but none was willing to invest in fertilizer. Only two were using animal manure but also in very small quantities that would otherwise not even make a significant change. The farmer also were not familiar with methods that could improve yields. In this regard, it would require a lot of effort to mobilize and convince the farmer in the use of press cake as organic manure. However, for the ones that are growing Jatropha it would not be a problem as such as they would be using what has come out of their own Jatropha seeds.

Market for Bagaco (press cake fertilizer) can not be assumed as it is somehow complex as the people are not accustomed to applying manure. It would however be worthwhile trying briquettes and charcoal.

3.3.3.2 Oil for diesel engines for maize mills, generators and cars

The vegetable oil in its pure form, used as diesel replacement in diesel engines is known as **PPO** (Pure Plant Oil)**, SVO** (Straight Vegetable Oil), or **JPO** (Jatropha Plant Oil). This is in contrast to bio-diesel which is esterified oil, treated with chemical ingredients.

Oil qualities in relation to use in diesel engines.

From the first literature research in the project it became clear that using oil as fuel in diesel engines is not so simple. Various experiments done by people showed that running any diesel engine on oil for 24 hours is not a problem. But problems often occur after the first 500 hours in which total breakdowns of engines occurred.

The experiences with rape seed oil, as reported from Denmark and Germany gave good guidelines for PPO.

The variables which might cause difficulties are:

- Much higher viscosity of PPO in comparison with fossil diesel,
- Too high values of contents of phosphor, acid, water, contamination with particles, oxidation, etc.

There exist also a great variety between diesel engines, both in type, the DI (Direct Injection) types and IDI (In-Direct Injection) types and with different types and makes of fuel pumps. The result is that each engine has to be modified and tuned in its own way to let it run smoothly on PPO.

A very good description of all these facets is given by Niels Ansø in section 5.2 of the Jatropha Handbook [see www.fact-foundation.com]

After some surveys in QNP many different diesel varieties were discovered.

		
The Feidong engine driving the maize mill at EPF Bilibiza	*A one cylinder Chinese make engine at a maize mill in Bilibiza*	*Another Chinese type of diesel engine with a maize mill.*

The high viscosity of the PPO can be reduced to the level of fossil diesel, by increasing the temperature of the PPO. Diesel engines can be modified, making use of surplus heat, like exhaust, engine oil or cooling water to increase the temperature of the PPO. Start up problems, when the engine is still cold , can be overcome by mounting a second tank, with fossil diesel, so that the engine can be started on normal diesel and after some minutes, when it has got heated up, the fuel can be switched to PPO. This is commonly known as ”dual fuel mode”`.

There exist diesel modification kits in Europe (like delivered by Elsbett) but they are too expensive for the diesel owners of the maize mills in QNP to be earned back in a short time.

Therefore, within the project funds were re-directed to develop a technical investigation program to find out if a cheap kit to modify the most suitable diesel engine could be developed. Then consequently some diesel engines should be modified and some endurance tests done to check if the engines were performing well on PPO.

This needed to be done before diesel engines of real users were to be modified. Some guarantee has to be given and demonstrated to the potential clients.

From the survey in QNP it emerged that most of the recently bought diesel engines were of the Chinese Feidong make. It was decided then to develop a modification kit for this type of engine.

The first modification kit was developed in The Netherlands by Ger Groeneveld of PPO Groenveld. It was based on building a heat exchanger around the exhaust pipe of the engine a Lister type aircooled engine of DI type. This engine did run over 600 hrs on all kinds of PPO without problems, which was encouraging.

	
The modified Lister ST3, running on PPO in Netherlands	*The Feidong in Chimoio, modified with 2 tank system*

The second kit was made in Mozambique at Evretz, a farm of a Zimbabwan farmer who was experimenting with biofuels. First a Chinese Feidong diesel engine, which is a typical engine used in QNP was bought by the project in Cabo Delgado and transported to Chimoio. Ger used the same principle of using the heat of the exhaust to pre-heat the PPO, but in a different way. He used as much as possible local materials and the diesel could run on it, driving a water pump for the farm. As fuel cotton oil was being used, which was pressed at Evretz. During a visit after one year by Niels Ansø and Jan de Jongh, it was found that the engine with the water pump was not running at all. Logistic problems was the reason. Also the modification was no longer in order. The cheap plastic hoses used for the fuel had become brittle and were broken. After repair by Niels the engine ran again and the farmer promised to resume the testing. Unfortunately, this experiment failed in the end, as the number of planned hours were not made.

At the BBC two Feidong diesel engines were modified by Niels using imported parts from Denmark. The principle was to use the cooling water to pre-heat the PPO.

Parts of the Modification kit, by Niels Ansø

The diesel engine modified.

One engine is the drive engine of the BBC generator set, the other the drive engine of the maize mill of the EPF school. Since there was no Jatropha available yet in sufficient quantities, cooking oil is used to do the tests. Data loggers were attached to the engines to measure the exhaust temperature, as indicator for the load, against time. Data has been sent via the internet to Niels on a regular basis for further analysis.

The generator set with the modified Feidong diesel engine,

running on PPO (cooking oil)

Due the mentioned setbacks the endurance test could not be finished before the end of the project. Up to now however no problems were mentioned. It might well be that this kit at a total cost of around € 200, is suitable for these types of engines. Apart from this, thermostats were needed, since the engine did not heat up sufficiently. Also for one of the engines the injection pressure has been slightly adapted by Niels.

Since these tests have not been concluded, and therefore no guarantee can be given yet, potential clients could not be approached yet for modification.

See reports of Niels Ansø (forthcoming)

Modification of the Nissan 4Wd car.

The project car, a Nissan 4wd was repaired and modified by Niels in Oct 2009, to run on PPO.

The system is a 1-tank system enabling the car to start and run on 100% PPO without starting first on diesel. Niels provided the parts from Denmark, costing around € 700, which is rather costly.

The purpose was mainly to demonstrate that driving on PPO with a normal modern car is also possible.

The car was driven to Maputo on sunflower PPO (over 2,000 km) and was present at the one day Seminar on the 25th of November 2010 where the project results were presented to the public. The car modification was shown and got a lot attention. In future when JPO of good quality will be available, the car can drive on it, meanwhile it still can drive on fossil diesel.

Nyasha and Nacir filling up the Nissan with cooking oil

The modified Nissan project car.

Oil quality.

As soon as the first oil had been pressed, around Dec 2009, Flemming Nielsen took a bottle and send it to ASG, a recognized laboratory in Germany for testing. (see table below)

The test gave very negative results. Nearly all the critical variables were far too high to make the oil valuable for using as PPO in engines. It was decided to use this oil for making soap and continue the endurance test with the diesels with cooking oil.

Report-No. : 182600 end of test period : 03.05.2010

Sample Designation : Jatropha oil from FACT project Mozambique
Sample Appearance : yellowish, turbid, characteristic odour
Sample Container : PE-bottle 500 ml
ASG-ID : 168411 Seal : -

Parameter	Method	Result	Specification DIN V 51 605	Unit
Total contamination	DIN EN 12662	32	max. 24	mg/kg
Acid value	DIN EN 14104	13,34	max. 2,0	mg KOH/g
Oxidation stability 110 °C	DIN EN 14112	11,6	min. 6,0	h
Phosphorous content	DIN EN 14107	19,4	max. 12	mg/kg
Earth alkali content (Ca + Mg)	DIN EN 14538	12,6	max. 20	mg/kg
Ash content	DIN EN ISO 6245	0,010	max. 0,01	% (m/m)
Water content	DIN EN ISO 12937	1393	max. 750	mg/kg

Notice:

All results out of specification limits were confirmed by repeat analysis

The test report of ASG

The quality of oil is to be controlled during the whole production chain, from soil preparation to oil storage and distribution, while there are still unknowns to be solved. For example: up to now it was said that harvesting green unripe seeds would result in too high phosphor contents, bad for diesel engines, but samples taken recently from yellow seeds in Mali showed that these seeds had the worst acidity level.
Also during pressing the quality can change, e.g. too high pressing temperature increases the phosphor contents in the oil, while storage in galvanised tanks leads to creation of polymers, blocking fuel filters.

It was clear that a system of oil quality control had to be established. From the neutralizing experiments with the cotton oil by Evans it was learned that the acidity could be neutralized by adding caustic soda and heat, resulting in clean cotton oil and soap residues. Samples of both untreated cotton oil and treated oil were also sent by us to ASG and results compared. Apart from the lowering of the acidity, also the other variables lowered, and came within acceptable values for PPO.

Experiments were done at BBC by Jan de Jongh with this method and indeed the JPO acidity could be lowered from 17 to 3. However a lot of oil is lost as sediments after neutralization. It is better to use non chemical treated plant oil, i.e. only pressing, sedimentation and filtering.

	
Jatropha oil, before treatment left, acidity 17, after treatment right, acidity 3	*Cotton oil, before treatment left, acidity 20,4 after treatment right, acidity 0.08.*

With help of titration the level of acidity can be determined.

Some staff members were trained to do the titration so they are able to check the JPO acidity in the future. If from time to time a JPO sample could be send to ASG for the full testing, then together with the regular titration for checking the acidity, the JPO quality can be guaranteed.

Even better would be to build up a small laboratory and attract a chemical engineer who could be trained at Diligent in Tanzania to execute the required for testing of the PPO on the standards as set in DIN V 51605.

Alternatively it could be explored if for instance the laboratory at Pemba hospital could undertake the tests for a fee.

3.3.3.3 Oil & Cake for other products as soap

Soap production

In July 2010 the first good bars of hard soap were made of the Jatropha oil, mixed with caustic soda and water. Further experimenting started with shapes, additives etc.

Figuur 2 Jatropha soap production at BBC.

In October 2010 Krishna Raghavan, who was giving technical assistance, went to Tanzania and visited amongst others Kakute, where he got much information about soap making and other products that can be made from the Jatropha oil like: shampoo, shower gel, handwash, disinfectant, mosquito repellant, bio-pesticide. A quotation to train BBC staff to set up a production line and small laboratory to produce these was given.

Compared with the soaps available at the local market, it seems that producing soap at BBC will be a profitable business. Farmers are also very interested in producing soap themselves and many have received training in soap making at BBC. Many business models can be envisioned. For example farmers could deliver Jatropha seeds to BBC and in return get some of the oil as well as caustic soda for their own soap making. BBC could then focus on producing a better (more pure and clean) soap targeting a higher priced market segments.

Other products

Fuel for Lamps, fertilizer, bio-pesticide, biogas,

The market survey revealed that the families living within QNP consume about 2 million litre of lamp oil per year. This means that if the BBC would produce 40,000 litres of PPO per year, this could contribute to 2% of the total market of lamp oil. There is one big constraint up to now; there are no lamps yet that can burn on PPO (except for the binga lamp, but that has its constraints as well. A number of different lamp designs were tried in Bilibiza, but they did not burn longer than a few minutes. The main problem is that the viscous PPO cannot easily been absorbed by the wick and cannot keep up with the flame. The challenge is to develop a lamp that is low cost and can burn on PPO.

The market survey indicated clearly that all the farmers were looking forward to increased production but none was willing to invest in fertilizer. The farmers also were not familiar with methods that could improve yields. In this regard, it would require a lot of effort to mobilize and convince the farmer in the use of press cake as organic manure. A market for press cake fertilizer (Bagaco) can therefore not be granted.

All Farmers Clubs members are using plants occurring in the environment, planted in between their crops, as a bio-pesticide. It is known from literature that mixing JPO with water can be sprayed as bio-pesticide on plants when plagues or pests occur. It has not been tested yet in the project.

The Jatropha presscake contains oil remains from which bio-gas can be produced with anaerobic digestion. With a conservative calculation it shows that the energy contents of the gas of 4 kg press cake is about 90% of the energy contents of 1 litre of oil.

Footnote: (5 kg of seeds give 1 liter of PPO (energy contents of PPO is 9,5 kWh/l). With the 4 kg of press cake about 4x0,4 m3 = 1,6 m3 biogas can be produced (energy contents 1,6 x 5,5 kWh/m3= 8,8 kWh).

A small Biogas system was set up at Evretz in Chimoio to demonstrate the working of a bio-gas unit. The feed stock was cowdung with cotton oil cake. The experiment was unfortunately not conducted well.

In Mozambique there is no tradition with biogas and also there is a cultural reluctance to collect dung, while cattle is roaming around dispersing the dung. An option that could be explored is to have the waste from the many students and staff at EPF directed into a digester that would also be fed with other waste materials. The cooking that is currently relying on firewood could then switch to biogas.

The Jatropha press cake can also be turned into briquettes that can substitute firewood. Due to uncertainty about the contents of the smoke it is currently only recommended to use Jatropha briquettes where people do not inhale the smoke. The large bakeries and some other industries in Pemba that currently rely on firewood are potential customers.

3.3.3.4 Edible products; sesame oil, Peanut butter

There are two edible oil crops produced in the area, but not on a large scale, namely sunflower and sesame. Both can be pressed and sold as edible oil for cooking. It has not been investigated yet if there is a market for these products. Sesame seeds (not oil) is often bought by dealers and sold to Japanese clients.

Groundnuts or peanuts, is a crop that is already cultivated in the area. There is however no industry in the region to produce peanut butter. After trials with the oil press it showed that it is very easy to make peanut butter, which was highly appreciated by those who got some samples. Since it is a very nutritious product, it could be a valuable product to increase health of the population in Cabo Delgado. During the start up of the bio-oil production, when there are not yet sufficient Jatropha seeds for full time production, the surplus time could be used

for making this peanut butter. If marketing is successful, even the set up of a separate factory for peanut butter could be considered.

3.3.3.5 Water technologies, lined wells and hand rope pumps

To be able to grow horticulture in the dry season, irrigation is required. The periods of rain are changing, possibly due to climate change. Even in the wet season there are now regularly extended periods with no rain. Therefore a reliable source of water, in or nearby the field is necessity. The way as practised up to now is that a well is dug by hand, and buckets are used to draw water from the open well. No horticulture was done in the dry season.

In the project, all 36 FC demonstration plots have now been provided with stable wells, equipped with hand rope pumps. Together with better seeds and some watering cans for irrigation by hand, these are the only investments in hardware given to the FC's.

The wells were lined out with concrete rings made by the water team of the project.

The staff at the BBC workshop was trained by Jan de Jongh to construct, install and maintain the low cost hand rope pumps (design from Nicaragua). Achieving quality was a problem but at present all 36 pumps are working and maintained.

Although some farmers have showed interest to have such a hand rope pump on their own field, no pumps have been installed yet at individual farms. If micro-credit could be arranged for purchasing a pump, there is certainly also a market for the hand rope pumps.

3.3.3.6 Car & motorbike maintenance

Since the cars, trucks and motorbikes wear out very fast due to the bad sandy roads and pot holes in the few tarmac roads much maintenance is needed. The nearest by garages for maintenance are in Pemba, more than 3 hours driving. Moreover they are very unreliable and sometimes replace parts with even worse parts. The experiences with hired mechanics at BBC were also not so positive in general since most of them in the end disappeared with theof money given to them to buy spare parts. Employing a good and reliable mechanic to do the car and motorbikes maintenance themselves would be a very good asset for BBC.

3.3.4 Development of a Training centre on Bio-fuels in Mozambique

The original target was: Setting up of Bio-fuel Training Center on bio-fuels in Mozambique

There are 3 main elements for establishing such a center:

1. Establishing workshop + accommodation buildings + equipment
2. Capacity building of TC head, TC teachers, and future experts-teachers
3. Development of "Training Centers for Rural Technologies",

The results are:

Re 1: Improving existing school building into center and mechanical workshop,

	
The BBC workshop building with generator house.	*Accommodation for trainees established into EPF accommodation building*

BBC Workshop Equipment:

- 2 presses, *Sayari press plus Double Elephant press*
- 3 stage Oil Filtration system consisting of:
  - Sedimentation tank
  - Frame (cloth) filter
  - Cartridge filters
- Storage drums
- Small room for titration etc.
- Store room, with spare parts etc.

	
Sayari press (forefront) plus Double Elephant press	*Frame (cloth) filter in use*

	
Feeding the double elephant press, green sedimentation tank in foreground	*Cleaning oil, through plate filter (on top) and candle filters (bleu)*

Transport
The first cab truck bought, worn out after 2 years,
A second one was bought

	
The second truck bougth a 3.5 ton	*The first cab truck bougth, Toyota High ace*

Re 2: Capacity building of TC head, TC teachers, and future experts-teachers

The methods followed were:

- Learning by doing, developing and giving training courses
- Learn from foreign experts, which have come to BBC to provide Technical Assistance
- Send the staff to specific training centres abroad, like Diligent and SHIPO Tanzania.

Re: Learning by doing, developing and giving training courses

From 14-26 September 2009 first 2 weeks training course on "***Jatropha cultivation"*** was successfully held. The course was positively evaluated by the 7 participants coming from various institutes and provinces in Mozambique. Presentations and exercises in class were developed and given by project leader Henderson Maposa, Flemming Nielsen and Jan de Jongh of FACT. More than 50% of the time the participants were involved in practical work, during which they jointly prepared a field and planted that with Jatropha seedlings. Practical

exercises, like pruning of the Jatropha plants around the center and germination tests were also done. Visits to existing farmers clubs were made as well. The presentations of the course are placed on FACT's website.

In 2010 the course was planned to be repeated at the same period in November. It did not take place however, due to lack of participants. Announcement for this course should have been much earlier and more marketing effort is needed.

	
September 2009 first 2 weeks training course on "Jatropha cultivation" *Field work was more than 50% of the time*	*Class presentations and exercises for the participants.*

For the development of a Technical Course on ***"Rural Technologies for Bio-fuels"***, to be held in future, already some participants from Mozambqiue and from BBC participated in the two events in Bilibiza during which Diesel engines were modified and also the NISSAN Car. In July and October 2010. Both external experts Niels Ansø and Krishna Raghavan did the training, with main topics:

a) production of Fuel grade Jatropha oil (pressing, filtration, neutralisation)

b) Conversion of Nissan engine to run on PPO

Re: Learn from foreign experts, which have come to BBC to provide Technical Assistance

Niels Ansø explaining and demonstrating to the course participants the modified generator set that is now able to run on plant oil.

Re Send the staff to specific training centres abroad, like Diligent and SHIPO Tanzania.

Re 3: Development of "Training Centers for Rural Technologies",

The first **"Training Center for Rural Technologies"** was developed in Bilibiza, with the BBC as the core center of activities. Initialy it was intended that BBC should only focus on the **Jatropha Cultivation** subjects and that a second "**Training center for Rural Technologies"** should be be established in Chimoio.

In Chimoio there are 2 institutions that were thought capable to form a centre together, namely:

1. **Evretz**, the farm of Brendon Evans, where Specific technologies related to biofuels are being installed, like a biogas tank system and a modified Feidong diesel engine undergoing a endurance test.
2. **EPF: T**here are workshops at EPF where various Affordable Technologies for rural development can be demonstrated and produced, like hand rope pumps. There is also a well established conference center at the EPF teacher training school, with sufficient accommodation for participants.

The idea was that the center would focus on technical subjects, like oil conversion and hand rope pumps for water supply.

	
The 1 m3 biogas system, installed in 2 days. The left feeding pipe still to be shortened, when the concrete at the bottom will have been hardened	*The Feidong diesel engine, modified to run on PPO , with heat exchange in the exhaust; ready to be connected with an alternator for an endurance test.*

At Evretz, the farm of Brendon Evans in Chimoio, a 1,000 litre biogas system has been built by Niels Ansø together with Jan de Jongh and Brendon Evans in October 2009. Further technologies in place are a Chinese Lister copy diesel engine (make: Feidong) which has been modified already and is undergoing an endurance test on cotton oil, and two oil presses which are used to press the cotton oil. They have been used for pressing Jatropha for the project too.

However, due to several causes, both Evretz and the EPF workshop did not perform according expectations and it was mutually agreed with these parties that it was better not to continue with development of a Training center for rural technologies.

Instead, also these type of technologies will also be concentrated in Bilibiza.

A small bio-diesel demonstration system was planned to be installed by Ger Groeneveld, in 2010, but did not take place.

3.3.5 ***Information in the form of training and informational material, stories of best practices on the communal energy self supply model made public through manuals pamphlets, internet, radio programme, video films and conferences.***

The pilot project in Bilibiza has become a learning model for people and organizations wanting to engage in biofuels with involvement of the local people in Mozambique. The project success stories have reached people from far and wide. The project was designed in such a way that it never affected any production of food crops. This coupled with the idea to plant Jatropha in a form of a fence around crop fields to keep wild animals from destroying food crops made the project gain tremendous support from the ministry of agriculture.

The district agricultural offices in each of the five districts have been organizing stakeholder meetings where the project model had been presented and applauded by all. Seminars and conferences have been held in Chimoio and Maputo where problems and successes have been shared with other stakeholders.

48 radio programs were recorded and aired in the languages of Macua, Kimuani, Maconde and Kiswahili. This resulted in an increase in the quantities of seeds coming to the BBC, as more people had been made aware of the existence of a market in Bilibiza.

Several TV programs were made of the project. The latest one was in November 2010 of the modified car in Maputo, which was broadcasted nationwide.

Story of best practice:
One outstanding example is a woman president of a FC in Pemba Metuge, who has raised US$ 3000 in one year, selling horticulture products, grown on her own field, on contract basis to a luxury hotel in Pemba.

	
Participants of one of the 4 Seminars organized by FACT-ADPP in Chimoio	*Picture of first lady visiting the project*

3.3.6 Large scale proposals developed and submitted together with governmental authorities to upscale and out scale this rural energy self supply model

The GAIA-Movement has developed a proposal to EU for a 3-years food security project in Cabinda, Angola, which has been approved. Farmers are assisted to use their forest resources sustainably and increase forest cover. One of the elements is to promote Jatropha and to set up model engines that use the dual fuel system.

Another proposal to EU for a 3-year food security project in Malawi has been developed by GAIA and also been approved. Several hundred self-help groups will be assisted to set up irrigated gardens and to plant Jatropha as live fencing as protection of the gardens. The GAIA-Movement has also submitted a proposal to Global Village Energy Partnership (GVEP) International for a continuation of the existing community development project involving the promotion of Jatropha and its use in stationary engines in Zambia.

A new EEP proposal has been approved. The main idea in this proposal is to use the Jatropha press cake as feedstock for biogas production for cooking and electricity. There shall be constructed one small and one big biogas digester at the ADPP center and a small digester at the health Clinique in Bilibiza

A new EU program has been approved for the Quissanga district, where solar panel centrals shall rent out chargeable lamps to the population in villages. One central shall have 50 lamps and the population pays a small amount for the use of a lamp for the night and return it next day for recharging. The central will be run as a business. The program will be carried out in

cooperation with ADPP and the Indian organization Teri which has experiences with the distribution and training of people in the use of this kind of lamps.
Other proposals submitted but not yet approved are:

To install generators running on Jatropha oil in villages where the national energy grid won´t reach. One proposal aims at using a generator to power en elephant fence around the farmers' fields and provide light for the village.

Training of farmers in Jatropha soap production so they can make their own soap. Planting of more Jatropha plants in the Chiure district.

3.3.7 Expansion of Jatropha production capacity building activities, in rural Mozambique providing training to farmers and others, Cabo Delgado & Nampula Provinces providing equipment, for processing, making soap and lamps

The expansion to three other provinces in Mozambique, Niassa, Itoculu and Macuse, was scheduled to start in 2008.

The provinces were selected because FCs are being created there by ADPP with the aid of an USDA program. [see workplan 2008] Niassa was later changed and replaced by Gorongosa in Sofala before the start of implementation due to environmental and climatic conditions that are more favourable to Jatropha in Gorongosa as opposed to Niassa.

The status per December 2010 as reported by Jacob Zulu was:

Itoculo. Large problems with Jatropha cultivation. It happened three times already that after planting and seeds germinated, they died, either by drought or flooding. Combination of soil and climate conditions are not good for Jatropha in Itoculo. Since no plants are left, it was mutually agreed to stop with Jatropha in Itoculo.

Macuse/Macuba: about 4000 plants are doing well. At the end of this year they will have seeds to be pressed. However, the Macuse FC project will stop this year and the trained extension worker Zeca is out of work, and no one is going to continue with the Jatropha However, it is worth noting that both in Mocuba and Macuse the Jatropha plants have started bearing seed now and in a months or two the farmers will have their first harvest.

Sofala Gorongoza, Because the drought from December 2009 to January 2010 happened just after sowing, most Jatropha plants died, New plants have been planted in February 2010 and are growing now to a height of about 0,5 m. It will take another two years before seeds can be harvested. Since there is a press at Gorongoza, with Environtrade, which they can borrow, there is no need for a press from the project. [Jacob Zulu in mission report JJ 2010]

The FC program ended in 2010 but ADPP has secured another funding for the next three years for the project in Gorongosa that will also cover the neighbouring district of Maringue, this is good news as it means that the Jatropha element will continue in Gorongosa and also in Maringue. As the plants in Gorongosa are less than a year old, it is estimated that seeds could only start being produced sometime early 2012.

3.3.8 *Coordination Exchange project experience between Honduras and Mozambique*

The "exchange of knowledge" project component was meant for exchanging the knowledge developed in each of the three FACT pilot projects with the project teams of the other pilot projects.

This form of "horizontal learning" has contributed significantly to good developments and innovations within the three projects. The built up knowledge by the various project staff, coordinators and experts involved has been either directly transferred or written down in

several presentations and reports, with the new version of the Jatropha Handbook (2009) in English, Spanish and Portuguese as the culmination. The following activities of the FACT team members and experts were executed in 2008:

One mission was made to Tanzania by Jan de Jongh, in combination with a visit to the FACT pilot project in Mozambique in June 2008. The International Seminar of COMPETE was attended and for several day were spent visiting Diligent, Tanzania and Jatropha fields around Arusha. The experience gained was used to develop an overview of the necessary equipment for the new Workshop for the Bilibiza Biofuel Center (BBC) in the Mozambique project.

A technical expert meeting on knowledge exchange between Mali, Mozambique, Honduras and Tanzania, was organised by STRO in Utrecht on 24th of Sept. 2008. For this meeting experts involved in FACT projects in Mozambique, Honduras and Mali were invited and made presentations about: oil presses, biodiesel, oil producing and refining equipment, modification of cars on PPO ,etc.

Several experts have worked in the Honduras Gota Verde project and the knowledge and outputs obtained were also used in either the Mali or the Mozambique project, to mention: the modification of diesels and cars by Ger Groeneveld and Niels Anso.

Towards the end of 2010 a Conference about the Gota Verde project was planned by Zamorano in Honduras, but due to political upheaval, the conference was canceled.

International Seminar in Maputo Sept 2008

3.4 Organization

FACT

FACT will coordinate the project and take the lead in disseminating and exchanging the gathered knowledge, expertise and information. In the current project FACT has laid the total coordination and overall management in hands of Jan de Jongh of Arrakis, who is an associate of FACT. Arrakis will in turn work jointly with the local partners: in Mozambique with the main partner Ajuda de Desenvolvimento de Povo para Povo (ADPP), an organization under the Humana People to People organization, and with IIAM-FNR Research (Flemming Nielsen-Bananahill). A third partner involved was GAIA-Movement (Christian Fenger), an NGO working

in close relation with Humana especially in sub Sahara Africa. GAIA was one of the first to start with Jatropha cultivation for use as PPO, in Zambia and Mozambique.

FACT-Arrakis primary role in this project was:

- To execute project and financial management;
- To carry out monitoring and evaluation;
- To provide the required experts for training on agricultural and technical aspects (oil pressing and conversion of diesel engines);
- To select and procure the required hardware (typically the oil presses and conversion kits for the engines);
- To support the market development component;
- To coordinate and monitor the research components;
- To collaborate with information processing and promotion;
- To actively follow-up the upscaling phase.

Ajuda de Desenvolvimento de Povo para Povo (ADPP)

ADPP is a non-governmental organisation for development and has been active in eight African countries, including Mozambique, for approx. 25 years. ADDP operates under the umbrella of Humana People to People, an institution which is active worldwide with member organisations such as ADPP. Financial resources are obtained from the collection of used clothing, but also from numerous partners.

ADPP has acquired a strong position in Mozambique as a result of its Teacher Training Colleges programme (Escolas de Professores do Futuro, EPFs). The colleges are commonly started up for a number of years by people with experience in education who are highly dedicated to this task. When sufficient capacity has been developed with local staff, they take over the direction. Although the EPFs are supported by the Ministry of Education, which pays the salaries of the teachers, they are partly self-supporting, which is an important element of the programme. They achieve this by establishing small companies linked to the school, such as a carpentry workshop to produce school furniture in Bilibiza, corn mills, etcetera. The school staff supports the enterprises by contracting them.

ADPP combines knowledge transfer and education with the practical application thereof and has projects throughout the country. E.g. in the EPF programme the curriculum has been extended with methodologies and techniques acquired through ongoing projects, such as for water supply; the schools obtain a pump and training on irrigation and crop production for self-supply.

<u>ADPP's primary role in this project was:</u>

- To support the "farmer clubs" which were created by ADPP.
- To mobilise the farmers to plant Jatropha and provide support to them by giving training, extend seeds, hand pumps and lined wells. Therefore, ADPP´s "community workers" frequently visited the farmers;
- To support market development for bio-oil, ADPP needed to select the owners of diesel engines who are willing to adapt them to plant oil.

4 MAIN RESULTS

The donors of this project HIVOS, DOEN and Solidaridad mentioned the following indicators for the results of the project:

Number of beneficiaries; Acreage covered, hectares of Jatropha planted; Number of diesel engines adapted; Volume of PPO produced; CO_2 savings (in tons per year); Scaling up with new projects (per country)

4.1 Number of beneficiaries

The exact number of beneficiaries are not known, but the maximum possible is 36 Farmers clubs of 50 farmers each = 1800 farmers, plus staff at BBC.

4.2 Acreage covered with Jatropha, nr of ha planted

Most of the 600.000 Jatropha plants have been planted in hedges around farmers' fields. With 1,000 plants per ha, this gives an acreage equivalent of 600 ha.

4.3 Nr of diesel engines adapted

Two diesel engines were modified and are running on PPO at BBC, still as an endurance test run, but used for real applications, a generator and a maize mill. Two more diesels have been modified for endurance tests; One in the Netherlands and One in Chimoio.

One project car, a NISSAN 4Wd has been modified to run on PPO.

4.4 Volume of PPO produced

In 2009 some 100 litre, and in 2010 some 200 litre, but the amount in 2010 could have been much higher, because an estimated 10 tons of seeds have been bought directly from the farmers by Tanzanian companies for planting seeds at a high price (1 US$/kg)

4.5 CO2 savings (tons per year)

The JPO replaces diesel. To assess the CO2 savings resulting from substituting diesel with JPO it is necessary to estimate both the diesel that is being displaced as well as the carbon expenses involved in the production of Jatropha. As explained in the following a number of factors like transport fuel costs are of the same size whether diesel of JPO is used and can therefore be omitted from the calculations.

The current area planted with Jatropha is the equivalent of 600 ha. It is expected that at maturity the yield will be 800 kg/ha, resulting in a total production of 480 t/y of dry Jatropha seeds. 96,000 l JPO can be extracted from the seeds. The weight of 96,000 l JPO is 88 t.

JPO has an energy density of 39.5 MJ/kg and diesel 48 MJ/kg so 96,000 l JPO can substitute 79,000 l diesel. The weight of 79,000 l diesel is 66 t.

The diesel that is being displaced is currently obtained in Pemba and transported on mini busses and old pick-up trucks. The pick-up trucks can typically load 1 t. The truck used by BBC carries 4 t. The fuel consumption of the pick-up trucks is estimated to be 1 l per 8 km.

Through the use of GIS, modelling and custom made transport planning software it was found that the BBC truck has to drive 16,760 km/y to collect the 480 t, which

consumes 3,258 l diesel.

To transport the equivalent amount of diesel, i.e. 66 t from Pemba to Bilibiza using the local pick-up trucks requires 66 trips of a total of 13,200 km (counting only one-way because the cost of the return trip is paid for by transporting other goods). This results in a fuel consumption of 1650 l diesel. Using JPO instead of diesel therefore requires 1,600 l/y extra diesel for transport. This is equivalent to 1,945 l JPO or 2.1 t JPO.

Another factor to consider is the effect of Jatropha cultivation on the carbon balance in the fields. Research undertaken in collaboration with University of Copenhagen found that if forest is cleared to give place for Jatropha then large amounts of carbon is lost. However, farmers are not clearing forest to plant Jatropha but instead replace existing hedges with Jatropha.

The long term carbon build up under Jatropha hedges is probably similar to what would occur if the hedges still consisted of common local woody species. However, export of nutrients through harvesting of Jatropha needs to be considered:

The traditional hedges are pruned for firewood and plants like chilli and medicinals are harvested in small qualities. Jatropha is harvested too but due to the low utility value of the wood the prunings are mostly left in situ. The harvesting of seeds will probably at maturity represent a larger drain of nutrients than the harvesting from traditional hedges and this could with time lead to slower soil carbon build up under Jatropha compared to traditional hedges. However, this is counteracted by the use of Jatropha press cake as manure which returns most of the nutrients and carbon to the fields. In practise the press cake will often not be applied on Jatropha hedges but in higher value crops. This does, however, not affect the balance at the farming system level. Overall it is therefore reasonable to assume that there is no net effect on the soil carbon balance from the cultivation of Jatropha with the current practise. The effect on soil carbon can therefore be omitted from the calculations.

Also farmers are not using any fertiliser, manure or pesticide for the Jatropha, so these factors can be omitted too.

It takes energy to extract and process the Jatropha oil. The Sayari press can process 70 kg Jatropha seeds per hour into 14 l JPO. The generator powering the press consumes about 1 litre diesel per hour. JPO has an energy density of 39.5 MJ/kg and diesel 48 MJ/kg so 1 l diesel can be substituted by 1.2 l JPO. In other words 8.6% of the expelled oil is used for processing so the annual JPO production of 96 t, 87.7 t will be available. Deducting the 1.2 t JPO to cover the extra transport needs 86.5 t are left to substitute diesel consumption. In terms of energy content that is equivalent to 71 t diesel.

Green House Gas savings are measured in Carbon Dioxide Equivalent (CO_2e). According to DEFRA (2010) one t diesel is equal to 3.2 t CO_2e. The 71 t diesel that is being substituted by the project at full production is therefore equal to 227 tCO_2e/y.

It can be questioned if it is reasonable to use fossil fuel in Pemba as a benchmark. By doing so the energy used to extract the fossil fuel, refining it and transporting it to Pemba is omitted. If that was included the CO_2e savings calculated for the project would be significantly higher.

4.6 Scaling up with new project (per country)

In Mozambique, it has not been scaled up yet, although the farmers of the clubs are increasing the number of Jatropha plants (Flemming, Nov 2010) and more clubs are being developed.

5 ECONOMY

Since PPO produced has to compete with fossil diesel fuel, the sales price of the PPO has to vary with fossil fuel price and has to stay below it in order to make it attractive to users. The prices of fossil fuel have varied enormously over the years during the project execution. It is therefore hard to say if the overall economics of the BBC unit is viable over the years to come or not.

A positive point is that the project area is very remote, fossil fuel prices are locally much higher (about 30%) than in neighbouring cities. Furthermore the government is removing subsidies to fossil fuel.

All cost items added up in the chain to produce PPO determine the total costs to produce the PPO. The price to be paid for the seeds makes up a large proportion of these costs. Negotiations with the farmers will determine the actual price to pay, but the prevailing fossil fuel prices will determine if PPO can be produced with profit.

Based on the business plan that has been developed, the following cost price calculations can be made:

First the case with 2.5 MT/kg seed gave a total cost price of 1 liter of PPO of USD 1.08, if the BBC would operate on full production. The sales price has to add profit or risk.

At present farmers tend to accept only 5 MZN or more. The second case with a seed purchase price of 5 MT/kg gives a cost price of USD 1.52/liter PPO. At the moment this is too high too make the BBC economically viable to produce PPO alone. However when production of soap, bio-pesticides, and press cake fertilizer is taken up in the business calculations, the combination of all products will make BBC a viable business.

Two cases for cost price calculation of PPO			
		Case 1 : Seed price 2.5 MT/kg	**Case 2: seed price 5 MT/kg**
Cost item	**Assumptions**	**Cost/liter PPO**	**Cost /liter PPO**
Purchase of seeds	4.5 kg seeds needed to press 1 litre of PPO	11.25	22.50
Transport	Seeds collected by own truck	8	9
salaries	Only part time	8	8
processing	PPO used to drive engines for press	3	4
Other costs		2	2
Subtotal		32.25	45.50
TAX 17 % VAT		5.48	7.74
Total cost		37.72	53.24
In USD		**1.08**	**1.52**

6 MAIN OBSTACLES ENCOUNTERED AND MEASURES TAKEN

6.1 Short project duration

The original project duration was 3 years but this soon turned out to be unrealistic. for various reasons: For instance it takes at least 3 years before the Jatropha plants yield significant amounts of seeds and pressing and refining can start.

A number of logistic issues, like obtaining building permits, importing equipment from abroad etc, took much longer than anticipated. Therefore the project was extended with 1 year to 4 years duration, which in the end proved still to be too short. The budget was not increased.

6.2 Communication

Communication has been cumbersome during the whole project. Making telephone calls from Bilibiza is very difficult. While internet came in 2007, it is often off line and very slow. Often weeks would pass without any possibility of communication between FACT and the field staff.

Transfer of funds from ADPP Head Quarters (HQ) Maputo to the project was not always on time, mostly due to communication problems between the project staff and HQ. This has been improved however over the years, but is contributed somewhat to delays in project implementation.

In the beginning of the project there were some difficulties with the local authorities, but these were resolved by giving them proper information and involve them in meetings. Finally they became so enthusiastic about the project results that they started to donate, like bags of Urea, a motor pump etc.

6.3Turn over of staff and personnel in Bilibiza

Since the project area is quite remote and underdeveloped, little infrastructure, poor roads, no shops, no electric grid, no leisure possibilities, etc. It is hard to find educated and experienced people to work in the area. Since the Humana organizations like ADPP have a large staff in many countries, it was possible for them to find good Project leaders, but only in the second year 2008. The first two project leaders in 2007 left, and were followed up by the main project leader from Malawi, and a local project leader from Bilibiza. This team worked very well together and made the present result possible. The locally found (end 2008) project manager for the BBC however did not perform as expected and it took again untill Sept 2010 to find a better BBC manager (from Zimbabwe). This person has off course little experience with the project and in 2011 the main project leader will return to Malawi, so the whole projects is in hands of the new Zimbwe project leader.

6.4Lack of technical knowledge and infrastructure

Both staff members of ADPP and FACT project coordinator Mozambique went visiting and/or received training in Tanzania, Diligent plus Vuyahumu trust (producer of Sayari oil press, which was bought from them). Two ADPP staff members were sent to a training in Tanzania (with SHIPO) for water technologies and business development. Exchange of knowledge with project Gota Verde in Honduras took place.

Still a new team of 2 persons (Itai +?)need to be trained at Diligent for 2 weeks.

Furthermore training on the spot was given by FACT staff members and partners (Jan de Jongh, Flemming Nielsen, Christian Fenger) during their missions, and specialised training was given in topics as diesel engines + car modification (Niels Ansø), building up oil processing equipment (by Krishna Raghavan), and Jatropha production (by Flemming Nielsen).

6.5 Market distortion

Throughout the project their were rumours of other parties buying Jatropha seeds for higher prices. In 2010, when the project exptected around 10 tons of seeds, the project collected no more than about 1 ton.

Jacob Zulu reported:

"The seeds have been there in the community, but there is tough competition when it comes to buying. Buyers from Tanzania paid Nearly 1 $/kg and bought up nearly all seeds.

There are traders from Tanzania who have been buying the seeds at 40 MZN per kg, and they need about 20 tons. You see they sent an email to me asking me to sell them 20 tons of Jatropha seed, I told them we did not have as the little we had was to use in the fabrica in Bilibiza, so they disguised themselves and went to Bilibiza like partners who wanted to learn more about the program and see how they could support. They were told were our farmers are and were we expect more seed, so they went out there and told the farmers they wanted to buy the seed and gave the offer of 40MZN per kg. They probably have bought more than 10 tons.That kicks us totally out of competition when we are getting the seed between 2.5 and 5 MZN. The farmer does not sell to us but prefer to get a higher value for the seed, and we can not pay that much unless we are say we shut down the fabrica."

This event also severly hampered the progress of the developing and testing out of the processing facilities. There were too little seed to run the workshop and tune processing, pressing, sedimentation and filtering. Plus not enough oil to make more soap and PPO, and start to set it out in the market.

7 IMPLEMENTATION PROCESS

7.1 Effectiveness & efficiency

The implementation process was effective in the sense that everything is in place to start producing PPO and use it in diesel engines and one car from the next season on in 2011.

This was one of the three first pilot projects of FACT and partners in focusing on bio-fuels from Jatropha for use as PPO in diesel engines. Little was known about this topic before the projects. Knowledge had to be acquired by experimenting under difficult conditions, which increased the project duration. Also the main obstacles mentioned before in section 5 led to less effectiveness and efficiency. The result was very much extra work for the project coordinator Jan de Jongh and also for the Jatropha research coordinator Flemming Nielsen, as well as for the project leaders in Bilibiza, especially Henderson Maposa.

A flaw in the system of ADPP is that when staff left and were replaced by new staff, knowledge gained by the leaving staff member was not transferred to the newcomer.

E.g. the new extension workers were not trained enough in pruning. This led to the situation that in November 2010 nearly all the farmers had pruned there Jatropha bushes, too far back (at knee height above the ground, while they should have been pruned at shoulder height, due to the age and size of the plants. This will give a set back in the amount of Jatropha produced in 2011. [reported by Flemming Nielsen]

Communication has been a problem in the smooth cooperation between the project and ADPP HQ. As there is very limited cellphone coverage in Bilibiza, and electricity supply by generator has been scarce it was difficult to have an ongoing contact between the project and ADPP HQ. The people of EPF taking care of the internet, did not always switch it on. The other cause is that ADPP staff members from HQ did not often visit the project and had insufficient insight in what was happening on the ground.

This has caused mistakes and delays in the development of the project.

ADPP staff members had no prior knowledge of Bio fuel, therefore the technical part of the bio fuel centre could not be adequately supported by ADPP and comprehensive Technical Assistance from experts from abroad had to be provided.

Sustainability

7.2

There is an ownership of the farmers regarding the Jatropha plants, which they consider as giving additional income and not a cash crop. This is supported by the fact that they continue to plant more Jatropha on their own initiative. ADPP has shown its ownership with BBC, but linking the BBC to the FC's, by making them share holders has not been established yet.

With the present scale of Jatropha plants, surrounding cash crop fields in hedges, it can be said that it is agricultural technical viable in Cabo Delgado. The experiments in the other porovinces showed however that Jatropha is not suitable everywhere and that there are unique factors that contribute to success in the project area.

The question if BBC can become a viable and profitable business is hard to answer at this moment. Major constraints are that there are no sufficiently educated and experienced technicians around to be hired for the BBC. In general there are no real entrepreneurs around, the general approach is too much a project approach (now and then a project and only work when there is a project). Therefore people with potential entrepreneural capacities do not see role models in the area, nor have the chance to develop it in practice.

Moreover, the market for all products has still to be developed from scratch and although there is a definite need for most products, it will require considerable marketing.

Also the applications like modified diesel engines have not been fully tested yet and the quality of the oil to use for PPO still requires carefull attention/ The technical viablity is theefore not fully proven yet.

Lessons learned from Diligent [Janske van Eijck] plus project lessons learned are that it takes at least 4 years to establish a beginning quality level processing unit, operating at low capacity level, but first estimates of the viability of the business are possible after 4 years of operation. The long term data on Jatropha growth also shows that full production can first be expected after about seven years. Thus it takes in total probably eight years before business viability can be proven.

7.3 extension and replicability

Regarding time to Up-Scale to new projects it can be concluded that there are still too many unknowns to recommend significant up-scaling at this time.

It is however very worthwile to continue to improve the existing projects with innovative solutions in order to increase viability and to generate more knowledge and insights. See also the next chapter on Recommendations

8 LESSONS LEARNT

- Implementing through an organisation that is well established on the ground, that has already earned the confidence of the communities and that is experienced in community mobilisation has proved crucial to the success of the project. The project partner, ADPP had before the project started extensive experience in working with Farmers' Clubs. These clubs were used to introduce Jatropha into the communities. In the project area in Mozambique, Cabo Delgado, where 'slash and burn' shifting cultivation agriculture is practiced, the Farmers Clubs, with its typical organisation as introduced by the project partner ADPP, proved to be the most important actors in the project; their role is crucial.

- Choosing the location of the project partly on thorough observations of the performance of Jatropha at different localities proved wise. Research undertaken after the project started has confirmed that Cabo Delgado has the lowest pest pressure in the country.

- Providing benefits to farmers upfront has ensured a high level of acceptance by the farmers. One of the most important reasons why the subsistent farmers in this project are willing to grow Jatropha, which gives income earliest after 2 years, is the integrated Farmers Clubs approach by ADPP (as introduced by Humana in a number of surrounding countries). It includes bringing knowledge to the farmers and some investments, instead of money. Knowledge of conservation farming, whereby vegetables are raised, for own use, but also for selling. The demonstration fields of the FC's are provided with a lined water well, with a hand rope pump and with some water cans and seeds of Jatropha and vegetables. In exchange for these tools, they promise to raise and plant a certain number of Jatropha plants. It is very important that the project leaders and extensionists visiting the farmers regularly to train them, speak the local language.

- Developing the oil processing unit also requires an industrial approach. Guaranteeing the PPO quality is already a challenge in itself. To develop a commercial operating business, with cooperation with the farmers (most probably as legal shareholders in the future as well), is also a major challenge, which cannot be achieved overnight.

- The combination of food crops and Jatropha is a "conditio sine qua non" for smallholder farmers, in order to maintain their fields against fire and animals. By placing Jatropha fences around their fields with vegetables, tight fences (with short plant distances) keep (theoretically)the animals out, while the food crops ensure field maintenance also in the first years when Jatropha is not yet giving yield. The practice in the FACT project is however that plant distance in the fences is around 1 m or more which is not enough to keep the animals out. The reason why the farmers have planted the Jatropha plants and maintained them the first two years is because they see the result (increased income from sales of vegetables they have raised, and therefore are willing to follow up on the target of the ADPP project team, which had good motivation capabilities. From the second year on, the project team started to buy Jatropha seeds from the farmers as well.

- Project duration of three years is generally too short. To obtain sufficient harvest the project should preferably cover a minimum of four years.

- The technology part of using PPO for diesel engines of stationary engines and for cars is highly underestimated. From the tests done in the programme (two endurance tests in the Netherlands, one in Chimoio and now one started in Bilibiza) it became clear that due to the variety in types of diesel engines plus the unavailability of good quality material for conversion, the idea of developing a universal applicable modification kit is practically untenable. However importing of reasonable low cost kits from Europe might still be a possibility. Secondly, the quality control of the PPO still needs to be developed in Mozambique. The first PPO produced in Bilibiza, was tested in Germany and it was found that it had far too high acidity number (7 instead of max 2). This will ruin the engine in a short time. Although the high acidity can be neutralized with a treatment with caustic soda and water, it is better to use non chemical treated plant oil, i.e. only pressing, sedimentation and filtering to be done. Then laboratory equipment and capacity building is required for testing of the PPO on the standards as set in DIN 51605.

- The quality of oil is to be controlled during the whole production chain, from soil preparation to oil storage and distribution, while there are still unknowns to be solved. For example: up to now it was said that harvesting green unripe seeds would result in too high phosphor contents, bad for diesel engines, but samples taken recently from yellow seeds in Mali showed that these seeds had the worst acidity level. Storage in galvanised tanks leads to creation of polymers, blocking fuel filters.

- The agricultural research component of the project has been important in addressing the needs for knowledge on issues like seed pre-treatment, pests, pruning etc. Important trials on varieties and improved hedges have been established but it will take several years for them to yield useful results. The national knowledge base has been strengthened as several students have based their thesis on research done with the project. An active research network involving Mozambican and European researchers has been established and will likely have a long-term positive impact.

- In the course of implementing the project we have become aware of two major problems that threatens the long term viability of not only the project but of the communities in the area. Deforestation, even in Quirimbas park , is going on at a very high rate. This fact, combined with lack of measures in water conservation, like dams in rivers, etc, is making water scarcity a real problem, which will worsen over the years. The government considers the project area as not valid for drilling wells, since the water is saline. This could mean that complete villages might have to move to other places, making the pressure on water even higher. This problem could greatly reduce results of development efforts. Sem Água não há Futuro! Water and elephants remains a problem in the area, requiring more training of farmers and investigation into solutions.

9 CONCLUSIONS

The overall goal was to test if Jatropha can be used for local development. Currently a "proto-type" value chain is in place. All problems ranging from seed pre-treatment at one end to the effect of using JPO in diesel engines has been researched and where problems have occurred solutions have in most cases been found. The chain works technically but is fragile. It looks as if it can be both profitable to the farmers and to the processing plant (BBC) but it will take at least a few years before firm conclusions on this can be reached.

The specific purpose of the project: to develop a local market for Jatropha, has not been achieved within this period, but the possibility to do so is still realistic. The developed business plan from which more and more assumed variables are checked against reality (and are in conformity) indicates that it is possible to set up a business with Jatropha for oil and other products like soap. A fully equipped workshop for producing PPO has been established and is ready for operation, while sufficient Jatropha plants are growing. The main partner ADPP has committed itself to continue and has developed proposals for continuation.

From the components for the market development the following has been achieved:

Jatropha cultivation by small hold farmers: over 600.000 living Jatropha plants have been established by 36 Farmers Clubs of 50 farmer each in the area of ca 75x100 km.. Which by far exceeds the minimum project target of 250.000 The plants are mostly placed in hedges around their fields with the crops such as maize and casave

During the project the Jatropha seeds were bought from them for 5 MZN /kg . However to make the business profitable only from selling oil from Jatropha as PPO for diesel replacement viable, the maximum allowable price should be 2,5 MZN /kg (see calculations). If more valuable products like soap are produced and the press cake is utilised too then a higher price can be paid.

Jatropha production in extension provinces:

From the small scale trials in the three other provinces it can be concluded that Jatropha cannot be grown everywhere. It is dependent on a number of factors, to start with soil and climatologic characteristics. The second lesson is that a project should be large enough to include longer term (at least 4 years) project management and all elements to develop a local market.

Pests

The quick survey of pests carried out at the beginning of the project showed that there were severe pest problems in Manica Province. In Cabo Delgado Province where the project is located few problems were found and a later in depth study undertaken with UEM confirmed that Cabo Delgodo is the place in Mozambique with the lowest pest pressure. Till today no serious pest problems have emerged in the project area. Occasionally the golden flee beetle and termites cause minor damage.

Farmers do not undertake any pest management. Intercropping, dispersed settlements, poor infrastructure and reliance on own seed sources together with the good growing conditions give some insurance against pest problems.

However, any crop that is suddenly cultivated on a much larger scale sooner or later experience pest problems. Therefore research was undertaken on simple control methods of the major pests in Jatropha with UEM. As of today we have not heard back from UEM about

the results and are therefore not able to report on them. When the results are made available by UEM they will be posted on the projects website.

Research

The extensive research undertaken as part of this project has contributed significantly to the knowledge base both within the country and internationally. The results have been shared widely through courses, reports and presentations at conferences. The research program has been much more comprehensive than anticipated because new issues emerged as the project developed. An example is the research on carbon and energy balance. The expansion of the research program happened without exceeding the budget due to collaboration with and contributions by a number of other interested parties. Among them Danida and Wageningen University paid directly for travel expenses and other logistic costs.

Developing an oil producing workshop.

Building plus processing equipment has been established.

Capacity building of staff has been done, but much turnover of personel, only 1 trained manager left, who joined the project in September 2010. (Itai)

First production of oil end 2009, about 100 litre. Oil quality was too poor to be used for diesel engines (tested at ASG in Germany)

Building up quality control: a number of staff (3) were trained in titration to determine the acidity of the oil.

Conclusion: The workshop is equipped and ready for production, staff is however very small, and they have not been experienced in all facets of such a business. They need more training to run BBC as a business.

I**nvestigating market**

The needs for PPO, lamp oil, soap and fertilizer have been established. A business plan for the BBC has been made and it conclude that it should be possible to develop a market for PPO and soap, and maybe for fertilizer. If low cost lamps can be developed that work on PPO then there is also a big market for lamp oil .

Development of modification kits for diesels + endurance tests

2 Diesel engines were modified and are running on PPO at BBC.

2 more diesels had been modified for endurance tests.,1 in Netherlands and 1 in Chimoio.

1 car NISSAN 4Wd modified to run on PPO.

Endurance tests not long enough yet, need longer testing.

Some BBC staff; Itai and 2-3 others, plus 2 electricians from Pemba were trained to modify the diesels and the car

Soap production

Good bars of hard soap were made of the Jatropha oil, mixed with caustic soda and water. Further experimenting started with shapes, additives etc.

Compared with the soaps available at the local market, it seems that producing soap at BBC will be a profitable business. Other products are also possible, like shampoo, shower gel, handwash, disinfectant, mosquito repellant, bio-pesticide, but for this training from Tanzanian experts is required.

Other products

Lamps, fertilizer, bio-pesticide, biogas,

There is great need for cheaper lamp oil, soap and fertilizer. According to the business plan made for the BBC for PPO, it should also be possible and recommendable to develop a market for soap, maybe for fertilizer and if low cost lamps can be developed that work on PPO also for lamp oil there is a big market.

Edible products; sesame oil, Peanut butter

Two edible oil crops produced in the area on a small scale, namely sunflower and sesame, can be pressed and sold as edible oil for cooking. It has not been investigated yet if BBC can compete with other producers in the existing large market for these products

Groundnuts or peanuts, is a crop that is already cultivated in the area and there is no industry yet in the region to produce peanut butter. After trials with the oil press it showed that it is very easy to make peanut butter, which is a valuable product to increase health of the population in Cabo Delgado. If marketing is successful, even the set up of a separate factory for peanut butter could be considered.

Water technologies, lined wells and hand rope pumps

All 36 FC demonstration plots have now been provided with stable wells, equipped with hand rope pumps. Therewith a reliable water source has been established, making the Farmers more resilient to irregular rain patterns.

The staff of BBC has sufficiently been trained to produce, install and maintain the pumps. If the staff could assist the farmers to apply for micro-credits for purchasing a pump, there is certainly a market for the hand rope pumps.

Car & motorbike maintenance

Since the cars, trucks and motorbikes wear out very fast due to the bad sandy roads and pot holes in the few tarmac roads much maintenance is needed. Finding a good and reliable mechanic to do the car and motorbikes maintenance at BBC would be a very good asset.

Training courses,

With the available practical knowledge in various topics, which are quite new for Mozambique, like Jatropha cultivation, PPO production, diesel engine modification, construction of low cost handrope pumps and line wells, the establishing of farmers clubs with introduction of conservation farming, etc. The BBC center can offer a range of practical training courses. The accommodation and demonstration fields and equipment plus good workshops are in place.

Experience was gained by running already a one 2 weeks course on Jatropha Cultivation, with paid fees. The second planned course however did not come through. When better and earlier information about the courses will be distributed and lobbying for funding is pursued in SADC countries, these courses could certainly be a source of income generation.

10 recommendations

10.1 productive use of press cake

From an economical point of view it is clear that the press cake should be used to raise income as well. Therefore the needs in the project region should be studied and the following suggestions could be considered.

Extend with developing various small businesses, using the Jatropha cake, e.g. for briquetting, both for supplying larger institutes like hotels and small industrial boilers. However, there is

not much experience which briquetting of Jatropha yet. It would be good to bring in some different briquetting machines and start practicing with it to find out the best machines.

Use Jatropha cake for producing charcoal for cities, in areas around towns where trees have nearly been cleared, e.g around Maputo, Pemba, etc.

The advantage of briquetting is that the oil in the cake is preserved and adds to the energy content of the briquettes, while the charcoal made from the cake, probably has lost its oil contents during the process of charcoal making, only leaving the energy contents of the remaining fibre contents.

Diligent in Arusha, Tanzania has some experience with these technologies, see FACT Jatropha Handbook, Chapter 5.

10.2 Establish regional pressing centers

Since transport costs of collecting seeds from far and bring it to a central processing unit lay a heavy burden on the profitability of the oil processing unit, the following potential solution could be build in successive project extensions:

Expand number and areas with Farmers Clubs (FC's) to include Jatropha. Instead of establishing an industrial level oil processing workshop, like BBC, establish regional pressing centers, within clusters of FC';s , so that transport of Jatropha seeds can be done by farmers themselves (on bicycles or animal driven transport).

These units should be of simple layout with one diesel driven press (if no electricity is available), with only a roof. The idea is to fill up barrels with crude oil and have the drums being collected by the BBC centre, where the crude oil can be purified.

If it goes well, as a next step all conditions should be studied, in a feasibility study, if other industrial units similar to BBC can be established as well to produce PPO of good quality for diesel engines, that can buy the crude oil from the regional presses.

10.3 Biogas and electricity with gas engines.

Another option is to use the Jatropha cake, together with manure of cattle or humans to produce biogas for institutes or households.

If sufficient load is present, like for institutions, gas or diesel engines can be applied to produce electricity. Also gasoline car engines could be used. But with standalone diesel engines with variable load maybe max. 50% biogas blend can be reached.

10.4 Improving Jatropha cultivation and harvesting

It should be considered to extend the Jatropha plantation around BBC, to become somewhat more independent of the irreguar supply of the farmers.

Allmost all the time used by farmers on Jatropha is for harvesting. About half of that time is for de-shelling by hand. Transfering of knowledge of producing and making of low cost seed de-huller (from Gota Verde) should be considered**.**

10.5 Diversification in products & services, analogy with food and fuel production

For the oil processing plant BBC, expansion to other agricultural products could be investigated and included. E.g pressing groundnuts and sesame (with the second press specially dedicated for this), and produce cooking oil for local use.

Commercial production of peanut butter is already being tested and looks promissing.

Another line of development is to let BBC operate as a dealer of the staple food of the farmers of the FC's, i.e. maize. They have the truck and some storage for this already. Working capital is needed for this.

Similar activities are already done by Gapi in Chimoio, with registered Farmers Associations. Of the 36 FC's of the FACT project, 10 have already been officially registered.

11 REFERENCES

[1] ADPP, *Household Survey data*. 2007.

[2] ADPP, *Relatório da Visita do Ministério de Energia Novas e Renovaveis*. 2009.

[3] ADPP, *Jatropha counts 2008-2009-2010*. 2010.

[4] ADPP, "Clubes de Agricultures de ADPP em Mocambique," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/seminar-maputo-2010/Presentation_ADPPCaboDelgado.pdf?attredirects=0&d=1.

[5] T. Adriaans, *Duurtesten met minimaal omgebouwde DI motoren op PPO*. Ingeia, 2008, p. 2.

[6] T. Adriaans and J. de Jongh, *Experiences with Jatropha oil conversion technologies, Mali, Mozambique, Honduras and Tanzania*. FACT, 2008, p. 12.

[7] B. Afonso, "ADPP Clubes de Produtores Agricola, Cabo Delgado," Nov-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_Bachir_Farmer_Clubs.pdf?attredirects=0&d=1.

[8] N. Ansø, *Short note regarding Pure Plant Oil, PPO, as engine fuel*. Dajolka, 2007, p. 3.

[9] S. P. Assamo, "Organic Pest Control in Jatropha (in press?)," Universidade Eduardo Mondlane, Faculdade de Agronomia e Engenharia Florestal, 2011.

[10] P. Beerens and J. de Jongh, *Note on Jatropha pressing for FACT pilot projects*. FACT, 2008, p. 8.

[11] FACT, *Project Summary: Jatropha Oil for Local Development in Mozambique*. 2006.

[12] FACT, *2007 Annual Progress Report Jatropha oil for local development in Mozambique*. FACT, 2007, p. 29.

[13] FACT, *2008 Annual Progress Report Jatropha oil for local development in Mozambique*. FACT, 2008, p. 5.

[14] FACT, *End report FACT pilot project "Jatropha oil for local development in Mozambique" 2007-2010*. FACT, 2011.

[15] FACT and ADPP, *Progress report no 1:* FACT and ADPP, 2007, p. 4.

[16] FACT and ADPP, *Progress report no 2: Narrative Progress report,1st of November 2007*. FACT and ADPP, 2007, p. 11.

[17] FACT and ADPP, *Progress report no 3: Narrative Progress report, 15th of July 2008*. FACT and ADPP, 2008, p. 18.

[18] FACT and ADPP, *Progress report no 4: Narrative Progress report, 1th of December 2008*. FACT and ADPP, 2008, p. 24.

[19] FACT and ADPP, *Progress report no 5: Narrative Progress report, 1th of July 2009*. FACT and ADPP, 2009, p. 17.

[20] FACT and ADPP, *Progress report no 6: Narrative Progress report, December 2009*. FACT and ADPP, 2009, p. 32.

[21] C. Fenger, Ed., *Biodiesel from Jatropha - For a Sustainable and Decentralised Development EPF Chimoio, Friday Dec. 9, 2005*. 2005.

[22] C. Fenger, *The GAIA-Movement Narrative Progress report No 1 November 2007*. GAIA Movement, 2007, p. 7.

[23] P. C. Gagnaux, "Entomofauna associada à cultura da Jatrofa (Jatropha curcas L.) em Moçambique," Universidade Eduardo Mondlane, Faculdade de Agronomia e Engenharia Florestal, 2009.

[24] P. Gagnaux and L. Santos, "Entomofauna associada à cultura da Jatrofa (Jatropha curcas L.) em Moçambique," Oct-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_UEM_Santos_pests.pdf?attredirects=0&d=1.

[25] G. J. Groeneveld, *Development of a modification kit for diesel engines suitable for PPO*. PPO Groeneveld, 2008, p. 33.

[26] M. Henderson, "Training Course Day 3: ADPP Clube de Produtores Agricolas Cabo Delgado.," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-03/Jatrophasemi.ppt?attredirects=0&d=1.

[27] M. Henderson, "Training Course Day 5: Husbandy - Common Field Problems," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-05/Husbandry-Jatrophacourse.pdf?attredirects=0&d=1.

[28] K. Hornberger, "Dutch-German Partnership on Energising Development.," Nov-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_GTZ_Hornberger.pdf?attredirects=0&d=1.

[29] R. Jamice, "Teste de germinação de sementes de Jatropha curcas - Resultados preliminares," 2007. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/04-jatropha-seed-pre-treatmentb/04Jatrophaseedpretreatment.ppt?attredirects=0&d=1.

[30] R. Jamice, "Testes de Germinação de sementes de Jatropha," *Magazine do Investigador*, vol. 5, p. 6, Jun. 2007.

[31] J. de Jongh, Ed., *Seminar Proceedings: Jatropha for local development Held from Thursday 19 – Friday 20 January 2006 At the conference centre of ADPP/EPF in Chimoio, Manica Province, Mozambique.* FACT/Arrakis, 2006.

[32] J. de Jongh, *Diesel survey Cabo Delgado, 2007-2008*. Arrakis, 2008, p. 15.

[33] J. de Jongh, *Plan of Operations: Developing a modification kit for Chinese diesel engines in Mozambique*. 2008.

[34] J. de Jongh, "Equipment for oil processing - Solution for BBC (Bilibiza Biofuel Center) in Mozambique; based on workshop of Diligent Tanzania," Sep-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/technical-research-annexes/technical-research-activities/bbc-equipment/Equipment-

Oil_Process_JJ.pdf?attredirects=0&d=1.

[35] J. de Jongh, "Introduction to FACT project: Jatropha oil for Local Development Mozambique," Nov-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_Jongh_Project_Overview.pdf?attredirects=0&d=1.

[36] J. de Jongh, "FACT Pilot Project: Jatropha oil for Local Development Mozambique; Market aspects," Nov-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_Jongh_Market.pdf?attredirects=0&d=1.

[37] J. de Jongh, "Training Course Day 3: Introduction to FACT project: Jatropha oil for Local Development - Mozambique," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-03/FACT-ADPP-JatroMoz_ProjectIntro.ppt?attredirects=0&d=1.

[38] J. de Jongh, *Capacity Building & Development of "Training Centers for Rural Technologies", In Bilibiza and in Chimoio, within the FACT pilot project in Mozambique*. Arrakis, 2009, p. 2.

[39] J.de Jongh, *Mission Report: Mission of Jan de Jongh from 6 Sept-7 Oct 2009, Maputo, Bilibiza, Chimoio*. 2009.

[40] J. de Jongh, *Note on Cotton Oil quality for use as PPO*. Arrakis, 2009, p. 2.

[41] J.de. Jongh, *Development modification kit; state of the art.* Arrakis, 2010, p. 2.

[42] J. de Jongh, *Mission report June-July 2010*. 2010.

[43] J. de Jongh, "Development of a local market for the oil.," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/seminar-maputo-2010/Developmentofalocalmarketfortheoil_fin.pdf?attredirects=0&d=1.

[44] J. de Jongh and T. Adriaans, *Jatropha oil quality related to use in diesel engines and refining methods.* Arrakis, Ingenia, 2007.

[45] J. de Jongh, C. Zana, F. Nielsen, J. Zulu, A. Zangado, and A. Lerner, Eds., *Major Findings of the 4th Seminar on Jatropha for local development 7-8 November 2008 Chimoio, Mozambique*. FACT, 2008.

[46] J. A. Larrauri, "Jatropha curcas L. development explained by soil nutrient status," Plant Production Systems group, Wageningen University,, 2011.

[47] J. Mafalacusse and T. Alvy, "Notes for Jatropha GIS proposal.," Jul-2007. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2006-nov-19-2/JatrophaGIS.ppt?attredirects=0&d=1.

[48] F. Nielsen, "Poster: Jatropha in Mozambique," 2007. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/01-rapid-survey-of-pests-in-jatrophab-1/01PestSurveyPosterbyFNielsen.pdf?attredirects=0&d=1.

[49] F. Nielsen, "Poster presentation: Rapid Survey of Pest in Jatropha," 2007. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/01-rapid-survey-of-pests-in-jatrophab-1/01PestSurveyPosterbyFNielsen.pdf?attredirects=0&d=1.

[50] F. Nielsen, *Research Program: Progress Report No. 1, 2007 Reporting period: January 2007 – July 2007*. IIAM/Danida, 2007, p. 10.

[51] F. Nielsen, "Physic nut (Jatropha curcas L.) Current Knowledge," Jul-2007. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2006-nov-19-2/2007-07-04_FN-present_01-comp.pdf?attredirects=0&d=1.

[52] F. Nielsen, "Hedgerow Trials, Cabo Delgado," 2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/09-hedgerow-trials-cabo-delgado-1.

[53] F. Nielsen, "Hedgerow Trials, Cabo Delgado.," 2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/09-hedgerow-trials-cabo-delgado-1.

[54] F. Nielsen, "Provenance Trials, Cabo Delgado," 2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/10-variety-trials-cabo-delgado-1.

[55] F. Nielsen, *Mission Report: Jatropha Research, Field Visit to Mozambique 13th to 30th April 2008*. 2008.

[56] F. Nielsen, "Jatropha Research: Achievements - Stock taking of Research Activities under the FACT Jatropha project," Nov-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_FNresearch_Research.ppt?attredirects=0&d=1.

[57] F. Nielsen, *Pruning of Jatropha curcas*. 2008.

[58] F. Nielsen, *Economic Assessment*. Banana hill/FACT, 2009.

[59] F. Nielsen, "Simple Seed Size Selection," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/14-simple-seed-size-selection-1.

[60] F. Nielsen, "Training course day 1: Presentation: Introduction to biofuels," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-01/2009-09-13_Biofuel_introduction.ppt?attredirects=0&d=1.

[61] F. Nielsen, "Training Course Day 2: Establishing Jatropha," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-02/2009_09_EstablishingJatropha.pdf?attredirects=0&d=1.

[62] F. Nielsen, "Training Course Day 7: Pruning of Jatropha," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-07/PruningofJatropha.ppt?attredirects=0&d=1.

[63] F. Nielsen, "Training Course Day 6: Growth and Yield of Jatropha," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-06/2009_Misc_Follow_up.pptx?attredirects=0&d=1.

[64] F. Nielsen, "Training Course Day 8: Pest & Diseases," 2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/training-course/day-09/2009_Pest_and_Diseases.ppt?attredirects=0&d=1.

[65] F. Nielsen, "Jatropha curcas oil production for local development in Mozambique," in *African Crop Science Society Conference Proceedings*, vol. 9, p. 10, 2009.

[66] F. Nielsen, *Mission Report: Mozambique, April 2009*. Banana hill, 2009.

[67] F. Nielsen, *Analysis of Yield Data, April to August 2009*. Banana hill, 2009, p. 7.

[68] F. Nielsen, "Jatropha Yield Forecasting.," in *Trip Report: FACT/ADPP Project Mozambique Sept./Oct 2009.*, FACT/Banana hill, 2009.

[69] F. Nielsen, *Trip Report: FACT/ADPP Project Mozambique Sept./Oct 2009*. 2009.

[70] F. Nielsen, "Harvesting Labour Requirements," 2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/15-harvesting-labour-requirements-1.

[71] F. Nielsen, "Agronomic & Socio-Economic Research," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/seminar-maputo-2010/2010-11_FN-Research.pdf?attredirects=0&d=1.

[72] F. Nielsen, "Jatropha curcas Oil Production for Local Development - Time to up-scale?," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/seminar-maputo-2010/2010-11_JatrophaforLocalDevelopmentFN.pdf?attredirects=0&d=1.

[73] F. Nielsen, "Suitability of Jatropha in semi-subsistence agriculture," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/documents-1/misc/2010-11_ICJC-2010_FN_Presentation.ppt?attredirects=0&d=1.

[74] F. Nielsen, "Transport Plan Model," Dec-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/16-seed-transportation-plan-1.

[75] F. Nielsen, "Seed Transportation Plan," 2011. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/research-program/research-activities/16-seed-transportation-plan-1.

[76] F. Nielsen and J. de Jongh, "Jatropha curcas Oil Production for Local Development in Mozambique," Nov-2009. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/documents-1/misc/2009-11-04_Presentation_JatrophaforLocalDevelopment2.pdf?attredirects=0&d=1.

[77] F. Nielsen and J. M. Zulu, *Mission Report: Visit to Bilibize, Cabo Delgado 25th to 27th May 2007*. IIAM and ADPP, 2007.

[78] R. Petre, *Mid Term Evaluation Report October 2008: Jatropha Oil for Local Development in Mozambique*. Solidaridat, 2008, p. 12.

[79] K. Raghavan, *Technical Assistance to ADPP-FACT Jatropha Biofuel Project during Sept, Oct 2010*. Arrakis, 2010, p. 51.

[80] K. Raghavan, "Setting up of Bio-fuel Training Center in Mozambique," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/training-courses/technical-course/2010-10_Bio-fuelTrainingCenterRAGHAVANslides.ppt?attredirects=0&d=1.

[81] J. Rogerio, M. D. L. Quinhentos, A. L. Gungulo, and J. Monteiro, "Proposta de Investigação sobre Jatropha em Manica e Cabo Delgado," Jul-2007. [Online].

Available: https://sites.google.com/site/mozambiquejatropha/workshops/2006-nov-19-2/PropostadeInvestigacaosobreJatropha.ppt?attredirects=0&d=1.

[82] L. Santos, "Pragas da Jatrofa Proposta de Investigação Chimoio, Julho 2007," Jul-2007. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2006-nov-19-2/PragasdaJatrofa_Chimoio_4Jul.ppt?attredirects=0&d=1.

[83] E. Schurmann, "Business plan for the BBC in Bilibiza.," Nov-2010. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/seminar-maputo-2010/BusinessplanfortheBBCinBilibiza_ES.pdf?attredirects=0&d=1.

[84] M. Schut, *Notes on field visit small-scale Jatropha project ADDP-Fact Foundation*. Wageningen University, 2009, p. 19.

[85] M. Speiser, "Status of Jatropha activities by ELAION Africa Ltd.," Nov-2008. [Online]. Available: https://sites.google.com/site/mozambiquejatropha/workshops/2008-nov-7-8/2008-11-07_Elaion_Speiser.pdf?attredirects=0&d=1.

[86] A. Sugrue, *Final Evaluation report of the FACT/ADPP project: Jatropha Oil for Local Development in Mozambique*. 2011, p. 34.

[87] V. Uys, *Orthoptera Identification Job Sheet 1*. Plant Protection Research Institute, Pretoria, South Africa, 2007.

[88] V. Uys, *Orthoptera Identification Job Sheet 2*. Plant Protection Research Institute, Pretoria, South Africa, 2007.

[89] L. Vang, "Climate Change Mitigation - Dyrkning af Jatropha blandt småbønder i Mozambique," University of Copenhagen, Institute of Geography and Geology, 2009.

[90] L. Vang, "Dyrkning af jatropha blandt småbønder i Mozambique - En strategi til reduceret CO2-udledning og lokal udvikling?," *Geografisk Orientering*, no. 1, pp. 420-425, 2010.

[91] J. M. Zulu, *Report on Market research for Jatropha Oil and Press Cake done in Quissanga District of Cabo Delgado, Mocuba District of Zambezia and Gorongosa District of Sofala*. ADPP, 2009, p. 8.