EMPOWERING RURAL COMMUNITIES BY PLANTING ENERGY
Roundtable on Bioenergy Enterprise in Developing Regions

BACKGROUND PAPER [1]

1. Introduction

Concerns about climate change, energy security and the potential for rural development are the main drivers spurring interest in innovative solutions to meet the growing energy needs, and ways to enable economic development and improving living conditions. Biofuels are part of these innovative solutions.

We witness huge investments into large scale production of biofuels, often enough foreign investments in production for exportation. However, learning from the experience in Brazil, establishing a local market is just as important for a country both to use natural resources to satisfy own energy needs and to create a more stable market less exposed to price fluctuations on the commodity markets.

To realise the full potential benefits of biofuels without creating new pressures, biofuel development needs to be carefully planned and implemented in a sustainable manner. This means that competition for other land uses, such as production of food or other crops that are being produced already, needs to be factored in at the beginning of the decision making process. Furthermore, from a variety of oil bearing crops (actually the same would go for plants used in the ethanol production chain) the most suited needs to be chosen, matching local soil, water and climatic conditions alongside classical economic arguments.

Jatropha is receiving heightened attention due to its specific characteristics of being able to grow on marginal land and with limited rainfall.

This paper aims at laying a basis for discussions in the Roundtable. Rather than giving the answers, it pinpoints to issues that need to be addressed to help businesses to be developed sustainably, using Jatropha and other similar plants:

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[1] This report is commissioned by UNEP as background to a Roundtable on biofuel sustainability in developing countries with special focus on Jatropha. The MFC Nyetaa (Mali-Folkecenter) who worked on the report comprises Dr. Ibrahim Togola, Mr. Pierre Dembele , Mr. Ousmane Ouattara and Mr. Tom Burrell.

- plant and technological requirements, challenges in the production and conversion phases and ways to address them;
- business models and ways to help smallholders to get organised, including taking into account environmental and social co-benefits into classical cost-benefit analyses;
- barriers and ways to overcome them (financial, agronomical and technological, and political)

The Roundtable process overall aims at developing and disseminating guidance on design, implementation and evaluation of socially responsible, sustainable and economically viable biofuel projects using Jatropha.

2. Jatropha

The Jatropha L. Curcas plant originated in Central America but can now be found throughout the tropics, including much of Africa and Asia. Jatropha is shrub of up to 6 m height, belonging to the Euphorbiaceae family. It produces black seeds that are toxic and which contain a non-edible oil content of between 35% and 37% (up to 40% under optimal conditions). The Jatropha plant is drought-resistant and thrives on different soil types, including soils considered infertile. Some 170 species are currently known.

Traditionally, Jatropha has been cultivated as a hedge (living fence) around gardens and fields to protect them from animals, and the seeds are used by women to produce soap. In addition, the oil extracted from the seeds can either be combusted as unrefined fuel (bio-oil) or further processed into biodiesel.

Apart from planting seeds, Jatropha can also be propagated vegetatively from cuttings. Use of branch cutting for propagation results in rapid growth and the bush can be expected to bear fruit within one year. Normally, a Jatropha plant bears fruits from 2nd year of its plantation and the economic yield stabilizes from 4th or 5th year onwards. The plant has an average life with effective yield up to 40 years.

Typical planting pitches have been found to be 2m x 2m thus resulting in 2 500 plants per hectare, or 3m x 3m, or 4m x 3m. Wider spacing gives larger yields of fruit

Fig.1. Jatropha seeds on the bush (left); Fig.2. MFC Jatropha plantation in Tiékourabougou, Koulikoro region (right).

Fig. 3. Jatropha seeds being collected from the bush by a Malian woman (left); Fig. 4. Jatropha seeds – the green ones are straight from the bush, the black ones have had the green shell removed, and the white ones have had the black husk removed as well (right).

Jatropha potentially has additional benefits for fighting deforestation and desertification, and can increase soil fertility:

- Jatropha fixes the soil with its root system, thus reduces wind and water erosion of the soil;
- the roots allow entry of surface water into the ground, thus increase water absorption and reducing runoff, which also improves the soil.
- Jatropha fixes nitrogen, and thereby enhances soil quality, potentially recovering degraded land for other uses.

Fig. 5. Jatropha intercropping with peanuts -Jatropha is the tall plant on the right, peanuts are at ground level (left); Fig. 6. Jatropha seedlings in a line going into the distance intercropped with fonio – a green grass type plant (right).

Possibilities for intercropping are currently being explored by Mali-Folkecenter NYETAA (see photos above). Usually the Jatropha plants are spaced 3 to 4 metres apart and this leaves significant space for other complimentary plants to be planted between. However, young Jatropha plants (0-3 years) need a lot of sunlight to grow, so any species to be used in the first 3 years or so should be low level ground cover (peanuts, gombo etc.). In later years it will be possible to experiment with taller crops like maize or millet. Where successful intercropping can be developed, Jatropha production will be able to go hand in hand with food production.

Fig. 7. A young Jatropha seedling under termite attack (left); Fig. 8. A close up of leaves under termite attack (right).

Jatropha is generally considered quite pest resistant. Due to the slightly toxic nature of the plant, it is non-edible for animals, and a natural pesticide can be produced from its oil. However, Jatropha is susceptible to attack by termites (see Fig. 7. and Fig. 8. above), particularly young plants, and particularly during dry periods where Jatropha plants may be the only significant source of moisture when other vegetation has dried up.

3. Environmental issues

Jatropha has numerous qualities and properties that make it an exciting proposition as a renewable energy source, to empower development in Africa, Latin America and Asia. However, materialisation of these benefits depends on where and how the Jatropha is planted. Sustainability is not a given, and the following potential environmental risks have been identified:

Land use

While marginal land can be used for Jatropha production, the seed yield is of much higher when Jatropha is planted on good quality land. Commercial pressure to maximise yields can force food production off the best land to make way for Jatropha, thus leading to competition with food or other productive uses of land.

Water requirements

Jatropha can survive in low rainfall areas. However, the seed yields are higher if the plant has better access to water. There is a risk that unfettered commercial pressure will push for large scale irrigation, thus allowing multiple harvests or year round production. Overzealous extraction of limited ground water resources can put people's livelihoods and lives in jeopardy, particularly in areas with fragile ecosystems. This effect might be exacerbated when climate change induced drought is affecting an increasing number of people in more and more countries, and climate change induced reduced rainfall is already putting pressure on underground water resources.

Soil

Jatropha can survive on marginal or degraded land, and even has the capacity to improve its quality for other usages as it improves absorption of water, reduces wind and water erosion of the topsoil, and is binding nutrients in the ground. However, there is a risk that land is first degraded, for example, by cutting forests for large plantations, thereby generating the funds for initial investment by selling the wood.

GHG balance

Biofuels can have a better GHG balance than fossil fuels as the combustion of biofuel releases only the amount of CO_2 that the plant removed from the atmosphere when it was growing. However, the net balance of CO2 savings depends on the amount of energy used for cultivating, harvesting, transporting and converting the plants. Thus, the choice of the crop and the technology pathways affects the CO_2 balance. For example, local production of Jatropha pressed into Straight Vegetable Oil allows for maximum CO2 savings as this pathways requires no additional chemical entrants or water, has reduced CO_2 emissions linked to transport due to the decentralised nature of operations, and has very low energy and CO_2 reductions associated with its use. Producing biodiesel, on the other hand, is a more technical process which is typically more centralised, leading to increased transport needs (oil and other entrants like methanol), and energy needs for production and utilisation. Yet, providing that the oil has been produced sustainably, its CO2 balance is still better than that of fossil diesel. Detailed Life Cycle Assessments for the different pathways would help decision making.

It should be noted that if virgin rainforest has been destroyed to make way for biofuel feedstock plantations, and the oil has been transported to distant markets, the biofuel produced starts out with a negative CO2 balance.

4. Social aspects

Greatest tangible benefits to local people can be achieved when locally produced biofuel is used locally, for rural electrification, transport, or provision of mechanical power for agro processing for mechanisation of agriculture and other services that require energy input, such as ICT, which in turn allow new enterprises to flourish. Fuel costs are then ploughed back into the community, generating huge potential development effects. Where farmers become only producers of a cash crop for export, the local development benefits are limited to job creation, which of course has a development value as well, allowing for higher purchase power, enhancing economic development. Social benefits then depend much on labour conditions, wages and other entitlements fixed in international labour standards by the ILO.

Social risks

Social risks comprise effects of land use changes, particularly if indigenous people are expropriated without proper compensation and resettlement schemes, and pressure on scarce natural resources such as water and good quality soil.

Food insecurity is an issue receiving more and more attention. While availability of food on an international level will not be threatened, local shortages can arise. Furthermore, food prices can rise, generating more income for farmers, and putting more pressure on poorer communities in urban areas.

Finally, with 2nd and 3rd generation biofuels being developed in developing countries, the current high demand for first generation biofuels might drop eventually, impacting prices for crops/biofuels and likely social impacts for producers. This risk is mainly for large scale production for export. Production for a national/local market gives more independence and stability.

Garalo Bagani Yelen Project, Southern Mali – a new paradigm of energy for sustainable development

MFC is currently implementing the Garalo Bagani Yelen Jatropha bio-oil project in the village of Garalo, southern Mali, to provide ***300 kW of electrical power*** *to a dynamic village, as well as all the social benefits and improved living standards associated with electricity. In addition, the population of the municipality will have the chance to diversify their incomes by producing Jatropha on part of their land. This project, with deep rooted local support and ownership, is blazing a trail to provide socio-economic benefits without harming the fragile Sahel-Savannah ecosystems. A vision of many small producers is pursued in the project to avoid problems associated with monoculture plantations. The project is also designed primarily to benefit the local population and will promote inter cropping with Jatropha.*

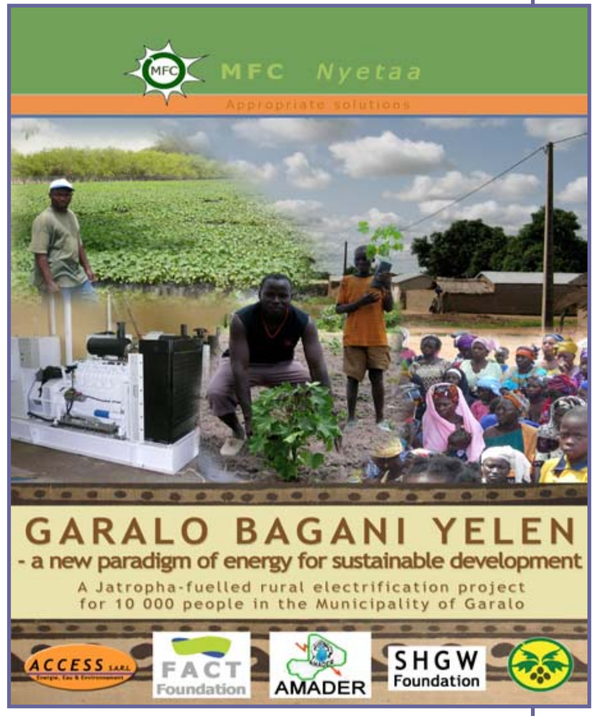


Fig. 9. Poster (right) representing the different project activities (Jatropha nursery & plantation, electric grid, gensets to run on Jatropha PPO, and a meeting in the village of Garalo with the population). The project partners are also indicated.

The project is the result of the request by the rural commune of Garalo and was developed by a consortium of partners active in the field of energy, biofuel and economic development. The project is now in its execution phase. Three generators of 100 kW each have been installed and converted to run on pure Jatropha oil, and a nursery has been created to produce the 1 000 000 Jatropha seedlings needed to plant a total of 1 000 hectares of decentralised Jatropha on many small plots of land in the municipality to produce more than enough oil for power production. The project can serve as a model for sustainable biofuel projects in the future.

Biodiesel 1, Ghana Limited

Biodiesel 1, Ghana Limited owns a Jatropha oil processing plant located in Accra. The plant has a processing capacity of 2,000 tonnes of seeds per month and has the following equipment installed:

- 4 expelling machines;
- 1 filter;
- 7 storage tanks each with capacity to store 3.5 tonnes of oil;
- 1 hot air drier; and
- 1 sheller.

Anuanom Industrial Bio Products Ltd. (AIBP)

AIBP is the first company to build a special-purpose Jatropha oil processing factory to produce biodiesel in Ghana. The company is situated at Pomadze in the Central Region. Currently, AIBP has installed a 500-tonne capacity plant for processing Jatropha seeds into biodiesel. Also installed is a 2000-tonne capacity equipment for producing organic fertilizer from the by-product of biodiesel (the seedcake). Commercial production of biodiesel is yet to commence.

Fig. 10. Biodiesel Refinery under Construction in Ghana.

Small-scale production of biofuels and the Millennium Development Goals

Small-scale locally produced and used biofuels can contribute to the achievement of the MDGs. The table below shows concrete contributions made by the Garalo Bagani Yelen project, designed for a village of 10 000 people.

MDG (Millennium Development Goal):	Relevant Garalo Bagani Yelen project impact
Goal 1: Eradicate extreme poverty and hunger	• Access to affordable energy services from locally produced biofuel (Jatropha oil) and electricity enables enterprise development • Lighting permits income generation beyond daylight hours • Machinery increases productivity; Energy for mechanisation of agriculture increases yields and efficiency; Energy for crop transformation adds value in Garalo • Local energy supplies provided by small-scale, locally owned businesses • Creating employment in local energy service provision and maintenance, fuel crops, etc. • Cost of the locally produced Jatropha oil is injected into the village economy as income earned by local people • Jatropha biofuel replaces imported fossil fuel • Post-harvest losses are reduced through better preservation (for example, drying and smoking) and chilling/freezing • Garalo population can use energy for irrigation, helping increase food production and access to nutrition
Goal 2: Achieve universal primary education	• In Garalo, energy can help create a more child-friendly environment (access to clean water, sanitation, lighting, and space heating/cooling), thus improving attendance at school and reducing drop-out rates • Lighting in Garalo schools helps retain teachers, especially if their accommodation has electricity • Electricity enables access to educational media and communications in schools and at home that increase education opportunities and allow distance learning • Access to energy provides the opportunity to use equipment for teaching (overhead projector, computer, printer, photocopier, science equipment)
Goal 3: Promote gender equality and empower women	• Availability of modern energy services frees girls' and young women's time from survival activities (fetching water, crop processing by hand, manual farming work) • Good quality lighting permits home study and allows evening classes • Street lighting improves women's safety • Affordable and reliable energy services offer scope for women's enterprises
Goal 4: Reduce child mortality	• Electricity enables pumped clean water and purification • Garalo clinics and health centres have access to electricity in order to provide access to better medical facilities for maternal care, including medicine refrigeration, equipment sterilization, and operating theatres, better conditions for giving birth
Goal 5: Improve maternal health	• Garalo clinics and health centres have access to electricity in order to provide access to better medical facilities for maternal care, including medicine refrigeration, equipment sterilization, and operating theatres, better conditions for giving birth • Excessive workload and heavy manual labour (carrying heavy water and grinding millet for daily meals) may affect a pregnant woman's general health and well being
Goal 6: Combat HIV/AIDS, malaria, and other major diseases	• Electricity in health centres enables night availability, helps retain qualified staff, and allows equipment use (for example, sterilization, medicine refrigeration) • Energy for refrigeration allows vaccination and medicine storage for the prevention and treatment of diseases and infections • Energy is needed to develop, manufacture, and distribute drugs, medicines, and vaccinations • Electricity enables access to health education media through information and communications technologies (ICTs) allowing spread of information on precautions against HIV/AIDS, malaria etc.

Goal 7:Ensure environmental sustainability	- Garalo will contribute to reduction of green house gas emissions as Jatropha process is CO_2 neutral - Increased agricultural productivity is enabled through the use of machinery and irrigation, which in turn reduces the need to expand quantity of land under cultivation, reducing pressure on ecosystem conversion - Organic compost produced as a by-product (Jatropha press cake) can improve soils - Jatropha plants reduce wind and water erosion, improve water absorption, prevent desertification

5. Conversion Technologies

Jatropha biofuel can be used either directly as Jatropha pure oil (Pure Plant Oil or PPO) through simple extraction of the oil from the seeds, or as biodiesel through transformation of the Jatropha. There is widespread experience in developing countries with the utilisation of pure Jatropha oil to fuel small one cylinder Lister-type diesel engines that power cereals grinding machines, electric generators, mechanical presses etc. In addition, PPO can also be blended in a certain percentage with diesel to run modern diesel engine (yet, manufacturers normally only guarantee engines with a use of 5 – 10% biodiesel blends). But the utilisation of Jatropha oil in modern diesel engines requires some modifications which consist mainly of heating the Jatropha oil to reduce its viscosity. Due to these technical changes required, some people promote the conversion of pure Jatropha oil into biodiesel through a transesterification process. In most developing countries biodiesel production is in its infant stage in most of developing countries and requires higher investments and transport costs, and is a more centralised technological solution.

Straight Vegetable Oil (SVO)

The extraction of Jatropha oil does not require sophisticated technology, simple equipment similar to that being used for production of groundnut oil or palm oil extraction can be used. The ripe fruits are collected from the trees and decorticated manually or with the help of a decorticator. The seeds should be dry before they are pressed as this improves efficiency of the extraction process. The oil from Jatropha seeds can be extracted using different methods, including mechanical extraction with a screw press and solvent extraction. The extracted oil can then be

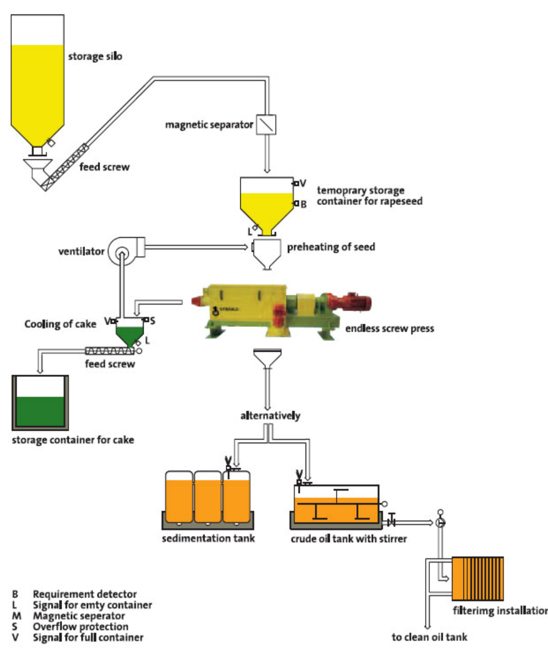


Fig. 11.Schema of a cold pressing installation to produce pure plant oil
Source: www.straehle-maschinenbau.de

purified by sedimentation or filtration.

Extraction using a mechanical screw press is the simplest method and has found wide use in rural areas in developing countries. The main, best documented initiatives in rural Africa, for example, use small scale presses of roughly the size required for Multi-Functional Platforms (size similar to the Sundhara press). In Europe, a huge variety of types and sizes of presses are used to produce pure vegetable oil. For example, experience with rape seed, the most common feedstock, is well documented, and quality standards have been developed. However, this technology cannot be transferred 1:1 to Jatropha and a developing country village context. Research is required to adapt the given press/technology. In contrast, adaptation of filtration and sedimentation systems is relatively easy.

Biodiesel

Biodiesel is an alternative to petroleum diesel which can be produced from oil crops such as rapeseed, soybean oils, Jatropha, palm oil, hemp, algae, canola, flax and mustard; animal fats or waste cooking oil. First, pure oil which has been produced by solvent extraction is treated in a process called transesterification to produce biodiesel. The transesterification process involves mixing of alcohol (usually methanol which is toxic but cheap) with the oil in presence of a catalyst and then separation of lighter methyl ester phase by gravity from the heavier glycerol. The process flow chart for production of biodiesel is illustrated in the Figure below.

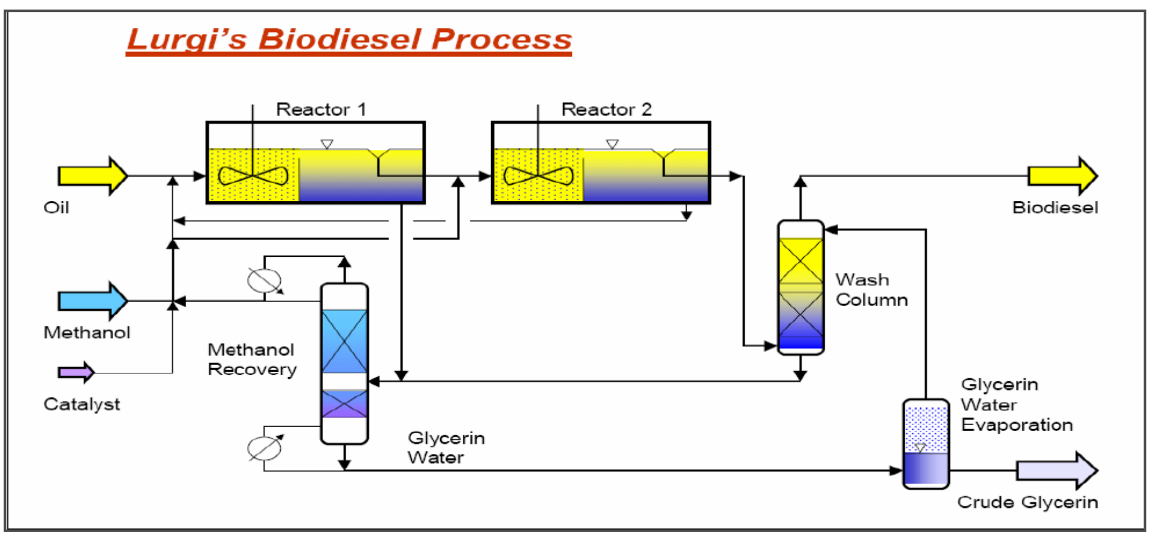


Fig. 12. Lurgi's biodiesel process (source: www.techbizindia.com/Article1)

Oil, methanol and sodium methylate catalyst are mixed in the reactor (R1) and allowed to separate into two phases. The lighter methyl ester/oil phase is mixed with additional methanol and catalyst in the reactor (R2) followed by gravity separation. This second reactor stage maximizes the biodiesel yield and quality. The lighter phase is washed with water to remove residual glycerol or methanol dissolved in the ester phase, followed by vacuum drying to yield biodiesel. The denser glycerol phase from R2 containing excess methanol and catalyst is recycled to the front end of R1. The denser glycerol phase leaving R1 still containing excess methanol is distilled for its recovery in the Methanol Recovery Column and sent back to R1. The wash water from the Water Wash Column is used in the Methanol Recovery Column. Thus the entire methanol is consumed in the production of methyl ester. The heavier fraction from the Methanol Recovery Column is processed in the Glycerin Water Evaporation Column to recover crude glycerine as a by-product. This can be further upgraded to pharmaceutical glycerine by distillation, bleaching, if required, and vacuum drying. This process requires more sophisticated technology and a considerable amount of water.

6. Economics - a matter of scale or choice?

Different business models can be applied, ranging from large scale over large scale with involvement of smallholders, smaller and small-scale production. Economies of scale change the economics, but also the likelihood of environmental impacts. Input and output also influence economic viability of any given business model. In the case of Jatropha, yields are higher on good quality soil and with sufficient watering, making projects that use higher input more interesting economically. However, this is only true applying a traditional cost-benefit analysis. If co-benefits of projects are taken into account, economics of small scale projects on marginal land look much more promising. The traditional approach of cost benefit analysis needs to be developed further to create a more comprehensive means of judging project profitability and sustainability.

Development of a sustainable cost benefit analysis for Jatropha projects

In order to better understand the benefits of the Garalo Bagani Yelen project, work is currently underway to elaborate a sustainable cost benefit analysis of the project, which takes into account all the benefits of local production, added value, job creation, environmental protection, added productivity of the land, CO_2 emission mitigation, renewable energy use, micro and macro economic effects, This is needed in order to create loyalty to the project inside the village and to make sure that farmers prefer to sell their Jatropha seed for use in the village.

The social well being of producing populations, development benefits such as improvements in healthcare provision, the environmental and climate benefit and access to modern energy services and to all the other services which can be based on energy availability, need to be accounted for. The microeconomic effects of village level added value, and injection of fuel costs into the local economy, need to be considered, and so need the macroeconomic effects of reduced or mitigated fossil fuel imports. In traditional diesel electrification projects, the money paid for fuel leaves the village and eventually leaves the country. This might amount to around half the cost of the electricity and contributes to the country's energy autonomy.

Environmental benefits need to be considered in this new means of evaluation, including increased productivity from intercropping and the creation of a better more humid microclimate, reduced soil erosion, protection against desertification, and increased productivity due to availability of quality organic fertiliser in the form of press cake.

7. Barriers & challenges

The Garalo pilot project has been the first experience of a business centred model for Jatropha based rural electrification in Mali. As such it is paving the way in terms of technology and organisational model, as well as methodology and business model. The project has been very well promoted in Mali. And yet if there are to be future Jatropha based electrification projects, there are still barriers to be overcome.

Agronomic challenges

In all countries where Jatropha projects are being explored there is a huge variety of types of Jatropha plants, with different oil content, yields, maturity periods, resistance to drought and pests, and rainfall requirements. Within Mali, for example , Jatropha from Sikasso in the south of the country is recognisably different from that found in the west of the country (as shown in the images below). The best Jatropha type for a given region needs to be determined, and what is best for one region or continent is not necessarily appropriate elsewhere.

Fig. 18. Jatropha from Sikasso. Mali has leaves with 5 noticeable points (left);
Fig.19. Jatropha from Kayes region in Mali has more rounded leaves (right).

The first Jatropha plantations in most developing countries are just reaching maturity, 4 to 5 years of age in 2007. The results of these plantations will provide important data for future Jatropha exploitation, in terms of selection of Jatropha type. This information needs to be analysed and disseminated internationally, e.g. through a number of specialised centres of excellence providing hand-holding services to entrepreneurs.

In Garalo, MFC is carrying out research into resistance to drought, yields, maturation periods of different types from other regions in Africa and Latin America, and different rainfall/watering requirements for Jatropha nurseries.

Fig. 20. Jatropha test field.

Technological challenges (transfer of technology / price etc.)

As can be seen in the Annex of this document, there is a wide variety of pressing and biodiesel conversion technologies. Much of the available technology has been designed for rape seed or palm. Equipment is available for different capacities, in different qualities, and with varying requirements for technical competence on the side of equipment operators and managers. However, very few of these technologies have been proven for commercial use with Jatropha. For use in the context of rural areas in developing countries, and to facilitate decentralised use, hardware which is relatively simple, robust and easy to maintain and operate, is needed. More research needs to be conducted in order to bring the technology used in research or pilot projects to the level required for business.

The Jatropha Roundtable and the centres of excellence can play a role in both dissemination of best proven technologies for small and medium scale commercial use, and coordination of research and testing.

Finance barriers (overcoming mistrust of Financial Institutions for small scale/ small farmers/new crops)

There is a lot of scepticism on the part of Financial Institutions, be they international, national, or even micro credit institutions on the ground both with regard to crops, pathways and creditworthiness of the recipients. The AREED program has revealed that new technologies based on renewable energy sources are still not widely known, and each new type of project has to break barriers down. Despite progress in AREED, raising awareness of the potential of renewables, Jatropha or other biofuel projects still face this problem. Local, regional and international Financial Institutions and donors need to be sensitised on the economics of Jatropha, and on what appropriate finance mechanisms would be required to stimulate the emerging biofuel sector.

Smaller loans may be needed by individual farmers to allow them to make the investment in planting a few hectares of Jatropha, particularly as Jatropha only starts producing significant quantities of seed after the 3^{rd} year.

Credit may be required by SMEs/SMIs, or cooperatives to set up oil production or biodiesel businesses in combination with rural electrification projects or other rural infrastructure projects. In a feasibility study with Ericsson it became apparent that a company willing to provide services requiring energy to run equipment may act as a pull for biofuel enterprise development. A sort of `buyers guarantee` to purchase a certain amount of biofuel per year might help unblock credits needed to start such businesses.

Set up (planning and management)

There is also a lack of awareness of the possibilities of Jatropha based business. In several countries, Jatropha has been promoted for some years now, and people are aware of technical potential. Yet, the translation of this theoretical potential to actual money in pockets is not widely understood. Despite a large experience of community organisation and cooperation in agriculture, for example for cotton production in Mali, there is a need to adapt this to the new case of Jatropha. As mentioned above, the start up of Jatropha production can appear risky even though there is mostly no need for pesticide or fertiliser, due to the 3 year production gap before the first significant harvest. So there must be some medium term confidence in a healthy Jatropha market for people to take this leap of faith. To date this has only been possible in areas where projects for local use and production including some kind of infrastructure, has been installed in villages, showing the medium to long term interest of the entrepreneur.

Policy barriers

As shown in the Brazilian experience with biofuels, continuous government support is necessary to help develop a new sector. Now, after almost 30 years of experience, the ethanol production is viable without subsidies, but a new programme to help develop biodiesel, mainly in form of small-scale projects in the poorer northern regions, has been put into place.

In most countries, where Jatropha biofuel could be produced, there is a lack of policies to support small-scale Jatropha development at the local level, including fiscal and financial incentives; the emphasis on biofuel development to meet local energy needs is not a priority.
Policies are needed to ensure that local households, businesses, and communities receive the benefits of energy services from biodiesel development, as well as associated income and job opportunities.

Policies should be long term, stable, and clear, and ensure Jatropha development by local people, for local people.

To ensure effective policy promotion, government decision makers will need to engage small farmers and producers in the policy formulation discussions.

Policy support will need to consider a range of issues including feedstock production methods, transformation, Jatropha biofuel quality standards and testing to ensure a high quality of product that will not inadvertently damage the engines it is used in, guidelines for suitable available technology (and maybe even certification), logistics, linkages, outreach, technical assistance, end user acceptance and pricing.

Other rural electrification and transport projects can be redesigned to promote Jatropha biofuel through more favourable conditions for organisations using these fuels.

National energy companies can also be encouraged to use biofuels through incentives – the chief incentive must be that the litre cost is lower for pure Jatropha oil and Jatropha biodiesel. Favourable tax regimes (either tax exemption or reduced tax on Jatropha biofuels) would reduce the price at the pump and encourage users to take up the technology.

Environmental standards need to be created and bodies executing EIAs (Environmental Impact Assessments)/LCAs (Life Cycle Assessments) need to have their capacity built up to understand the complex issues involved in biofuel production and transformation.

8. Lessons learned

In several developing countries small-scale projects have shown positive results, providing access to clean modern energy services, increased income for local communities, higher agricultural productivity, improvement of women's working and living conditions, more efficient management of natural resources and general improvements of conditions of life. Two examples of small-scale projects from Ghana and Mali:

GRESDA Ghana project

The Gender Responsiveness Renewable Energy System Development Application (GRESDA) Ghana Project is a shea butter and Jatropha processing initiative being coordinated by the Ghana Regional Appropriate Technology Industrial Services (GRATIS) Foundation at Gbimsi, a community located 70 km on the Tamale-Bolgatanga road in the Northern region. The Gbimsi Shea Butter Extraction Group was formed in 1998 from a grant provided by the United Nations Development Fund for Women (UNIFEM). The Jatropha component of the project is funded by UNDP-GEF.

Although the project is primarily focused on the processing of shea butter, the diesel engine used to power the processing equipment is run by a blend of diesel and Jatropha oil extracted by the women themselves on the same platform. The project in collaboration with New Energy, a local NGO, has developed a 5-acres Jatropha plantation near Walewale in the Northern Region, to provide the feedstock (seeds) for the production of oil. Another 5 acres of Jatropha plants is being cultivated in the Gbimsi area in collaboration with the West Mamprusi District Assembly.

The Gbimsi Women's group is producing its own Jatropha oil to run a Multi Functional Platform (MFP). The equipment used in producing the Jatropha oil comprises a sheller and grinding mill (both coupled to a Lister engine), a Bridge Press and a solar dryer. The oil extraction process is similar to the shea butter extraction process which the local women are very conversant with. A separate grinding mill (from the one used in milling the Jatropha seeds for processing the oil) is installed on the platform for processing cereals because of the toxicity of Jatropha.

Fig. 14. An Operator Pouring Jatropha Oil into a Lister Engine at Gbimsi

Apart from the corn mill used in the platform, all the machines used for the other processes were produced by the RTTU of Tamale with design support from the Technology Consultancy Centre (TCC) of KNUST and Intermediate Technology Transfer Unit (ITTU) of Suame, Kumasi.

MFC Jatropha demonstration project in Mali (funded by Siemenpuu Foundation, Finland)

The project's official title is "Jatropha as a tool to combat desertification, poverty alleviation & provision of clean energy services to rural women". This project was designed to promote Jatropha, with a strong focus on three key areas in which Jatropha can bring positive change in the rural Malian context: desertification, poverty reduction and energy service provision. The project also had a strong gender aspect because of the nature of Jatropha and the tradition of women's use of the plant for making soap, as well as in management of multi-task energy platforms.

The multi-task energy platform can help improve the living conditions of rural women as it overwhelmingly caters for their needs: it is women and young girls who do the vast majority of the hard physical work of pounding millet, maize, karite (shea) nuts which will be replaced to some extent by the platform. This saves women both physical energy and time.

The installations are owned by the women's associations, and income generated by the multi-function platforms is for the use of the association. The platforms use locally produced fuel from a renewable source – Jatropha biomass.

Main project objectives were to:

1. Contribute to the fight against desertification: increased knowledge about the actual potential and benefits of Jatropha plant in the villages, and increased use of Jatropha as a living hedge to protect plants from animals and soil from erosion.
2. Alleviation of poverty by providing income generating opportunities for women.
3. Reduced workload for rural women in the villages provided with Jatropha-fuelled multi-task platforms.
4. Dissemination of information about Jatropha potential and benefits of multi-task platforms.
5. In the long term, reduction of imports of fossil fuel as Jatropha oil is used to replace diesel.

Fig. 15. Small Jatropha press installed with MFP in Siemenpuu project, Mali (left); Fig. 16. The MFP also provides public lighting services (centre); Fig. 17. The MFP also provides rural energy services in the form of cereal grinding to reduce the burden on rural women (right).

9. Conclusion

Jatropha oil and Jatropha biodiesel can bring many benefits for developing countries in terms of providing access to clean modern energy services for productive uses in rural areas. In this context, many developing countries are encouraged to making maximum use of their biofuel potential, using their natural resources in a sustainable manner.

To ensure the sustained use of natural resources, the development of biofuel needs to be carefully planned and managed, addressing issues such as agricultural land competition, scarce water resources, soil erosion, biodiversity concerns, food versus fuel competition issues, equity concerns of large versus small-scale biofuel development, and biofuel trade issues.

Jatropha "living fences" in Mali not only control unwanted animal access to the fields. Jatropha can also reduce wind and water erosion of the soil. The ingress of the plant's roots into the soil creates paths for water penetration during and after rainfall, increasing the sinking in of water.

Fig. 13. Jatropha trunks and roots create raised low earth banks which can act to capture rain water runoff (left).

Coherent and responsible policies and legislation, capacity building, technology transfer and technological development are needed to ensure that a part of developing countries` growing energy needs can be met through sustainable production of Jatropha biofuels.

The economic structure in regions with heavy reliance on agriculture, favourable climate, and land availability means that biofuel production can contribute to making a leap forward.

Creation of and catering for a local market is an important precondition to a stable biofuel industry development as it secures a level of independence both from costly oil imports and commodity prices for biofuel production. Local production and essentially local transformation and utilisation assure benefits for local national and sub-regional populations, with added value created within the continent, for the continent.

Biofuel projects, which are driven by local ownership, in which small farmers produce fuel for their own use or for community use, appear likely to produce and sustained benefits for a rural community. With a typical MFP or rural electrification project, half the running costs typically go on paying for the fossil diesel fuel. This money leaves the village and then leaves the country, with negative macro and micro-economic effects. However, if this money instead is ploughed back into the local economy to pay for local fuel production with local added value, the local economy is boosted and the national budget deficit is also reduced.

A stimulated local economy and availability of clean modern energy services can together drive local economic growth, create jobs and improve living conditions in rural areas. This in turn reduces rural exodus, where the most dynamic section of society is forced to move to urban centres to look for work, and thus also reduces indirectly urban employment problems.

ANNEX: Some Biofuel technology options

Various types of commercially available oil presses

Bielenberg ram press 	A ram press is a small hand-press. Moving the bar up and down operates a piston which applies pressure on the seeds, extracting the oil, which then drips into a container. About 5 kg of seed is needed for 1 litre of oil. The capacity is about 1.5 litres per hour. The ram press has the advantages of being of simple and economic construction, easy to maintain and operate and being operated by a single person. The two most common, mid-sized models range in price between USD 100-280.
Mafuta Mali (Swahili term for Oil Wealth) press 	The oil wealth press is a manual press for local, small-scale production and represents a more efficient version of the Bielenberg Ram Press. The extraction efficiency is considered better than any other manual press with about 12 kg seeds per hour. It is easy to use and durable, and its price is around USD 250.
Sayari/ Sundhara screw press 	The Sayari (former Sundhara) oil expeller can be powered by a diesel engine or an electric motor. It can extract 1 litre of oil from 3kg of seeds and the extraction rate is circa 20 litres per hour. It presses almost any hard seeds with more than 25% oil content. The price is about USD 3,200 for the one operated by the electric motor and about USD 3,400 for the one with the diesel engine.

Täby Press

Source: http://www.oilpress.com/

The Täby Press is a screw press manufactured in Sweden. Various models are available for cold-pressing rapeseed, linseed, flaxseed, sunflower seed, sesame seed, peanut, groundnuts, mustard seed, poppy seed, cotton seed, jojoba, etc. Various models are available with different capacities (from 6 kg seeds per hour producing circa 2 litres of oil to 90 kg seeds per hour producing circa 25 litres of oil. Prices vary from about USD 1,200 to USD 14,000.

Straehle GmbH & Co SK250/1

www.straehle-maschinenbau.de/

Designed for chaining in continous run,

integration into complex

technical processes.

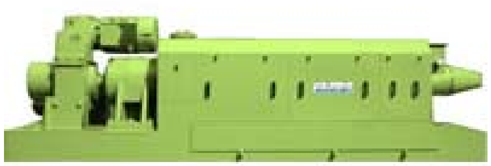
electric: 30kW, 380V, 50Hz

capacity: approx. 500 kg rape seed/hr =

approx. 167 kg oil/hr

weight: approx. 7.000kg

Reinhartz Screw press type AP25



www.reinartzpressen.com/

The Reinartz Screw Press model AP 25 is an economic finish press for the cold pressing of soft oil seeds such as:

- rapeseed/canola
- linseed
- sunflower seed

Rapeseed capacity 1 800 kg/hour

Annual capacity (approx 8 000 hours/year) of 14 400 tonnes

Weight 21.5 tonnes

Power consumption 90 kW

La Mechanique Moderne

www.la-mecanique-moderne.com/

The MBU series of presses, with capacities of more than 10 tonnes of seed per day

e.g. MBU 330 for cold pressing
45 tonnes seed per day
Power consumption 110 kW

Small and medium biodiesel production technologies

Biodiesel Reactor 	B400 Biodiesel Reactor (400 litres BIODIESEL per batch) Power required: 14.4 kw @ 415v Empty weight: 260 kg Dimensions: 1.0m wide x 1.2m deep x 2.1m high. Stainless steel construction.
Biodiesel Processor: Settler 	Settlers are stand alone, supplementary settling tanks that increase production by allowing more than one batch to be processed in the reactors. Capacity 1500 litres Empty weight 180 kilos Dimensions 1.2m wide, 1.2m deep, 3m high 12mm thick high density polyethylene bottle, steel frame construction Plastic settling tanks are available in other sizes (500 litres, 3500 litre etc.)

Biodiesel Washing Units  	In order to produce biodiesel according to standards EN14214 or ASTM, one method for washing the biodiesel is magnesol. Magnesol washing is a method that does not require water. Magnesol is an adsorbent. This means Magnesol adsorbs impurities in the biodiesel such as glycerin, water and sulphated ash.

Biodiesel Polishing Units 	Biodiesel Filtration Unit ,TWO Pod Filtration unit , 240 VAC power supply, Water and particulate removal rig, 600 l/hr flow rate removing magnesol particulate.
Sources: *http://www.ukfueltech.com/biodiesel-catalogue.htm*	
Biodiesel Technologies  www.biodieseltechnologies.com	CPU 1000 - TECHNOLOGY The CPU 1000 is a compact, pre-tested & standardized machine for the production of biodiesel: • From oils and fats of vegetable and animal origin, or used edible oils • Designed for 24 hour operation • Produces 1000 litres of biodiesel per hour (8 000 000 litres per year) • Installed in a 20ft. ISO container • Quality assurance testing prior to delivery