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# Developing jatropha projects with smallholder farmers

## Conditions for a sustainable win-win situation for farmers and the project developer

*Développer des projets de jatropha avec de petits exploitants agricoles. Conditions pour une situation gagnant-gagnant durable pour les exploitants et le responsable de projet*

*Desarrollo de proyectos con jatrofa con agricultores a pequeña escala. Condiciones para una situación de ganar-ganar sostenible para los agricultores y el desarrollador del proyecto*

**Anne-Claire Degail and Julien Chantry**

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## Developing jatropha projects with smallholder farmers

# Conditions for a sustainable win-win situation for farmers and the project developer

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**Abstract.** Based on the observation, the analysis and the comparison of four smallholder based jatropha projects developed by Eco-Carbone, located in distinct climatic and socio-economical conditions, this paper aims at drawing on the operator's experience to show what are the social, technical and economical prerequisites and the necessary management strategies, for such projects to be a success, both for the project operator and the farmers.

Beyond the climatic and soil conditions which need to be present, the existing dynamics of the farming system should be assessed in order to establish whether and how, jatropha can be integrated in the existing farming system. Jatropha shall represent only a complementary income to farmers' existing agriculture income; therefore, the time, capital and land that farmers will be ready to dedicate to this crop will be proportionate to the revenue they yield.

It is also necessary to assess the government's energy policy in terms of subsidies and tax. The sale price of the oil and fertiliser will define the purchasing price of the grain from the farmers and therefore, the profitability of establishing jatropha plantations for the farmers and developing the whole project for the operator. A jatropha project will thrive if the mass of grains purchased from the farmers reaches the expected targets. Adapted cultivation practices and improved genetics shall be introduced to optimise the technical potential of jatropha. However, once the trees start producing, the purchasing price is a fundamental variable in the success of a jatropha project. It needs to be interesting enough for farmers to harvest, shell, dry and sell their grains. However, this level of price can be maintained as long as the project developer can ensure or anticipate sufficient value extraction from both oil and seedcake commercialization on the market.

Until the trees reach full production, short-term revenue strategies need to be devised for the farmers and for the project operator. These include the production of annual cash crops intercropped with the jatropha which provide an income for the farmers and in some cases, they would also benefit from a share on the sale in advance of sequestration carbon credits generated by jatropha plantations that the project developer will conduct in order to finance the first years of the project.

**Keywords.** Smallholder agriculture, jatropha, biofuel projects, private-public partnerships

## 1. Introduction

*Jatropha curcas L*. (below referred to as jatropha) is a perennial oil-bearing shrub, which originates in Mexico (Heller, 1996) and was disseminated throughout the tropical world during the 17thcentury by Portuguese merchants and missionaries. During the 17 th century, jatropha oil was produced mainly in Cape Verde. Its oil was then used to make soap.

Jatropha produces fruits if it receives at least 900 mm of rain over at least 4 months and is provided with sufficient nutrients during the first years of its development (Pirot and

Domergue, 2008). Jatropha is sensitive to frost and thus grows only in tropical areas (Jongschaap et al., 2007). Over the years, the propagation through cuttings to develop live hedges has narrowed the already thin genetic base of jatropha exported outside Mexico.

Jatropha has received world attention in the past ten years as a potential feedstock for an alternative to fossil fuel. As such, it is a relatively new plant and research on jatropha cultivation practices and genetic selection to produce oil was only initiated in the late 1990s (Achten et al., 2008, 2010).

This "new" plant was dubbed wrongly a "miracle" crop at a time when fossil fuel prices skyrocketed. This has attracted the attention of NGOs and large multinational companies alike.

Agricultural projects in low-income tropical countries are developed according to a number of different business models, with distinct objectives, implementation modalities, levels of sustainability and involvement of local communities.

On one end of the spectrum are the government led or NGO-led projects, which have the objective to contribute to "pro-poor" development mainly through the improvement of agricultural value chains, focussing on the agricultural production by farmers on their land, with their own labour force in order to increase their agricultural income.

Much has been written on the benefits and limitations of the project approach (Gittinger, 1984; Dufumier, 1996). The limitations being often due to an underestimation of the importance of the financing. As a result, once the funding dries up, the project stops and the farmers are left at best with improved knowledge on a certain crop production but more often with a non-profitable investment (Bako-Arifari and Le Meur, 2001). Unfortunately, not enough attention is given to fostering the market in anticipation of the project's termination (Grieg-Gran and Wilson, 2007).

A certain number of NGOs initiated small scale projects especially in West Africa aimed at making rural communities self sufficient in energy (GERES, 2008; Nyetaa, 2012; Fact-Foundation, 2006). This was done with some success albeit concerns on the long term sustainability once the donor funding stops.

At the other end of the spectrum lie company-operated projects where the means of production are contracted by a national or an international company. Land is purchased or rented out for at least 50 years and either farmers in the vicinity or migrant workers are hired as agricultural labourers.

This model has been tried on jatropha in Mozambique, Madagascar and India and has to date not proven to be highly successful for a number of reasons: companies have been accused of land grabbing, of triggering social instability or like palm oil projects, of forest logging.

Such business models applied to jatropha have been the focus of much criticism (Baker and Ebrahim, 2012; Pohl, 2010). Unfortunately these criticisms were also unjustly focussed on the plant itself (Eco-Carbone, 2010).

In the midst of a growing disappointment, a third model has emerged, where smallholder farmers are the actors of their own development and where a long-term economic relationship is developed between a project operator and the farming communities.

There are many "community based" business models which encompass a wide range of situations. They differ ultimately in the level of freedom of choice and decision power that the smallholder farmers' have in the use of the land they are tilling.

In fact, FAO established the broad conditions for jatropha production to benefit smallholder farmers and be sustainable (Brittaine and Lutaladio, 2010) and how best to integrate food and energy crops in a sustainable way (Bogdanski et al., 2010).

This paper aims at presenting how these conditions can best be adapted in the field for smallholder jatropha projects to be a sustainable profitable venture both for the farmers and for the project operator.

Based on a close observation of Eco-Carbone's four smallholder projects, this paper will present the main aspects of each project and discuss the conditions they meet or not to be sustainable ventures for all parties involved.

## 2. Methodology

Since 2008[1], Eco-Carbone has been developing integrated jatropha value chains in four sites through the creation of local subsidiaries, namely:

- Jatropha Mali Initiative (JMI) founded under Malian law in 2008, in Kita, Kangaba and Bafoulabé districts ("Cercles") in Mali,
- PT Eco-Emerald Indonesia (EEI) founded under Indonesian law in 2009 in Jayapura and Biak Regencies, Papua Province, Indonesia
- Eco-Energy (EEV) founded under Vietnamese law, in 2010, in Bac Binh and Tiy Phong districts of Binh Thuan Province, Vietnam
- Tan Phuc Linh (TPL) founded under Lao law, in 2010 in all districts of Savannakhet Laos.

Figure 1 shows the different locations of the project sites.

These projects are closely monitored by Eco-Carbone's agronomists and project managers through regular field visits and data collection (localization of plantations, number of trees planted, density of plantation, maintenance status, recording of new farmers, contract signing, grain collection data, etc.).

Moreover, research studies have been conducted by agronomists, in the field, in order to have a better understanding of the dynamics of the farming systems, the place jatropha occupies and could occupy in these systems, whether or not jatropha is provoking land use changes, having an impact on food production and forest degradation.

Finally, a number of small scale research experiments aimed at optimizing jatropha cultivation practices in farmers' conditions were set up in each project sites. These experiments provided sufficient results to be able to demonstrate new techniques to field technicians and to farmers.

This paper relies on all the above-mentioned documentation generated by these activities.

1 Eco-Carbone launched pre-feasibility studies in Mali in 2007 and founded JMI early 2008

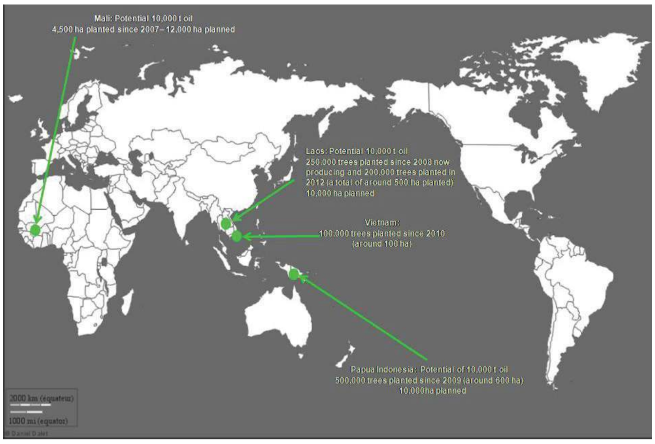


**Figure 1.** Location of Eco-Carbone's four project sites

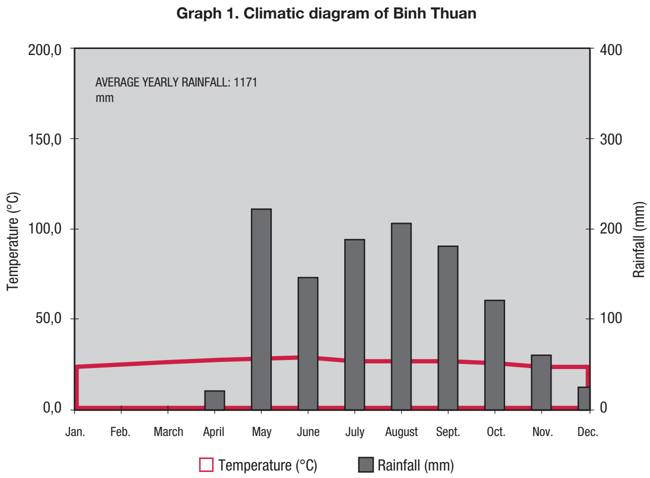


**Figure 2.** Climatic diagram of Binh Thuan

## 3. Results

### 3.1 General operational model of Eco-Carbone's subsidiaries

While Eco-Carbone's subsidiaries differ in their daily management for cultural, historical and financial reasons, the broad lines of the business models in all four subsidiaries are similar:

- Farmers own the land they till and remain the sole decision makers concerning its use;
- Eco-Carbone's subsidiary provides free technical advice to farmers through teams of locally based field technicians;
- Eco-Carbone provides seeds or seedlings either free of cost or at a subsidised rate;
- No large advance payments are made, which would distort farmers' decisions on the short run and encourage them to plant a crop which may not integrate well in their farming system;
- Eco-Carbone's subsidiaries purchase jatropha grains from the farmers at a fixed price for a given quality standard.

### 3.2 General climatic features of the project sites

#### 3.2.1 Temperature and rainfall

Figure 2[2] to 5 present the climatic data for the four project sites.

The main features of these climates are:

- A very marked dry season in Mali, Vietnam and Laos, with total rainfall ranging between 980mm (in Kita) and 1460 mm (in Laos) spread over 4 to 5 months
- In Papua rainfall is spread throughout the year with a total rainfall of more than 1 800 mm
- In all project sites the temperature amplitude is limited with temperatures oscillating around 27°C throughout the year. There is never a risk of frost.

#### 3.2.2 Soil conditions (Appendix A)

These soil analyses show the two extreme situations observed in Eco-Carbone's projects: Vietnam where jatropha is promoted on sandy soils with little or no nutrients and Papua where organic matter content of the soil and other nutrients are present in sufficient quantity.

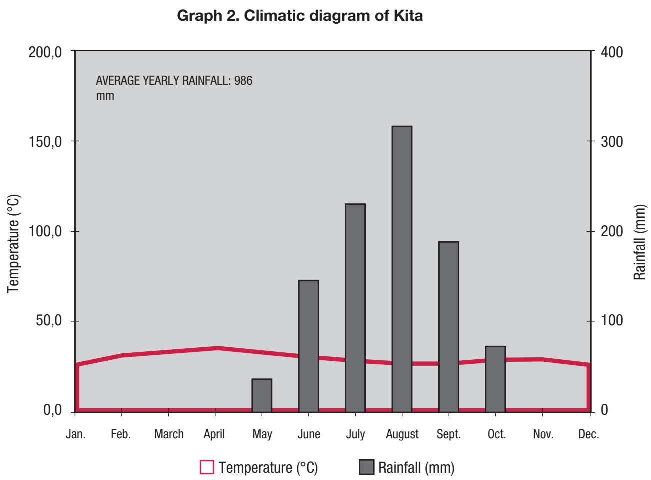


**Figure 3.** Climatic diagram of Kita

2 Figure 2: source: http://www.gso.gov.vn/default_en.aspx?tabid=466&idmid=3&ItemID=11642 (average monthly temperature proxy Nha Trang) & Phan Thiet climatology centre (average monthly rainfall 2002 to 2007)
Figure 3 : source: CMDT rainfall data 1990 to 2003 and Meteorological station for temperature 2010, Kita
Figure 4 : source: http://www.sentani.climatemps.com/
Figure 5 : source: http://www.world-climates.com/city-climate-savannakhet-laos-asia/

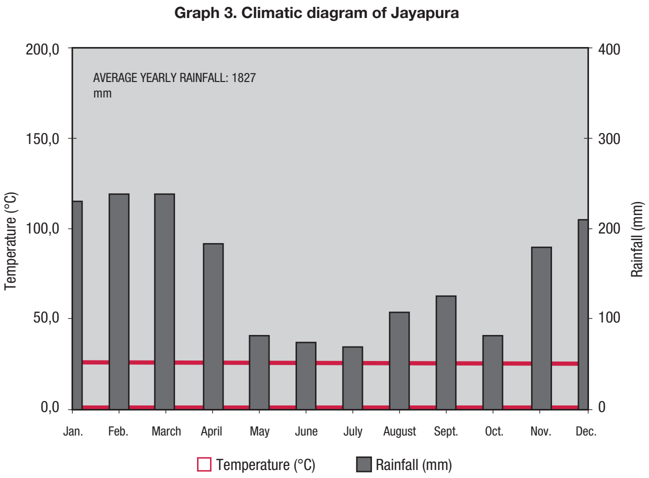


**Figure 4.** Climatic diagram of Jayapura

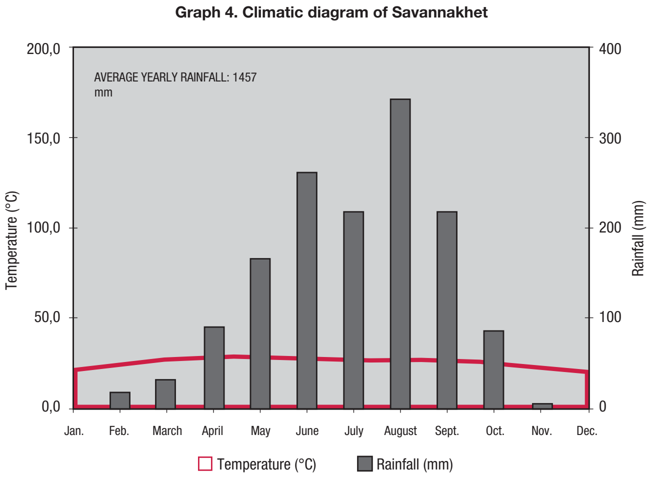


**Figure 5.** Climatic diagram of Savannakhet

### 3.2.3 Description of the project sites

The results of the observations and analysis of the four smallholder jatropha projects developed by Eco-Carbone, are summarised in Tables 1 to 4

**Table 1.** Socio-economic and political context of the project sites

| | Mali – Jatropha Mali Initiative | Laos – Tan Phuc Linh | Vietnam – Eco-Energy | Indonesia – Eco-Emerald |
|---|---|---|---|---|
| **Country Population**[1] | 15.3 million | 6.2 million | 87.8 million | Indonesia 239.8 million<br><br>Papua 2.4 million (Yun, 2010) |
| **GDP/capita**[2] | 610 USD | 1,130 USD | 1,260 USD | 2,940 USD |
| **% Pop. living under the poverty line**[3] | 47.4% | 27.6% | 14.5% | Indonesia: 12.5%<br><br>Papua: 41% (UNDP, 2002) |
| **HDI**[4] | 175/177 | 138/177 | 128/177 | 124/177 |
| **Specific features in the project area** | With cotton prices dwindling and a growing insecurity in the country, there are few agricultural market opportunities in the area. Illegal gold mining is a growing activity, which diverts the young agricultural work force from farming activities. This project area is in high need of market openings. | The emergence of new economic developments, the modernisation of the agriculture, new markets (rubber plantation, eucalyptus, sugar cane) through international companies can be observed in Savannakhet. As a consequence, land grabbing is becoming more frequent and with it the risk of smallholder farmers not benefiting from the boom (Cottin, 2012). | Vietnam is the fastest developing economy in the region. While pockets of poverty remain, the opportunity cost of labour is increasing each year, and farmers have a quick rate of adoption of new farming opportunities. As a result, jatropha, with its comparatively lower income prospects is less considered as an interesting opportunity by farmers. | Native Papuans have least benefitted from the country's economic boom. The major economic activity is ore extraction by one mining company with negative impacts on local communities. While Papua benefits from some government subsidies, farmers have little incentive to modernise their agriculture, as they are not coupled with market incentives. |

| | | | | |
|---|---|---|---|---|
| **National policies on energy and biofuels** | A net importer of fuel, Mali is focussed on promoting local sources of energy. Jatropha has integrated in the new energy programme of the country. In 2008, the government planned to achieve 39.2 ML jatropha oil by 2013 and 84 ML by 2023. (Gouvernement du Mali, 2008).<br><br>In order to achieve these figures, Malian government is currently considering tax exemptions on biofuel producing companies | Laos is geared towards hydropower for electricity production. Substantial infrastructure has been developed recently (i.e. Nam Theun II).<br><br>However, Laos imports a large part of its liquid fuel for transportation. To compensate this, Laos is planning the production of 4 ML biofuel by 2015 and that biofuels make up 10% of total fuel use in by 2025 (Vientiane Times, 2012).<br><br>In addition, remote villages have yet to be connected to the grid. | Vietnam subsidizes the price of fuel to individual consumers.<br><br>Vietnam has made a plan to promote biofuel production in the country in order that biofuels represent 5% of the petrol and diesel used annually in the country within the next 15 years. This represents 1.8 MT ethanol and vegetable oils (Commodity Online, 2010; Advances biofuels USA, 2011). The plan has yet to be implemented. After being the subject of much oversized expectation, jatropha is not promoted anymore by the government. | Indonesia subsidises the price of fuel for private consumption. However, the state is expected to lower or suppress this subsidy soon.<br><br>In addition, the Indonesian government has set the target that by 2025, 20% of all diesel use will be filled by biodiesel (Hadiwidjoyo, 2009).<br><br>There is serious talk to subsidise biofuel production by allocating the subsidy to the biofuel producer (Slette and Wiyono, 2011). |
| **Key economical figures on each of the projects' sites** | | | | |
| *Price of 1 ManDay unqualified labour (€/MD)* | 1.52 | 3.61 | 4.85 | 4.09 |
| *Price of 1 L diesel at the pump (March 2012) (€/L)* | 0.910 | 0.947 | 0.707 | 0.368 |
| *Market price of 1 kg jatropha grains (€/kg)* | 0.102 | 0.135 | 0.156 | 0.164 |
| *N kg dry grains to sell in one day to justify the labour opportunity cost* | 15 | 27 | 31 | 25 |

**Table 2.** Main agricultural features of the project sites

| | **Mali – JMI** | **TPL – Laos** | **Eco-Energy – Vietnam** | **Eco-Emerald - Indonesia** |
|---|---|---|---|---|
| **Farmer land rights** | Farmers own the land they till through a customary land right system. Apart from families who have recently moved in to the area and who are generally not allowed to plant trees on land which is given to them, all families have access to large areas of land. Land accessibility is generally not an issue in this project area (Clerino, 2010). | Farmers own the land they till although official land rights have yet to be distributed for all types of land, especially rainfed land where slash and burn practices were and sometimes are still carried out (Cottin, 2012). | Farmers own the land they till, although official land rights are rarely issued for non-irrigated land. Planting trees on rainfed land is a means for farmers to secure their land rights (known as "red books"). If the planted trees are listed in the official "Forest tree list" established by the Ministry of Forest, farmers are eligible to a 50 year red book. If the tree is not on the list (like jatropha) the red book has a validity of 20 years (Luong, 2012a). | Farmers own the land they till through a customary land right system In case of conflicts with land ownership the cultural leaders arbitrate them. This can happen at the level of the villages, the district or even the province (Eco-Carbone, 2012a). |

| | | | | |
|---|---|---|---|---|
| **Agriculture production in the project site** | Food crops such as millet, sorghum and maize and cash crops such as cotton and groundnut are produced in a rotation on plots located close to the village. Plots are tilled continuously between one to three years depending on their fertility and later left fallow one year depending on the capacity of the farmer to fertilise it.<br><br>Cattle are reared on plots further away from the village (Clerino, 2010). | Irrigated paddy cultivation takes place on paddy fields during the rainy season and more rarely also during the dry season.<br><br>Rainfed plots are cultivated according to a slash-and-burn system with a 5 to 10 year fallow period. Once the fallow plot is cleared, rainfed paddy, papaya, banana, and other crops are cultivated during the rainy season. The following year the plot is left fallow and a new plot is cleared (Cottin, 2012). | Irrigation paddy cultivation takes place 2 to 3 times per year as irrigation systems are in place during the dry season. Moreover, irrigated paddy fields are being increasingly used as plots to grow dragon fruit. The cultivation of this perennial cactus is intensive in capital and labour and provides high returns.<br><br>Along the coast, there are large expanses of unused sandy loams, where cattle are grazed or rainfed crops are produced to a limited extent. | Forests dominate; they serve as hunting and gathering ground. In some areas, this type of land is leased out and logged by companies.<br><br>Close to villages, land is cultivated according to a slash-and-burn rotation with a fallow period of up to 20 years. A number of short cycle crops (banana, papaya, cassava, maize, beans, taro, keladi, chilli, sweet potato) are associated.<br><br>Finally, large areas are occupied by Imperata cylindrica, an invasive grass (Degail, 2008a, 2008b; Moenne and Degail, 2012; Falloux, 2008). |

**Table 3.** Features of the introduction of jatropha in the project areas

| Mali – JMI | TPL – Laos | Eco-Energy – Vietnam | Eco-Emerald - Indonesia |
|---|---|---|---|
| Jatropha was first introduced in Mali at the time of the French colonial rule in the early 19th century. It was used as a protective hedge around vegetable gardens.<br><br>In the late 1980s the German Cooperation agency (GIZ), studied the potential to use jatropha to make soap and as a biofuel and developed a ten-year project to revalorize the jatropha hedges (Henning, 2007).<br><br>Jatropha is thus well known when JMI starts operating in Kita in 2007. Jatropha is then first promoted as a monoculture on marginal land far from the village. This strategy proved inefficient as the distance and long term expected returns of the tree meant that plantations were not taken care of regularly.<br><br>Jatropha is now promoted as part of an agro-forestry system, where it is intercropped with the usual annual crops on plots closer to the village. Farmers are increasingly adopting this system (JMI data). | Jatropha was introduced during the French colonial rule and used as a hedge, but at a lesser level than in Mali.<br><br>Prior to TPL's presence, the Farmer Association of Savannakhet, and two major Lao companies, under the impulse of national policies, started planting jatropha trees with farmer communities as early as 2007. With no long-term strategy planned, the operators couldn't honour their commitments to the farmers and left.<br><br>TPL started its activities within this context: farmers knew about jatropha but had been left by the previous operators. Their trust was thus limited.<br><br>Farmers intercrop jatropha with their rainfed rice and short term crops following the slash and burn of their 3 to 5 year fallow land. Due to their lack of trust in jatropha operators, they didn't tend to their jatropha plots once they shifted to a new plot and left the old one fallow (Cottin, 2012).<br><br>TPL's main challenge is thus to win the farmers' trust and deliver quality technical messages for them to take care of their jatropha. | Jatropha pre-existed in Binh Thuan province as large hedges growing on sandy land along paths.<br><br>Jatropha is being promoted as a tree which will limit the encroachments of the sand dunes. Initial trials on plots made of sandy loams far from the villages, prone to cattle grazing and subject to little maintenance, not surprisingly gave poor results.<br><br>Jatropha is now being promoted in agro-forestry systems where jatropha is intercropped with existing annual crops such as cassava. Tests have led to the definition of cultivation practices, which make it possible to produce jatropha fruits on sandy loams. This includes adding fertility, cultivating intercrops and using older seedlings than usual (Luong, 2012b).<br><br>Alternatively, other more profitable opportunities, associated with a general low density of population, renders it very difficult to make jatropha cultivation a profitable and interesting venture for farmers and project developers in this area. | Jatropha was introduced in the late 1940s by the Japanese colonial power for biofuel production.<br><br>Although farmers did little with the jatropha, they were familiar with the plant when Eco-Emerald started its activities in 2009.<br><br>Farmers chose to integrate jatropha as part of their slash-and-burn system. In this case, jatropha is planted along with a diversity of other crops. The challenge is to persuade farmers to continue maintaining their jatropha once they have shifted to another plot.<br><br>Jatropha cultivation is also being promoted on imperata grassland, which Papuan farmers, till now didn't have the means to cultivate. R&D is ongoing to propose the optimal cultivation practices, which reduce the production costs of jatropha while delivering sufficient yields. The plantations of jatropha have been established by farmers in distant plots; the labour required to harvest, transport and shell the fruits is higher than expected, which has led to the introduction by Eco-Emerald of shellers, which divide by 5 the shelling time (Fourtet, 2010). |

**Table 4.** Achievements and challenges faced by the four projects

| | Mali – JMI | TPL – Laos | Eco-Energy – Vietnam | Eco-Emerald - Indonesia |
|---|---|---|---|---|
| Achievements | Between 2008 and 2011<br><br>4,500 farmers have planted 4,000,000 jatropha trees with the support of JMI.<br><br>About 100 tons of grains have been purchased in 2011/12 to the farmers.<br><br>8 tons of oil were produced in 2010/11. Some experiments on locally set-up generators are being conducted.<br><br>JMI is now promoting the cropping of sunflower, which JMI purchases to produce edible oil sold locally. | Between 2008 and 2012<br><br>About 1,000 farmers have planted 550,000 jatropha trees with the support of TPL.<br><br>5 MT grains were purchased in 2011 and around 20 T grains are planned for purchase in 2012<br><br>First experiments with jatropha oil have been conducted on hand tractors.<br><br>TPL continues to strengthen its ties with the association of farmers in Savannakhet and works with it to provide full support to farmers. | Between 2010 and 2012<br><br>About 100 farmers have planted 100,000 trees with the support of EEV.<br><br>A R&D programme aimed at developing optimal cultivation practices for jatropha to grow and produce fruits, in farmers' conditions and on poor sandy loams has given some positive results (Luong, 2012b). | Between 2009 and 2012<br><br>Around 700 farmers have planted 500,000 trees, which are now producing.<br><br>20 tons of grains have been purchased since 2009.<br><br>4 tons of oil have been produced so far.<br><br>Jatropha starts producing only 4 months after transplanting and the production is the highest among all four projects.<br><br>R&D to develop cultivation practices to reclaim imperata grassland through agroforestry systems integrating jatropha and annual crops has started to yield interesting results. |
| Challenges | While JMI faces competition from other players in the zone to purchase farmers' grains, the main challenge remains the long period required for jatropha to produce grain, due to low yearly rainfall, and termite attacks. JMI is developing integrated pest management solutions, promoting agroforestry models and currently testing improved genetics. | TPL needs to build strong trust ties with the farmers. Roads and infrastructure being very poor, TPL also needs to optimise its transport costs in order to become profitable. Moreover, TPL has to focus in the future on areas where alternative farming income opportunities are low and thus where jatropha will be a welcome additional income by farmers. | EEV has yet to be sure jatropha will produce profitable quantities of grain on the sandy loam. Moreover, with a number of alternative farming income opportunities, farmers are not interested in jatropha which requires a lot of work compared to the returns. . | Jatropha has yet to be a profitable venture for farmers because of the high opportunity cost of the labour and competing subsidised crops such as cocoa.<br><br>Eco-Emerald has to find innovative ways to encourage farmers to plant jatropha, reduce their production costs and improve their productivity in order to increase their profit/cost ratio. |

## 4. Discussion

Based on the description, achievements and challenges facing the four jatropha projects described above, we discuss here the main aspects, which should be looked into prior to the inception and during the development of any smallholder based jatropha project.

### 4.1 The necessary climatic, agricultural and socio-economic pre-requisites

#### 4.1.1 Required soil and climatic patterns for jatropha to strive

Jatropha does grow in a diversity of pedo-climatic conditions as soil analysis of the project sites show. Nevertheless, as observed especially in Vietnam and Mali where nutrient contents of the soil are low, adapted quantities of fertilizers need to be added per planting pit to make sure the seedlings develop and produce the following season.

When clay contents are too high and large quantities of rain fall at once as is the case in Laos, Papua and Mali, the soil may become waterlogged and cause the death of even old jatropha trees.

Eco-Carbone's projects have therefore avoided areas prone to even temporarily flooding as well as areas prone to regular cyclones or storms.

#### 4.1.2 Presence of jatropha prior to inception of the project

Introducing new species in an environment not only triggers serious ethical questions, it can also have unforeseen consequences, such as undesired crossings or mutations.

Moreover, while jatropha pre-exists on all Eco-Carbone project sites as a hedge, farmers are initially still either reluctant to establish the tree in a plantation or rely on their knowledge of the tree as a rustic species to limit their maintenance of it. Their acceptance would have been even lower had they not known the plant in the first place.

#### 4.1.3 A secured land access

In all Eco-Carbone project sites, farmers were willing to plant jatropha only on land where they had a secure right, most often a customary land right. Interestingly, in Laos and Vietnam, planting jatropha was a way for farmers to secure formally their land right (Cottin, 2012; Luong, 2012a).

In Chhattisgarh in India, the state government financed the establishment of jatropha plantations in a work-for-money programme. The plantations were established but neither maintained nor harvested. The main reason being the land where the plantations had been established belonged to no one (Chantry and Degail, 2011).

#### 4.1.4 A profitable complementary agricultural income for farmers

Jatropha, integrated in the farming system, will provide a complementary income to the existing farming income. Therefore, farmers will be keen to invest their means of production at the pro rata of their expected returns.

On all four project sites, it is observed that given the choice, farmers do not substitute their existing food crops or cash crops, with a perennial shrub which they only know as a fence. At best, they find ways to include it in their existing farming activities without having it compete for labour especially at the peak times. This observation is further developed by GERES in Mali (Pallière and Fauveaud, 2009).

Be it in Mali, Laos or Vietnam, the inception of the rainy season is peak working time in the agricultural calendar. It is also the best time to transplant jatropha seedlings. In all project sites, farmers prioritize all the other crops before jatropha. The project teams worked with the farmers to define together a suboptimal time of the year to establish the jatropha plantation: either shortly before the inception of the rainy season or directly after the end of the sowing of their usual crops.

Moreover, Eco-Carbone realized how crucial it was to estimate the agricultural and non-agricultural income opportunities that different farmers have on a given project site and compare them with the potential income of jatropha. In Vietnam for example, new income opportunities have flourished quickly since 2010 turning the interest away from jatropha.

Studying closely the project sites' farming system has enabled Eco-Carbone to propose better adapted techniques and farming practices than the ones, which were presented at the very initial stages. For example, Eco-Carbone promotes today the inclusion of jatropha in agro-forestry systems which are being widely adopted by farmers who see many technical and financial advantages in intercropping jatropha with their annual food and cash crop.

**Figure 6.** Women group in charge of maintaining a nursery in Daféla commune, Kita district, Mali

#### 4.1.5 The required political and economic context

##### 4.1.5.1 General strength of the economy

A country's Gross Domestic Product per capita, its poverty rate are all indicators which need to be taken cautiously but which give an indication of the income expectations of the population and the farmers in particular. Jatropha will be all the more adopted by farmers as they are living in areas with low and few income opportunities.

Eco-Carbone has realized that the projects which develop best are those where there is a sufficient spread between the cost of oil at the pump and the opportunity cost of 1 man-day.

In Mali, for instance, Eco-Carbone can observe more interest for jatropha than in other countries. In Mali, one man day has to harvest and sell more than 15kg/day to earn more than if he sold his labour on the unqualified labour market. In Vietnam, this value is doubled, which explains why farmers in Vietnam are much less keen than those in Mali to produce jatropha.

#### 4.1.5.2 National policies on energy

The price of the jatropha oil sold as a fuel is closely related to the price of fossil fuel. The price of fossil fuel depends not only on the world price but also on the legislation in place concerning the price of energy.

Moreover, the government's position on jatropha and biofuel also impacts the profitability of a project. The contrasting positions of Vietnam and Mali illustrate this. While Mali is slowly developing policies favoring the sector, Vietnam has opted for crops with faster returns such as cassava or sugar cane.

## 4.2 Key factors in project development

### 4.2.1 The human dimension: building trust

In such jatropha projects, farmers are at the centre of the activity. They remain the sole decision makers on their plots, on whether to establish, maintain, harvest and ultimately sell the jatropha grain. The project developer thus needs to build with them a long-term relationship based on trust, mutual respect and a good understanding of their needs and problems in order to find adapted solutions.

**Figure 7.** Farmer training on jatropha transplanting in Doyobaru, Sentani, Papua

### 4.2.2 Financing the long-run with short term revenues

This condition concerns both the farmers and the project developer.

Jatropha produces grains at best from year two. Even though it is a complementary cash crop, the farmer does not generate enough revenue for his work on jatropha during the first two years.

For the project developer, there is a long period of time to reach scalable grain quantities. As a consequence, the project developer has to mobilize and secure high amounts of money during these first years. This can become a major risk of failure for the project.

#### 4.2.2.1 Facilitating the generation of short term revenues for the farmer

In order for farmers to both maintain their jatropha plantations and generate short-term revenues, Eco-Carbone advises to intercrop jatropha with annual crops. By doing so, farmers maintain their plot and the fertilizer that is spread on the annual crops indirectly benefits the jatropha. Moreover, when possible as in Mali, the operator purchases the annual crop (sunflower) from the farmer, thus securing the short-term revenue.

#### 4.2.2.2 Facilitating the generation of short-term revenues for the project developer

When certain conditions are met, jatropha trees sequestrate carbon and it is possible to generate sequestration carbon credits. Eco-Carbone, in Mali developed a carbon project, which was validated in 2012 (Verified Carbon Standard, 2012).

In 2007, EC's subsidiary JMI had sold 400,000 tCO2e to Novartis. This financing was crucial for the development of the Malian project. As a counterpart, Novartis receives from JMI, the carbon credits once they are generated. The first delivery of carbon credits took place in 2012 (Eco-Carbone, 2012b).

### 4.2.3 Optimising production and purchase

A common observation on all four projects is that the mass of grains produced by the farmers and purchased by the company is a key factor, which determines the survival of a project.

The purchase price is a key driver behind the choice of farmers to get involved in jatropha cultivation. Nevertheless, the project developer has limited room for maneuver to increase this purchase price as it mainly depends on the market prices of the end products (oil and fertilizer), which are largely out of the project developer's control.

Therefore on all project sites, Eco-Carbone strives to increase the yield potential and lower farmer production costs.

Eco-Carbone has set up an R&D programme on all project sites, aimed at finding the optimal cultivation practices, which will increase the yields. Moreover, Eco-Carbone is working closely with Quinvita, a company specialized in jatropha breeding in order to select the genetic material best adapted to the different ecological conditions and double the existing yields (Quinvita, 2011).

In Papua, farmers only have machetes, which is not a tool adapted to cutting grass or to weeding a plot (Mazoyer and Roudart, 2002). After discussions with farmers, simple tools required to cultivate jatropha and reduce their labor inputs (plastic sheets to dry their seeds, whipper snippers to reduce weeding time) were distributed to farmers along with close monitoring of the organization of the farmer groups on how the tools should be shared and maintained.

Harvesting and post harvesting of jatropha is a bottleneck. A mechanical nut-sheller developed by The Full Belly Project, a USA based NGO, was promoted in the Laos, Vietnam and Papua with success. The introduction of these shellers in the communities divided by 5 the labour requirements.

### 4.2.4 Finding local outlets

In order to maximize the social and economical aspect of such projects oil and the seedcake are sold locally.

Transporting oil to other countries would increase its carbon footprint; besides, there is a strong demand for such products in countries, which are importing their fuel at high cost.

As a consequence, by selling the jatropha oil in the country where it is produced, Eco-Carbone maximizes its environmental benefit and contributes to lowering the country's energy expenditures.

Finally, as it is observed in Eco-Carbone's four projects, farmers are all the more motivated in getting involved in the production of jatropha when they also consume themselves the end products such as oil or organic fertilizers.

## 5. Conclusion

The jatropha projects described in this paper have had to adapt and be creative in order to jointly benefit to the communities and the project developer.

The selected project site respects a number of economical, climatic and soil conditions. The design and management of the project keeps its long-term social, economical and environmental sustainability at its centre.

The corner stone guaranteeing the long-term sustainability of a project and thus its benefit to the communities and the project operator alike is the mass of quality grains collected. This factor is strongly correlated with the yield on the one hand and the economic incentive for farmers to manage their jatropha plantation, harvest, shell and dry the fruits on the other hand.

The jatropha project developer shall thus make sure that all agronomic conditions are gathered for jatropha to grow and produce well, develop R&D experiments to adapt cultivation practices to local conditions, strive to find the best genetics for a given project site and train farmers on all aspects of jatropha management.

The jatropha project developer shall also monitor closely the production costs incurred by the farmers and the benefits they yield from the sale of their production. The project operator shall thus adjust the price within the range of its possibilities; largely depending on the price of oil and fertilisers which operators have little power over. The project developer can also dedicate its effort in finding ways to add more value to its production: biopesticide production from the oil and animal feed from the seedcake for instance. In parallel, lowering farmers' production costs is another solution to improve the benefit/cost ratio of the farmers. It can also entail the identification of appropriate tools such as the shellers introduced recently.

Once yield is secured over a few years time, all the other conditions shall reinforce the alignment of the interests between the communities and the project developer.

Until jatropha reaches maturity, the project developer shall find solutions to ensure short-term revenues for both himself and the communities. In Eco-Carbone's project, integrating jatropha as part of an agro-forestry system where annual cash and food crops are produced on the same plot has proven an efficient solution for the communities and so has pre-selling carbon credits for the project developer.

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# Appendices

## Appendix A: Soil Analyses

2012 Soil Analysis Eco-Carbone sites.xls

### Binh Thuan Vietnam

| sample name | sample # | date | GPS data | SDF (cm) | SDT (cm) | N-tot. (mg/kg) | C/N | P (mg/kg) | P-AL (mg P2O5/kg) |
|---|---|---|---|---|---|---|---|---|---|
| EEVN-PT-2012-1-A 30-90 | 507025 | 18052012 | ELO-ENERGY-VIETNAM | 30 | 90 | 200 | 6 | 0,4 | 5 |
| EEVN-PT-2012-1-B 30-90 | 507026 | 18052012 | ELO-ENERGY-VIETNAM | 30 | 90 | 200 | 5 | 0,2 | 3 |
| EEVN-PT-2012-1-A 0-30 | 507027 | 18052012 | ELO-ENERGY-VIETNAM | 0 | 30 | 200 | 6 | 0,2 | 3 |
| EEVN-PT-2012-1 B 0-30 | 507028 | 18052012 | ELO-ENERGY-VIETNAM | 0 | 30 | 200 | 6 | 0,2 | 3 |

| sample name | S-tot (mg/kg) | Mg (mg /kg) | Na (mg /kg) | B (mg /kg) | Cu (mg /kg) | Mn (mg /kg) | Zn (mg /kg) | pH | SOM |
|---|---|---|---|---|---|---|---|---|---|
| EEVN-PT-2012-1-A 30-90 | 50 | 5 | 17 | 76 | 20 | 7120 | 220 | 5,1 | 0,2 |
| EEVN-PT-2012-1-B 30-90 | 50 | 5 | 15 | 76 | 20 | 8010 | 120 | 4,7 | 0,2 |
| EEVN-PT-2012-1-A 0-30 | 50 | 5 | 13 | 76 | 20 | 7250 | 140 | 4,8 | 0,2 |
| EEVN-PT-2012-1 B 0-30 | 50 | 5 | 12 | 76 | 20 | 8250 | 120 | 4,5 | 0,2 |

| sample name | Clay (%) | CEC (mmol+/kg) | Ca (mmol+/kg) | K (mmol+/kg) | Mg (mmol+/kg) | Na (mmol+/kg) | Mn (mmol+/kg) | AL (mmol+/kg) | Fe (mmol+/kg) |
|---|---|---|---|---|---|---|---|---|---|
| EEVN-PT-2012-1-A 30-90 | 17 | 10,5 | 3,5 | 0,3 | 0,5 | 0,7 | 0,7 | 1,9 | 0,04 |
| EEVN-PT-2012-1-B 30-90 | 6 | 5 | 1,7 | 0,3 | 0,3 | 0,6 | 0,3 | 4,4 | 0,2 |
| EEVN-PT-2012-1-A 0-30 | 7 | 6 | 2,1 | 0,3 | 0,3 | 0,6 | 0,3 | 6,2 | 0,3 |
| EEVN-PT-2012-1 B 0-30 | 6 | 4,5 | 1,2 | 0,3 | 0,2 | 0,5 | 0,3 | 6,5 | 0,3 |

**Abbreviations used:**

SDF sampling depth from
SDT sampling depth till
N-tot. N-total
SOM soil organic matter

2012 Soil Analysis Eco-Carbone sites.xls

### Jayapura Papua

| sample name | sample # | date | GPS data | SDF (cm) | SDT (cm) | N-tot. (mg/kg) | C/N | P (mg/kg) | P-AL (mg P2O5/kg) |
|---|---|---|---|---|---|---|---|---|---|
| EEI-N-2012-1-A 30-90 | 40953 | | | 30 | 90 | 270 | 16 | 1,9 | 45 |
| EEI-N-2012-1-B 30-90 | 40953 | | | 30 | 90 | 320 | 12 | 2,5 | 44 |
| EEI-N-2012-1-A 0-30 | 40953 | | | 0 | 30 | 1220 | 16 | 1,3 | 40 |
| EEI-N-2012-1-B 0-30 | 40953 | | | 0 | 30 | 1320 | 16 | 0,6 | 39 |

| sample name | S-tot (mg/kg) | Mg (mg /kg) | Na (mg /kg) | B (mg /kg) | Cu (mg /kg) | Mn (mg /kg) | Zn (mg /kg) | pH | SOM |
|---|---|---|---|---|---|---|---|---|---|
| EEI-N-2012-1-A 30-90 | 50 | 5 | 6 | 77 | 20 | 7850 | 120 | 5,2 | 0,8 |
| EEI-N-2012-1-B 30-90 | 50 | 5 | 6 | 81 | 20 | 8410 | 130 | 5,3 | 0,8 |
| EEI-N-2012-1-A 0-30 | 60 | 5 | 6 | 78 | 20 | 9820 | 100 | 5,2 | 4 |
| EEI-N-2012-1-B 0-30 | 80 | 6 | 6 | 78 | 20 | 9310 | 100 | 5,2 | 4,2 |

| sample name | Clay (%) | CEC (mmol+/kg) | Ca (mmol+/kg) | K (mmol+/kg) | Mg (mmol+/kg) | Na (mmol+/kg) | Mn (mmol+/kg) | AL (mmol+/kg) | Fe (mmol+/kg) |
|---|---|---|---|---|---|---|---|---|---|
| EEI-N-2012-1-A 30-90 | 40 | 28 | 11 | 0,6 | 1,1 | 0,3 | 0,2 | 1,3 | 0,2 |
| EEI-N-2012-1-B 30-90 | 45 | 19 | 11 | 0,6 | 1,1 | 0,4 | 0,2 | 1,3 | 0,3 |
| EEI-N-2012-1-A 0-30 | 40 | 30 | 11 | 0,6 | 1,1 | 0,4 | 0,3 | 0,7 | 0,2 |
| EEI-N-2012-1-B 0-30 | 43 | 28 | 11 | 0,6 | 1,1 | 0,4 | 0,3 | 0,6 | 0,1 |

**Abbreviations used:**

SDF sampling depth from
SDT sampling depth till
N-tot. N-total
SOM soil organic matter