2nd Draft Final Technical Report

Costs and Benefits Analysis of Small Scale Jatropha Curcas Plantation in Cambodia

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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to Literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, and Papua New Guinea.

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Executive Summary

Internationally, biofuel is being promoted for two main reasons - to fight climate change and to reduce dependency on fossil fuel. Besides fighting climate change and oil dependency, the promotion of biofuel in Cambodia is motivated to reduce rural poverty through cheap energy supply. Most of the literature on Jatropha curcas (JC) in Cambodia is very positive in terms of the contribution reduction of impacts of climate change, oil independency, especially in the the rural area it was put forwards as poverty reduction strategy.

Although biofuels are promoted internationally and domestically, the practical benefits for the promotion of biofuel is still debatable. Some prominent of bio-energy claimed that biofuel will contribute to higher concentration of greenhouse gases (GHG). On the other hand, many experts have argued that bio-energy will greatly help to mitigate climate if a proper selection of source of plants, place and land use is adhered to.

This study will, then, employ costs and benefits analysis (CBA) to examine the all potential costs and benefits based on the status quo of Jatropha curcas tree in a district following by 4 scenarios. After presenting the result of CBA, the study examines the GHG benefits from consuming biodiesel followed by the discussion of substitution of import fossil-based fuel. Also, the research has discussed on the rural poverty reduction when there is an introduction of biodiesel production. Last but not least, the research has explored the tools that can be used to expanse the activities within the rural of Cambodia followed by some sensitive analysis.

The study found that from Base Case (which is the analysis of current benefits yielded from Jatropha curcas tree, and does not include the biodiesel production) has provided benefits (in net present value terms) relatively high compared to the rest of scenario 1, 2, 3 and 4 at 1,553; 1,463, 2,170; 917 and 1,150 million riels respectively.

In terms of the implication with CO_2, we considered that the consumption of biodiesel will contribute to CO2 reduction. Then, the study found that there will be a reduction of CO_2 from 35 tones in scenario 1 and the higherst amount at scenario 4 at about 60 tones. This amount is relative small to apply for CMD, unless the project taken places the whole district.

The substitution of fossil based diesel is greatly, for the production of biodiesel demand only a small fraction during the transportation of seeds to the processor premise. Then, we considered the small scale plantation is totally the net gain of energy. If we consider that all biodiesel will be substituted fossil fuel, then we found that the communes will have 13 thousand liters, 15 thousand liters, 19 thousand liters, and 21 thousand liters of diesel with the 4 Scenarios respectively if there is a biodiesel production project.

Besides the overall implausible biodiesel production, we found that income per household is not really invitingly tradable activities. We found that the first quintile (who has less plants) enjoys only about USD1.00 per annum followed by the last quintile about USD12.00. However, the amount of income does not really express any barriers for biodiesel production, for everyone is willing to participate the marketing.

In a nuts shell, the result and analysis found that biodiesel production is not very positive, but we do not think that small scale biodiesel will happen at the current status providing that capital costs are not granted for communities. The farmer participation is likely but investment on processing plant is unpredictable.

I. Introduction

The interest in Jatropha, which contained diesel like liquid, was largely started in Cambodia sometimes in 2004 by an NGO (namely: Development and Appropriate Technology called DATe), Andrew Williamson and David Granger. The interest was then spread through the media, especially the interview with key players in Jatropha promotion by Voice of America (VoA) and Radio Australia (in Khmer) in 2007. Two literature reviews (by Andrew in 2006 and Markandya in 2008) and an empirical study in 2007 have drawn a similar conclusion that Cambodia has a potential to produce biofuel from Jatropha.

Given widespread dissemination on the benefits of Jatropha in Cambodia, the government of Cambodia has no specific policy to promote this particular development, but the government provides economic land concessions for agricultural development, and agricultural activities are taxed at very low rate. In the second communication to UNFCCC, the reported has highlighted the potential option of biofuel, including biodiesel producing from Jatropha curcas (JC) seeds, to mitigate climate change effects (MoE, Forthcoming).

One of the strong arguments against biofuel promotion is that it can bring negative impacts to the environment. In other words, it will exacerbate the global warming due to the changing land use and increase in the use of chemical fertilizers. Moreover, the agro-crop will contribute to land use competition and food price crisis; which will then exacerbate vicious rural poverty cycle.

This research is, therefore, to examine the above skeptical arguments based on biofuel literature, field work survey, focus group discussion, key informants interview, stakeholders' dialogues. It employs costs and benefits analysis approach, and then examines the global warming mitigation before providing policy tools to intervene on the promotion of small scale JC plantation in Cambodia.

1.1 Background

The arguments for biofuel production are largely environmental, economical, and political, focusing on national, international perspectives.

In environmental terms, biofuel is one of the alternatives to fossil fuel which can potentially mitigate climate change, as combusting the former produce less greenhouse gas emission (GHGE's) than the later. Climate change is a long-term significant change in the "average weather" that a given region experiences. The main cause of climate change is the release of greenhouse gases, especially CO_2 from the burning of fossil fuel in running automobiles and generators. In combating CO_2 emissions from the burning of fossil fuel to generate energy, there are alternative forms of energy being promoted at the various scales - local, regional and international. These alternative forms are not limited to biofuel, but also include wind, wave, solar, biomass, and so on.

In terms of economics, dependency on the fossil fuel is not best alternatives for two main reasons. Firstly, fossil fuel is a non-renewable resource, and it is currently the primary energy source. Most countries rely on fossil fuel for power plants, generators and automobiles. Secondly, some countries do not have this kind of resource and solely rely on fossil fuel from other countries. In this case, the increase in price of fossil fuel will give negative impact on these people's livelihood considerably. Moreover, in the remote areas where a national grid is not available, small generator running on fossil fuel is the common form of energy supply.

Moreover, the promotion of biofuel in Cambodia is motivated to reduce rural poverty through energy supply at low cost[1].

Cambodia has imported almost 100% of its' oil fuel from overseas (ECFA, JDI, & KCP, 2007, p. 672). In terms of fossil diesel, the quantity accounts for 685 KTOE[2], that is, 41% of total energy sources (Heng, 2008); this quantity does not include the amount that is smuggled into the country. This energy is mainly used for generators and automobiles. In 2000, mineral diesel oil was requested to replace by palm oil by the former King (ECFA, et al., 2007). There was an introduction of biodiesel made from Jatropha in 2004 by a local NGO, namely Development and Appropriate Technology (DATe). DATe run a project in 4 villages of Ponley District, Kampong Chhnang Province of Cambodia. It is worth noting here that as Cambodia is situated within a tropical country suited to Jatropha production, it can be commonly found grown in rural areas where it is offent used as a fence.

Data for Jatropha production and survey to establish the baseline potential is not available in Cambodia (Markandya & Setboonsarng, 2008). However, there were four reviews of the potential to produce biodiesel in Cambodia (De Lopez, 2003; ECFA, et al., 2007; Markandya & Setboonsarng, 2008; Williamson, 2006). Lopez, in his analysis, focused on biomass potential to produce renewable energy. Lopez concluded that the technical potential for the use of bio-energy technologies in Cambodia is high. He also recommended assessing technical feasibility in the field, as well as the economic and social potentials for the adoption of bio-energy technologies. This author did confirm that poverty reduction remains the principle objective of any adoption of bio-energy technology. Thus, applications and services that use energy productively to improve the livelihoods of people ought to be favoured. Bio-energy technologies will be adopted in Cambodia if they present direct benefits for the poor and contribute to national sustainable development objectives (De Lopez, 2003).

William (2006) has conducted another review regarding to renewable energy. The author suggested that biodiesel from Jatropha will be a substitute for fossil fuel imported countries such as Cambodia. He puts forward that local production and use of biofuel also offers other benefits such as improve of energy security, rural development opportunities and environmental benefits. The author concluded that local production of biofuel in Cambodia, based on the JC species or other sources, would offer potential benefits for the investors, the economy, rural communities and the environment (Williamson, 2006).

Following William, there was another review conducted by a joint partner among three institutions; Engineering and Consulting Firms Association of Japan (ECFA), Japan Development Institute (JDI), and Kimura Chemical Plants (KCP) Co., Ltd. The study found that the estimated cost price of biodiesel from Jatropha is about UDS 43[3] cent/l (ECFA, et al., 2007). ECFA *et al* recommended that Cambodia should promote biofuel by using cassava and Jatropha, since Cambodia has been exporting cassava to Thailand. This study has

[1] It is generally observe that the more remote the location is in Cambodia, the more expensive the electrical expenses as the supply is made by small scale private sectors using their own generators

[2] KTOE means kilotons of oil equivalence

[3] The price of fossil diesel at station is $1.20 on 19 May 2008.

provided some policy frameworks to promote the two agricultural crops and Cambodia Bioenergy in general. Although this study has proposed these national policy frameworks, no major actions have been taken so far.

Markandya and Setboonsarng (2008), in their analysis, confirmed the possibility of investment in energy crops namely cassavas and Jatropha in Cambodia and Laos. The authors concluded that benefits of both activities in terms of poverty reduction and environmental sustainability to developing countries like Cambodia and Laos would be significant. They claimed that poverty impacts appear to be greater for organic agriculture than for biofuel but since the growing areas do not generally overlap, both could be promoted. The authors did confirm that biofuel from organic agriculture would contribute to the poverty alleviation in Cambodia (Markandya & Setboonsarng, 2008).

Within a Cambodia, the agriculture sector is highly promoted. In the policies within the Strategic Development Plan 2006-2010 (Rectangular Strategy), give a lot focus on expanding the agricultural sector. Although the Cambodia Government has no specific policy on biofuel promotion, the government has granted economic land concessions to investors for agricultural investment.

1.2. Problems Statement

Given environmentally, economical and political positive, there are counter argument on biofuel production at local, national and international level.

1.2.1 Is biofuel Environmentally Friendly?

Although biofuels are promoted internationally and domestically, the practical effects of biofuel in the environment are still debatable.

It has been proved that biofuels potentially contribute to the reduction of greenhouse gases, especially CO_2 emission when they are used in combusting. However, this claim is not always true when taking into account the ways of productions of biofuel. Fargione, Hill et al. (2008) argued that converting forests land, peatland, savannas or grasslands to produce food-based biofuels in Brazil, Southeast Asia, and the United Stated creates a ‘biofuel carbon debt’. The authors claimed that CO_2 will be released 17 to 420 times more than the annual greenhouse gas reductions these biofuels provide by displacing fossil fuel. However, they claimed that if biofuel is made from abandoned agricultural lands planted with perennial crops, there will be little or no carbon debt and offer immediate and sustained GHG advantages. A study by Searchinger, Heimlich et al. (2006) found that carbon dioxide emissions will occur when farmers worldwide convert forest and grassland to grow biofuel organic plants. Their study estimated that corn-based ethanol (instead of producing a 20 percent savings) nearly doubles greenhouse emissions over 30 years and this conversion will increase greenhouse gases for 167 years.

From the positive impacts, Ogunwole, Chaudhary et al. (2008) conducted a study in a degraded land in India and proved that JC plantation can improve soil quality, for it maintains organic carbon and nitrogen stock and increase carbon sequestration rate. Another study in India related to JC found that diesel extracted from Jatropha meets EN 14214 stardard (Ghosh, et al., 2007). This study concluded that the fuel from JC is safer as a result of the high flash point. The mileage obtained is comparable to that of fossil fuel and the GHG emission is greatly reduced (Ghosh, et al., 2007). A study by Farrel, Plevin et al. (2006) has refuted the results of some studies that reported negative net energy, for those studies ignored co-products and used some obsolete data. In a similar argument of Farrel Plevin et al. , Sedjo (2007) attempted to prove that some feedstock such as corn would involve in planting, harvesting and transport operations, as well as the application of fertilizers. However, the author mentioned that cellulosic biomass (switchgrass and hybrid poplar) can reduce greenhouse gas emissions by about 115 percent when compared to petroleum.

Besides energy and greenhouse gas emission reduction, plants to produce biofuel like JC does not need fertile land to grow and provide fruit up for to 30 years. It can grow on sandy or saline soil. It requires 220mm of annual rainfall. In the past, this plant is used as a live fence, for it is not browsed by animals. Some countries use Jatropha as medicines. Recently, Jatropha has many uses such as raw material to make soap, plastics, synthetics fibres, and hydraulic oil. The plant is actively used to enrich infertile soil in some countries like India, China and Thailand. In Ghana, the plant is used as insecticide/pesticide, non conventional energy crop and profitable agro forestry crop (Banajata, 2008).

1.2.2 Is Biofuel Economically Viable?

The practical usages of Jatropha in Cambodia, however, are: a livinv fence, property demarcation, and to some extent, to prevent soil erosion. This plant is grown countrywide. But Jatropha plantation in the commercial form is now widely practiced in Kampong Chhnang , Banteay Meanchey and Kampot. While Jatropha plantations are being promoted for commercial scale, the detailed study on its economical viability does not exist (ECFA et al., 2007; Williamson, 2006). Moreover, the latest study recommended that Jatropha plantation will generate the greatest increase in poverty reduction for the least outlay (Markandya & Setboonsarng, 2008).

1.2.3 Market Failure: Government Intervention

Kahn (2005, p. 15) argued that the market will not promote a level of environmental quality that maximizes the well-being of society. In other words, market institutions are not likely to give us results that are socially efficient (Field, 1997, p. 66). An externality will occurs when the action of one party or more impose costs or benefits to others, that is, the costs or benefits of the action(s) of those parties are not fully reflected in market price. For instance, in the case recycling paper, there is a positive externality as the firms reduce their material inputs and the pressure on the natural environment. But those firms (the parties providing the spillover benefits) are not receiving the full remuneration for their positive spillover effect. On the other hand, the case of pollution, the costs of firms that generate pollution are not *fully* reflected in the market price; those costs are imposed to society in terms of its impact on the natural environment.

So, given worldwide and local promotion, it is heavily dependent on the contexts. The promotion can come at the costs and benefits to countries, for from countries to countries there are variations of land use, types of plants and government intervention on the market of biofuel.

1.3. Study Objective

Broadly speaking, it can be seen that the promotion of biofuel should be scaled up in order to reduce dependency on oil and decrease CO_2 emission from using fossil fuels, which contributes to climate change. In a Cambodia context, the promotion is not only to fight climate change and oil dependency, but also to reduce poverty in rural areas. For these reasons, the study is necessary to assess the following:

(1) What are the costs and benefits of producing JC in Cambodia?
(2) How much CO_2 (and other GHG) can be saved from the Jatropha curcas production which contribute to social benefits?
(3) How much can biodiesel be produced that will substitute imported fossil-based fuel?
(4) How much income can be made to contribute to rural poverty reduction?
(5) What is the policy option (tax or subsidy) that can be used to shape the right direction of Jatropha promotion in Cambodia?

1.4. Significance of the Study

The promotion of biofuel may lead to negative or positive impacts on Cambodian society from environmental and economical points of view. This study is conducted to determine the negative impact of biofuel production and the positive impact of increasing livelihoods of the rural poor. Reiteratively, JC has been used as live fence throughout rural Cambodia. Since biofuel is being promoted throughout the world, there is still controversy of CO_2 emission related to land use, or from competing with food crops. This study is conducted to provide the empirical evidence over this controversy. If small scale promotion is proved to be environmentally friendly and contribute to local economic promotion, there should be an intervention at this scale. On the other hand, if it is proved that using biofuel from existing Jatropha has a negative impact on society, there is an urgent need to phase out any promotion in Cambodia, especially at the small scale. This is further examined in data analysis section.

Moreover, biofuel is being promoted by politicians, for the reason that the production of biofuel is believed to promote employment, break the poverty circle, enhance economic growth, and be used as an environmentally friendly fuel. In Cambodia, on the other hand, biofuel will provide a source of renewable energy for rural Cambodians. It can be used to replace firewood, which is currently accounted for 85% of rural people collecting wood from forest for cooking. Biofuel, therefore, will reduce the pressure on Cambodia forest.

The study will also contribute to the literature of biofuel status of Cambodia, the views of producers, agents, users, politicians and technicians who are involved in biofuel. The study will be a stepping stone to future study at the commercial scale. Without rigourous research on the small scale, especially when attached to poverty reduction in Cambodia, promotion of Jatropha plantation will produce less impacts for the poor, and the promotion can give a wrong signal to the development of the countries' economy.

1.5. Scope of the Study

While there are other feedstocks available in Cambodia, at bigger quantities such as sugarcane, cassava, corn, and forest, this study is mainly interested in JC. The main reason is that almost every household in the rural and remote areas plants Jatropha trees. If Jatropha is economically viable, this plant will play a key role in poverty reductions as mentioned by many authors. It is emphasised that the study will not cover the whole supply chain of Jatropha biodiesel, but it will take from collecting Jatropha seeds to usage.

The study will focus mainly on small scales, especially household based plantation. One of the provinces of Cambodia, namely, Kampong Chhnang province is chosen for the study.

This province is chosen because it is the province where JC promotion has been mostly strongly promoted. Moreover, Kampong Chhnang is a place of transaction where there is a potential to sell its Jatropha diesel to other consumers in other provinces such as Pursat, Battambong and Banteaymean Chey.

Although economic impacts from producing biodiesel from JC can be done at the national level, this is beyond this study. Baseline data on JC coverage areas is not available yet. As recommended by Markandya and Setboonsarng (2008) there is an urgent need to establish the baseline on Jatropha production. The introduction of small scale of JC promotion or fuel extraction is still at the informative stages. As mentioned earlier, only 4 villages of Ponley District, Kampong Chhnang Province were selected for trial. It is worth mentioning here that the commercial forms of JC plantation is now moving to the north of Cambodia such as Battambong and Banteaymean Chey province, where fertile soil and forest land are located.

The promotion of Jatropha will involve many sectors while this study will seek policy intervention from NGOs, local people and government institution such as the Ministry of Industries, Mine and Energy and the Ministry of Environment. The policy intervention information will be obtained from those stakeholders, then, the study will examine if the effectiveness of such intervention based on the findings. At last, there will be a recommendation of economic tools to promote Jatropha plantation if the results show that it is viable to do so.

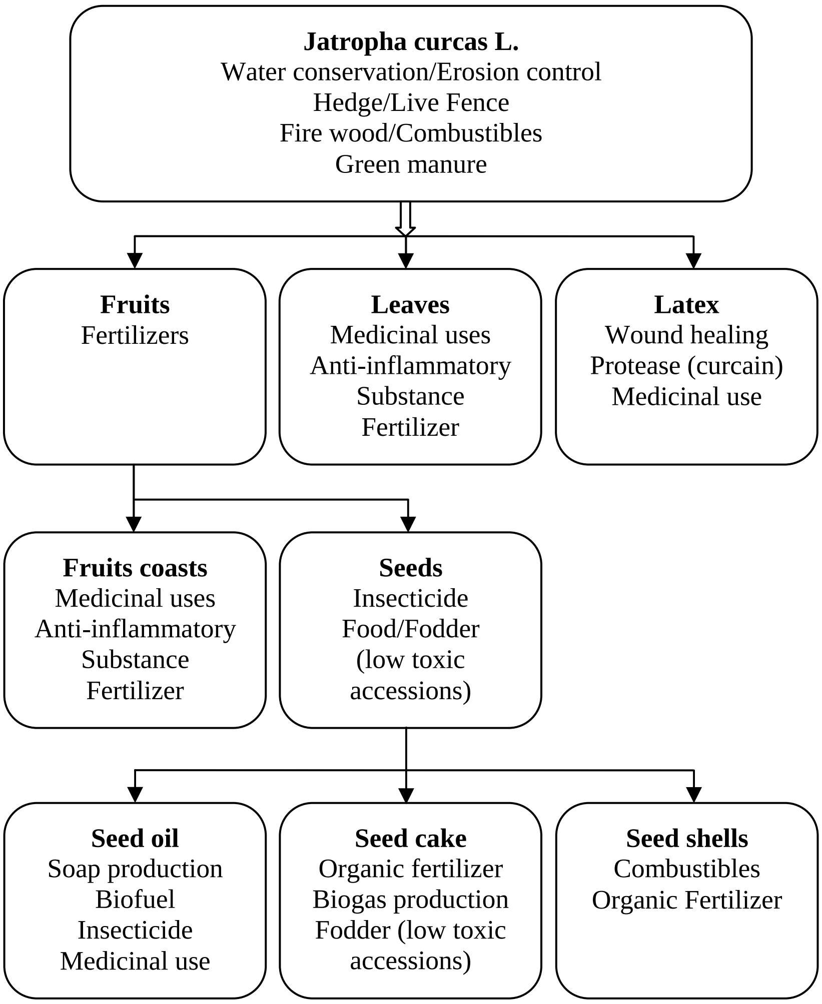
Jatropha promotion needs some forms of intervention. Government intervention is believed to be the most powerful. While there are a number of economic tools to accelerate Jatropha plantations, this study will also examine subsidies and taxes. The two scenarios are to ensure that the government will give the most appropriate signal for the promotion.

II. Conceptual and Analytical Framework

2.1. Jatropha Curcus

Jatropha curcas (locally know as **Lahong Kwang**) is a non-edible oil bearing tree. The tree can grow in dry, arid land. JC can be grown in areas of low rainfall (200 mm per year), on low-fertility marginal, degraded, fallow, waste and other lands, but not flooded land (San, 2009a; Tham, 2009a). JC is easy to establish in nurseries, grows very quickly by seeds or cuttings. The seeds can be collected easily, for the plant is about 2 meters tall. JC is not browsed by animals. Being rich in nitrogen, the seed cake is an excellent source of plant nutrients. There are more benefits from JC trees as shown in Figure 1, while the farmers in Cambodia use the plant as live fence and compost (green manure like).

Figure 1: Value Chain of Jatropha curcas components



Sources: Adapted from (Gübitz, Mittelbach, & Trabi, 1999)

In Cambodia, Jatropha tree flowers two times per annum during April-May and October-November, while in other countries it flowers and fruits from 1 to three times per annum (Chachage, 2003; Estrin, 2009). It takes about 60 days from flowering to harvesting stage.

Throughout the literature, the oil yield per hectare for JC varies greatly from 0.5 t/h/yr to 15 t/ha/yr (Estrin, 2009; Heller, 1996; Mathews, 2007; San, 2009a; Tham, 2009a). The yield varies due to water, soil conditions, altitude, sunlight and temperature (Ghosh, et al., 2007; Openshaw, 2000). The yield of JC live fence is quoted from 0.5 kg to 1 kg per metre in other countries (Henning, 2004).

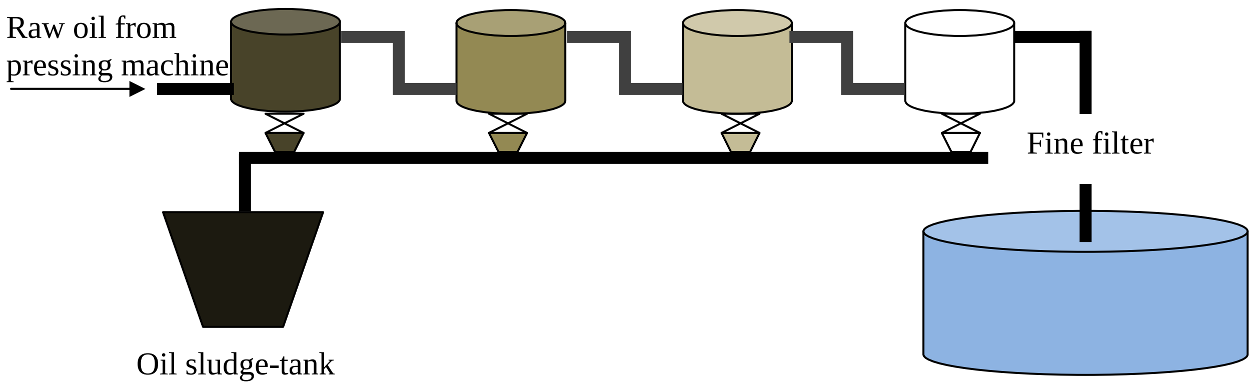
Since the research is interested in the small scale production of biodiesel, processing technologies will explored in order to gain an understanding of chemical process. There are a number sources supplying extracting machinery such as China, German. The expelling capacity ranging from 60kg/h manually pressing to 300 t/day by modern machinery from Japan (Eijck van & Romijn, 2008; Joseph, 2006). So far, the potential biggest biodiesel producer is Cambodia Bio Tech Development Company.

Based on Kim’s study, the basic reactions employed at local research institutes is as following (2005).

CH2COOR’’			CH_2OH	R’COOP
|		Catalyst	|	+
CHCOOR’’	3ROH	⟶	CHOH	R’’COOR
|			|	+
CH_2COOR” ’			CH_2OH	R’’ ’COOR
60 kg Oil	6.78kg Alcohol	0.6kg NaOH	6.5kg Glycerin	58kg Biodiesel

The study also found that the burning of biodiesel is 75% cleaner than conventional diesel (Kim, 2005; Starbuck & Harper, 2009). He claimed that the fuel can be used in any diesel engine and even better lubricant than a conventional engine as it extends the life of the engine. The production of biodiesel can be viewed as following figure after oil is extracted.

Figure 2: Particles removing process conducted by Institute of Technology of Cambodia



Source: (Kim, 2005)

2.2. Greenhouse Gases Emission in Cambodia

The first report on greenhouse gas (GHG) emission in Cambodia was released in 2001 and updated in 2010 during the Second National Communication to the UNFCCC (Cambodia Climate Change Office, Forthcoming). In terms of CO_2 equivalents emission, the primary source is from diesel consumption. Among the 4 emission sectors, namely Energy Industries, Manufacturing Industries, Transport and Other (which are commercial institution, Residential and Agriculture), the last sector is accounted for 24 percent of total emission or equal to 1,304 Gg in 2010. This sector is highlighted here due to the fact that biodiesel from JC seeds can be used directly with these stationary generators with minimal modification, or just simply clean the injector before starting the engine (UNIDO, 2007b) with crude JC oil to generate electricity for either a local grid or small business/factories.

2.3. Renewable Energy Development in Cambodia

To meet the growing demand of energy, the Royal Government of Cambodia has made an effort to import electricity from the neighbouring countries through grid connection. However, the government plans to build a series of hydropower plants. At the same time, the Rural Electrification and Transmission Project has been trying to connect 50,000 households to Solar Home Systems with 45$ subsidy per connection (Cambodia Climate Change Office, Forthcoming). Besides this effort, JICA has made an ambitious attempt to connect 168,000 rural households with biomass gasification in coming years.

Although in the status of energy development in Cambodia remains unclear, the Government has stated that "*The Rural Electrification by Renewable Energy Policy is an integral part of the Government's overall agenda for the Energy Sector including Rural Electrification and the Government's Rural Development Plan. The Government recognizes that supply of modern energy source for community applications like biomass, biogas, small hydro, wind, solar and liquefied petroleum gas as also critical in the rural area*" *(Source)*.

2.4. Energy Implication in Rural Poverty

Based on Cambodia Inter-censual Population Survey 2004, 83 percent of population have no access to power grid (National Institutes of Statistics, 2004). Most of power supply is available in Phnom Penh and provincial or district centers. The main energy sources of rural residents are firewood/charcoal for cooking; kerosene for lighting and some well off households have battery for lighting.

Collecting firewood is becoming costly due to the fact that people have to travel days to collect wood. Moreover, most of forest areas are closed for the sake of environmental protection. A study by the Royal University of Phnom Penh found that people spent about 25 hours to collect an ox chart of wood (Cheng, 2009).

3.5. Existing Policy on Biofuel in Cambodia

The Second National Communication to UNFCCC in the mitigation section, the report has highlighted that Biofuel produced from small scale could be viable, but if large scale, Cambodia need for Policy development, especially land allocation and agricultural zoning (Cambodia Climate Change Office, Forthcoming). Although the national policy on agro-fuel does not exist, there is consensus on the need a good policy in this regard (Roberts, 2009).

Around the globe, biofuel, especially biodiesel, has been attractive among policy makers such as some countries in OECD (Mathews, 2007) is called for 20 percent replacement by biofuel by 2020. By looking at second highest fuel consumption from the U.S.A namely China the governments are ready to promote biofuel in various form. The state's central planning commission of China, known as National Development and Reform Commission (NDRC) has set several targets in using fuel ethanol and biodiesel. Along with target, the government also subsidies including initial ethanol project, price of gasohol, tax waive, and encouragement on using non-grain feedstock (O'Kray & Wu, 2010). In India, on the hand, has mandated a five percent ethanol blend (IATP, 2008). In promotion of biofuel, neighbouring countries of Cambodia have made effort on expanding the consumption, especially Thailand, for it has mandated that E10 (ethanol 10 percent with petrol 90 percent) and B10 (biodiesel 10 percent with fossil diesel 90 percent) must be complied by 2012 (Joseph, 2006).

It has been mentioned that JC seeds can be pressed to get oil. This oil can be developed to use as biodiesel. Although, the technology is not yet fully developed, the oil can be used for stationary machines without or small modification on machine. The consumption of biodiesel, especially from JC seeds, is considered as option to mitigate with Climate Change exacerbation. As a member of UNFCCC, Cambodia also commits to reduce the impact of climate change by introducing a number of approaches, mainly adaptation and mitigation ones. In adaption, biofuel development is recommended during the second national communication to UNFCCC. While there are many possible options in supplying energy to rural household renewable energy is the main focus by the Royal Government of Cambodia. Although no clear policy on promoting renewable consumption like neighbouring countries such as Thailand, the Government commits to supply energy to rural communities.

III. Methodology

Firstly, this research is done based on desktop research and survey tools to get the information for CBA, especially from the growers, processors, and the users. Next, the social benefits will be shown by imputing the total amount of CO_2 (and other GHG) emission savings with the assumption that the entire amount of biodiesel from JC production is used to replace by petroleum-based diesel. Thirdly, the energy balance is examined to check if there is a net gain of energy balance. Fourthly, the study will analysis on household level (unit of analysis) to see the income generation from the selling JC seeds to the producer based on household survey questionnaires. Finally, subsidy mechanism will be tested to ensure the promotion of processing biodiesel from small scale JC based on redistribution of total social benefits, especially to the grower.

There are three cases of the analysis: first, existing live JC fence, expansion of JCL fence, and JC plantation on idle land. The study was conducted in Samaki Mean Chey District, Kampong Chhnang Province. The province is about 91 kilometres from Phnom Penh. This province is one of the target provinces that studied on JC plantation, especially small and medium plantations including JC live fence (S. Fauveaud, 2008; San, 2009a; UNIDO, 2007).

3.1. Costs and Benefits Analysis of Small Scale Jatropha Plantation in Cambodia

The generic costs of biodiesel production and consumption are based on following formula:

Costs account

$$C_{st} = \sum_{t=1}^{T} Q_{st} P_t + A_{st} + D_{st} + F_{st} \quad , \qquad (3.1)$$

where
C_{st}: the cost of production at 's^{th} (from 1 to 4)' stage in t^{th} year,
Q_{st}: the amount of input required in production at s^{th} stage in t^{th} year,
A_{st}: the abatement cost in production at s^{th} stage in t^{th} year, if applicable,
D_{st}: the charge for depreciation of fixed asset in production at s^{th} stage in t^{th} year
F_{st}: the distributive cost in production at s^{th} stage in t^{th} year, if applicable

The generic benefits of biodiesel production and consumption are based on following formula:

Benefits accounting

$$B_{st} = \sum_{t=1}^{T} Q_{st} P_t + M_{st} \ , \qquad (3.2)$$

where
B_{st}: the benefits of production at 's^{th} (from 1 to 4)' stage in t^{th} year,
Q_{st}: the amount of out put in production at s^{th} stage in t^{th} year,
M_{st}: the other benefits in production at s^{th} stage in t^{th} year, if applicable,

The CBA of biodiesel production and consumption are based on following formula:

Net Present Value

At each stage of production and each settings (that is, 'without project case - the existing JC plantation' and 'with project case - JC seeds is converted to fuel), there will be an estimation of net present value (NPV) of producing biodiesel will be based on the following equation:

$$NPV_{ij} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \quad , \tag{3.3}$$

where

NPV_{ij} = Net Present Value of i at j scenario

B_t = Benefit at time t *(t is from 0 to 30 years as a life span of Jratopha is 50 years)*

C_t = Cost at time t

r = Discount rate

t = Number of years

Environmental Net Present Value

Based on costs imposed by CO_2 emission from biodiesel production (estimated by equation (2.5)) and the benefits generated by biodiesel consumption (estimated by equation (2.6)), it is possible to estimate the net present value of environment by employing the following equation:

$$ENPV_{ij} = \sum_{t=0}^{T} \frac{(B_t + B_{it}) - (C_t + C_{it})}{(1+r)^t} \ , \tag{3.4}$$

where:

$ENPV_{ij}$ = Social Net Present Value of i at j scenario

Cost of CO_2 and Other GHG emission accounting

The production of biodiesel from JC will be associated with CO_2 and other GHG emission. The CO_2 emissions can be from the consumption of fossil fuel during transportation and oil extraction from JC seeds. Other GHG emission can be from the use of chemical fertilizer. The emission costs will not be at the individual producer level but reflect the society as a whole. Therefore, this cost will be further calculated to reflect social marginal cost and benefits. The estimation is based on the following equation:

$$C_{it} = E_i \ x \ P_i \quad , \tag{3.5}$$

where

C_{it}: the total cost of emission from i items of GHG in t^{th} year

E_i: total amount of emission from i items of GHG in t^{th} year

P_i: unit charge per i items of GHG in t^{th} year

Benefits of CO_2 emission reduction from replacing fossil diesel

We assume that biodiesel will substitute the consumption of fossil fuel (in the case that Cambodia will replace fossil diesel by biodiesel in a long run). It means that every unit of biodiesel is contributed to the benefits of CO_2 emission reduction as present in equation (3.7).

$$Bit = e_i \ x \ p \quad , \tag{3.6}$$

where
B_{it}: the total benefits of emission reduction from i items of GHG in t^{th} year
e_i: total amount of emission reduction from i items of GHG in t^{th} year
p_i: unit charge per i items of GHG reduction of GHG in t^{th} year

Since the production of biodiesel is not in place where the study is conducted, then the CBA is done under two different scale of production which is summarized in the following.

Defining the Cost-Benefits Analysis Scenarios

The Cost-Benefits Analysis (CBA) is inclusively based on:

- Base Case – existing fencing, excluding any biodiesel production.
- Scenario 1 – existing fencing plus expansion of fences using wooden poles, with biodiesel production.
- Scenario 2 – existing fencing plus expansion of fencing with some poles but predominantly new JC plantings, with biodiesel production.
- Scenario 3 – existing fencing plus plantation plantings of JC, with biodiesel production.
- Scenario 4 – existing fencing plus expansion of fencing mainly comprising new plantings of JC plus plantation[4]. plantings of JC, with biodiesel production.

3.2. CO_2 (other GHG) Saving Emissions as Social Benefits

The total amount of CO_2 saving is calculated with the assumption that all the amount of biodiesel from JC production is replaces petroleum-based diesel consumption. Then, the total of biodiesel production is converted to petroleum-based diesel with the factor of 0.96 (Tham's experiment). The CO_2 emission conversion factor is 2.6391 (National Energy Foundation, 2009).

3.3. Substitution of Imported Fossil-based Fuel

One can claim that the promote energy independence only if the energy input to produce a unit of biodiesel is less than the energy output; that is, the amount of energy of biodiesel. Based on Jaeger, Cross & Egelkraut (2007), the net energy balance (NEB) is expressed with the following equation:

$$NEB = energy\ output/energy\ input \qquad (3.7)$$

The energy output is that generated from biodiesel, while the energy input can be calculated from biodiesel itself or from fossil fuel.

3.4. Rural Poverty Reduction

Baseline data on income of household from secondary crop will be established based on household survey. With the collected data, the study is able to compare the income from

[4] Small Scale Jatropha Plantation refers to existing plantation around households, farm or rice field with possible expansion on idle land or converted land that is less than 1 hectare.

selling JC that contributes to raise their income. Also, it can estimate how many households will be able to move out of poverty through the production of JC.

3.5. Subsidy as a Tool to Promote Jatropha Production in Cambodia

The amount of total social benefits will be discus with regard to the grower and the processor to see how much the quality of biodiesel can be improved. More option can be explored along the line of analysis.

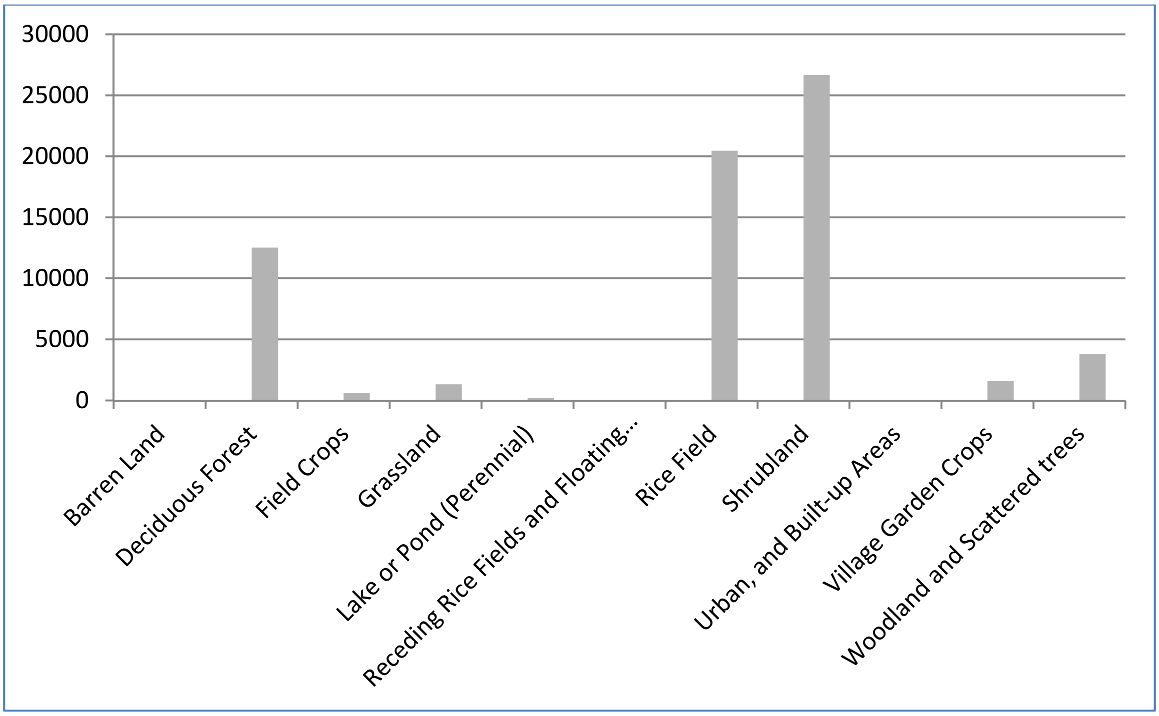
3.6. Sensitivity Analysis

To avoid misleading information to policy makers, the study will examine some of possible distortion, especially related change in the price of fossil diesel, charge of CO_2 emissions, and energy efficiency of biodiesel and the like. Some scenarios of discount rates (risk-free rate “3 to 4 percent”, official discount rate, and long-term-decision-making discount rate “1 to 2 percent”) will also highlight if these rates impact on the result of the study.

IV. Data Analysis

There are nine communes under the administration of Samaki Meanchey district. With 71 thousand hectares of land of the district, it mainly uses for shrubland, rice field, deciduous forest, woodland and scattered trees and village garden crops (Figure 3). The district's statistic of land is that 40 thousand hectares is forest land, 24 hectares thousand is crop land and about 4 thousand hectares is residential land of which there are 14,419 households in 2008 with the average household size of 4.5 (MoP, 2008; NCDD, 2009).

Figure 3: Land Use of Samaki Meanchey district, 2000



Source: (Land set 2000)

This section is to discuss the background information of the study site and some of the statistic that will be used for BCA on small scale JC Plantation. The following sub-sections will also logically analysing the data which will be employed in the full analysis in section 5.

4.1. Overview of Research Site

We selected 3 out of the 9 communes in Samaki Mean Cheay district, Kampong Chnang province, namely Sedthei, Tbeng Khpos and Thlok Vien, then we selected 3 villages from each communes. The communes have the population of 4,348 household of which Sedthei has 1,526; Tbeng Khpos has 1,705; and Thlok Vien has 1,117 households. The selection of commune is based on the present of (1) Jatropha live fence, (2) poor access to grid, (3) high poverty incident, and (4) with access to market and/or district hall.

4.1.1. JC as Live Fence

In general, the household fences their property with Jatropha curcas (JC) tree, Wooden Pole with barbwire, Concrete Pole with barbwire and some other type of fence temporary materials. Based on the interview with commune headmen, JC is planted as live fence in these villages the most within the district. The other usage of the plant is its leaves and cuttings for making compost mixed with animal dung. The compost is to enrich soil fertility for farming, especially for rice cultivation.

In relation to fencing, JC tree is equally qualified to wooden pole. This is measurable benefits that the study will highlight. Table 1 shows that not all households have fenced their property with JC. Given that, we can be assumed that about 98 percent of households from Thlock Vien have fenced with JC followed by Tbaeng Khpos 84 percent and Sedthei 65 percent. Based on the sample size, we can estimate that Sedthei, Tbaeng Khpos and Thlok Vien have JC live fence about 53,164; 84,418 and 82,975 meters respectively.

Table 1: Percentage and estimated JLC length of household sample in reference communes, 2010

ComName	Do you have Jatropha?	Frequency	Percent	HH Sample Size	Total No. HH	Mean of JCL per HH	Estimated Total JCL live fence in communes (in meter)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)=(5)*(6)*(3)[5]
Sedthei	Have	67	64.4	n=67			
	Have not	37	35.6	n=37			
	Total	104	100.0	104	1526	52.0	53,164
Tbaeng Khpos	Have	84	82.4	n=84			
	Have not	18	17.6	n=18			
	Total	102	100.0	102	1705	60.4	84,418
Thlok Vien	Have	98	87.5	n=98			
	Have not	14	12.5	n=14			
	Total	112	100.0	112	1117	75.8	82,975

Source: (Field survey 2010 and authors' calculation)

Table 2 shows the comparison of property-fence length with different types of materials namely JC, wooden pole (with barbwire), concrete pole (with barbwire) and other types of fence with temporary materials. In general, Thlok Vien commune household has the longest length of JC tree, that is about 7,541 meters, followed by Tbaeng Khpos at 5,053 meters and the shortest is Sedthei commune at 3,366 meters.

Compared to JC live fence, wooden pole with barbwire is the most popular fencing material among the three communes. Again, it appears that Thlok Vien commune used wooden pole at the length of 15,485 meters, Tbaeng Khpos at 14,966 meters, and Sedthei at 3,196 meters. The concrete pole fencing is too short to discuss, but we will discuss other type with temporary material, which is potentially converted to JC live fence (FDG in Thlock Vien Commune).

> *Yes, we will plant Jatropha Tree around our house. We cannot buy concrete pole. It is very expensive. We cannot go forest to cut the pole as they are now closed by the government. So Jatropha Tree is our last option. And if the seeds are bought, this is very good for our village. We can also plant along with the old fence and get the fruit. If Jatropha trees planted closed to our house, they will grow very well.*
> (FDG in Thlok Vien Commune)

[5] The multiplication factor with column (3) is the percentage of HH who has Jatropha

Although the length of other type of fence around the property is less common, that is 1,935 meters for Sedthei, 1,002 meters for Tbeng Khpos, and about 300 meters for Thlock Vien commune, it worth of discussion, for it will contribute to biodiesel production in the future. In short, fencing by JC is about 25 percent of the total property length fence while 69 percent is by wooden pole, 0.25 percent is concrete pole and 5 percent is by the temporary materials.

Table 2: Fencing status by village in the reference communes, 2010

ComName	VilaName	Jatropha as Fence (m)		Wooden pole as Fence (m)		Concrete pole as Fence (m)		Other Fence (m)		No. of sample
		Mean	Total	Mean	Total	Mean	Total	Mean	Total	
Sedthei	Boeung Leach	55.41	1496	112.00	3248	37.33	112	120.00	240	n=35
	Khnach	62.14	870	193.96	5043	0	0	180.33	541	n=31
	Phear Reach	38.44	1000	148.64	4905	0	0	115.40	1154	n=38
Tbaeng Khpos	Tbeng Khpos	68.10	2043	131.43	3812	13.67	41	80.25	642	n=34
	Meanork	46.00	1334	149.15	4922	0	0	115.00	230	n=35
	Sresa	67.04	1676	194.75	6232	0	0	65.00	130	n=33
Thlok Vien	Thlok Vien	70.60	2118	129.39	4788	0	0	200.00	200	n=37
	Spean Doek	78.74	2835	164.89	6596	0	0	0	0	n=40
	Prakout	78.06	2498	117.20	4102	0	0	67.50	135	n=35
Total		62.73	15,869	149.05	43,647	10.20	153	117.9	3,272	318.00

Source: (Field Survey 2010)

Expansion of Jatropha live fence and plantation

As mentioned in the FDG above, we also found similar consensus across communes, especially the during commune council discussion. They can see that the expansion can be around property of households, pagodas and schools, especially the idle land around schools and pagodas to have greenery. Given that people are willing to expand their live fence as in Table 3, we will have JC live fence increase dramatically as in Table 3.

Table 3: Potential (in percentage) JC expansion as live fence in the reference communes, 2010

Will you expanse you live fence if there is		Not Marketed the seeds		Marketed the seeds?	
		Frequency	Percent	Frequency	Percent
Sedthei	Yes	68	65.4	95	91.3
	No	35	33.7	8	7.7
Tbaeng Khpos	Yes	71	69.6	92	90.2
	No	31	30.4	9	8.8
Thlok Vien	Yes	89	79.5	103	92.0
	No	23	20.5	9	8.0

Source: (Field Survey 2010)

It seems that almost all respondents will plant more JC trees around their property once there is a market for the seeds. Without market, households will expanse their live fence at 65 percent in Sedthei, about 70 percent in Tbaeng Khpos, and 79 percent in Thlok Vien.

Samaki Meanchey district governor mentioned that his district has potential to grow JC, for there are so many pieces of land staying idle owned by households. It appears that this amount is overstates by him, for we found that the investigated communities do have idle land but not as big size of idle land as the governor envisaged.

With the biodiesel benefits, the governor said that he would add biofuel production plan at district and commune strategic development plan. He is very positive with the participation of people as long as there is market for JC seeds. He feels that biodiesel can be used by almost all kinds of machinery.

With the above responses, we can compute the potential JC live fence as in Table 4. The computation is based on the total fence that households will fence around their property inclusively house, farms, and rice fields. We expect that they will replace or duplicate current wooden pole and other temporary fence.

Table 4: Potential JC expansion as live fence in the reference communes, 2010

ComName	VilaName		How long is your fence around your house? (m)	How long is your fence to protect your rice field? (m)	How long is your fence around your Farm? (m)	How long is your fence around your other area? (m)
Sedthei	Boeung Leach	Mean	138	-	-	-
		Sum	4,554	-	-	-
	Khnach	Mean	426	400	-	-
		Sum	12,354	400	-	-
	Phear Reach	Mean	130	60	405	400
		Sum	4,826	120	1,620	400
	Total per commune		21,734	520	1,620	400
Tbaeng Khpos	Tbeng Khpos	Mean	92	190	471	115
		Sum	2,838	1,330	4,240	230
	Meanork	Mean	122	281	-	-
		Sum	4,277	2,246	-	-
	Sresa	Mean	144	181	240	-
		Sum	4,743	1,630	720	-
	Total per commune		11,858	5,206	4,960	230
Thlok Vien	Thlok Vien	Mean	105	229	201	50
		Sum	3,765	1,373	2,012	50
	Spean Doek	Mean	203	84	187	152
		Sum	8,114	585	374	457
	Prakout	Mean	180	170	-	-
		Sum	6,285	340	-	-
	Total per commune		18,164	2,298	2,386	507
	Grant Total		51,755	8,024	8,966	1,137

Source: (Field Survey 2010)

Table 4 shows the total length of fence around the property of the three communes. The longest fence types is for protecting house at 51,755 meters, followed by farm and rice field at similar length at 8,966 and 8,024 meters respectively. Given a little bit different in sample size, Sedthei commune has the longest length around their residents at 21,734 meters, then Thlok Vein at 18,164 meters and Tbeng Khpos at 11,858 meters.

However, we also check with household if they wish to expanse their plantation on other land such as idle land or convert land to JC plantation (as shown in Table 5). Based on our primarily observation, there will not be much expansion on other land rather than their fence. This seems contradict to the claimed by the District Governor that people may have 1 hectare of idle to plant JC tree if there is market of JC seeds.

Table 5: Potential JC expansion as plantation on unused land in the reference communes, 2010

Do you have unused land?

ComName			Frequency	Percent
Sedthei	Valid	Yes	22	21.2
		No	82	78.8
		Total	104	100.0
Tbaeng Khpos	Valid	Yes	28	26.9
		No	76	73.1
		Total	104	100.0
Thlok Vien	Valid	Yes	24	21.6
		No	86	77.5
		Total	110	99.1
	Missing	System	1	.9
	Total		111	100.0

Based on Table 5, there is 21.2 percent of household in Sedthei will plant JC on their scattered forest land or unused land, Tbeng Khpos 28 percent and Thlok Vien at 21.6 percent.

Table 6 shows the status quo of JC in the three communes. From this table, we can compute and analysis of the prospect of biodiesel as in following session 5.

Table 6: Distribution of JC by communes and growing type, 2010

ComName	Existing Live Fence (meter)	Expansion Live Fence (meter)	Plantation (hectare)
Sedthei	49,382	144,311	15
Tbaeng Khpos	84,464	186,835	25
Thlok Vien	74,305	124,643	19
Total	**208,151**	**455,789**	49

Source: (Authors calculation based on Field Survey 2010)

Table 6 shows the status of current live fence of JC, the potential live fence expansion and small scale plantation in the three communes based on the estimation of current length of JC, willing to expansion with and without biodiesel production. It appears that the live fence expansion is as much as two times compared to the existing one. However, the small scale plantation is quite small about 59 hectare of idle land.

Jatropha curcas Yield

Based on key informant interview, fruit yield in one meter live fence JC age from Year 1-Year 4 is at minimum weight of fruit 1.2kg and from Year 5-Year 30 is 2.5kg. This is due to the fact that JC live fence is planted densely which will reduce fruit yield per tree, Mr. Than Bun Hak, the grower and processor, confirmed that every meter of JC live fence yield about 2.5 kg for mature tree and 1.5 kg for pre-mature tree. In terms of plantation, growers in Cambodia confirmed that 2 tons per hectare per year of fruit for pre-mature and it is up to 4.5 tons for mature tree. This is consistent with most of the JC literatures. JC fruit contains from 1 to 3 seeds. The weight of the seeds is about 55-65 percent of that fruit. The oil content of the seeds is 30 percent of the weight.

4.1.2. Accessibility to Electricity Grid

Samakki Mean Chey district have no access to national electricity grid, however, it has access to private grid. Although, there is private grid, less than 1 percent of total population of the district enjoys this accessibility (Government of Kampong Chnang, 2009). The rest rely on kerosene light and battery. The communes in this study has neither public nor private grid. They use kerosene light with battery (as in Table 7)

Table 7: Population Access to Electricity in Samiki Meanchey, 2010

ComName		Do you have kerosene light?		Do you have Battery?	
		Frequency	Percent	Frequency	Percent
Sedthei	Yes	93	89.4	70	67.3
	No	10	9.6	34	32.7
Tbaeng Khpos	Yes	72	70.6	76	74.5
	No	29	28.4	25	24.5
Thlok Vien	Yes	99	88.4	60	53.6
	No	13	11.6	52	46.4

Source: (Fieldwork survey 2010)

Table 7 shows that Thlok Vien commune used kerosene for lighting at 99 percent followed by Sedthei at 93 percent and Tbaeng Khpos at 72 percent. Using battery is quite common within the communes at around 70 percent each. In terms of cooking energy, almost all of households, 98 percent relied on firewood, collecting from bush land around their house or from the mountain nearby. At the same time, households in the communes use charcoal for cooking as well, at 18 percent.

4.1.3. Poverty Incident Occurrence

Although, there is no empirical study on poverty occurrence for Samakki Mean Chey district, We will not do any in deep research on this poverty occurrence. However, we have conducted several focus group discussions, mainly with district governors and NGOs. We also browsed from district to district of the province. We found that most of poor people reside in this district with more than 95 percent of household working in agriculture sector, mainly rice.

Figure 4: Income from rice production of Households in the reference communes, 2010

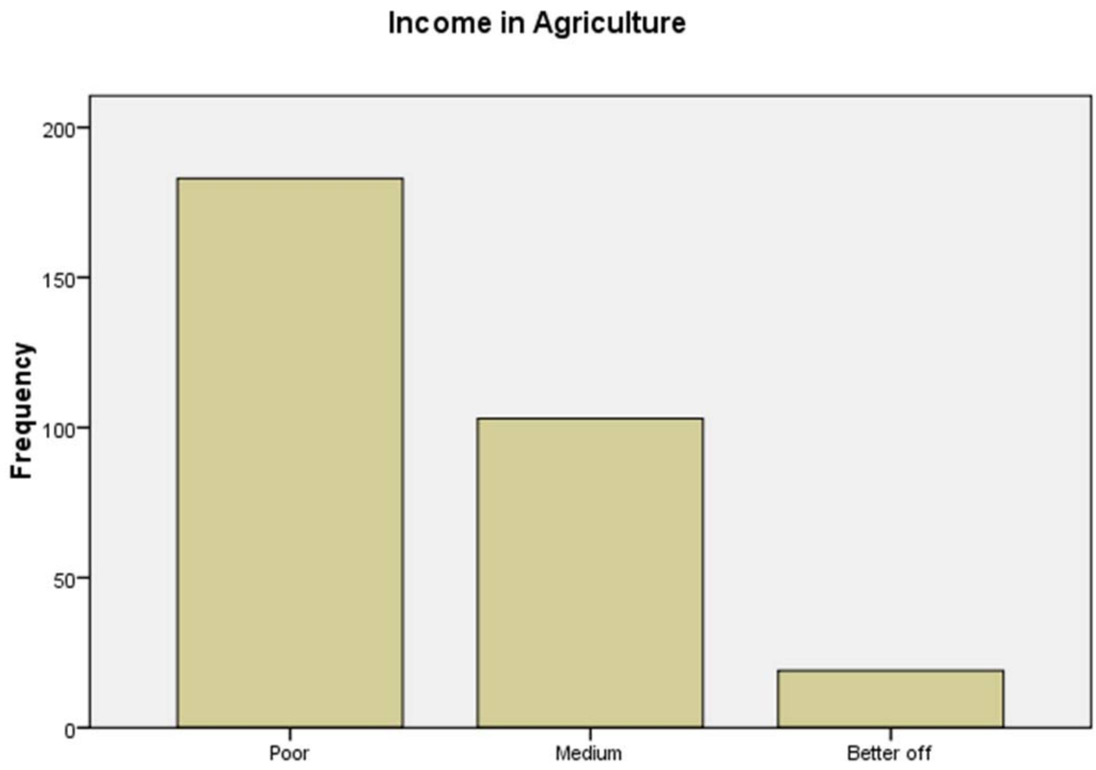


Figure 4 shows that 58 percent of households in the communes is poor, earning from agriculture up 1 million riels (about USD 250 per year). There is 32 percent who can earn from 1 to 2.5 million riels. The number of household who can be considered as better off in wealth ranking (earning from 2.5 million riel) is about 6 percent.

4.1.4. Access to Market and/or District

The Sedthei, Tbaeng Khpos, and Thlok Vien commune can access on unpaved road to district hall, where a biodiesel production can be established and sell production, about 6, 3 and 14 kilometres respectively. However, the common market that the people from the communes go to is the market resided along the National road number 5. Then the distant from the market is 14, 13, 7 kilometres to Sedthei, Tbaeng Khpos, and Thlok Vien commune respectively.

4.2. The Sceptical of Jatropha Curcas Plantation on the Move

In the reference site, we found that the major of households use wooden pole with barbwire to fence their property (Table 2), and almost half of the fence were made from JC trees. The study observed that about 45% among those live fences were planted during the last five years. The trend will increase due two reasons. First, the wooden pole is increasingly expensive if it is bought from the market. If not and people go forest, the forest that people used to access to cut the pole is either too far from their home or the area is protected. Secondly, the organic fertilizer is becoming popular, meaning that people shifting from chemical fertilizers to compost one. As the FGD in the reference site claimed that compost is very good and it will not degrade their land.

Private sector involvement in JC production is still in formulation stages. So far, there is one local NGO who plant 80 hectares of Jatropha in Kampong Chnang Province, Toek Posh District in 2008. There was also a private sector, some private banks in Cambodia who planted about 80 hectares of JC, but now the plants were died due to (1) poor the structure of the land which is not holding any fertilizer plus high precipitation and (2) flooding (Hor, 2010). At least, there was hundreds of hectare of JC were planted within 2008-2010. Those plantations were not success due to high water content of soil and flash flooding. Mr. Tam Bun Hak also planted about 5 hectares last year, but the plants are now died due to land condition. Given bad sign of farming size plantation, Asian Development Bank has an ambitious target to promote plantation all of the provinces along Tonle Sap Lake, which is 6 provinces (personal communication). Also, thousand hectares of land in Kampong Spue, Banteay Meanchey, Posat and Siem Reap province are/will be planted JC.

There is only one small scale processing plant available in Cambodia owned by Mr. Bun Hak. He is trying to buy the JC seeds from household fence through the country. However, the production is very minimal 2,000 litres in 2009. There is a big processing plant own by Cambodia-Japanese SME. They can produce with high productivity, which 10 kg seeds equal to 4.5 litres biodiesel compared to Mr. Bun plant at only 3.00 litres. A 2 million USD processing plant with a capacity of as much as thousand hectares of JC plantation[6] by a private company is also a promising buyer.

Besides local production, there is middle man who is looking for seasonal JC seeds to Japan. They offered a good price compared to local price at USD170/tone with USD350/tones. The middle man made direct contact to all key persons such as district governors, commune headman and big plantation JC growers and biodiesel processors.

4.3. Diesel Demand in Local Community

Since biodiesel from Jatropha curcas L. (JCL) can be used with many types of machinery, just the matter of blending with conventional diesel, we have investigated on demand side at local level. The discussions with users, especially with battery charger shop owners, rice threshed milled, motor cultures and the like, were very positive. They are willing to purchase biodiesel produced at their community.

[6] The search Team cannot get the actual figure due to company confidential policy.

V. Results and Discussion

These sections will show all possible costs and benefits analysis (CBA) that associated with JC in the 5 aspects: (1) Base Case, (2) Scenario 1, (3) Scenario 2, (4) Scenario 3, and (5) Scenario 4 as mentioned in section IV. Basically, the CBA is mainly based in appendix A.

Costs' component of farmer

Currently, farmers produce compost from JC leaves and cuttings. The cost of this activity is only the opportunity cost of time. Compost is used to replace chemical fertilizer. Almost all households who have JC live fence, they have been practicing this for long, especially the trend has increase due to the fact that the chemical fertilizer price is increasing while the environmental groups are promoting organic fertilizer. Each commune has set master plan to train farmers how to make organic fertilizer and pesticide. The opportunity of labour cost, moreover, is considered as much as one third to the agricultural wage labour which is at 1,300 riels per hour.

When farmers participating in biofuel production, the cost incurred would be (1) Cost of land (2) Cost of land preparation, (3) Cost of labour, (4) Cost of inputs, and (5) Other costs as in Table 8.

The cost of land will be imputed when farmer used their idle land for JC plantation. Although the land is apparently idle, we consider that there is opportunity cost. The price of land rental at community is estimated based on traditional exchange-benefit rice cultivation, which is about 10% of total harvest yield or at 120,000 riels/ha. Similar to cost of land, the cost of land preparation incurs when farmers plant JC in their idle land. For live fence expansion, there is no requirement to prepare land. The cost of land preparation would be associated with land clearance, and ploughing land. This cost is estimated based on fee renting a tractor at 1 million riels per hectare.

The labour costs incur (including land preparation, planting, weeding, branch cutting, spraying pesticide, fruit collection and the like) both forms of production, which is JC nut from live fence and plantation. However, this cost will impute higher rate in the form of plantation form. The inputs cost (including pesticide, fertilizers, and seedlings) is involving with plantation only. This cost is estimated at 200,000 per hectare per year.

Table 8: Cost of JC nut production in Samakimeanchey District, 2010

No	Itemized Costs	Unit	Amount	Percentage
1	Land Rent	riel/ha	120,000	4
2	Land preparation	riel/ha	1,000,000	32
3	Labour	riel/ha	1,300,000	42
4	Inputs (O&M)	riel/ha	600,000	19
5	Other costs*	riel/ha	73,200	3

(*) 3 percent of items (3), (4), and (5)

On a hectare based unit costs, 42 percent of costs spends on labour, as it is a labour intensive agricultural product, followed by land preparation. However, the land preparation incurs only the beginning of the year.

Costs' component of producer

According to a feasibility study of a small scale production of crude JC oil in Cambodia done by Swan FAUVEAUD (2008), the establish cost of a complete set of one production house is as following table.

Table 9: Start-cost for producer to producer biodiesel in rural area

Items	Unit price	Unit	Quantity	Unit	Total
Warehouse (conversion of a house)	$ 5,000	complete	1		$ 5,000
Material for drying area (concrete)	$ 1	per sq.m	100		$ 100
Labour force for construction	$ 75		2.5	man-mth	$ 188
Dehulling machine	$ 500	complete	1		$ 500
Oil expeller	$3,500	complete	1		$ 3,500
HP engine	$ 150	complete	1		$ 150
Press filter	$ 1,500	complete	1		$ 1,500
Oil storage vessels (set)	$ 500	complete	1		$ 500
Other accessories	$ 500	complete	1		$ 500
Basic quality testing equipment (1 set)	$ 500	complete	1		$ 500
Total Start Up cost					**12,438**

Source: (Swan Fauveaud, 2008)

The main start-up-costs for the producer are an oil expeller, a set of filters and the shade for the production process. The other associated costs can be adjusted. Based on the table above, the cost is up to USD 12 thousand. In attaching with the life span of JC or the equipment must be renewed within 15 years and some maintenance cost annually. Beside the establishment costs, there is an operational costs including: Operation cost, Labour cost, Maintenance, Depreciation on Diesel engine, Depreciation on Expeller, Depreciation on Production unit, and Depreciation on one motorbike (part time collection of fruit), of which account for 1,476 riels per litre.

Benefits associated with JC plant

The main benefits generated from the biodiesel production from JC would be the price of selling this biodiesel for consumption. However, there are many other benefits as described here and in the Figure 1 in section II.

Although JC nut is not widely marketed in Cambodia, there is potential price of seeds at 700 riels per kilogram at household resident. The co-benefits of JC tree are: live fence, and compost that farmers may generate. It appears that the wooden poles price can be bought from local market at 8,000 riels per pole while comparable fertilizer that compost will substitute is at 1,800 riels per kilogram at local market.

At the producer end, they can sell the biodiesel at 3,500 riel at local market. Moreover, the co-benefits of this biodiesel production are seed cake, sold at local market at 300 riel per kilogram.

5.1. Financial Analysis of Jatropha curcas in Cambodia

5.1.1 CBA Base Case

The Base Case means that there is no marketing of JC seeds and/or no biodiesel production exist in Cambodia. Still JC tree has direct benefits for house and direct benefits to the environment. The household can prevent animal instruction into their property, land demarcation, and greenery around their house. These benefits, however, is not measured in this study.

People can make this kind of organic fertilizer by adding all kind of plants but the most popular one is *Chromolina* known as Torn Treang Khet. The quality of this fertilizer is as high as the best chemical fertilizer in the market that you can find (FGD in Field Survey). People prefer to use this organic fertilizer than chemical one, for its quality and environmental friendly to the land. However, the quantity that can be produced is not as much as to meet the need of farmer. One meter of length of JC, compost fertilizer can be made 0.5Kg at the lower end of production and 1.0Kg at the highest end of production. One 1Kg of compost requires about 5 minutes producing the compost per tree. This is included collecting leaves and branches, chop into small pieces and mix with animal dung.

Table 10: Distribution of compost weight in the reference communes per year, 2010

ComName	Estimate Total Compost	Estimate Total time making compost	Opp. Cost of composting	Total estimate benefit
	0.5 kg/tree	5mn/tree	500 Riel per hour	1,800 riel/kg equivalence
	(kg)	(Hour)	(in million Riel)	(in million Riel)
Sedthei	24,691	4,115	2.05	44.44
Tbaeng Khpos	42,232	7,038	3.51	76.02
Thlok Vien	37,152	6,192	3.09	66.87
Total	**104,075**	**17,345**	**8.65**	**187.34**

Source: (Field survey 2010)

Note: Opp. Cost: Opportunity cost own labor

The composting is highly benefits at 187 million riel per year compared to costs at only 8 million Table 10 and 11. The cost, moreover, is the opportunity costs of time spending to compost maker. Since making compost does not really demanding, that is it can be make at anytime and by anyone in the family the time cost is at about one third of the actual agricultural wage labor.

Table 11: Value of Compost from existing live fence Jatropha tree in reference communes, 2010

Description	Y1	Y2	…	Y5	…	Y30
Total Benefits (million riels)						
Compost	187.34	187.34	…	187.34	…	187.34
Total Costs (million riels)						
Labour	22.55	22.55	…	22.55	…	22.55
Net Benefits	***164.98***	***164.98***	**…**	***164.98***	**…**	***164.98***
Net Present Value (NPV)	*1,553.43*					
Benefit-Cost Ratio (BCR)	*8.31*					

Table 11 shows that the benefit of live fence for making compost which is very much higher than cost in the present value terms, that is about 8 times higher. The net benefit per year is equal to 164 million riels within the communes. If we share this total amount, each household would receive at average of 37,718 riels (about USD$9.00) per year.

5.1.2. Scenario 1[7]

The scenario 1 analysis is based on the fact that live fence of JC nut will be the raw material for biodiesel, at the same time people are assumed to fence their property with wooden pole, especially the existing temporary materials fence. It is worth noting here that the wooden poles are extracted from value forest, which will cost, if the household bought at the local market, at 8,000 riels per pole. Assuming that wooden poles will replace the other fence (made from temporary materials), then the quantity of wooden poles needed as following Table. In this case, we found that the cost of wooden pole is at 387 million riels within the three communes.

Current live fence attribute to compost and biodiesel production. Compost can be made at two levels: household (leaves and cutting) and processor (seeds cake). Based on the interview with Tham Bun Hak, the biodiesel producer in Cambodia, he used seeds cake of from JC seeds for fertilizer. He claimed that the fertilizer is full of quality compared to chemical fertilizers. Other than the seeds cake, the shelf of the seeds can be used for biogas with proper installation. However, the plant provides other benefits to human such as soap and ecology such soil enrichment or erosion. Since these benefits are not captured in this study, we will not elaborate those aspects in our report.

Those who have JC trees as live fence; they will participate in the market. However, they prefer to sell the seeds at home or village headman as it is closed to their house. Then, the assumption made along the line with this finding is that the village headman will play the role as seeds-buyer/collector and send it to the commune hall for production, for this is the closest distance within communes.

Table 12: Wooden pole costs for fencing the property in reference communes, 2010

ComName	Total length to fence by temporary materials	Total length to replaced by wooden pole	Unit price of wooden pole	Total Amount
	(meter)	(pole)	(riel)	(in million riels)
Sedthei	28,392	29,607	8,000	227
Tbaeng Khpos	16,749	16,271	8,000	134
Thlok Vien	3,341	40,339	8,000	27
Total	**48,482**	**86,217**		**387.9**

Source: (Author calculation)

Once the farmer participate in marketing the drying seeds for biodiesel production, they generate another benefits, but not as much as composting as in Table 13. On the other hand, if they replace their temporary fencing with wooden poles, they experience at very high costs.

[7] existing fencing + expansion of fences using wooden poles, with biodiesel production

Table 13: CBA of farmer in Scenario 1, 20101

Description	Y1	Y2	...	Y5	...	Y30
Total Benefits (million riels)	213.56	213.56	...	213.56	...	213.56
Compost	187.34	187.34	...	187.34	...	187.34
Selling seeds	26.23	26.23	...	26.23	...	26.23
Total Costs (million riels)	417.92	30.07	...	30.07	...	30.07
Wooden pole	262.55	0	...	0	...	0
Labour	66.84	52.62	...	52.62	...	52.62
Net Benefits	(115.82)	160.95	...	160.95	...	160.95
Net Present Value (NPV)	**1,265.62**					
Benefit-Cost Ratio (BCR)	**2.69**					
Internal Rate of Return	**1.39**					

Table13 shows that Scenario 1 does not impact on the NPV greatly compared to the Base Case, however, the wooden pole involve at very high cost at the initial cost. This is not to discuss about the environmental degradation from the deforestation.

Table 14: CBA of Producer in Scenario 1, 2010

Year	Benefits (million riels) Selling Biodiesel	Selling seed Cake	Costs (million riels) Costs Capital (equip & WH)	Cost of Production	*Net Benefits*		
Y1	45.90	2.02	51	19.36	(22.43)		
Y2	45.90	2.02	0	19.36	28.56		
...	...	...	...	...	...		
Y11	45.90	2.02	51	19.36	(22.43)		
Y12	45.90	2.02	0	19.36	28.56		
...	...	...	...	...	...		
Y21	45.90	2.02	51	19.36	(22.43)		
Y22	45.90	2.02	0	19.36	28.56	**NPV**	**198.15**
...	...	...	...	...	...	**BCR**	**1.78**
Y30	45.90	2.02	0	19.36	28.56	**IRR**	**1.27**

The production of biodiesel is still positive in present value term that is at 198.15 million riels during 30 years project period at 10 percent discount rate (Table 14). The heavy cost is the processing plant establishment; especially the life span of equipment and warehouse replacement must be made within 10 year periods.

In Scenario 1, farmer and producer gain positive net benefits. This finding is contrary to most of studies, especially the big plantation with big capacity of processing plant, this is due to the fact the small scale biodiesel production in this study is taking less capital cost.

5.1.3. Scenario 2[8]

The scenario 2 analysis is based on the fact that live fence of JC seeds will be the raw material for biodiesel, at the same time people are assumed to fence their property with JC tree instead of wooden pole. This expansion live fence will contribute to two tangible benefits namely opportunity costs on wooden pole and buying chemical fertilizer for farmer. With the current income, people will plant more JC to make live fence for two reasons. First, wooden

[8] existing fencing + existing of fencing with new Jatropha plantings, with biodiesel production

pole is hard to collect from the forest, for the location that used to be the place for collection is no longer available. Second, concrete pole appears unpopular in the study site. Moreover, the two materials are more and more expensive, that is 8,000 riels and 10,000 riels per pole respectively.

Since JC live fence is ready for composting[9], we consider the around 70 percent of wooden pole fence (or doubled fencing) and other types of fence that will be replaced as shown in Appendix A. This will increase the current JC live fence from about 200 thousand meters almost up to 700 thousand meters. With this expansion, we will re-calculate the costs and benefits as following.

The first year plantation will not generate any benefit, for the tree is too small to consider as replacing live fence as well and to cut leave and braches for compost. However, from third year onward we will get the return for composting and fencing value, as shown in Table 15.

Table 15: CBA of Farmer in Scenario 2, 2010

Description	Y1	Y2	Y3	...	Y30
Total Benefits (million riels)	476.11	213.56	247.23	...	247.23
Compost	187.34	187.34	216.87	...	216.87
Selling seeds	26.23	26.23	30.36	...	30.36
Opportunity Cost of WP	262.55			...	
Total Costs (million riels)	66.84	52.62	60.91	...	60.91
Labour	66.84	52.62	60.91	...	60.91
Net Benefits	**409.27**	**160.95**	**186.32**	**...**	**186.32**
Net Present Value (NPV)	**1,938.16**				
Benefit-Cost Ratio (BCR)	**4.38**				

Source: (Field Survey, 2010 & Authors' calculation)

Table 15 shows the CBA of farmer in Scenario 2, which is telling us that, this investment yield high return rate at 4.38. The NPV of this scenario is almost 2 thousands. The net benefit is very high during the first year during to the fact that farmer saves so much money on costs of wooden pole if they bought for fencing their property instead of planting JC. Farmer is this Scenario appears to gain more benefits than biodiesel producer (Table 16).

Table 16: CBA of Producer in Scenario 2, 2010

Year	Benefits (million riels) Selling Biodiesel	Selling seed Cake	Costs (million riels) Costs Capital (equip & WH)	Cost of Production	*Net Benefits*		
Y1	45.90	2.02	51.0	19.36	(22.43)		
Y2	45.90	2.02	0	19.36	28.56		
...	...	...	...	...	...		
Y11	53.13	2.34	51.0	22.41	(17.93)		
Y12	53.13	2.34	0	22.41	33.07		
...							
Y21	53.13	2.34	51.0	22.41	(17.93)		
Y22	53.13	2.34	0	22.41	33.07	**NPV**	**232.79**
...	...	...	...	...	...	**BCR**	**1.84**

9 According FDG in the 3 communes and district development council, people are encouraged to produce compost for their farming with training support from NGOs and CBOs.

Y30	53.13	2.34	0	22.41	33.07	**IRR**	**1.36**

Source: (Field survey 2010 & authors' calculation)

With capital cost of 51 million riels at the beginning period and replacement within 10 years, producers get the NPV at 232 million riels during the course of JC live span (assumed to be 30 years) (Table 16).

5.1.3. Scenario 3[10]

The scenario 3 analysis based on the assumption that existing live fence, small scale plantation and biodiesel production are taking into account for financial analysis. This Scenario assuming that farmer does not expand JC tree as live fence, but they start to plant on their idle land for biodiesel production. Based on field survey, the plantation will not generate any compost, for the leaves and cutting from pruning are dropped in the farm for recharging the nutrient. Moreover, farmer will experience extra costs as shown in Table 17.

Table 17: CBA of farmer in Scenario 3, 20101

Description	Y1	Y2	Y3	…	Y30
Total Benefits (million riels)	213.56	213.56	229.67	…	229.67
Compost	187.34	187.34	187.34	…	187.34
Selling seeds	26.23	26.23	42.33	…	42.33
Total Costs (million riels)	191.64	158.40	158.40	…	158.40
Land Rent	7.08	7.08	7.08	…	7.08
Land preparation	59	59	59		59
Labor	85.85	85.85	53		53
Inputs (O&M)	35.4	35.4	35.4		35.4
Net Benefits	4.307	4.307	4.307	**…**	4.307
Net Present Value (NPV)	**613.66**				
Benefit-Cost Ratio (BCR)	**1.40**				

Source: (Authors' calculation)

Compared to Scenario 2, this Scenario provides smaller NPV (at 613.66) and BCR (at 1.40). This is due to the high cost on opportunity cost of land, cost of land preparation and other costs. The seeds yield is doe not higher than in the Scenario 2. This is true, for the idle land for the plantation is very small of which there are less quantity of JC tree can be planted (See Appendix A for more information). Based on Table 18, we can tell that farmer enjoy less benefits than producer at 613.66 and 303.63 respectively.

[10] existing fencing + plantation plantings of Jatropha, with biodiesel production

Table 18: CBA of Producer in Scenario 3, 2010

Year	Benefits (million riels) Selling Biodiesel	Selling seed Cake	Costs (million riels) Costs Capital (equip & WH)	Cost of Production	*Net Benefits*		
Y1	45.90	2.02	51.0	19.36	(22.43)		
Y2	45.90	2.02	0	19.36	28.56		
Y3	60.03	4.09	0	27.85	42.28		
...	...	...	...	...	...		
Y11	60.03	4.09	51.0	27.85	(8.72)		
Y12	60.03	4.09	0	27.85	42.28		
...							
Y21	60.03	4.09	51.0	27.85	(8.72)		
Y22	60.03	4.09	0	27.85	42.28	**NPV**	**303.63**
...	...	...	...	...	...	**BCR**	**1.95**
Y30	60.03	4.09	0	27.85	42.28	**IRR**	**1.52**

Source: (Field survey 2010 & authors' calculation)

5.1.3. Scenario 4[11]

The scenario 4 is based on the assumption that all the existing and expansion live fence and small scale plantations are brought together in the financial analysis. Then, this Scenario is seeking all possible benefits and costs associated with biodiesel production within possible expansion of JC in the study areas (Table 19).

Table 19: CBA of farmer in Scenario 4, 20101

Description	Y1	Y2	Y3	...	Y30
Total Benefits (million riels)	311.32	48.78	263.34	...	263.34
Compost	22.55	22.55	216.87	...	216.87
Selling seeds	26.23	26.23	46.47	...	46.47
Opportunity Cost of WP	262.55	0	0	...	0
Total Costs (million riels)	311.32	48.78	263.34	...	263.34
Land Rent	7.08	7.08	7.08	...	7.08
Land preparation	59.00	59	59	...	59
Labor	100.07	52.62	53	...	53
Inputs (O&M)	35.40	35.4	35.4	...	35.4
Land Rent	4.31	4.307	4.307	...	4.307
Net Benefits	**105.46**	**(109.63)**	**104.94**	**...**	**104.94**
Net Present Value (NPV)	**812.40**				
Benefit-Cost Ratio (BCR)	**1.53**				

Source: (Authors' calculation)

Table 19 shows that there are some improvements in NPV term when farmer expands their live fence and make use their idle land for JC plantation. It appears that the net benefit during year 2 is negative while year one and the rest are positive is due to the fact that year one was offset by opportunity cost of wooden pole and year three onward was by high yield of JC seeds.

[11] existing fencing + expansion live fence + plantation, with biodiesel production

Table 20: CBA of Producer in Scenario 4, 2010

Year	Benefits (million riels) Selling Biodiesel	Selling seed Cake	Costs (million riels) Costs Capital (equip & WH)	Cost of Production	*Net Benefits*		
Y1	45.90	2.02	51.0	19.36	(22.43)		
Y2	45.90	2.02	0	19.36	28.43		
Y3	73.27	4.41	0	30.90	46.78		
…	…	…	…	…	…		
Y11	73.27	4.41	51.0	30.90	(4.22)		
Y12	73.27	4.41	0	30.90	46.78		
…							
Y21	73.27	4.41	51.0	30.90	(4.22)		
Y22	73.27	4.41	0	30.90	46.78	**NPV**	**338.27**
…	…	…	…	…	…	**BCR**	**1.99**
Y30	73.27	4.41	0	30.90	46.78	**IRR**	**1.59**

Source: (Field survey 2010 & authors' calculation)

In Table 20, the biodiesel producer does still enjoy the benefits at NPV 338 million riels within 30 years with the capital investment for 3 periods. The reinvestment on capital (equipments) must be made three times because the JC live fence can be last for 30 years, while the machinery will be torn within 10 year period.

Table 21: Summary of Financial Analysis of Biodiesel production in Cambodia, 2010

	Base Case	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Total Benefit	5,620.08	7,844.50	9,261.41	8,917.23	10,004.57
Total Cost	676.49	2,588.90	2,644.08	5,756.73	5,856.40
Net Benefits	4,943.59	5,255.60	6,617.33	3,160.50	4,148.17
PNV	1,553.43	1,463.78	2,170.96	917.29	1,150.67
BCR	8.31	2.46	3.55	1.50	1.61

Source: (Authors' calculation)

In a nut shell, at discount rate 10% within the project life of 30 years, the financial analysis of the biodiesel production at small scale in Cambodia is feasible within the four Scenarios (Table 21). In NPV terms, the Scenario 2 is the best, for it we will gain 2,170 million riels which is the highest followed by Scenario 1, 3 and 4. However, Scenario 2 has smaller size of economy compared to the Scenario 4, for there is less quantity of JC trees are planted for biodiesel production.

5.3. CO_2 Saving Emission as Social Benefits

During the course of production, there is the involvement of consumption of fossil fuel petroleum (transport dry seeds from commune headman to a central processing plant within the 3 communes) and land preparation for small scale plantation. Also, there is a need of initial conventional diesel for start up the processing plant. The latter two consumption of fossil diesel commune is viewed minimal. The 50 hectares of land will need about 500 litres of diesel and the initial start up will not need more than 2 litres. The transportation of dry seeds, however, is very small either. By taking the total production possibility of JC seeds, about 70 tons within the 3 communes at the radian distant of 6 kilometres, we found that this transportation will consume about 3,000 litres of petroleum, which is about 6 tone of CO2 emission.

Mr. Tham Bunhak claimed that the consumption of fuel for 4 hours to produce 15.8 Kwh is (1) 12 Litres for Caltex diesel, (2) 12.5 Litres for biofuel (his own biofuel extracting from JC seeds or Kapok), and (3) 13.3 Litres for normal diesel (that is the diesel sold at local market). The CO_2 conversation factor is 2.63 kgCO2 per litre of diesel.

Table 22: Total emission reduction with Biodiesel production in the study area, 2010

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Total Biodiesel (liter)	13,114	15,181	18,866	20,934
Caltex Diesel Equivalence (liter)	13,660	15,814	19,652	21,806
CO2 Equivalence (tone)	35.93	41.59	51.68	57.35
CDM Benefits (million riels)	0.59	0.68	0.85	0.94

Source: (Authors' calculation)

Table 22 shows amount of fossil diesel equivalence to calculate the CO2 emission that potentially reduce from avoiding the consumption of fossil diesel, then, the total CO2 saving is 57 tones the Scenario 4 . At the lower end (USD4.00 or 16,400 riels per tonne) of carbon credit in the Clean Development Mechanism (CDM), we can generate the income of USD 0.94 million riels.

The price of CO_2 on free market (Clean Development Mechanism: CER) and commonly practical in Cambodia is ranging from USD3.00 per tonne to USD8.00 per tonne depending on the nature of the project (Ouk, 2010). However, we can also consider applying for other CO_2 credit, namely Voluntary Emission Reduction (VER) with the price ranging from USD6.00 to USD8.00. To be conservative, we take the price at USD4.00 for the calculation with this implication of CO_2 saving.

5.4. Substitution of Imported Fossil-based Fuel

The substitution of imported fossil-based fuel is possible when the energy input to produce a unit of biodiesel is less than the energy output, that is, the amount of energy of biodiesel. Based on Jaeger, Cross & Egelkraut (2007), the net energy balance (NEB) is the energy output which is the one that generated from biodiesel, while the energy input can be from biodiesel itself or from fossil fuel (equation 2.7).

It appears that the energy input at the grower side does hardly relate to the consumption of fossil fuel. However, to some extend the seeds transportation to the processor site may associate with a small amount of petroleum which is ignorable due to the distance of household to village head man is walking distance.

Related with the processing, the consumption of fossil fuel is considered as zero, for the biodiesel is totally used for the production. The production process of JC in Cambodia at the moment is following three steps. First, the shell of the seeds is hulled, and then we get the kernels. The kernel is then dried before feeding it into pressing machine. Last but not least, the liquid is ready for machinery consumption as soon as it was filtered. This process was presented by DATe and it is now employed by local biodiesel producer. Mr. Tham, the biodiesel producer, confirms that the production process does not really skilled engineer.

Mr. Tham was very proud of the diesel he could produce. He is using his own-production fuel in three different categories. For stationary machine such as his pressing machine or generator, he uses 100% biodiesel with minor modification to his machine. Next, similar modification to slow-automobile such as ploughing-motor culture, he would recommend to blend with Caltex diesel 40/60, while with the fast automobile such as his car the blending should be 50/50 or less biodiesel. Attaching to the replacement of fossil diesel for his generator, he argues that using biodiesel is very good for the environment. He claimed that while he was using fossil diesel, the trees around the generator shade was shrivelled. Now, the trees are back to normal even they give more fruits than before. Moreover, he could build his pig cage next to the generator share where it used to be safely.

Based the above argument and Table 22, we found that the communes will have 13 thousand liters, 15 thousand liters, 19 thousand liters, and 21 thousand liters of diesel with the 4 Scenarios respectively if there is a biodiesel production project.

5.5. Rural Poverty Reduction

There are about 20 percent of households who did not planted JC as live fence. However, most of them are willing to replace or double the fence with JC if there is market. If we investigate household by household (who has JC as live fence) based on 5 quintile (ranging from 1 to 400 meters) to see at what extend that JC contribute to income generation, we found at following information in Table 23.

Table 23: Existing JC Seeds Production by Quintile of the Communes, 2010

	1st Qnt (m) (1-80)	2nd Qnt (m) (81-160)	3rd Qnt (m) (161-240)	4th Qnt (m) (241-320)	5th Qnt (m) (321-400)	Total
Number of Household*	2,541	5,55	202	54	13	3,365
Total Seeds Production (kg)	18,292	11,993	5,815	2,714	872	39,686
Total Income (million riel)	12.8	8.4	4.1	1.9	0.6	28
Total Income (USD) per HH	1.23	3.69	4.92	8.60	11.06	n/a

** The household who has planted JC plants as live fence*

Table 23 shows the existing live fence owned by household in the three communes and divided by 5 quintiles. Those who have no live fence are not taking into this analysis. The income from selling JC seeds based on the actual plant is not that much to contribute the livelihood improvement. For the first quintile of the households (almost 60 percent of total households) who has JC live fence from 1m to 80 m generate income from selling seeds is about 13 million riels per year, which is about UDS1.2 per year per household. The income increases for those who has longer JC live fence. In the commune, we found that if a house has 400 meters JC live fence, they will generate up USD12.00 per year. This figure is relatively low if compared to shared income of household with other cash crop. Although, it does not sound plausible for the farmers who have less than 240 meters JC live fence to participate the biodiesel production, we found that they are willing to pick up the seeds to sell at any case.

5.6. Policy implication on Biofuel Production and Consumption

There is no tax or subsidy that has been imposed on the production of small scale JC diesel production. However, the government has encouraged small-medium entrepreneurs (SME) to invest on biomass and biofuel. Currently, there is one company, who produce ethanol made from cassava. The company has contracted farmers to sell cassava for their production. In returns they provide technical and financial support to the farmers.

There are at least 3 main approaches that we believe that there will be JC production within the communes. Firstly, at national level there is a great interest of mitigating climate change through reduction in fossil fuel consumption. The department of Climate Change (the former Cambodia Climate Change Office) of the Ministry of Environment has Trust Fund. The Fund is opened to public to access the fund. Then, if SME, local NGOs or community based NGO or the like are willing to implement the project, we believe that the Office will grant the project.

Secondly, each commune has their own Development Plan with the support of national budget. Then, if they can see that the project will benefits to their community the most, they are likely to set the priority on this particular development. Based on FGD with commune head man and council of communal development, they are willing to set up the processing plant at the communal hall, if we confirm that the study is positive. However, they request us to provide technical support.

5.7. Sensitive analysis and Next Phases of Research

While visiting DATe[12], we met Mr. San You, the executive officer of the NGO. The meeting was to seek his past experience on buying JC seeds and the demo of the production of fuel. Based on his experience, he would not suggest any further development of bio-diesel from small scale (fence based production), for the trees will not enough produce seeds for not only country wide demand, but just the local diesel demand (San, 2009a). Based on his study for an international organization, it suggests that we should terminate all further activities in JC seeds processing otherwise there should be a survey on growing and planting potential of JC at any particular side where the fuel cost is high (San, 2009b).

However, the demoing period is much suspected due to the following reasons. (1) The seeds were not dry as good as to maximize the liquid content from the seeds[13]. (2) The seeds collect was done one period only. This is not reflecting the whole year production from the fence. Moreover, there is no scenario of expanding live fence around the people house. As indicated in his unpublished report, JC plant as fences is ranging from 1 meter to 30 meters. In the case of expanding when there is a market for the seeds, the length of the fence can be from 30 meters (the maximum length of San You study) to 250 meters (based on our field work survey). Then, the production of the liquid from the JC seeds is up to 100 times more. And (3) there was no study on Present Value of the production, especially when we take into account of the live of the plants and the depreciation of the production inputs. Therefore, there is a gap of study to reach a conclusion if we need to discourage the small scale JC production while there is boom of expansion throughout the country.

GERES Cambodia is one of the international NGO who is working on Energy Saving in Cambodia. The research team went to see Jocelyn Davie Roberts who is the Policy and Study Manager. Based on our interview with her, she warns two things before we come to policy conclusion(Jocelyn, 2009). First, the seeds of JC must be squeezed to the liquid as soon as we harvest the seeds. This makes two inconveniences. (1) There will be high in production costs, for we must have enough equipment to do so and (2) there will be too much work during the

[12] DATe stands for Development Appropriate Technology

[13] Based on experience of Mr. Tham, the nut should be dried at least 4 hours before pressing for the liquid.

harvesting period, and we must have a proper storage before we send the liquid to turn it into biodiesel. Second, if the JC is planted in the form of farming, then, by the time it reaches to mature, that is, 5 years old, there will be a strange disease that will destroyed the plants. Along the line with the global trend of biofuel promotion, GERES Cambodia and NGO Forum are working together to form a policy advocacy unit to develop a National Policy on Agro-Fuels. The aims of this initiative are to 1) raise awareness about agro-fuel production in Cambodia; 2) encourage stakeholders to voice their concerns; 3) facilitate dialogue among policy-makers at the provincial and national levels on the agro-fuel sector.

Based on the practical experience from a local entrepreneur, what is mentioned by Jocelyn was not appropriated. The seeds can be stored as long as you want, but must be free from moisture and heat. We need to dry the seeds from 4hours to 8 hours in order to harvest the maximum oil/liquid (Tham, 2009b). In terms of disease, he claimed that he has one hectare of JC plants. It is more than two years old. He found some diseases on the tree, but he said that he could manage to control the diseases by planting some local crop. Moreover, he also has some JC plants which are more 75 years old. They are there firmly and healthily.

4.7.1. Discount Rate

We have changed the discount rate from 2% to 14% but it does not change the NPV from positive to negative value as shown in Table 24.

Table 24: Sensitivities analysis of NPV of biodiesel production in Cambodia, 2010

Discount Rate	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
0.02	3,691	3,848	4,974	2,328	3,032
0.04	2,849	2,906	3,872	1,771	2,287
0.06	2,268	2,258	3,109	1,387	1,775
0.08	1,855	1,798	2,567	1,115	1,413
0.10	1,553	1,464	2,171	917	1,151
0.12	1,327	1,215	1,874	770	956
0.14	1,154	1,024	1,645	657	808

Source: (Authors Calculation)

4.7.2. Change in Oil Price

The oil price has been changing during the last few, especially last year in Cambodia. The fossil diesel price was starting from USD 3,200 in September 2007 to the peak of 5,800 riels in July 2008 and to 3,500 riels in April 2010. The fluctuation will impact on the producer and the farmer. For our analysis we compute the biodiesel price at the same price of conventional diesel. This is due to the fact that the diesel is locally demanded. Moreover, the analysis does not into account the tax, for most of the small scale industrials, especially the rural area, are tax exemption.

4.7.3. Introducing Biofuel from JC to Replace Fuel Wood

The NPV of JC production will provide additional benefits if it is used for cooking. Rural households rely heavily on firewood collecting from the forest. The distant to collect firewood from the forest is increasing further. Since the biofuel from JC can also be burn for cooking, at any among of this fuel will save the forest.

Therefore, there should be further research on this particular aspect, especially on the consumption of fuel wood: the potential costs of fire wood consumption and potential deforestation that may cause by fuel wood and wooden pole demand.

VI. Conclusion and Remark

The study found that the existing live fence contributes the benefits to farmer, especially for their compost and wooden fence substitute. The NPV value is still positive when we introduce biodiesel production into the communes in all Scenarios.

In terms of the implication with CO_2, we considered that the consumption of biodiesel will contribute to CO_2 reduction. Then, the study found that there will be a reduction of CO_2 of some 50 tons in the case that all possible JC cultivation. This amount is relative low to attract CDM project.

The substitution of fossil based diesel is greatly, for the production of biodiesel demand only a small fraction during the transportation of seeds to the processor premise. Then, we considered the small scale plantation is totally the net gain of energy. If we consider that all biodiesel will be substituted fossil fuel, then we will have 20 thousand liters from existing live fence, liters from expansion live fence, and the small scale plantation.

Besides the overall implausible biodiesel production, we also found that income per household is not really invitingly tradable activities. We found that the first quintile (who has less plants) enjoys only about 4,000 riels per household per annum for whole harvesting period followed by the last quintile about 40,000 riels. However, the amount of income does not really express any barriers for biodiesel production, for everyone is willing to participate the marketing.

It appears that the benefits of Jatropha trees are beyond the biodiesel production. This study considers composts from leaves and cutting, seed cake, husk, and wooden pole replacement are co-benefits, while there are other benefits, for example, reduction pressure on forest and replacing fuel wood for cooking. Then, there should be further research on similar aspects of benefits.

In a nut shell, the result and analysis found that biodiesel production is quite positive, for all scenarios have NPV positive with different BCR. If there is biodiesel production within the district, the production is very small that may contribute to climate change mitigation. However, it may reduce pressure on forests, mainly wooden pole extraction. The study found that poverty reduction through biodiesel production is quite humble. To make the project viable at communal level, there should be subsidies, especially on the processing plant.

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APPENDIX A: Jatropha Curcas Small Scale Plantation in Cambodia, Status Quo and the Scenarios, 2010

	Base Case				Scenario1				Scenario2				Scenario3				Scenario4			
	L. Fence[14]	L. Exp[15]	Plant[16]	Total	L. Fence	L.FExp	Plant	Total	L. Fence	L.FExp	Plant	Total	L. Fence	L.FExp	Plant	Total	L. Fence	L.FExp	Plant	Total
A. NUMBER OF TREE (one tree/meter)																				
Sedthei	49,382	-	-	49,382	49,382	-	-	49,382	49,382	18,455	-	67,837	49,382	-	19,500	68,882	49,382	18,455	19,500	**87,337**
TbaengKhpos	84,464	-	-	84,464	84,464	-	-	84,464	84,464	11,724	-	96,188	84,464	-	32,500	116,964	84,464	11,724	32,500	**128,688**
ThlokVien	74,305	-	-	74,305	74,305	-	-	74,305	74,305	2,639	-	76,944	74,305	-	24,700	99,005	74,305	2,639	24,700	**101,644**
Total	**208,151**	**-**	**-**	**208,151**	**208,151**	**-**	**-**	**208,151**	**208,151**	**32,818**	**-**	**240,969**	**208,151**	**-**	**76,700**	**284,851**	**208,151**	**32,818**	**76,700**	**317,669**
B.POTENTIAL COMPOST (KG)																				
Sedthei	24,691	-	-	24,691	24,691	-	-	24,691	24,691	9,227	-	33,918	24,691	-	-	24,691	24,691	9,227	-	33,918
TbaengKhpos	42,232	-	-	42,232	42,232	-	-	42,232	42,232	5,862	-	48,094	42,232	-	-	42,232	42,232	5,862	-	48,094
ThlokVien	37,153	-	-	37,153	37,153	-	-	37,153	37,153	1,320	-	38,472	37,153	-	-	37,153	37,153	1,320	-	38,472
Total	**104,076**	**-**	**-**	**104,076**	**104,076**	-	-	**104,076**	**104,076**	**16,409**	**-**	**120,485**	**104,076**	**-**	**-**	**104,076**	**104,076**	**16,409**	**-**	**120,485**
Value of compost (in million riels)																				
Sedthei	44.44	-	-	44	44.44	-	-	44	44.44	16.61	-	61	44.44	-	-	44	44.44	16.61	-	**61**
TbaengKhpos	76.02	-	-	76	76.02	-	-	76	76.02	10.55	-	87	76.02	-	-	76	76.02	10.55	-	**87**
ThlokVien	66.87	-	-	67	66.87	-	-	67	66.87	2.38	-	69	66.87	-	-	67	66.87	2.38	-	**69**
Total	**187.34**	**-**	**-**	**187.3**	**187.3**	-	-	**187.3**	**187.3**	**29.5**	-	**216.9**	**187.3**	**-**	**-**	**187**	**187.3**	**29.5**	-	**216.9**
Cost of Making compost																				
Sedthei	5.35	-	-	5.3	5.35	-	-	5.3	5.35	2.00	-	7.3	5.35	-	-	5.3	5.35	2.00	-	7.3
TbaengKhpos	9.15	-	-	9.2	9.15	-	-	9.2	9.15	1.27	-	10.4	9.15	-	-	9.2	9.15	1.27	-	10.4
ThlokVien	8.05	-	-	8.0	8.05	-	-	8.0	8.05	0.29	-	8.3	8.05	-	-	8.0	8.05	0.29	-	8.3
Total	**22.55**	**-**	**-**	**22.5**	**22.55**	**-**	**-**	**22.5**	**22.55**	**3.56**	**-**	**26.1**	**22.55**	**-**	**-**	**22.5**	**22.55**	**3.56**	**-**	**26.1**

[14] L Fence: Live Fence
[15] L. Exp: Live Fence Expansion
[16] Plant: Plantation at small scale

C.POTENTIAL WOODEN POLES REQUIRE IF NOT EXPANSION WITH JATROPHA (POLE)

Sedthei	-	-	-	-	-	18,455	-	18,455	-	18,455	-	-	-	-	-	-	-	18,455	-	-
TbaengKhpos	-	-	-	-	-	11,724	-	11,724	-	11,724	-	-	-	-	-	-	-	11,724	-	-
ThlokVien	-	-	-	-	-	2,639	-	2,639	-	2,639	-	-	-	-	-	-	-	2,639	-	-
Total	-	-	-	-	-	**32,818**	**-**	**32,818**	-	**32,818**	-	-	-	-	-	-	-	32,818	-	-

Value of wooden pole if bought for fencing property (million riels)

Sedthei	-	-	-	-	-	148	-	148	-	148	-	148	-	-	-	-	-	148	-	148
TbaengKhpos	-	-	-	-	-	94	-	94	-	94	-	94	-	-	-	-	-	94	-	94
ThlokVien	-	-	-	-	-	21	-	21	-	21	-	21	-	-	-	-	-	21	-	21
Total	**-**	**-**	**-**	**-**	**-**	**262.5**	**-**	**263**	**-**	**262.5**	**-**	**263**	**-**	**-**	**-**	**-**	**-**	**262.5**	**-**	**263**

Costs of planting wooden pole or tree if plant for fencing property (million riels)

Sedthei	-	-	-	-	-	8.0	-	8.0	-	8.0	-	8	-	-	8	8	-	8.0	8	16
TbaengKhpos	-	-	-	-	-	5.1	-	5.1	-	5.1	-	5	-	-	14	14	-	5.1	14	19
ThlokVien	-	-	-	-	-	1.1	-	1.1	-	1.1	-	1	-	-	11	11	-	1.1	11	12
Total	-	-	-	-	**-**	**14.2**	**-**	**14**	**-**	**14.2**	**-**	**14**	**-**	**-**	**33.2**	**33**	**-**	**14.2**	**33.2**	**47**

D.DRYJATROPHASEEDSFORBIODIESELPRODUCTION(KG)

						(125kg/hour)		270,000	kg/year			*0.16*				*0.22*				*0.25*
Sedthei	-	-	-	-	8,889	-	-	8,889	8,889	3,322	-	12,211	8,889	-	5,850	14,739	8,889	3,322	5,850	18,061
TbaengKhpos	-	-	-	-	15,204	-	-	15,204	15,204	2,110	-	17,314	15,204	-	9,750	24,954	15,204	2,110	9,750	27,064
ThlokVien	-	-	-	-	13,375	-	-	13,375	13,375	475	-	13,850	13,375	-	7,410	20,785	13,375	475	7,410	21,260
Total	**-**	**-**	**-**	**-**	**37,467**	**-**	**-**	**37,467**	**37,467**	**5,907**	**-**	**43,375**	**37,467**	**-**	**23,010**	**60,477**	**37,467**	**5,907**	**23,010**	**66,385**

Value of Jatropha seeds(FARMER) (in million riels)

Sedthei	-	-	-	-	6.2	-	-	6	6.2	2.3	-	9	6.2	-	4.1	10	6.2	2.3	4.1	13
TbaengKhpos	-	-	-	-	10.6	-	-	11	10.6	1.5	-	12	10.6	-	6.8	17	10.6	1.5	6.8	19
ThlokVien	-	-	-	-	9.4	-	-	9	9.4	0.3	-	10	9.4	-	5.2	15	9.4	0.3	5.2	15
Total	**-**	**-**	**-**	**-**	**26.2**	**-**	**-**	**26.2**	**26.2**	**4.1**	**-**	**30.4**	**26.2**	**-**	**16.1**	**42.3**	**26.2**	**4.1**	**16.1**	**46.5**

Cost of collecting seeds (FARMER)

Sedthei	-	-	-	-	7.13	-	-	7.1	7.13	2.67	-	9.8	7.13	-	2.82	9.9	7.13	2.67	2.82	12.6
TbaengKhpos	-	-	-	-	12.20	-	-	12.2	12.20	1.69	-	13.9	12.20	-	4.69	16.9	12.20	1.69	4.69	18.6
ThlokVien	-	-	-	-	10.73	-	-	10.7	10.73	0.38	-	11.1	10.73	-	3.57	14.3	10.73	0.38	3.57	14.7
Total	**-**	**-**	**-**	**-**	**30.1**	**-**	**-**	**30.1**	**30.1**	**4.7**	**-**	**34.8**	**30.1**	**-**	**11.1**	**41.1**	**30.1**	**4.7**	**11.1**	**45.9**

E.BIODIESELPRODUCTION(LITER)

Sedthei	-	-	-	-	3,111	-	-	3,111	3,111	1,163	-	4,274	3,111	-	1,463	4,574	3,111	1,163	1,463	5,736
TbaengKhpos	-	-	-	-	5,321	-	-	5,321	5,321	739	-	6,060	5,321	-	2,438	7,759	5,321	739	2,438	8,497
ThlokVien	-	-	-	-	4,681	-	-	4,681	4,681	166	-	4,847	4,681	-	1,853	6,534	4,681	166	1,853	6,700
Total	**-**	**-**	**-**	**-**	**13,114**	**-**	**-**	**13,114**	**13,114**	**2,068**	**-**	**15,181**	**13,113.51**	**-**	**5,752.50**	**18,866**	**13,114**	**2,068**	**5,753**	**20,934**

Value of Biodiesel (million riels)

Sedthei	-	-	-	-	10.89	-	-	10.89	10.89	4.07	-	**14.96**	10.89	-	5.12	16.01	10.89	4.07	5.12	20.08
TbaengKhpos	-	-	-	-	18.62	-	-	18.62	18.62	2.59	-	**21.21**	18.62	-	8.53	27.16	18.62	2.59	8.53	29.74
ThlokVien	-	-	-	-	16.38	-	-	16.38	16.38	0.58	-	**16.97**	16.38	-	6.48	22.87	16.38	0.58	6.48	23.45
Total	**-**	**-**	**-**	**-**	**45.90**	**-**	**-**	45.90	**45.90**	**7.2**	**-**	**53.13**	**45.90**	**-**	**20.1**	66.03	**45.90**	**7.2**	**20.1**	73.27

Cost of Producing Biodiesel (million riels)

Sedthei	-	-	-	-	4.59	-	-	4.59	4.59	1.72	-	**6.31**	4.59	-	2.16	6.75	4.59	1.72	2.16	8.47
TbaengKhpos	-	-	-	-	7.85	-	-	7.85	7.85	1.09	-	**8.94**	7.85	-	3.60	11.45	7.85	1.09	3.60	12.54
ThlokVien	-	-	-	-	6.91	-	-	6.91	6.91	0.25	-	**7.15**	6.91	-	2.73	9.64	6.91	0.25	2.73	9.89
Total	**-**	**-**	**-**	**-**	**19.36**	**-**	**-**	19.36	**19.36**	**3.05**	**-**	**22.41**	**19.36**	**-**	**8.49**	27.85	**19.36**	**3.05**	**8.49**	30.90

F.SEED CAKE PRODUCTION ('000KG)

Sedthei	-	-	-	-	959.99	-	-	5.96	959.99	358.76	-	8.18	959.99	-	1,053.00	8.31	959.99	358.76	1,053.00	10.53
TbaengKhpos	-	-	-	-	1,641.98	-	-	10.19	1,641.98	227.92	-	11.60	1,641.98	-	1,755.00	14.11	1,641.98	227.92	1,755.00	15.52
ThlokVien	-	-	-	-	1,444.49	-	-	8.96	1,444.49	51.31	-	9.28	1,444.49	-	1,333.80	11.94	1,444.49	51.31	1,333.80	12.26
Total	**-**	**-**	**-**	**-**	**4,046.46**	**-**	**-**	**25.10**	**4,046.46**	**637.99**	**-**	**29.06**	**4,046.46**	**-**	**4,141.80**	**34.35**	**4,046.46**	**637.99**	**4,141.80**	**38.31**

Value of Seedcake(million riels)

Sedthei	-	-	-	-	0.48	-	-	0.48	0.48	0.18	-	0.66	0.48	-	0.53	1	0.48	0.18	0.53	1.19
TbaengKhpos	-	-	-	-	0.82	-	-	0.82	0.82	0.11	-	0.93	0.82	-	0.88	2	0.82	0.11	0.88	1.81
ThlokVien	-	-	-	-	0.72	-	-	0.72	0.72	0.03	-	0.75	0.72	-	0.67	1	0.72	0.03	0.67	1.41
Total	-	-	-	-	**2.02**	-	-	2	**2.02**	**0.3**	-	2	**2.02**	-	**2.1**	4	**2.02**	**0.3**	**2.1**	4.41

G. COST OF LAND RENT(million riels)

Sedthei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.80	2	-	-	1.80	1.80
TbaengKhpos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.00	3	-	-	3.00	3.00
ThlokVien	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.28	2	-	-	2.28	2.28
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**7.1**	7	-	-	**7.1**	7.08

H. COST OF LAND PREPARATION (million riels)

Sedthei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.00	15	-	-	15.00	15.00
TbaengKhpos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.00	25	-	-	25.00	25.00
ThlokVien	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.00	19	-	-	19.00	19.00
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**59.0**	59	-	-	**59.0**	59.00

I. COST OF INPUTS (million riels)

Sedthei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.00	9	-	-	9.00	9.00
TbaengKhpos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.00	15	-	-	15.00	15.00
ThlokVien	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.40	11	-	-	11.40	11.40
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**35.4**	35	-	-	**35.4**	35.40

J. COST OF OTHER (contigency) (million riels)

Sedthei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.10	1	-	-	1.10	1.10
TbaengKhpos	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.83	2	-	-	1.83	1.83
ThlokVien	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.39	1	-	-	1.39	1.39
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**4.3**	4	-	-	**4.3**	4.31