Interim Report

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

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Economy and Environment Program for Southeast Asia
(EEPSEA)

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Executive Summary

Internationally, biofuel is being promoted for two main reasons - to fight with climate change and to reduce dependency on fossil fuel. Besides fighting with climate change and oil dependency, the promotion of biofuel in Cambodia is motivated to reduce rural poverty through energy supply at low cost. Most of literature on Cambodia Jatropha curcas is very positive toward the contribution of climate change, oil independency, especially the rural area, and poverty reduction.

Although biofuels are promoted internationally and domestically, the practical efforts for the promotion of biofuel is still debatable. Some prominent on bio-energy claimed that biofuel will contribute to higher concentration of green house gas, on one hand. On the other hand, many experts argued that bio-energy will greatly help to mitigate climate if a proper selection of source of plants, place and land use. Jatropha is, then, arguably introduced for biodiesel.

This study will, then, employ costs and benefits analysis to examine the all potential costs and benefits by setting two scenarios: (1) calculate the net present value of existing plantation regarding in a two setting manly, “Without” and “With” biodiesel production and (2) calculate the environmental net present value of expanding plantation regarding in a two setting manly, “Without” and “With” biodiesel production.

The study found that the “Without” project cases are the scenario to estimate the net present value (NPV) of Jatropha plantation in the reference that associate with producing organic fertilizer and fence the property of the house hold. The study found that the existing plantation contribute the NPV up to 130 million riels (about USD 30,952.00) with the study period (50 years) when the discount rate is 5%. The NPV is increased from 130 million riels to 470.82 million riels (about USD 112,100.00) when the Jatropha curcas live fence is expanded 81% in the coming years in the survey site.

The “With” Project cases are the scenario to estimate the NPV of total possible value associate with biodiesel production. There are two main players in this scenario namely farmer and biodiesel producer.

When taking into account on biodiesel production with existing plantation, the total NPV of the two players is 1,912.2 million riels (about USD 455,286) (Table 13). However, the share among the farmer and producer is quiet different, that is, about 13 times higher. Since there is one producer, then, the net benefit shared among all farmers are too bad to compare.

The value of Jatropha curcas is rocking when more people participate in the market. The Table 13 shows that the farmers will gain NPV from 135.9 million riels before marketing the nut to 4,390.6 million riels when they involve with biodiesel production. Similarly, the producer also enjoys the benefits when more people selling the nut for their production. The case of expansion plantation, the NPV of the two players is 10,952.8 million riels (about USD 2,607,809.00) (Table 13).

The consumption of biodiesel will contribute to CO2 reduction, meaning that we replaced or avoid using fossil diesel. If this is the case, we can estimate that environmental net present value of existing Jatropha curcas is about USD 9,003.00 and USD 23,250.00 for the expansion of plantation within the 50-years-project calculation with 5% discount rate.

I. Introduction

Jatropha curcas is an oil baring plant grown widely in tropical countries. In Cambodia, moreover, there were a boom of promoting the biodiesel production from this plant during the last few years through media, NGOs, and agro-business sectors. However, there is no research study on costs and benefits analysis (CBA) of this promotion yet. The positive or negative impact from this promotion is the central question among academic, researcher, policy makers, NGOs and investors.

This interim report is to presents the result of CBA of small scale Jatropha curcas plantation in Cambodia with other associated benefits along the line of biofuel production from this plant seed. Although the complete study is not made, we found that biodiesel produced from Jatropha seeds provide positive benefits to grower, processor, and end users. It also reflects that the society also gain the benefits from the consumption of biodiesel. However, more tasks have to carryout to see what can be done to promote the biodiesel production, especially the policy from national, provincial and local level.

This interim report is to show the progress of CBA of small scale Jatropha curcas plantation in Cambodia. It starts with the rational of biofuel production in global in general and in Cambodia as a particular case study following by its 5 main objectives. Then, it provides the methodologies to achieve its objectives. Last but not least, it highlight a primarily result based on the one third field work survey.

1.1 Background

Internationally, biofuel is being promoted for two main reasons - to fight with climate change and to reduce dependency on fossil fuel.

Climate change is a long-term significant change in the “average weather” in a given region experiences. The main cause of climate change is the release of greenhouse gas emission, especially CO_2 from burning of fossil fuel in running automobiles and generators. In combating with CO_2 emission from the burning 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 but not limited to wind, wave, solar, biomass, and so on. ‘Biomass’ refers to plant matter grown to generate electricity or produce biofuel, and it also includes plant or animal matter used for production of fibres, chemicals or heat.

Dependency on 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 automobile. 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 impact on their people livelihood considerably. Moreover, in the remote areas where national grid is not available, small generator running by fossil fuel is the common form of energy supply.

Besides fighting with climate change and oil dependency, the promotion of biofuel in Cambodia is motivated to reduce rural poverty through energy supply at low cost[1].

[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

Cambodia has imported almost 100% of oil fuel from overseas (ECFA et al., 2007). In terms of fossil diesel, the quantity is account 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 of His majesty the 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 Cambodia is located in Tropic and Jatropha trees are growing everywhere because rural people like planting them as their live fence.

With regard to 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 focuses on biomass potential to produce renewable energy. Lopez concludes that the technical potential for the use of bio-energy technologies in Cambodia is high. He also recommends 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 this renewable energy. The author suspected that biodiesel from Jatropha will be a substitute of fossil fuel imported countries such as Cambodia. He puts forward that local production and use of biofuel also offers other benefits such as improved energy security, rural development opportunities and environmental benefits. The author concluded that local production of biofuel in Cambodia, based on the Jatropha Curcas species or other sources, offers good potential benefits for the investors, the economy, rural communities and the environment (Williamson, 2006).

Following William, there is another review conducted by joint partner among three institutions; they are 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, for Cambodia is now exporting cassava to Thailand. This study has provided some policy frameworks to promote the two agricultural crops to promote Cambodia Bioenergy. Although this study has proposed these national policy frameworks, no major actions have been taken so far.

Last but not least, Markandya and Setboonsarng (2008) conducted a desktop research trying to confirm the possibility 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

[2] KTOE means kilotons of oil equivalent
[3] The price of fossil diesel at station is $1.20 on 19 May 2008.

sustainability to developing countries like Cambodia and Laos will 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 will contribute to the poverty alleviation in Cambodia (Markandya & Setboonsarng, 2008).

1.2. Problems Statement

The production of biofuel can be viewed from 2 dimensions of challenges. First, it is the questions of CO2 or other greenhouse gases saving, and next it is about market failures that retard the biofuel production.

1.2.1 Sceptical of Biofuel Promotion based on empirical study

Although biofuels are promoted internationally and domestically, the practical efforts for the promotion of biofuel is still debatable.

It has been proved that biofuels potentially contributed to the reduction of greenhouse gases, especially CO_2 emission when they are used. However, this claim is not always true when taking account 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 from 17 to 420 times more than the annual greenhouse gas reductions these biofuels provide by displacing fossil fuel. However, they claimed that if biofuel made from abandoned agricultural lands planted with perennial, there will be little or no carbon debt and offer immediate and sustained GHG advantages (Fargione et al., 2008). A study by Searchinger, Heimlich et al. (2008) found that carbon emissions will occur when farmer 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 Jatropha curcas plantation can improve soil quality, for it maintains organic carbon and nitrogen stock and increase carbon sequestration rate. Another study in India related to Jatropha curcas found that diesel extracted from Jatropha meets EN 14214 (Ghosh et al., 2007). This study concluded that the fuel from Jatropha curcas 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, p. 672). A recent study by Farrel, Plevin et al. (2006) has refused the results of some studies that reported negative net energy, for those studies ignored coproduces and used some obsolete data. In a similar manner, Sedjo (2007) was trying to prove that some feedstock such as corn will 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 Jatropha curcas does not need fertile land to grow and provide fruit up to 50 years. It can grow on sandy or saline soil. It requires 220mm of annual rainfall. In the past, this plant is used as 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).

The practical usages of Jatropha in Cambodia, however, are live fence, demarcation property, and to some extent are used 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 plantation is being promoted to commercial scale, the study on economical viable does not exist yet (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).

1.2.2 When invisible hand does not work

Kahn (2005, p.15) argued that 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 instant, 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, in terms of case of pollution, the firms that generate pollution are not *fully* reflected in the market price; at the same those costs are imposed to society in terms of its impact on the natural environment.

So, given worldwide and local promotion, it is heavily depending 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 market of biofuel.

1.3. Significant of the Study

The promotion of biofuel may lead to negative or positive impact on Cambodia society from environmental to economical point of view. This study is conducted to determine the negative impact of biofuel production and positive impact of increasing livelihood of the rural poor. Reiteratively, Jatropha curcas has been used as live fence through out rural areas in Cambodia. Since biofuel is being promoted through out the world, there is still controversy of CO_2 from 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 local economic promotion, there should be an intervention for 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 for small scale one. To promote or to phase out is 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 poverty circle, enhance economic growth, and environmental 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 involve in biofuel. The study will be a stepping stone to future study on commercial scale. Without rigour research on the small scale, especially when attached to poverty reduction in Cambodia, promotion Jatropha plantation will give less impact on the poor, and the promotion can give a wrong signal to the development of the countries' economy.

1.4. Scope of the study

While there are feedstocks available in Cambodia, even at bigger quantity such as sugarcane, cassava, and forest, this study is mainly interested only Jatropha curcas. 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 nut to usage.

The study will focus mainly on small scales, especially household based plantation. One of the provinces of Cambodia, namely, Kampong Chhnang province will be chosen for the study. This province is chosen because it is the province where Jatropha curcas promotion has been encouraged. Moreover, Kampong Chhnang is a place of transaction where there is a potential to sell its Jatropha diesel to other consumer in other provinces such Pursat, Battambong and Banteaymean Chey.

Although economic impact from producing biodiesel from Jatropha curcas can be done at national level, it is beyond this study. However, baseline data on Jatropha curcas coverage areas is not available yet. As recommended by Markandya and Setboonsarng (2008) that there is an urgent need to establish the baseline on Jatropha production. The introduction of small scale of Jatropha curcas promotion or fuel extraction is still at the informative stages. As mentioned earlier that only 4 villages of Ponley District, Kampong Chhnang Province were selected for trial. It is worth mentioning here that the commercial forms of Jatropha curcas plantation is now moving to the north of Cambodia such as Battambong and Banteaymean Chey province, where fertile soil are 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 it will work or not based on the finding. 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 plantation, this study will examine subsidy and tax. The two scenarios are to ensure that the government will give the most appropriate signal for the promotion.

1.5. 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 fuel, which contributes to climate change. In Cambodia context, the promotion is not only to fight with 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 Jatropha curcas in Cambodia?
(2) How much CO_2 (other GHG) can be saved from the Jatropha curcas production which is contributed 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?

II. Research methodologies

Firstly, this research is based on desktop research and survey tools to get the information for CBA, especially from the grower, processor, and the user. Next, the social benefits will be shown by imputing the total amount CO2 (and other GHG) emission saving with the assumption that all the amount of biodiesel from Jatropha production is replaced the petroleum-based diesel. Thirdly, the energy balance is examined to check if there is a net gained of energy balance. Fourthly, the study will analysis on household level (unit of analysis) to see the income generation from the selling Jatropha nut to the producer based on household survey questionnaire. Finally, subsidy mechanism will be tested to ensure the promotion of processing biodiesel from small scale Jatropha based on redistribution of total social benefits, especially to the grower.

2.1. 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

$$C_{st} = \sum_{t=1}^{T} Q_{st} P_t + A_{st} + D_{st} + F_{st} \tag{2.1}$$

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

$$B_{st} = \sum_{t=1}^{T} Q_{st} P_t + M_{st} \tag{2.2}$$

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 Jatropha plantation' and 'with project case - Jatropha nut is converted to fuel), there will be an estimation of net present value (NPV) of producing biodiesel will be based on the following equation:

$$NPV_{ij} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t} \qquad (2.3)$$

Where
NPV_{ij} = Net Present Value of i at j scenario
B_t = Benefit at time t *(t is from 0 to 50 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 CO2 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:

$$ENPV_{ij} = \sum_{t=0}^{T} \frac{(B_t + B_{it}) - (C_t + C_{it})}{(1+r)^t} \qquad (2.4)$$

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

Cost of CO2 and Other GHG emission accounting

The production of biodiesel from Jatropha will be associated with CO_2 and other GHG emission. The CO2 emission can be from the consumption of fossil fuel during transportation and oil extraction from Jatropha nut. Other GHG emission can be from the use of chemical fertilizer. The emission costs will not be showing on the producers but the society. Therefore, this cost will be further calculated to reflect social marginal cost and benefits. The estimation is based on the following equation:

$$C_{it} = E_i \ x \ P_i \qquad (2.5)$$

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 CO2 emission reduction from replacing fossil diesel

We assume that biodiesel will substitute the consumption 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 CO2 emission reduction as present in equation (2.7).

$$Bit = e_i \ x \ p \qquad (2.6)$$

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 summary in the following table.

Defining the "Without" and "With" Cost-Benefits Analysis Scenarios

The "Without" scenarios refers to the calculation of net present value of small scale Jatropha plantation for the period of 50 years old, while the "With" scenarios means that the nut of Jatropha is marketed (Table 1). Both scenarios will take into account of expansion of plantation at the small scale based[4].

Table 1: Net Present Value estimation of Jatropha Plantation in Cambodia

	Existing Plantation		**Expansion of plantation**	
	Without project	**With project**	**Without project**	**With project**
Mode of Valuing the Jatropha Plantation	*NPV (equation 2.3)*	*ENPV (equation 2.4)*	*NPV (equation 2.2)*	*ENPV (equation 2.4)*

The Net Present Value (NPV) and Environmental Net Present Value is calculated based on the costs and benefits account as explained in the following equations.

2.2. CO2 (other GHG) saving emission as social benefits

The total amount of CO2 saving is calculate with the assumption that all the amount of biodiesel from Jatropha production is replaced the petroleum-based diesel. Then, total of biodiesel production is converted to petroleum-based diesel with the factor of 0.96 (Tham's experiment). The CO2 emission conversion factor is 2.6391 {National Energy Foundation, 2009 #167}.

2.3. Substitution of imported fossil-based fuel

One can claim that promoting 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:

$$NEB = energy\ output/energy\ input \qquad (2.7)$$

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

2.4. 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 selling Jatropha that

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

contribute to raise their income. Also, it can estimate how many households will be able to move out of poverty at the current status through the production of Jatropha.

2.5. Subsidy as a tool to promotion Jatropha production in Cambodia

The amount of total social benefits will be tested with the case of giving to (1) the grower to see how much the promotion can be made to promote biodiesel production, (2) the processor to see how much the quality of biodiesel can be improved, and (3) users to see if the are willing to use biodiesel. More option can be explored along the line of analysis.

2.6. Sensitivity analysis

To avoid misleading information to policy makers, the study will examine some of possible distortion, especially related change in price of fossil diesel, charge of CO_2 emission, and energy efficiency of biodiesel and the like. Some scenarios on discount rate (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.

III. Preliminary Results

This section is to show the preliminary results from the grower survey (household based), focus group discussion, key informant interview (the local processor, commune chair man, village headmen, and local businessmen (who is willing to operate biodiesel production).

This interim report is the preliminary results focusing on the first four objective of the research study within one reference site out of 3 sites. It starts with the CBA of small scale Jatropha plantation, followed by discussing about the social benefits. Then, this interim report explore the feasibilities of rural poverty reduction based on household as a unit of analysis after conducting a test on the energy gain from biofuel production

3.1 Costs and Benefits Analysis of producing Jatropha curcas in Cambodia

To be able to impute the costs and benefits analysis of this study, some basic costs must be set as the following: man-hour cost is imputed base on local agricultural wage labour that is at an average of 1,300 riels per hour. The wooden polls can be bought from local market at 8000 riels per poll. Assuming that this 100-meter can be fenced 25 meters on the ground. For the rest of assumption is shown in Table.

Currently, Jatropha curcas is planted on marginal land for live fence only. Jatropha live fence in Cambodia is planted densely. The pace from one tree to another is ranging from 20cm to 50cm. The space from one to another will affect the fruit yield. However, Mr. Tham, a local processor from other province of Cambodia, suggests that it does not matter with the space if we consider one tree can produced approximately 1.5kgs (before 3 years old) and 2.5kgs (thereafter). Based on this information we can employ (1) 35cm the space to calculate the number of tree within the total length of Jatropha-live fence and (2) 1.5 kgs for the yield of 3 years old tree and 2.5kg for more than 3 years old tree to calculate the nut production within the within the total length of Jatropha-live fence.

Mr. Tham, is not only planting Jatropha plants to harvest for his own production, but he also buys the nut through out the country. He offers 700 riels ($0.17 Cent) per kilogram of Jatropha nut. He left his mobile phone with commune head man if there is a stock of Jatropha nut. However, this activity is not known by most of villagers through out the country, for commune head man did not active in promoting this market in their premise. This is due to liability and intervention from national, provincial and local authorities. One the other hand, buying Jatropha nut from every where contribute to (1) high production cost due to transportation charge, and (2) make CO2 overhead from producing biodiesel very high which is not encouraged for the small scale Jatropha plantation.

Table 2 : Some basic information for CBA

Description	Unit	Unit price/weight	Source
Agricultural wage labour per hour	riel/h	1,300	Study/FGD
Average price of chemical fertilizer	riel/g	1,800	Study/FGD
Wooden poll	riel/poll	8,000	Study/FGD
Compost	kg/m	0.5	Study/FGD
Time spend to make compost	kg/h	1	Study/FGD
Nut sell at market	riels/kg	500	Tham
Fruit per tree (Y1 to Y5)	kg/tree	1.5	Tham
Fruit per tree (Y6 onward)	kg/tree	2.0	Tham
Time spend to plant the tree	tree/hour	12	Tham
Seek cake	riel/kg	300	Tham
Fossil Diesel price	riel/Litre	3,500	Station
Biodiesel price (10% lower)	riel/Litre	3,150	Study
Biodiesel production per kg of nut	Litre/kg	0.3	DATe
Expeller Production capacity	kg/hour	125	Swan Fauveaud
Seek cake production	kg/kg nut	0.67	DATe
Equivalence of Caltex and bio diesel		0.96	Tham
CO2 emission conversation factor	Kg/Litre	2.63	www.nef.org.uk
CO2 emission costs in CDM	$/tone	4.00	Veng

In the reference site, we found that the major of house holds use wood for their fence as pole with barbwire Table 3, while half of the fence was made from Jatropha curcas trees. The study observes that about 45% among those live fences were planted during the last five years. The trend will increase due two reasons. First, the wooden poll is increasingly expensive, and if not bought from the market, the forest that people used to access to cut the poll is either to 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.

Table 3: Fencing materials

Fencing Materials	Jatropha (m)	Wooden poll (m)	Concrete poll (m)	Other (m)
Length in sample	7,451	15,205	0	335
Length for the whole commune	119,276	238,964	0	5,373

Table 3 shows the length of fence in the survey site. Based on the figure, the study estimates the rest of commune and imputes the commune data for the calculation of CBA in this study. The base length of live fence in the reference commune is 119,276 meters and the projection is 312,837 meters including the current length of live fence.

Below section will show all possible costs and benefits that associated with Jatropha curcas in the two settings as explained earlier. However, more explanation is needed here to set the ground information for analysis. For the existing Jatropha plantation, we would consider the cost of seedlings and labour put on plantation are consider as sunk cost. For the future plantation, all costs and benefits will be taken into account. Then, the benefits and costs of the two settings are imputed based on existing plantation and prospective plantation from the survey questionnaires. Then the net present value (NPV) of those settings will be estimated.

3.1.1. "Without project" existing plantation

Composting

Traditionally, making compost fertilizer requires not only the leave and branches of Jatropha, but also with animal dung such as cow, pig, and chicken. People can also 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). 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.

Then, here are the costs of having Jatropha curcas as live fence.

Costs = Unit price of agricultural wage labor x Total time spent on making compost (3.1)

Where

Unit price of agricultural wage labor

Total time spent on making compost

One meter of length of Jatropha, 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 10 minutes. This is included collecting leaves and branches, chop into small pieces and mix with animal dung. Table 4 shows the costs and benefits of compost and live fence.

Live fence

One can argues that Jatropha live fence can not replace the wooden or concrete fence with barber wire, for both are different in terms of their property. However, they have common ground as they are used to demarcate the property and protect animal disturbance. On the other hand, most of the wooden or concrete fence incurs costs which are making the difference among the two types of fence. Then, making fence from Jatropha will be considered additional benefits that are the opportunity costs of wooden or concrete fence. With the current income, people will plant more Jatropha to make live fence for two reasons. First, wooden poll is hard to collect from the forest, for the location that used to be the place for collection is no longer available. Second, concrete poll 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 poll respectively.

Then, here are benefits of having Jatropha curcas as live fence.

Benefits per year = Unit price of good chemical fertilizer x Total compost (3.2)

Where

Unit price of good chemical fertilizer
Total compost

Based on Equation (2.3), table 3 is the net present value of existing Jatropha plantation in the case of having no market for Jatropha nut.

Table 4: Present Value of Fencing and Composting from Jatropha curcas for existing plantation

Description	Y1	Y2	…	Y5	…	Y50	Total
Total Cost (million riels)	77.5	77.5	…	77.5	…	77.5	3,876.5
Total Benefit (million riels)	107.3	107.3	…	107.3	…	107.3	5,367.4
NPV (million riels)	**130**						

Table 4 shows that the benefits of live fence and organic fertilizers (composting) is very much higher than costs, that is about 30%. The net benefit per year is equal to 30 million riels within the commune. If we share this total amount with the 1,713 house holds in the commune, this benefits is about 20,000 riels (about USD$5.00).

3.1.2. "Without project" expansion plantation

Although there is no market for nut, people 81 percent of respondents will plant Jatropha curcas for two main reasons, namely making compost account for 42 percent and live fence 83 percent of total respondents who will plant the tree in the coming year. This means that 15,205 meters of wooden-poll-fence will be replaced or jointly planted by Jatropha curcas to for making compost (6,387 meters) and live fence (12,316 meters). Although respondents claimed that they plant Jatropha just for the live fence, we will take the 81 percent of total fence length (12,859 meters) for calculation.

With this expansion, we will re-calculate the costs and benefits with reference to above methods except that we will add up the costs of plantation.

Table 5: Present Value of Fencing and Composting from Jatropha curcas for Additional Expansion

Description	Y1	Y2	…	Y5	…	Y50	Total
Total Cost (million riels)	263.3	203.3	…	203.3	…	203.3	10,227.1
Total Benefit (million riels)	1,830.0	281.6	…	281.6	…	281.6	15,626.1
NPV (million riels)	**470.82**						

When we impute the costs and benefits of the expanding plantation within the reference area, we found that the benefits (fencing and composting) are almost 7 times higher than the costs per year. However, the benefits are very much higher than the existing plantation, which is about an average of 1 million riel per household for Thlok Vien Commune. The NPV of the expanding plantation is 470 millions riels (about USD 111,905.00) within 50 years with the interest rate of 5%.

3.1.3. "With project" existing plantation

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

Composting or Producing Jatropha Nut is the trade off between the two. If we make compost, it will not produce any fruit? If we keep the leaves for compost, it means that we will not have much nut?

Costs and Benefits for Farmer

When people participate in the market, the primary cost incur is time spending on collecting the nut and bring to the village headman. Picking nut can be done by any house holds member age from 10 to 60 or older. Then, the labour cost can be varied from one to another. To be able to do the calculation, we take the standard agricultural wage labour in the village as shown in Table 2.

Table 6: Net Present Value of Jatropha curcas for Current Plantation for Farmer

Description	Y1	Y2	…	Y5	…	Y50	Total
Total Cost (million riels)	77.5	77.5	…	77.5	…	77.5	3,876.4
Total Benefit (million riels)	108.7	108.7	…	108.7	…	108.7	5,435.6
NPV (million riels)	**135.9**						

Table 6 shows that the NPV of selling nut (plus composting and fencing benefits) is 136 million riels (about USD 32,380.00). Then, the average amount per household from selling the nut (plus composting and fencing benefits) is 79,392 riels (about USD 18.00). The selling of nut is pretty much higher (USD 11.00) than composting and fencing (USD 5.00). Since the composting may deter the full production of nut per tree (for we will cut most of the leave and branches), we make no scene if we impute the benefits of fencing and composting with the benefits of selling the nut. **Then, there is a need of investigation on the optimum amount of leave cutting for composting and the maximum of fruits that the Jatropha curcas plant can produce during the second phase of investigation.**

Costs and Benefits for Producers

The commune hall is assigned to be the producing place and the producer will collect the nut from village headman residential. This setting is used to calculate the distance from producer to nut supplying sources. It is 2 km from the commune hall to village head man at the average distance.
According to a feasibility study of a small scale production of crude Jatropha oil in Cambodia done by Swan FAUVEAUD (2008), the establish cost is as following table.

Table 7: 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: (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 Jatropha curcas or the equipment must be renewed within 25 years.

Table 8: Producer Net Present Value of Jatropha curcas from existing Jatropha plantation

Description	Y1	Y2	Y3	…	Y26	Y27	…	Y50	Total
Total Cost (million riels)	414.0	373.9	371.4	…	403.5	371.4	…	371.4	18,649.7
Total Benefit (million riels)	780.4	780.4	780.4	…	780.4	780.4	…	780.4	39,020.3
NPV (million riels)	**1,776.3**								

With the existing plantation, the producer is able to generate profits even in the first year of investment. The net benefit is increased in the second year onward from 366 million riels (about USD 87,143.00) to 406 million riels (about USD 96,666.00). The marginal net benefit of the producer is greatly high compared to the farmer, which is USD 32,380.00 for the whole commune. It is worth reminding here that the producer getting the benefits from the production are biodiesel and seek cake for fertilizer.

3.1.4. "With project" expansion plantation

Costs and Benefits for Farmer

As mentioned earlier that the base length of live fence in the reference commune is 119,276 meters and the projection is 312,837 meters including the current length of live fence. Since the farmer will expand the plantation only for the fencing, the opportunity cost of land use is considered as zero.

The costs that incur in this setting are mainly the labour costs and some tools such as spade and knives, which is used in the daily agriculture work. On the benefits side, we calculate from the selling nut for biodiesel.

Table 9: Net Present Value of Jatropha curcas for Additional Expansion Plantation

Description	Y1	Y2	…	Y5	…	Y50	Total
Total Cost (million riels)	263.3	203.3	…	203.3	…	203.3	10,227.1
Total Benefit (million riels)	3,539.6	1,037.1	…	1,175.4	…	1,175.4	5,282.8
NPV (million riels)	**4,390.6**						

As shown in the table 7, the new plantation is greatly contributed the household income, which is about an average of 2 million riels (USD 492.00) per household. The figure is appeared very high compared to the country GDP per capita, which is USD 523.00 in 2006 (MoP, 2006). The costs and benefits ration for the expansion plantation is 13.5 times.

Costs and Benefits for Producer

With the expansion of Jatropha plantation, the producer is greatly enjoyed the benefits. In order to cope with the increasing fruit production, the producer needs to invest another set of production including warehouse, oil expeller and the like. The costs of producer increase from 414 million riels to 1,248 million in the first year and from 374 million riels to 1,162 million riels in the second year (Table 10).

Table 10: Producer Net Present Value of Jatropha curcas for Additional Expansion Plantation

Description	Y1	Y2	…	Y6	…	Y26	Y27	…	Y50	Total
Total Cost (million riels)	1,248.0	1,162.7	…	1,301.0	…	1,386.2	1,301.0	…	1,301.0	64,527.6
Total Benefit (million riels)	2,510.6	2,510.6	…	2,827.3	…	2,827.3	2,827.3	…	2,827.3	139,779.5
NPV (million riels)	**6,562.2**									

Table 10 shows that the producer gain net benefits 1,262 million riels (about USD 300,476.00) in the first years and increase to 1,348 million riels (about USD 320,952.00) and more in the second years onward. The NPV of the producer in the setting of expanding plantation is 6,562 million riels (about USD 1,562,380.00) with the discount rate of 5% in 50 years.

3.1.5. "Without" and "With" Project Analysis on Small scale Jatropha plantation in Cambodia

This sub section is to summary the findings for the preliminary result of the study.

"Without" Project

The without project cases are the scenario to estimate the net present value (NPV) of Jatropha plantation in the reference that associate with producing organic fertilizer and fence the property of the house hold. The study found that the existing plantation contribute the NPV up to 130 million riels (about USD 30,952.00) with the study period (50 years) when the discount rate is 5%. The NPV is increased from 130 million riels to 470.82 million riels (about USD 112,100.00) when the Jatropha curcas live fence is expanded 81% in the coming years in the survey site.

"With Project"

The "With Project" cases are the scenario to estimate the NPV of total possible value associate with biodiesel production. There are two main players in this scenario namely farmer and biodiesel producer.

Table 11: Net Present Value of Jatropha curcas for Additional Expansion Plantation

	Farmer		Biodiesel Producer	
	Existing plantation	Expansion plantation	Existing plantation	Expansion plantation
NPV(million riels)	135.9	4,390.6	1,776.3	6,562.2

When taking into account on biodiesel production with existing plantation, the total NPV of the two players is 1,912.2 million riels (about USD 455,286) (Table 13). However, the share among the farmer and producer is quiet different, that is, about 13 times higher. Since there is one producer, then, the net benefit shared among all farmers are too bad to compare.

The value of Jatropha curcas is rocking when more people participate in the market. The Table 13 shows that the farmers will gain NPV from 135.9 million riels before marketing the nut to 4,390.6 million riels when they involve with biodiesel production. Similarly, the producer also enjoys the benefits when more people selling the nut for their production. The case of expansion plantation, the NPV of the two players is 10,952.8 million riels (about USD 2,607,809.00) (Table 13).

Social Benefits from Consumption of Biodiesel

The consumption of biodiesel will contribute to CO2 reduction, meaning that we replaced or avoid using fossil diesel. If this is the case, we can estimate that environmental net present value of existing Jatropha curcas is about USD 9,003.00 and USD 23,250.00 for the expansion of plantation within the 50-years-project calculation with 5% discount rate.

3.2. CO2 (other GHG) saving emission as social benefits

As mentioned earlier, the 'With' project is the main concern of this paper. We will estimate not only the private benefits from selling the nut to make biofuel, but also impute the CO2 saving from consuming the biodiesel from Jatropha oil.

With existing plantation

Table below is the total production of biodiesel from Jatropha curcas for Thloc Vien commune. Based on the experience at Mr. Tham Bunhak, he found 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 Jatropha nut 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 $kgCO_2$ per litre of diesel.

Table 12: Total CO2 saving and Social Net Present Value from Jatropha curcas from existing Jatropha plantation

Description	Y1	…	Y5	Y6	…	Y50	Total
Total nut production (tone)	681.5	…	681.5	681.5	…	681.5	34,078.9
Total biodiesel production ('000 Litre)	204.4	…	204.4	204.4	…	204.4	10,223.6
Total fossil diesel equivalence ('000 Litre)	196.2	…	196.2	196.2	…	196.2	9,814.6
Total CO2 Saving ('000 kg)	51.5	…	51.5	51.5	…	51.5	2,575
Total benefit of avoiding Fossil diesel consumption (USD)	2,065		2,065	2,065		2,065	103,251
Total ENPV (USD)	9,003						

If the production of nut from Jatropha with the existing plantation is 681 tones in the first year, then the biodiesel equivalence is 204,400 litres and equal to 196,200 litres of fossil diesel (Table 11). Then, if we take this amount of fossil diesel equivalence to calculate the CO_2 emission that potentially reduce from avoiding fossil diesel, the total CO_2 saving is 51 tones. At the lower end (USD4.00 per tone) of carbon credit in the Clean Development Mechanism (CDM), we can generate the income of USD 2,065 for the reference commune per year. The environmental net present value (ENPV) of consuming biodiesel for 50 years is USD 9,003 with the discount rate 5%.

With expansion plantation

The production of nut is increased more than double when we impute with the expansion of plantation, which is contributed to the increase of volume of total biodiesel production as well as the total CO_2 saving from avoiding the consumption of fossil diesel (Table 12).

Table 13: Social Net Present Value of Jatropha curcas for Additional Expansion Plantation

Description	Y1	…	Y5	Y6	…	Y50	Total
Total nut production (tone)	1,511	…	1,511	1,787	…	1,787	87,999
Total biodiesel production ('000 Litre)	453	…	453	536	…	536	26,400
Total fossil diesel equivalence ('000 Litre)	435	…	435	514	…	514	25,344
Total CO2 Saving ('000 kg)	4,578	…	4,578	5,416	…	5,416	66,645
Total ENPV (USD)	23,250						

Based on Table 12, the costs of avoiding CO2 emission by replacing biodiesel is USD 4,578.00 per year. For the whole life of Jatropha curcas plant, the ENPV is USD 23,250.00 with the same discount rate.

3.3. 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 not relate to the consumption of fossil fuel. However, to some extend the nut transportation to the processor site may associate with a small amount of petroleum. This consumption is not well investigated during this preliminary analysis.

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 Jatropha curcas in Cambodia at the moment is following three steps. First, the shell of the nut 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.

The shell from the nut is also used for biogas. Mr. Tham confirmed that with appropriate storage design we can derive the gas from the shell for cooking.

Mr. Tham was very proud of the diesel he could produce. He is using his own-production fuel in three different categories. For standing 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.

3.4. Rural Poverty Reduction

The commune investigated during this preliminary phase is one of the 9 communes in Samaki Mean Cheay district, Kampong Chnang province. The commune can be accessed on unpaved road about 10 kilometres from National road number 5 and it is about 10 kilometres away from railway station of the district. Based on 5 Year Communal Development Plan 2007, the total land area is 4,200 hectare with 200 hectare is for residential land, home gardening 205 hectares, rain-fed rice field 1,860 hectares and mountainous area 1,935 hectares.

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. The rest rely on kerosene light and battery. In terms of cooking energy, almost all of household based on firewood, collecting bush land around their house or from the mountain nearby. Then, having their own energy source, namely biofuel from Jatropha curcas plant, is the most benefits.

Although reduction poverty is one of the key variables, we consider this variable as second priority, for the first ones are Jatropha existence, and possible expansion of Jatropha plantation. We will not do any in deep research on this poverty occurrence. There is no empirical study on poverty occurrence for Samakki Mean Chey district. 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. In short, we will highlight the poverty reduction through this initiative energy development.

If we investigate household by household (who has Jatropha Plantation) based on 5 quantile to see at what extend that Jatropha contribute to reduction within the preliminary phase, we found at following information in Table 14.

Table 14: Jatropha curcas Nut Production by Quantile of Thlok Vien Commune

	1st Qnt	2nd Qnt	3rd Qnt	4th Qnt	5th Qnt	Total
Number of Household*	57	20	13	5	3	98
Total Fence (m)	1,744	1,857	2,034	1,020	796	7,451
Total Nut Production (kg)	1,220.80	1,299.90	1,423.80	714.00	557.20	5,215.70
Total Income (riel)	610,400.00	649,950.00	711,900.00	357,000.00	278,600.00	2,607,850.00
Total Income (USD)	152.60	162.49	177.98	89.25	69.65	651.96

** The household who has planted Jatropha curcas plants as live fence*

The income from selling Jatropha nut based on the actual plant is not that much to contribute the livelihood improvement. It does not sound plausible for the farmers to participate the biodiesel production. However, based on the interview we found that they are willing to pick up the nut to sell at any case.

3.5. Policy implication on Biofuel Production and Consumption

Since we found that there is a positive impact from the small scale Jatropha plantation, we will not test how tax will discourage the biodiesel production, but we will explore why tax should be exempted during this early stage of production, and discuss how subsidy will push the production of biodiesel and contribute to rural poverty reduction, especially the grower.

3.5.1. Why Tax Levy?

Since the production of biodiesel is still in the formative stage, no tax mechanism has been imposed on the producer and the farmer. Within the next few years, there is no expectation of tax imposed on this kind of production in the rural area. However, the study assumed that the local government will impose tax on the producer side and use the tax money to increase the price of nut of the farmer. Then, there will be an increase of farmer in the biofuel production. I need help from the economic expertise to oversee this event(s).

3.5.2 Subsidy?

Similar to tax levy, the subsidy will impact on the increase of biofuel production. The implication of subsidy will be the land use change, for more people will participate in the nut production. The study, therefore, will explore more on land use or government land that is available and can be allocated for Jatropha curcas.

3.6. Sensitive analysis and Next phases of research

While visiting DATe[5], we met Mr. San You, the executive officer of the NGO. The meeting was to seek his past experience on buying Jatropha curcas nut 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 nut for not only country wide demand, but just the local diesel demand{San, 2009, Biofuel Development in Cambodia}. Based on his study for an international organization, it suggests that we should terminate all further activities in Jatropha seeds processing otherwise there should be a survey on growing and planting potential of Jatropha curcas at any particular side where the fuel cost is high{San, 2009, Small Scale Jatropha Plantation Development in Cambodia}.

However, the demoing period is much suspected due to the following reasons. (1) The nut was not dry as good as to maximize the liquid content from the nut[6]. (2) The nut 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, Jatropha plant as fences is ranging from 1 meter to 30 meters. In the case of expanding when there is a market for the nut, 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 Jatropha nut 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 Jatropha production while there is boom of expansion through out 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, Policy Development on Agro-Fuel Development in Cambodia}. First, the nut of Jatropha curcas must be squeezed to the liquid as soon as we harvest the nut. 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 harvesting period, and we must have a proper storage before we send the liquid to turn it into biodiesel. Second, if the Jatropha curcas is planted in the from 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

[5] DATe stands for Development Appropriate Technology

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

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 nut can be stored as long as you want, but must be free from moisture and heat. We need to dry the nut from 4hours to 8 hours in order to harvest the maximum oil/liquid (Tham, 2009). In terms of disease, he claimed that he has one hectare of Jatropha 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 Jatropha plants which are more 75 years old. They are there firmly and healthily.

3.6.1. Discount rate

The change in discount rate will produce dramatically different result for the project life quiet long. The higher the discount rate will bring the lower interest on investment on biodiesel production. In contrary to this statement, the lower the discount rate, it makes the investment on biodiesel more attractive. This section will be explored more when the researcher well receive advice from the EEPSEA resource persons.

3.6.2. 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 3,250 riels in Jun 2009. The fluctuation will impact on the producer and the farmer. Then, we may need some analysis tools (simulation) to be able to see the pictures of changes in oil price.

3.6.3. Change in land use when the price of nut increase by subsidy

The NPV estimate will impact greatly when subsidy is introduced. We believe that people will convert their farm land (that is current secondary bush land) into Jatropha curcas plantation. Although, the belong-land size of the household is not big, but the whole commune participation will create different pictures.

3.5.4. Introducing biofuel from Jatropha curcas to replace fuel wood

The NPV of Jatropha curcas 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 Jatropha can also be burn for cooking, at any among of this fuel will save the forest. This emerging set of idea will explore more if there is an approval from EEPSEA and resource person. This introduction of replacement will need an extensive study.

3.6.5. Expecting work to be done for the coming quarters

We are expecting to finish our research as following time line:

1) By Jan 2010: Full administrative survey (2 more communes (3 village per commune) from Samakki Mean Chey, and 6 more communes from other 2 differences districts).
2) By March 1, 2010: The whole data analysis and report writing.
3) September 1, 2010: Dissemination result.

IV. Conclusion and remark

The preliminary result shows that the existing plantation contributes the NPV up to 130 million riels (about USD 30,952.00) within the 50 years and the discount rate is 5%. The NPV is increased from 130 million riels to 470.82 million riels (about USD 112,100.00) when the Jatropha curcas live fence is expanded 81% in the coming years in the survey site. The value of Jatropha curcas is rocking when more people participate in the market, meaning that the farmers will gain NPV from 135.9 million riels before marketing the nut to 4,390.6 million riels when they involve with biodiesel production. Similarly, the producer also enjoys the benefits when more people selling the nut for their production. The case of expansion plantation, the NPV of the two players is 10,952.8 million riels (about USD 2,607,809.00).

If we considered that the same of biodiesel is replaced the petroleum based fuel, the consumption of biodiesel will contribute to CO2 reduction. If this is the case, we can estimate that environmental net present value of existing Jatropha curcas is about USD 9,003.00 and USD 23,250.00 for the expansion of plantation within the 50-years-project calculation with 5% discount rate.

The substitution of fossil based diesel is greatly, for the production of biodiesel demand only a small fraction during the transportation of nut to the processor premise. Then, we considered the small scale plantation is totally the net gain of energy.

Besides the overall plausible biodiesel production, we found that income per household is not really invitingly tradable activities. We found that the first quantile (who has less plants) enjoys only about USD3.00 per whole harvesting period followed by the next quantile about USD8.50. However, the amount of income does not really express any barriers for biodiesel production, for every one is willing to participate the marketing. This is based on household interview.

In a nut shell, the preliminary result and analysis found that biodiesel production is very positive. The remaining task of this research is to collect more data to build up the whole picture of biodiesel production for a district of Kampong Chhnang Province before prescribing the mechanism of subsidy to promote biodiesel production in Cambodia.

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