International Journal on Advanced Science Engineering Information Technology

Vol.5 (2015) No. 5
ISSN: 2088-5334

Strategy to Reduce GHG Emission and Energy Consumption at Process Production of Biodiesel Using Catalyst From Crude Palm Oil (CPO) and Crude Jatropha Curcas Oil (CJCO) in Indonesia

Kiman Siregar

Agricultural Engineering Department, Syiah Kuala University, Jl.Tgk.Hasan Krueng Kalee No.3, Banda Aceh, 23111, Indonesia
E-mail: ksiregar.tep@unsyiah.ac.id

***Abstract*— Crude palm oil (CPO) is one kind of biologic resource that has been widely produced for biodiesel fuel, including Indonesia as the world main producer of palm oil. However, CPO is a food resource. This drives Indonesia to find another alternative source for biodiesel production. One promising source is *Jatropha curcas* L. which is considered as non-edible industrial plant used for biodiesel fuel. *Jatropha curcas* could be planted in marginal soil, semi dry climate, and suitable in tropical and subtropic climate. According to those aforementioned situations, an effort to address this issue should be conducted by identifying and presenting actual condition of Indonesian palm oil and *Jatropha curcas* estate. In this research, LCA is used to analyze the prospect of oil palm and *Jatropha curcas* development. The impact assessment calculation on stable production is lower than before-stable production. By considering that 4/5 or 20 years of 25 years of its life cycle lie on stable production, appropriate calculation method is needed. Agro-chemical utilization such as fertilizer, insecticides, pesticides, and fungicides produces significant contribution to environmental impact in biodiesel production. It is accounted by 50.46% for oil palm and 33.51% for *Jatropha curcas*. The use of organic fertilizer very influences the reduction of GHG emission value in fertilization sub-process. It could reduce up to 96.2 % for oil palm and 76.8% for *Jatropha curcas*. In term of electricity generation, shows that *Jatropha curcas* oil based biodiesel is better than fossil fuel. The improvement of Indonesian power plant should consider the utilization of low GHG emission fuel, such as natural gas and biodiesel fuel.**

***Keywords*— GHG emission; biodiesel; organic fertilizer; crude palm oil; crude jatropha curcas oil.**

I. INTRODUCTION

A. Background

In terms of its resource, biodiesel could be claimed as renewable energy. However, various activities and material as well as energy input to the production chain could abandon its renewability status if poorly managed. Biodiesel can be produced from various feed stocks. Due to its availability and suitability, Indonesia mainly uses oil palm (*Elaeis guineensis*) and jatropha (*Jatropha curcas L*) as biodiesel feedstock. This is rational since Indonesia is one of main oil palm producer in the world. On the other hand, jatropha is a non-edible industrial crop and easily grown at various part of Indonesia, that makes it as good alternative for biodiesel fuel production [14]. Each of the plants has its own characteristics along its production chain to be used as biodiesel feedstock.

Accordingly, life cycle assessment (LCA) of biodiesel production from each of the oil producing plants needs to be conducted in order to compare its state of renewability. Life cycle assessment (LCA) is a systematic tool for assessing the environmental impacts associated with any products, processes and activities [1], which is standardized in ISO 14000 series. The LCA needs elaboration of data in terms of life cycle inventory (LCI) to obtain a rational result of the assessment. The result of LCA is highly influenced by the reliability and sufficiency of data inventory of the assessed object. Data collection process is the main focus in inventory analysis and the most time-consuming process of all LCA process [11].

Unfortunately, despite of its high potentiality in providing the biodiesel feedstock, date accessibility in Indonesia is still very limited for a comprehensive LCA study. A number of LCA studies on biodiesel production using feedstock from Indonesia have been conducted. However, results discrepancy generated in the studies are due to inconsistency of the data used. Accordingly, continuous studies are indispensable to be conducted in order to perform a comprehensive LCA study on biodiesel production from oil palm and jatropha produced in Indonesia.

B. *Objective And Problem Formulation*

The objective of the research is to analyze and compare Life Cycle Assessment (LCA) of oil palm and *Jathropa curcas* as feedstock for biodiesel in Indonesia from cradle to gate using data based found in Indonesia, and to find strategy to reduce of value of green house gas emission and energy consumption.

According to those aforementioned situations, scientific approach needs to be taken in order to answer the problem related with global warming emission and others environmental effect along its biodiesel production path from palm oil and *Jathropa curcas*. Reducing emission value generated from oil palm and jathropa curcas for biodiesel production is important to be determined in order to meet the standard of global market. The following questions have been formulated from the previous problem in systematic and structured study to provide good result: (1) What is the emission distribution for planting, harvesting and post-harvesting of palm oil and *Jathropa curcas*-based biodiesel? Which stage has significant effect? What kind of material input is the most siqnificant increasing the global warming potential emission value? (2) How are the energy consumption, net energy balance, net energy ratio, and renewable index of biodiesel production from palm oil and jathropa curcas? (3) How much is the potentialing in reducing green house gas (GHG) emission generated from palm oil and jathropa curcas-based biodiesel compared to diesel-fuel one?

It is expected that the research could give solution and describe the net energy balance and net energy ratio for further development of biodiesel processing.

II. Methodology

The system boundary for LCA study is shown in Fig.1, which is a cradle to gate assessment. The production cycle to be assessed consists of eight sub-processes. The functional unit (FU) of this study is 1 ton of biodiesel fuel (BDF) production from jatropha and oil palm. Data to be used in this study was from oil palm plantation in *PTPN VIII Unit Kebun Kertajaya Lebak Banten* and from *Jatropha curcas* centre *Pakuwon Sukabumi* West Java. Both locations are in *Jawa* island of Indonesia.

Life cycle inventory analysis was performed on the material and energy inputs, air emission, waterborne emission, and solid wastes involved in biodiesel production from each oil plants. Each stage of analysis and calculations was carried out before and after the plants yield the usable fruits. Based on the field survey, oil palm and jatropha will have stable productivity after 5th years from seed plantation. The first production of palm oil occurs at 30 months old, while *Jatropha curcas* at 4 months after plantation.

Transportation from seed from nursery to plantation area was assumed to be as the distance from the centre point of the plantation, which was 30 km, using 5 tons capacity truck with 1 liter diesel oil consumption per each 5 km. Transportation of fruits from harvesting area to palm oil mills was 150 km, using 10 tons capacity truck, with 1 liter diesel oil consumption per 7 km travel. Transportation from palm oil mills to biodiesel plant was 200 km, using 10 tons capacity truck.

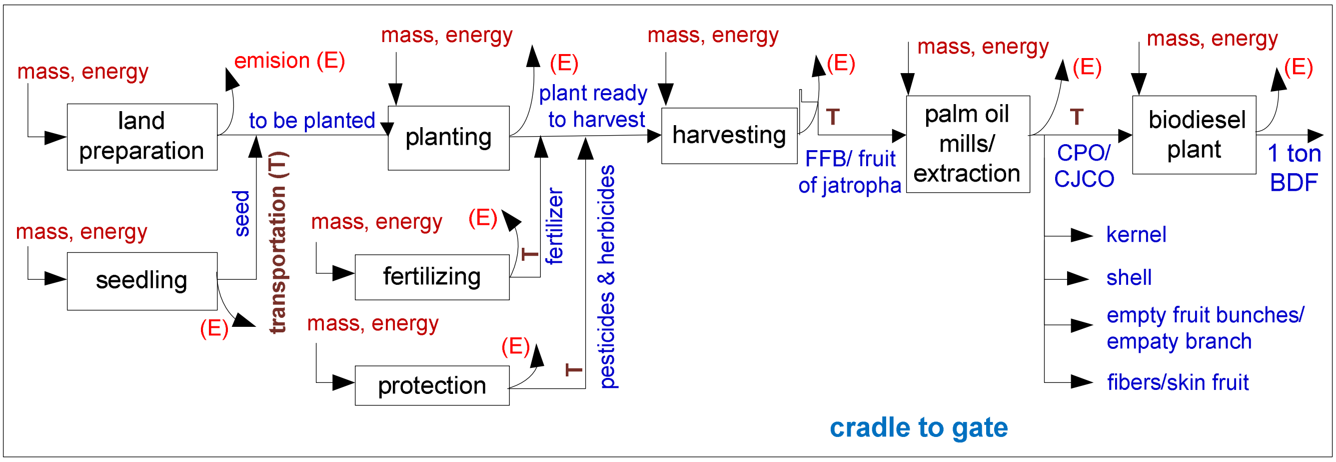

Fig.1. The system boundary of this study

III. Results and Discussion

A. *Life Cycle Inventory*

The LCI was conducted based on input-output analysis of mass and energy to each of the production line, as shown in Fig.1. Detail description of eight sub-processes involved in LCI for oil palm and jatropha is shown in Table 1. Comparison of material and energy used for 1 ton production of palm oil and jatropha based biodiesel is shown in Table 2 [8];[2]. Stable productivity of palm oil at PTPN VIII is approximately at 21.5 tons per ha [9]; [5]; [10], while jatropha has stable productivity at about 8 tons per ha for IP3-P [8]. Production amount of biodiesel from palm oil and Jatropha curcas oil during its life cycle (25 years) is shown in Fig. 2. From this figure it can be seen that stable productivity of each crops will be obtained at the 5th years.

Weeds population in palm oil estate is higher than in jatropha plantation, which needs more effort to control. This fact is the reason for higher herbicide requirement for oil palm plantation than for jatropha, as shown in Table 2. The height of seeds lived surrounding palm seedlings is approximately 1.5 m while Jatropha curcas tree is approx. 0.5 m. Oil palm also needs more diesel fuel than jatropha due to the requirement of mechanical tillage for oil palm plantation. On the other hand, jatropha plantation needs less tillage for the plant more resistant to critical environmental conditions.

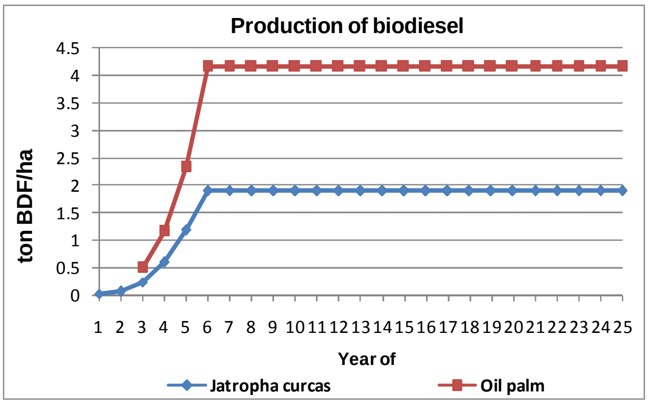

Fig.2. Productivity of biodiesel per ha from palm oil and Jatropha curcas oil

At nursery stage, oil palm plantation uses higher amount of pesticides and fertilizer due to longer seedling process (12 months) compared to jatropha plantation (3 months). Palm oil seedling consists of growth stage of seedlings and seedling nursery which need intensive amount of fertilizers and pesticides. However, jatropha needs more application of fertilizer during planting stage, since the number of trees per hectare of jatropha plantation is larger (2500 trees) than oil palm (136 trees) [2]; [13]; [5].

The table also shows that during the first five years growth, oil palm plantation needs more fertilizer, as well as other agro-chemicals for protection, than the jatropha plantation. Oil palm is more susceptible to plant pests than jatropha. Dose application will change continuously based on plant's requirement, which is analyzed and determined by soil and leaves nutrient needs. This analysis will give the appropriate amount of fertilizer and protection agro-chemicals. From Table 2 can also be seen that the Jatropha curcas more use of organic fertilizer and pospate fertilizer than oil palm in its growth.

Jatropha curcas grown in Indonesia is known as poisonous plant so it has high resistance to pest and disease attack. It is probably caused by the planting system that is generally mixed with other plants such as gamal (glyrecidiamaculata) and waru. If planting is conducted in monoculture system with wide space to others plants it might result the occurrence of pests and diseases.

At the stage of harvesting sub-process, the transport energy uses for oil palm is higher than Jatropha curcas due to the differences of harvesting yield. The yield of oil palm is higher than Jatropha curcas. In the case of crude oil production, Jatropha curcas oil needs only electricity and diesel fuel for its process. On the other hand, palm oil mills need more materials and energy. At the stage of biodesel production sub-process, due to high average value of free fatty acids (FFA) in jatropha curcas oils, it needs esterification stage before trans-esterification. Consequently, jatropha curcas oils needs more materials and energy.

TABLE I
THE COMPARISON OF BIODIESEL PRODUCTION FROM CPO AND CJCO WITH BOUNDARY CRADLE TO GATE

Input activities	**Component**	**Oil palm**	***Jathropa curcas***
(1) Land preparation	Early land uses	Primer & skunder forest	Coarse grass forest
	Soil fertility	Fertile	Less fertile
	Tree, diameter > 60 cm	26-100 trees/ha	No trees
	Tree, diameter > 30 cm	Approx. 2500 trees/ha	Approx. 500
	Coarse grass	10-30 groups/m2	10-30 groups/m2
	Soil tillage	Effective soil depth 50-150 cm	Effective soil depth 20-30 cm
	Plant above the soil surface	Nuts	No plants, usually
(2) Seedling	Seedling time	12 months	3 months
	Seedling source	Seed	Seed, steck
(3) Planting	Plants width space	9 x9x9 m	2x2x2 m
	Number of plants	136/ha	2500/ha
	Number of hole	50x40x40 cm	40x40x40
(4) Fertilizing	Fertilizer compound	N,P,K,Mg,B, organic	N,P,K, organic
	Intensity	Very intensive	Scarcely conducted
(5) Protection	Plant pest	Many kinds of pest	Almost not present
(6) Harvesting	Start to produce	30 months	4 months
	Production on stable productivity	8 tons seed/ha	21.5 tons FFB/ha
	Edible/non-edible	Edible	Non-edible
(7) Palm oil mills or Extraction oil	Production of crude oil	By milling	By extraction
	Value of FFA	< 2	>2
	Ratio of FFB to crude oil	21%	26%
	Produced biomass	Empty bunch, fruit fiber, shell, palm kernel	Kernel pulp, shell, jathropa oil cake
(8) Biodiesel production	Reaction of biodiesel production	Transesterification	Esterification and transesterification
	Ratio of crude oil to BDF	92%	91%
	Biodiesel source	Pulp, kernel	kernel
	Catalyst	Alkali	Acid and alkali

TABLE II
MATERIALS AND ENERGY FOR 1 TON BDF FROM JATROPHA CURCAS AND PALM OIL

Input activities	Input names	Unit	Palm oil	*Jatropha curcas*
(1) Land preparation	Herbicide	kg	0.861	0.624
	Diesel fuel for toppling & cleari	L	0.703	1.208
(2) Seedling	Fungicides	kg	-	0.852
	Insecticides	kg	0.00018	0.0057
	Chemical fertilizer Urea 0,2 %	kg	0.00492	-
	Organic fertilizer	kg	8.367	9.377
	Kieserite (MgSO4)	kg	2.008	-
	Urea	kg	0.000067	-
	Herbicide	kg	0.974	-
	Dolomite	kg	2.949	-
	Compound fertilizer	kg	4.686	-
	Electricity for Pump Water	kWh	0.436	-
	Pesticides	kg	0.004	-
Transportation	Diesel fuel for truck 5 ton	L	1.004	1.189
(3) Planting	TSP/SP36	kg	13.387	79.562
	Organic fertilizer	kg	-	994.524
	Rock Phosphate	kg	22.887	-
	KCl		-	15.912
(4) Fertilizing for five years	Compound fertilizer	kg	9.844	-
	Rock Phosphate	kg	252.492	-
	ZA/Urea	kg	279.464	87.518
	HGF Borate	kg	3.347	-
	TSP/SP36	kg	117.140	278.467
	MOP (K)/KCl	kg	245.995	95.474
	Kieserit	kg	184.078	-
	HGF Borate	kg	3.347	-
	Organic fertilizer	kg	-	994.524
(5) Protection for five years	Herbicide	kg	56.317	-
	Insecticides (liquid & powder)	kg	1.323	-
	Pesticides	kg	0.801	2.955
	Diesel for power sprayer & fogg	L	0.554	-
(6) Harvesting				
Transportation	Diesel fuel for truck 10 ton	L	5.027	2.468
(7) Palm oil mills vs Oil extraction	Electricity	kWh	34.392	14.833
	Steam consumption	kg	1325.397	-
	Water consumption	m^3	3.968	-
	PAC	kg	0.125	-
	Flokulon	kg	0.00053	-
	NaOH	kg	0.107	-
	H2SO4/HCl	kg	0.109	-
	Tanin Consentrate	kg	0.045	-
	Poly Perse BWT 302	kg	0.045	-
	Alkaly BWT 402	kg	0.043	-
	Shell consumption	kg	133.862	-
Transportation	Diesel fuel for truck 10 ton	L	2.540	1.890
(8) Biodiesel production	Methanol	ton	-	0.449
	H2SO4	ton	-	0.027
Esterification	Electricity	kWh	-	1.285
Trans-esterification	Methanol	ton	0.269	-
	Electricity	kWh	15.645	15.645
	NaOH	ton	0.080	0.080
	Water consumption	L	1700.68	1719.180
	Diesel fuel for Boiler	L	14.00	16.00

B. Impact Assessment

Impact assessment was carried out using data provided in inventory analysis and in MiLCA-JEMAI (Multiple interface life cycle assessment-Japan enviromental management association for industry) database version 1.1.2.5. Five categories of environmental impacts were interest i.e. global warming potential, acidification, waste for landfill volume, eutrophication, and energy consumption (Table 3). Table 3 shows that total environmental impact before stable productivity for biodiesel production from palm oil is higher than that of Jatropha curcas oil. Global warming potential is the most significant environmental impact caused by biodiesel production either from palm oil or Jatropha curcas oil. Most of the global warming emission emerges from utilization of agrochemical in form of fertilizer and plant protection, i.e. 50.46% and 33.51% of total emission of biodiesel produced from palm oil and Jatropha curcas oil, respectively. Other works conducted by Pramudita (2011) and Sekiguchi (2012) showed that the value of GHG emission in crude Jatropha curcas oil (CJCO) extraction process is estimated to be 1.34 kg-CO_2/kg-CJCO and 0.08 kg-CO_2/kg-BDF [10],[12]. In this research, the GWP value is 18.65 kg-CO_2eq./ton-BDF with assumption which assume that drying is carried out naturally (sun drying).

Life cycle of oil palm is about 25 years *[9]*; *[5]*, while Jatropha curcas can reach up to 50 years (Pranowo 2009; Ferry 2009; Tjahjana et al. 2010) even the productivity of Jatropha curcas is stable until the 25^{th} year. From Fig.3 and Fig.4, it can be seen that the GWP value for oil palm is higher than Jatropha curcas in every stages except for planting and biodiesel production stages. The most significant environmental impact based on GWP value is caused by fertilizing and biodiesel production stages both at oil palm and Jatropha curcas. The total value of GWP emission before stable productivity is 2568.82 and 1733.67 kg-CO_2eq./ton-BDF for oil palm and Jatropha curcas, respectively.

Fig. 3 shows that oil palm's GWP value of eight sub-processes which consist of land preparation, seedling, planting, fertilizing, protection, harvesting, palm oil mills, and biodiesel production is 0.44 %, 0.61 %, 0.91 %, 35.15 %, 15.31 %, 1.23 %, 22.90 %, and 23.44 %, respectively. While for Jatropha curcas as shown in Fig. 4 is 0.63 %, 0.74 %, 11.79 %, 29.49 %, 4.02 %, 0.48 %, 1.08 %, and 51.78 %, respectively. Table 4 shows the proportion of each stage which was regroupped into pre-harvest, harvesting and post-harvest.

Lord et al. (2009) stated that environmental impact towards aquatic, land, air and others of palm oil processing from operation to processing stage was 47 %, 24 %, 8 %, and 21 %, respectively. Prueksakorn et al. (2006) said that the major contribution of greenhouse gas (GHG) effect during biodiesel production from jatropha comes from the production and use of fertilizers, diesel oil consumption for irrigation, and transesterification process which is accounted for 31 %, 26 %, and 24 %, respectively.

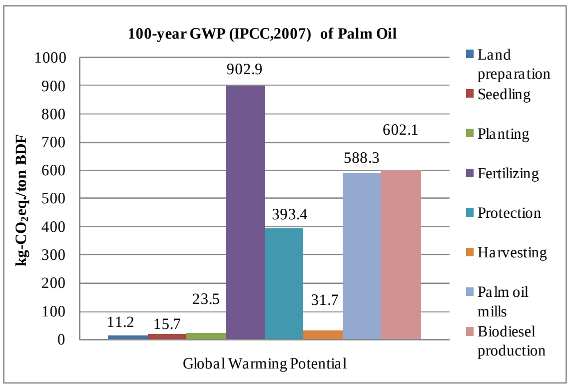

Fig.3. The total value of GWP for oil palm before stable productivity

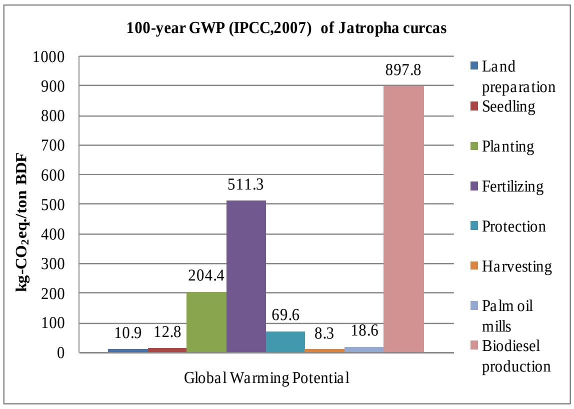

Fig.4. The total value of GWP for Jatropha curcas before stable productivity

TABLE III
ENVIRONMENTAL IMPACTS FOR PRODUCING 1 TON BDF FROM PALM OIL AND JATROPHA CURCAS OIL

Input activities	Input names	Unit	Palm oil	Jatropha curcas
(1) Land Preparation	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	11.21	10.88
	Acidification, DAF(LIME,2006)	kg-SO2e	0.020	0.017
	Waste,landfill volume(LIME,2006)	m3	4.9E-06	5.7E-06
	Eutropication, EPMC(LIME,2006)	kg-PO4e	1E-06	1.18E-06
	Energy consumption,(fossil fuel)	MJ	163.41	161.66
(2) Seedling	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	15.73	12.81
	Acidification, DAF(LIME,2006)	kg-SO2e	0.026	0.021
	Waste,landfill volume(LIME,2006)	m3	9.57E-05	1.62E-04
	Eutropication, EPMC(LIME,2006)	kg-PO4e	1.9E-06	1.34E-06
	Energy consumption,(fossil fuel)	MJ	242.94	186.28
(3) Planting	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	23.46	204.38
	Acidification, DAF(LIME,2006)	kg-SO2e	0.04	0.40
	Waste,landfill volume(LIME,2006)	m3	######	0.0044
	Eutropication, EPMC(LIME,2006)	kg-PO4e	2.9E-06	4.17E-05
	Energy consumption,(fossil fuel)	MJ	387.40	3,394.34
(4) Fertilizing	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	902.90	511.27
	Acidification, DAF(LIME,2006)	kg-SO2e	1.02	0.81
	Waste,landfill volume(LIME,2006)	m3	0.0071	0.0088
	Eutropication, EPMC(LIME,2006)	kg-PO4e	5.8E-05	0.000074
	Energy consumption,(fossil fuel)	MJ	18240.00	10841.11
(5) Protection	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	393.38	69.64
	Acidification, DAF(LIME,2006)	kg-SO2e	0.69	0.21
	Waste,landfill volume(LIME,2006)	m3	0.00067	0.0011
	Eutropication, EPMC(LIME,2006)	kg-PO4e	6.9E-05	8.93E-06
	Energy consumption,(fossil fuel)	MJ	6211.61	1178.64
(6) Harvesting	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	31.67	8.27
	Acidification, DAF(LIME,2006)	kg-SO2e	0.058	0.015
	Waste,landfill volume(LIME,2006)	m3	1.1E-08	2.86E-09
	Eutropication, EPMC(LIME,2006)	kg-PO4e	9.5E-11	2.47E-11
	Energy consumption,(fossil fuel)	MJ	422.55	110.38
(7) Palm oil mills or Extraction oil	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	588.34	18.65
	Acidification, DAF(LIME,2006)	kg-SO2e	0.98	0.053
	Waste,landfill volume(LIME,2006)	m3	0.00082	5.24E-06
	Eutropication, EPMC(LIME,2006)	kg-PO4e	0.000064	7.49E-06
	Energy consumption,(fossil fuel)	MJ	7994.14	234.18
(8) Biodiesel production	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	602.12	897.77
	Acidification, DAF(LIME,2006)	kg-SO2e	0.72	0.98
	Waste,landfill volume(LIME,2006)	m3	0.00031	0.00052
	Eutropication, EPMC(LIME,2006)	kg-PO4e	0.000047	0.000059
	Energy consumption,(fossil fuel)	MJ	16169.11	25623.45
Total	GWP, 100-year GWP(IPCC, 2007)	kg-CO2e	2568.82	1733.67
	Acidification, DAF(LIME,2006)	kg-SO2e	3.55	2.50
	Waste,landfill volume(LIME,2006)	m3	0.0094	0.015
	Eutropication, EPMC(LIME,2006)	kg-PO4e	0.00024	0.00019
	Energy consumption,(fossil fuel)	MJ	49831.17	41730.03

Prueksakorn et al. (2006) also explained that CO_2 emissions for producing biodiesel from crude jatropha oil with transesterification method is generated from land preparation, cultivation, irrigation, fertilizing, cracking, extraction oil, filtering, and transesterification process which is accounted for 4.7%, 0.2%, 26.1%, 30.3%, 3%, 10.9%, 0.5% and 24.3%, respectively. Ndong et al. (2009) gives the details of GHG emissions in the various processes as follows: the cultivation of jatropha is accounted for 52% of total emissions, while transesterification and combustion phase are 17% and 16%, respectively. Large emissions occur in fertilizer application, were estimated to be 93%.

Fig.5 and Fig.6, show that energy consumption for palm oil is higher than Jatropha curcas in every stages except for planting and biodiesel production. The largest energy consumption for Jathropa curcas occurs in biodiesel production sub-process i.e. 25623.45 MJ/ton-BDF. While the largest energy consumption for oil palm is fertilizing sub-process i.e. 18240.0 MJ/ton-BDF. However, energy consumption in biodiesel production sub-process of Jatropha curcas oil is higher than that of palm oil due to higher free fatty acid (FFA) content which needs esterification process prior to the transesterification process. The total value of energy consumption before stable productivity for oil palm and Jatropha curcas is 49831.17 and 41730.03 MJ/ton-BDF, respectively.

TABLE IV
PERCENTAGE OF GWP-100 YEARS FOR LCA WITH BOUNDARY CRADLE TO GATE AT OIL PALM AND JATROPHA CURCAS

Input activities	Percentage (%)	
	Palm oil	*Jatropha curcas*
Pre-harvest	52.42	46.66
Harvesting	1.23	0.48
Post-harvest	46.34	52.86

Fig.5 shows that oil palm energy consumption during land preparation, seedling, planting, fertilizing, protection, harvesting, palm oil mills, and biodiesel production is 0.33%, 0.49%, 0.78%, 36.60%, 12.47%, 0.85%, 16.04%, and 32.45%, respectively. While for Jatropha curcas, the value of each sub process is 0.39%, 0.45%, 8.13%, 25.98%, 2.82%, 0.26%, 0.56%, and 61.4%, respectively. Table 5 shows the proportion of each stage which comprised into pre-harvest, harvesting and post-harvest. Prueksakorn et al. (2006) also explained that energy consumption needed for transesterification is higher than fertilization. On the contrary, fertilization is higher in greenhouse gas emissions. It occurs because of the N compound and because the use of N_2O has strong effects on GHG.

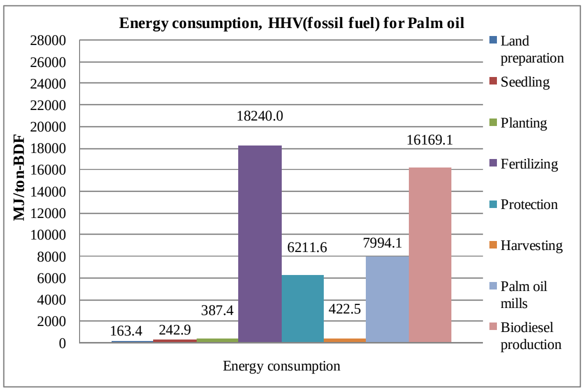

Fig.5. The total value of energy consumption for oil palm before stable productivity

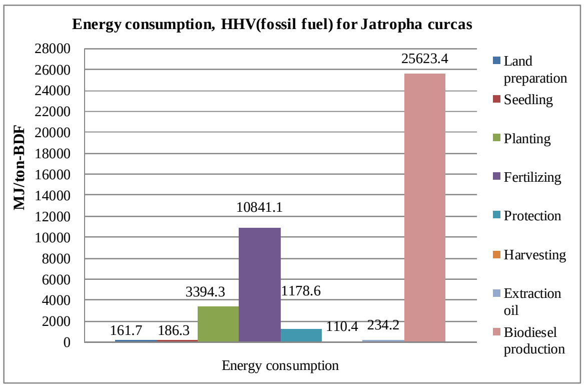

Fig.6. The total value of energy consumption for Jatropha curcas before stable productivity

TABLE V
PERCENTAGE OF ENERGY CONSUMPTION FOR LCA WITH BOUNDARY CRADLE TO GATE AT OIL PALM AND JATROPHA CURCAS

Input activities	Percentage (%)	
	Palm oil	*Jatropha curcas*
Pre-harvest	50.66	37.77
Harvesting	0.85	0.26
Post-harvest	48.49	61.96

Fig.7 and Fig.8 show that GWP emission at stable productivity (6 to 25 years) is 1658.50 and 740.90 kg-CO_2eq./ton-BDF for oil palm and jatropha curcas, respectively. The energy consumption for fossil fuel at stable productivity is 33190.05 and 19395.89 MJ/ton-BDF for oil palm and Jatropha curcas, respectively. The GWP value and energy consumption of oil palm and Jatropha curcas is decreasing until the 5th year and stable from there until the 25th year.

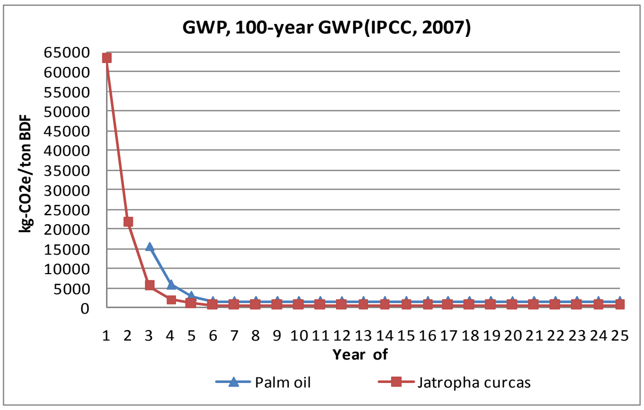

Fig.7. The value of GWP for oil palm and Jatropha curcas before and after stable productivity

Similar trend emerges in impact assessment also occurs at acidification, eutrophication, and landfill waste as shown in Fig.9, Fig.10, and Fig.11. Assessment conducted by Sekiguchi (2012) shows that total CO_2 emission is 0.46 CO_2eq./kg-BDF for SMV method, 0.79 CO_2eq./kg-BDF for alkali-catalyzed method and 3.4 CO_2eq./kg-diesel for diesel oil. The result differences might be due the differences in methods and assumptions adopted in the studies.

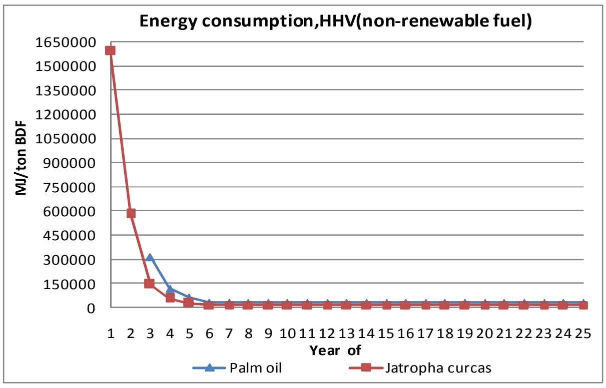

Fig.8.The value of energy consumption for oil palm and Jatropha curcas before and after stable productivity

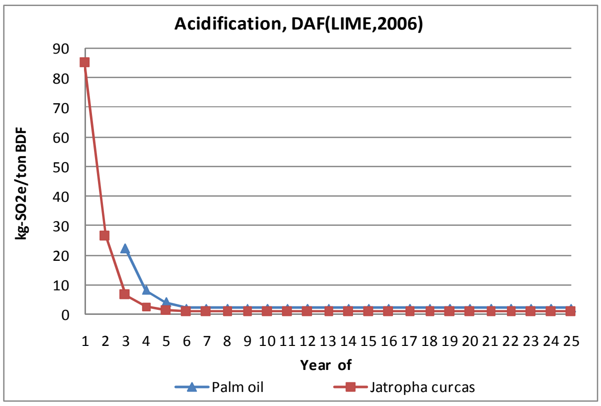

Fig.9.The value of acidification for oil palm and Jatropha curcas before and after stable productivity

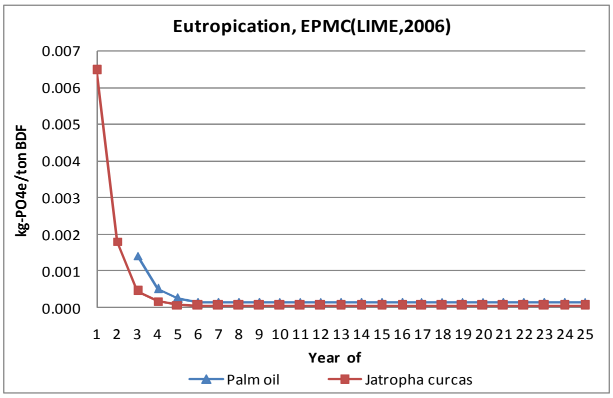

Fig.10.The value of eutrophication for oil palm and Jatropha curcas before and after stable productivity

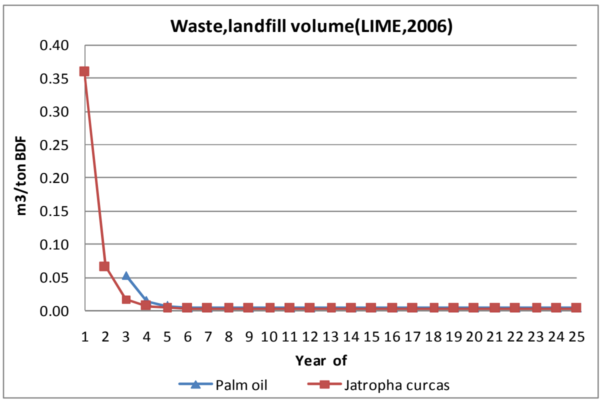

Fig.11.The value of waste landfill volume for oil palm and Jatropha curcas before and after stable productivity

Fig. 12, Fig. 13, and Fig. 14 show comparison between reduction value of CO_2 emission produced in oil palm and Jathropa curcas towards diesel oil. Fig. 12 and Fig. 13 show that reduction in CO_2 emissions is greater at stable productivity due to lower input energy and mass which only used for maintenance, fertilizing and harvesting. The sub-processes of land preparation, seedling, and planting are not carried out in this phase.

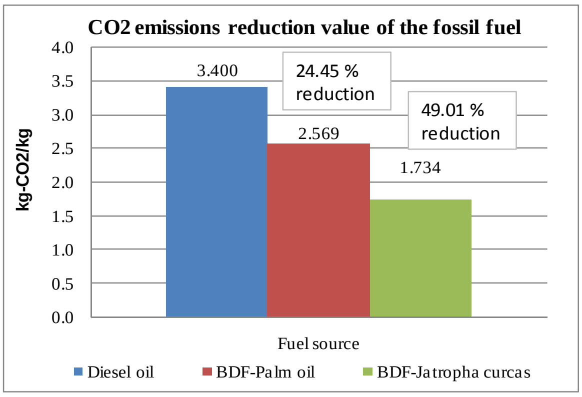

Fig.12. The reduction values of CO_2 emission before stable productivity

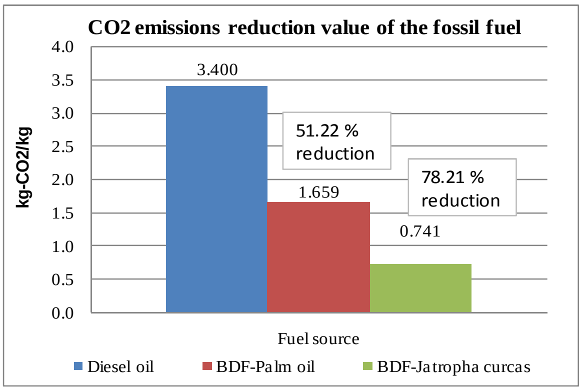

Fig.13. The reduction values of CO_2 emission after stable productivity

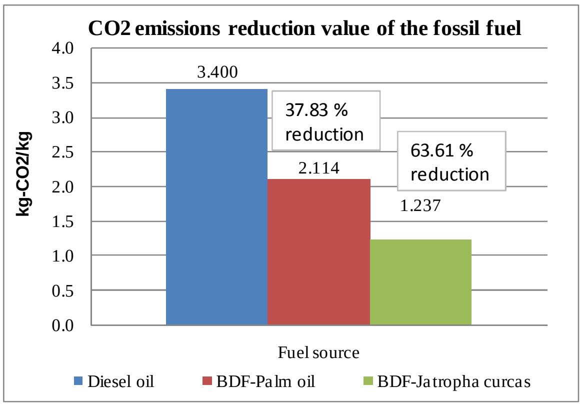

Fig.14. The total values of CO_2 emission

Fig.14 shows combination values of CO_2 emission before and after stable production. It can be seen that reduction value of CO_2 emissions for BDF-CPO and BDF-CJCO is 37.83% and 63.61%, respectively. Research conducted by Gomma et al. (2011) mentioned that biodiesel of jatropha can save greenhouse gas emission by 66 % compared with diesel fuel even it accounts pasture land use. Prueksakorn et al. [7] stated that greenhouse gas emission is 77% lower than production and diesel fuel consumption.

IV. Conclusions

Total environmental impact for biodiesel production from palm oil is higher than that of *Jatropha curcas* oil. Utilization of agrochemical in form of fertilizer and plant protection generate significant contribution to environmental impact of biodiesel production i.e. 50.46% and 33.51% for palm oil and *Jatropha curcas* oil, respectively. GWP emission until 5 years of plantation is 1695.36 kg-CO_2eq./ton-BDF and 740.90 kg-CO_2eq./ton-BDF for palm oil and *Jatropha curcas* oil, respectively. After stable production, CO_2 emission of diesel fuel decreases up to 37.83% and 63.61% for BDF-CPO and BDF-CJCO, respectively.

Acknowledgment

Thank you very much to Prof.Dr.Armansyah H.Tambunan,M.Agr, Dr.Ir.Abdul Kohar,M.Sc, Dr.Ir.Soni Solistia Wirawan,M.Ec, and Prof.Tetsuya Araki,Ph.D as my academic advisor in Bogor Agricultural university.

References

[1] Ciambrone DF (1997) Environmental Life Cycle Analysis. Florida: CRC Press LLC.

[2] Ferry Y (2009) Budidaya Jarak pagar (Jatropha curcas L). Estate Crops Research and Development Centre Bogor, Indonesia

[3] Gomaa M, Alimin AJ, Kamarudin KA (2011) The effect of EGR rates on NOx and smoke emmisions of an IDI diesel engine fuelled with Jatropha biodiesel blends, International Journal of Energy and Enviroment, Vol.2, Issue 3, 2011, pp.477-490

[4] Lord S, Clay J (2009) Enviromental Impacts of Oil palm-Practical Considerations in Defining Sustainibility for Impacts on the Air, Land and Water, USA

[5] Lubis RE, Widanarko A (2011) Smart palm oil : Agromedia Jakarta, Indonesia

[6] Ndong R, Vignoles MM, Girons OS, Gabrielles B, Pirot R, Domergue M, Sablayrolles C (2009) Life cycle assessment of biofuels from Jatropha curcas in West Africa : a field study, GCB Bioenergy (2009) 1, pp. 197-210, doi:10.1111/j.1757-1707.2009.01014.x

[7] Prueksakorn K, Gheewala SH (2006) Energy and Green house gas Implications of Biodiesel Production from Jatropha curcas L.. The 2nd Joint International Conference on “Sustainable Energy and Environment (SEE 2006)-Bangkok, Thailand, 21-23 November 2006

[8] Pranowo D (2009) Jatropha Cultivation Technology (Jatropha curcas L). Estate Crops Research and Development Centre Bogor, Indonesia

[9] Pahan IA (2011) Complete guide palm-agribusiness management from up stream to downstream, Jakarta, Indonesia

[10] Pramudita D (2011) Life cycle inventory analysis of postharvest handling and extraction of Jatropha curcas oil, Graduation Thesis, Bogor Agricultural University (in Indonesia)

[11] Searcy C (2000) An Introduction to Life Cycle Assessment. http://www.i-clps.com/lca/

[12] Sekiguchi T (2012) Possibilities and limitations in disseminating outcomes of technological development to utilize biomass for liquid fuel, Master Thesis, The University of Tokyo (in Japanese)

[13] Tjahjana BE, Pranowo D (2010) Cultivation and processing of Primary Jatropha curcas primary, Publishing and publication unit, Balitri Pakuwon Sukabumi, Indonesia

[14] Tambunan AH, Situmorang JP, Silip JJ, Joelianingsih A, Araki T (2012) Yield and physico chemical properties of mechanically extracted crude Jatropha curcas L oil, Biomass and Bioenergy, 43, 2012, pp.12-17.