Potential Environmental and Economic Impacts of Biofuel Production for the Local Community: A Case Study

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Abstract. Biorefinery technology development in Indonesia especially related to production of biofuel from Crude Palm Oil (CPO) and other biomass from oil palm has already been progressing quite significantly during the last ten years. In 2018, Indonesia has implemented B-20 policy where 20% of diesel is blended with biodiesel from CPO. Likewise, researches on development of enzymes for various application including its application in the production of biofuel from CPO and Oil Palm Empty Fruit Bunches (OP EFB) through an enzymatic process has also been progressing. However, there is not enough research or information on what are the economic and environmental impact of this biofuel production to local community. Does this biofuel production also provide direct and indirect benefit to local community surrounding oil palm plantation and CPO mills? If it does, How? This paper describes what are specific economic and environmental issues facing by local community and how a biofuel production in the surrounding of local community can get environmental and economic and benefits. This case study was conducted in 2018 at 6 villages in Putri Hijau District, North Bengkulu Regency, Bengkulu Province, Indonesia

Keywords: Economic and environmental issues, local community, oil palm, biofuel, inclusive economy

1. Introduction

1.1. Background

Indonesia is the largest oil palm plantation in the world. This commodity employs more than 8.4 million workers in 2016. Besides direct labour, many people also reside in the surrounding of oil palm plantation. This community also can take direct or indirect benefits from the existence of oil palm plantation and Crude Palm Oil (CPO) mills around them.

It is interesting to note that oil palm plantation and CPO mills produces abundant biomass during the CPO production process, i.e., Oil Palm Empty Fruit Bunches (OP EFB) and Palm Oil Mill Effluents (POME). Currently, OP EFB is mainly used as organic fertilizer with very low value as in...
certain plantation this biomass is just dumped because the cost of dispersing it can be higher than the value it creates [1]. On the other hand, in some CPO mills POME is converted into methane gas and use it for local use. However, not many CPO mills or oil palm plantation have utilized POME but remains as waste that needs to be processed before discharging to the field.

Both OP EFB and POME has the potential to be converted into biofuel. OP EFB can be converted into bio-ethanol while POME can be converted into biodiesel. Integrated Bio-refinery Technology Development Project collaboration between LIPI and KOBE University has developed lab-scale technology that can convert OP EFB and/or POME into biofuel. Bioenergy Corporation, Ltd., a bio engineering company and Kobe University on Japanese side and PT. Agricinal and LIPI on Indonesian side has also entered into a joint cooperation on development of Biofuel from biomass. It is therefore important to find out how community can take benefit from conversion of OP biomass into bioethanol or biodiesel so as to making sure that such a biofuel production will contribute to help local community to solve their environmental and economic problems.

Based on the above background, problem this study seeks to answer is what are specific potential economic and environmental benefit of local community surrounding oil palm plantation and biofuel production.

1.2. Objectives:
To contribute to explain example of specific economic and environmental problems and needs of local community that can potentially be addressed or met by availability of biofuel production. This comprehension is needed by key stakeholders engaged in planning and establishment of a biofuel production so as to avoid the occurrence of significant gaps on local impacts of biofuel production. This explanation will be useful in designing an inclusive business model of biofuel production where local community play important roles in the biofuel supply chain.

1.3. Methodology
Research methodology used is descriptive research. Data and information collection methodology through survey using a questionnaire related to economic and environmental issues of local community and how availability of biofuel can help to solve these issues or to meet their needs. Respondents for this survey were selected purposively from 6 villages in Putri Hijau District, North Bengkulu Regency, Bengkulu Province with the total of 20 respondents. The respondents are resided surrounding oil palm plantation, within oil palm plantation, and near the CPO mill within the plantation.

This survey reveals environmental and economic issues faced by local community; and possible opportunities local community can get from availability of biofuel and biofuel production in the surrounding oil palm plantation and CPO mill.

2. Conceptual analysis of local community relation to oil palm plantation/biofuel production company
The oil palm industry in Indonesia has a very strategic position. Through a partnership model between oil palm industry and community (as will be elaborated more) plantation area increased from merely 300,000 ha in 1980 to 11.6 million Ha in 2016. Contrary to general perception that says oil palm plantation is dominated by large corporation, in fact according to GAPKI (Indonesia Oil Palm Association) in 2017, 53% oil palm plantation are owned by community; not by corporation [2]. Yet, further observation suggests that even so the community has a strong partnership with companies. Community has become an essential part of the supply chain of the oil palms industry. For example, most of the FFB of the community is supplied to CPO mill of private companies and oil palm State Owned Companies.

Besides community plays a very significant role in development of oil palm plantation in Indonesia, it is also a fact that a large number of population surrounding oil palm plantation and CPO mills are also dependent on oil palm plantation owned by private companies. The existence of these
private companies also has direct and indirect impact on social and economic condition of the community. As can be seen on figure 1, there are two types of direct impact of the oil palm plantation to the local community, namely: (a) physical development in the form of infrastructure and (b) social economy impact such as new employment and income.

![Figure 1. Oil palm plantation and its impact to local community](image)

Social economy refers to someone’s position in relation to other people in terms of relationship, performance, right and obligation in relation to resources [3]. Social economy may consist of a change in income, opportunity to work or run an economic activity, and a change in a work pattern. Social condition also can be seen from such factors as education, age, and gender [4]. Based on these definition, social economy situation of an individual can be different and can have stratified level such as economy condition as high, middle, and/or low. As such, in general people can make efforts to improve its social economy level.

Local community can get benefit from oil palm plantation not only by directly working at the plantation or in the Crude Palm Oil mills as employees; but also by supplying goods and services to the oil palm plantation, CPO mills, employees of the oil palm plantation and CPO mills, and amongst the local community themselves. In certain cases, it is the local community that provides a larger volume of fresh fruit bunches to the CPO mill owned by a company. In this case, we can see how local community can get economic benefits from the CPO mills around them including to secure the market for their EFBs. Along this supply chain, there is also other business opportunities that can be tapped by the local community like providing transportation services to transport the FFB from farmers plantation into the CPO mills. This transportation services can be provided by other wealthier farmers or other local community who does not have any oil palm plantation but focus on doing transportation businesses.

Indonesian government realizes that local community surrounding oil palm plantation and CPO mill has to be part of the industry development. One of the strategies taken to ensure that local community will also have significant benefit from oil palm plantation development in certain region is by encouraging business partnership between a company and local community through the so-called People Nucleus Plantation (locally known as Perkebunan Inti Rakyat or PIR). Through PIR a company will assist local community to manage their oil palm plantation in their own land by providing financial and technical assistance. For example, a company can provide loan, good quality oil palm seeds, oil palm plantation management training to the farmers. In return, the farmers will sell their harvest (Fresh Fruit Bunches—FFB) to the company with market price based on quoted international price.

This kind of business partnership between a private company and local community through PIR are widely practiced in Indonesia. This shows that oil palm private companies in Indonesia have a quite different culture where they have been accustomed to include local community in its supply chain through this PIR business approach. In other words, oil palm plantation in Indonesia has a unique characteristic where business is not scale up simply by the power of investment or capital. But, oil palm plantation companies in Indonesia grows hand in hand with the growth of local community businesses or economy. With this business model, oil palm industry has also adopted an inclusive
economic development model. In this inclusive model, local community is not treated simply as employees or users of products from the industry but they also play as co-producers of goods and/or services.

Figure 2. “Green Transportation” at an oil palm plantation in Bengkulu supported by plantation company

Figure 2 shows a green transportation that help employees of an oil palm plantation to reduce their burden. This is an example of how a company support its employees by providing a kind of soft loan scheme. The employee pays back the loan after selling the cows. This cow cart helps employees to transport the Oil Palm Fresh Fruit Bunches from plantation to the road where the truck will load it up and bring it into the CPO mill. The employees used to carry on their shoulder the FFB to bring it into the road. The cow is also as a source of additional income for employees.

This business model where small farmers of oil palm plantation become part of oil palm company supply chain through. This business model goes beyond just supplier and buyer type relationship. Through PIR, the position of small farmers become strong. For example, although a farmer has a small oil palm plantation, where he or she will have a very weak position against the buyer of the FFB. Through partnership with the company (nucleus) under PIR scheme, the price fluctuation created by certain group or buyers (like independent collector locally known as pengepul), for example, will not affect the farmers as the company or farmer’s partners (nucleus) will have to buy his FFB on the basis of quoted international price. This is to suggest that this type of inclusive business model developed by understanding the real problems of small oil palm farmers that can be potentially addressed by the presence of local industry, in this context, medium and large oil palm plantation company surrounding the small oil palm farmers or local community.

It is therefore important to understand what are specific environmental and economic problems and opportunities of local community in the surrounding oil palm plantation and CPO mills. Identification of possible positive environmental and economic impacts aspects of a biofuel production for the local community can become an important step to explore possible ways to include local community to participate in the biofuel supply chain. Although availability of downstream oil palm industry in certain region or location will have direct impact to local community; however in reality there is significant gaps on local impacts of biofuel production [5]. As such, previous literature review suggested the importance of getting feedback from local community on how they can participate and what problems they are facing and how biofuel can help to address those problems and/or needs.

Engagement of civil society in the generation, diffusion, and utilization of innovation system concept (quadruple helix theory--where the key actors of innovation system comprise government, academia, business/industry, and civil society) become more important. This will ensure that economic growth, for example, will have positive impacts to community in general. One of the ways to achieve this objective is to involve civil society, of local community in particular, in the supply
chain of the production and distribution system. This concept integrates innovation into its social context [6]. It recognizes the role of the all key actors in promoting innovation in a democratic way, during development strategy and decision making seek feedback from key stakeholders [6][7]. This is to ensure that innovation deliver benefits to local community.

Recent development, local community is being viewed as an important actor in the supply chain [8] including in the biofuel supply chain. This was triggered, among others, by the fact that there is significant gaps on local impacts of biofuel production [5]. Without a proper consideration of specific problems and needs of local community during planning stage of a biofuel production a company tends to focus on technical and economic factors while social impacts might not be adequately taken into account. This may lead to exclusion of marginal community in the biofuel supply chain in some cases it led to controversial socio-economy impacts [9][10][11]. It needs a concerted effort to create an inclusive business model in the biofuel industry where local entrepreneur, local community can become important actors in the supply chain, not leave them just as employees and spectators.

Global concerns on energy security and climate change have brought many countries to make a global commitment to look for new and renewable energy sources like biofuels [5][12][13][14] including Indonesia. In 2018, Indonesia, for example, set the use of 20% biodiesel (B20) in its attempts to achieve its energy mix target to reduce dependence on fossil fuel to cut-down greenhouse gas (GHG) effects. The commitment to use a more environmentally friendly energy sources including biofuel has become a global trend. Many European countries has sold diesel contain up to 5% biodiesel with fossil fuel diesel, even biodiesel blends higher than 5% has been commercialized. Even in Germany and Portugal, 100% biodiesel (B100) has been sold in the market [15] with minimum quality requirement for biodiesel. Likewise, USA set a challenging target to meet its biofuel mandate [16]. This is to suggest that demand on biofuel will keep increasing in the years to come and this will need an increase in biofuel production capacity.

Public engagement in biotechnology was viewed positively contribute in promoting biotechnology application[7][17], product, and services. It also opens opportunity for local community to participate in the supply chain. The issue, then, how the bottom of the pyramid group (impoverished, marginal, and/or low level of economy of the society) can take benefit from this global trend such as by participating in the supply chain or other scheme. The trend of increase use of biofuel will create a more open participation of the low income population and local community along the supply chain[1], 9][17]. In particular, participation of local entrepreneur in the local market [18] including in biofuel supply chain needs to be encouraged.

One of the challenges for a biofuel production company in order the local community to be able to take benefit and participate in the biofuel supply chain is to know their specific needs and expected potential roles. Take for example an integrated biomass supply chain as in figure 3 [8]. Identification of specific roles the community especially bottom of the pyramid group can play along the supply chain becomes essential.

**Figure 3. Integrated biomass supply chain and Local Community**

![Figure 3](image_url)

*Source: Hong, How, and Lam., 2016:2176 [8]*

In this context, inclusion of community in the low carbon development can create entrepreneurial activity in low income environments[19]. The community might participate in certain parts of the
supply chain such as in the biomass harvesting and management, integrated biorefinery, and/or product distribution.

Although many NGOs have taken a view of adversed impacts of oil palm development to local community in Indonesia [20], research of Rist, Feintrenie, and Leyang in Kalimantan and Sumatra suggest positive impacts to local community [21]. Oil palm has been a source of significant livelihood improvement for the communities. It provides the community a continues source of income both directly and indirectly. Laing also found that the impacts of oil palm plantation to community has been positive [22]. Laing found that since the existence of oil palm plantation, social and economy of the community increase, community has a continual source of livelihood and also monthly wages to meets their daily needs.

One of the business models practiced in oil palm plantation that contribute to increase participation of the community in the supply chain is the so-called Perkebunan Inti Rakyat (PIR) or People Nucleus Plantation. In this scheme, big company as a nucleus opens oil palm plantation and assist community plantation/local farmers around the plantation as “plasma” in a sustainable and win-win cooperation. This will foster a sustainable livelihood for the community [23] as they can become a productive actor in the supply chain. In other words, local community can play important role in the supply chain of oil palm plantation despite financial and skill limitation. It is then interesting to explore the possibility of local community participate in a biofuel supply chain.

3. Data analysis and Discussions

3.1. Data Analysis

3.1.1. Respondents profile

There are 20 respondents interviewed during the survey with profiles of the respondents as shown in figures 4, 5, and 6.

Figure 4 shows that 40% of the respondents is in the age group between 46 to 55 years old; 35% are in the age group between 36 to 45 years old; 20% at the age group of 26 to 35 years old; and 5% is in the age group below 25 years old. In general the majority of the respondents are in the productive age.

Occupation category of the respondents, as shown in Figure 5, comprise 25% peasant/farmers, 10% traders, 5% entrepreneur (micro/small business), 35% labour or employees, and 25% has occupation in other category.

Figure 6 shows education level of the respondents, namely, 35% has Senior High School, 23% diploma, 15% Junior high school, 20% Primary School, and 5 bachelor degree. This finding suggests that the majority of the respondents (75%) has education level as High school and below; while only 30% of the respondents has education above Senior High School up to bachelor degree. In other words, most of the respondents tend to be low level. This level of education can have influence on the type of job or economic activities they can chose as can be seen in the following part.

3.1.2. Economic Issues of local Community
In terms of types of economic activities of the local community surrounding oil palm plantation and CPO mills can be seen as in figures 7 and 8.

**Figure 7.** Economic activity of local community in the area of agriculture.

![Economic activity of local community in the area of agriculture](image1)

Source: Survey, 2018

Figure 7 shows that respondents with occupation in agriculture, the agriculture commodity chosen are paddy 70% and other 30%; while those respondents with plantation as its main economic activity has the following description: 59% has oil palm plantation; 18% has rubber plantation, 17% has coconut plantation, and 6% has other type of plantation. This finding shows that majority of respondents have oil palm plantation.

Respondents’ occupation on Business and Other Economic activity can be seen as in Figures 9 and 10.

**Figure 9.** Occupation of respondents in the business field

![Occupation of respondents in the business field](image2)

Source: Survey, 2018

**Figure 10.** Occupation of respondents in the other economic activity category.

![Occupation of respondents in the other economic activity category](image3)

Source: Survey, 2018

Most of the respondents have trading as their main economic activity while the rest 33% do other type of business (Figure 9). On Other Economic Activity, 40% has trucking services to transport Fresh Fruit Bunches (FFB) from community or farmers plantation to the CPO mill near their plantation; 40% raises cattle like cows, and 20% has a kind of health clinics.

3.1.3. **Energy needs and sources**

In general, there are three types of use of energy by the respondents, namely: Cooking, Transport/Vehicles, and lighting as described in figures 11 and 12.

**Figure 11.** Source of energy of local community for cooking.

![Source of energy of local community for cooking](image4)

Source: Survey, 2018

**Figure 12.** Source of energy of local community for lighting.

![Source of energy of local community for lighting](image5)

Source: Survey, 2018

Note: Respondents can have multiple answer
Figure 11 shows that all respondents use LPG (Liquified Petroleum gas) as their source of energy for cooking. Normally this 3 kg LPG is allocated for low income community with subsidized price; the second major source of energy for cooking is electricity from PLN (State Owned Enterprise utility company) also with subsidized price; and the other 7 respondents still use wood for cooking especially when they have family party that need to cook a lot of foods.

On the source of energy for lighting, 8 respondents use personal electric generator, 8 use electricity from PLN, 3 respondents got it from oil palm plantation company as part of company services to its employees, and 1 respondent use other source of energy. It is interesting to find that 8 respondents (40%) use personal electricity generators. These generators use diesel with non-subsidized price.

Table 1. Description of diesel need of housing compound at an oil palm plantation.

|                     |               |
|---------------------|---------------|
| Number of Housing   | 12            |
| Sites               |               |
| Diesel for electricity need monthly | 117.79         |
| Lt                  |               |
| Diesel Price (non subsidy) | 10,000         |
| Rp/Lt               |               |
| Monthly Expenditure for diesel | 177,788,235     |
| Rp/month            |               |
| Annual expenditure for diesel | 2,002,400,000  |
| Rp/year             |               |

Source: Survey, 2018

It is interesting to find that oil palm plantation where a CPO mill also located normally will provide electricity for their employees for free. The source of energy for this electricity is power generator with diesel as its fuel (non-subsidized price). This services is only available for around 8 hours a day during the night until 11 pm and then start again at around 4 a.m. till 7 a.m. This type of practice is common in many oil palm plantations where there is also CPO mill in the plantation. Table 1 shows typical use of diesel in one housing compound in an oil palm plantation (PT. Agricinal). So there is quite large of expenses for diesel to provide this lighting services to employees within the oil palm plantation.

Figure 13 shows that 100% respondents use motor bike as their main mode of transportation and source of energy for this motor bike is gasoline; 15% of the respondents owned truck with non-subsidized diesel as its source of energy; and 25% own cars with gasoline and diesel as its sources of energy or fuel. This shows that 35% of the respondents needs diesel/gasoline for their trucks, and cars and all of the respondents (100%) needs gasoline for their motor bike.

This gasoline can be changed with biofuel with a simple converter kit. In other words, the availability of biofuel with an affordable price or at least not more expensive with the market price can be beneficial for the local community.

The above description shows that there are many types of source of energy for different use by the local community. Most of the source of energy used by the local community are gasoline and diesel for transportation; electricity from state owned enterprise with subsidized price and from electricity generator from oil palm oil company as part of the company services to the local community.

3.1.4. Potential use of Biofuel for the local community

Although currently there are no biofuel production in the surrounding area within the oil palm plantation, the respondents can describe what kind of economic activity they can possibly do with the biofuel.

Figure 14. Potential of economic use of biofuel/bio-diesel for the local community.
Figure 14 describes that there are four type of economic activity local community can do if biofuel available in the surrounding oil palm plantation, i.e., 40% would use the biofuel for their vehicle/transport to replace the existing gasoline and diesel; 25% want to become seller of the biofuel; 15% to replace diesel for their power generator at home, and 20% want to do culinary businesses. This is to suggest that involvement of local community in the supply chain of biofuel production and distribution can provide economic benefit.

3.1.5. Environmental and the role of biofuel/biodiesel

This finding suggests that local community will take economic benefit from the availability of biofuel or production in the surrounding area. Improved economic condition means enhanced social economic level or status. And more importantly this will make local community happier as it not only provides additional sources of livelihood for local community, but also at the same time can reduce the CO₂ emission within the houses (generators) and electricity generators in the housing compound at the oil palm plantation.

Description and analysis of economic issues in part 2 above in some ways also reveal some environmental issues faced by the local community surrounding the oil palm plantation and CPO mill especially on the use of diesel and gasoline as main sources of energy for their daily life. This fossil fuel can be substituted with biofuel produced in the surrounding area. This section environmental aspects and its relation to ecosystem in the area.

Table 2 describes some environmental issues faced by local community surrounding oil palm plantation and CPO mill.

| Type of Environmental Issues                              | Description                                      |
|------------------------------------------------------------|--------------------------------------------------|
| Garbage management                                         | Not well managed (at a nearby village)           |
| Use of garbage                                            | Agriculture                                     |
| Illegal lodging                                            | Not an issue                                    |
| Air pollution                                              | Sometimes during dry season                      |
| Water pollution                                            | Availability of drinking water during dry season |
| Encroachment of nature reserve                             | Not an issue                                    |
| Illegal hunting                                            | Not an issue                                    |
| Damage of peatlands                                        | Not an issue                                    |
| Other environmental issues                                 | Wild pig; abrasion                               |

Source: Survey, 2018

Table 2 shows that in general local community face specific environmental problems especially on the land abrasion and wild pig attack for their agriculture. Likewise, local community also find availability of drinking water especially during dry season is an issue that needs to be addressed. A respondent also mention the possibility of overflow of POME into the river although such incident has not been occurred in the last decade as the company has implemented a good waste processing treatment; and garbage management start to become an issue for some respondents. However, biofuel production located in the surrounding cannot give direct contribution to address those problems.

3.2. Discussion
Significant gaps on local impacts of biofuel production, where local community was not adequately taken into account in the supply chain and as such it delivered insignificant benefits, has been identified in previous study. However, it did not explain specific impacts or benefit on the local community existed in the gaps. This study explains specific economic and environmental issues faced by local community and identifies specific economic and environmental needs or benefits from biofuel production that can be delivered to the local community surrounding oil palm plantation and CPO mill in Putri Hijau District, North Bengkulu Regency, Lampung Province, Indonesia.

Several types of economic activities local community can consider from availability of biofuel production in the surrounding include in the following fields: transportation, food production and processing, agriculture, creation of micro and small businesses along the supply chains, and trading. While on the environmental include the use of biofuel to replace diesel currently used for electricity generator in the households; trucking for CPO transportation, electricity generator for housing complexes in the plantation and at employees CPO mills housing compounds.

This explanation will be useful in designing an inclusive business model of biofuel production where local community play important roles in the biofuel supply chain.

Practical implication of this finding is that there is a need to encourage the adoption of a distributed model of biorefinery in the production of biofuel through establishment of small and medium scale production capacity in many CPO mill locations assuming it is commercially feasible. This business model will also be interesting to be considered to be adopted in certain areas where the transportation cost of fossil fuel to reach such areas, is very expensive. Local production to serve local user or market not only can significantly reduce the transportation cost; also improve its life cycle analysis performance where environmental impacts of biofuel production and distribution reduced significantly. On the other hand, a concentrated and large scale biofuel production will limit participation of local community in the supply chain and even can exclude them to take benefit from it. Hence, planning and establishment of biofuel production need to consider the possibility of a proper role of local community in the biofuel supply chain. As such, identification of specific problems and needs of local community need to be carried out so as to get feedback in designing a more inclusive business model of biofuel production.

4. Conclusion
This study has identified the existence of significant gaps on local impacts of biofuel production. However, it does not identify specifics issues, problems, or needs existed in the gap. This study explains explain specific environmental and economic impacts or benefit of the local community from a biofuel production in the surrounding areas.

Several types of economic activities local community can consider from availability of biofuel production in the surrounding include in the following fields: transportation, food production and processing, agriculture, creation of micro and small businesses along the supply chains, and trading. While on the environmental include the use of biofuel to replace diesel currently used for electricity generator in the households; trucking for CPO transportation, electricity generator for housing complexes in the plantation and at employees CPO mills housing compounds.

Practical implication of this finding is that there is a need to encourage the adoption of a distributed model of biorefinery in the production of biofuel through establishment of small and medium scale production capacity in many CPO mill locations assuming it is commercially feasible. With this business model, the roles of local community in the biofuel supply chain needs to be taken into account so as to ensure optimal benefits of the biofuel production to the local community.

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