Economic Value of Fresh Fruit Bunch from Oil Palm Plantation as Feedstock for Bioenergy in Indonesia

Bintang Charles Hamonangan Simangunsong※1†, Fidelia※2, Vera Junita Sitanggang※1, Elisa Ganda Togu Manurung※1, and Armansyah Halomoan Tambunan※2

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Oil palm plantation is a very potential source of feedstock for biodiesel production in Indonesia. Its productivity is high in terms of biomass, such as fresh fruit bunch (FFB), trunk and frond. FFB can be processed into crude palm oil (CPO) and further into biodiesel. Currently, most CPO productions are exported even though a domestic demand for biodiesel is increased. The problem might be due to a low added value of biodiesel production from CPO/FFB. The objectives of this study were to estimate the potential production of biomass from oil palm plantation and calculate the economic value of FFB as feedstock for biodiesel. Data were obtained from observation and survey at one of large state-owned oil palm plantation companies in Indonesia. The results showed that potential production of biomass were 42.10 tons/ha/year based on photosynthetic approach. Further, based on conversion return approach, economic value of FFB when processed into CPO was found about USD 121.82 per ton FFB and this value would decrease to USD 95.20 per ton FFB is processed into biodiesel. This indicates that the CPO production is economically more favorable than biodiesel production. If the price of CPO decreases by more than 15%, implying at least 13% decrease in biodiesel production cost, the expansion of FFB use as energy source would be expected as the economic value of FFB derived from biodiesel production would be higher than that obtained from CPO production.

Key Words
Biomass valuation, Renewable energy

1. Introduction

Indonesia has the largest oil palm plantation in the world. Estimate of palm oil tree plantations in Indonesia was about 10.46 million ha, which were located in Sumatera (65%), Kalimantan (31%), Sulawesi (3%), Papua (1%) and Java (<1%) islands. In the year 2013, Indonesia fresh fruit bunch (FFB) production ranged from 113-123 million tons, which produced around 27.78 million tons of CPO. This makes Indonesia one of the main CPO producers in the world1,2.

This oil palm plantation is a very potential source of feedstock for biodiesel production since its productivity is high in terms of biomass, such as fresh fruit bunch (FFB), trunk and frond. Fresh fruit bunch (FFB) can be processed into crude palm oil (CPO) and further into many downstream products including bioenergy such as biodiesel. Currently, most CPO productions are exported even though a domestic demand for biodiesel is increased. The problem might be due to a low added value of biodiesel production from CPO/FFB3,4.

In order to reduce the fossil oil consumption, the Indonesia government issued the Presidential Regulation No.74/2014 on the National Energy Policy to extend the use of modern bioenergy and set the modern bioenergy share target of 10% in the total primary energy supply by 2025, however only 1.3% of the total primary energy supply was in the form of liquid biofuels such as biodiesel5,6.

The objectives of this study are to estimate the potential production of biomass from oil palm plantation and calculate the economic value of FFB as feedstock for biodiesel. The results are intended to foster a better future utilization of biomass resource and to inform energy policy.
developments.

2. Methods

The economic value of FFB, the value of FFB prior to any value added by processing, was estimated using the conversion return approach. This method is similar to the stumpage valuation as a residual value or the farm-gate valuation. The economic value indicates a maximum willingness to pay for FFB as a raw material. It is also an estimate of an efficiency price, which would prevail in a competitive market, free of any market imperfections (e.g. monopolies) or policy distortions (e.g. taxes or barriers to trade). The economic value is considered a more accurate reflection of the contribution of a good or service to social welfare. Resources will be efficiently allocated by market if price reflects both the full marginal costs of production and the full marginal benefits of consumption.

The conversion return approach has been used in several studies to estimate use values of non-timber forest products provided by Indonesia’s tropical rain forest. This technique was also used in estimations of the economic value of the Indonesia’s production forest and Indonesia’s forest biomass as feedstock for bioenergy 6) ~ 10).

Most required data were obtained from observation and survey at one of large stated-owned oil palm plantation companies in Indonesia, which also has a CPO production plant. The potential production of biomass from oil palm plantation was estimated using photosynthetical approach 11).

Two values of FFB were investigated: the FFB value derived from CPO production and the FFB value derived from biodiesel production. The first FFB value was estimated by subtracting the CPO production cost (excluding FFB cost) and a normal profit (gained from CPO production) from the market price of CPO. The CPO production cost includes fixed costs such as depreciations, interest, insurance, and maintenance, and variable costs such as raw material cost (FFB cost), wages and benefits, supplies, and electricity. The normal profit that is gained from CPO production is assumed to be 25% of the production cost.

Comparing the economic value of FFB derived from CPO production with that economic value of FFB derived from biodiesel production would indicate FFB use 8) 9) 12) ~14).

Sensitivity analysis was also conducted to study the effects of changes in the price of CPO on the FFB economic values derived from CPO and biodiesel productions. This was done by varying the price of CPO and showing how the results change under different values of that price. This would help in decision making whether FFB is used to produce CPO for food and other uses or processed it further into biodiesel.

3. Results and Discussion

The stated-owned oil palm plantation company has invested about US$ 8.79 million (at 2014 price) for oil palm plantation with area of 3,520 ha. Based on photosynthetical approach, the potential production of biomass from oil palm plantation was estimated about 42.10 tons/ha/year, but on average only 12.88 tons/ha/year was actually produced, a substantially lower yield. This is mainly due to a steep slope of land and a lack of labor force around plantation area. In 2014, about 43,618 tons of FFB were produced with a production cost of USD 84.94 per ton FFB, while FFB price ranged from USD 134 to 141 per ton. Variable cost (69%) was the largest component FFB production cost as shown in Table 1.

Another US$ 8.45 million (at 2014 price) have been invested in CPO mill to process further FFB into CPO. Of this, 56% was for machines/equipment, 36% for buildings and 8% for other infrastructures. About 93,574 tons FFB were processed to produce 22,543 ton CPO in the year 2014, implying a productivity of 24%. The company has bought FFB from its parent plantation company to meet its CPO mill intakes. The production cost of CPO was about USD 417.59 per ton CPO and shown in detail in Table 2. Similar to that FFB production, the largest component was the raw material cost (77.5%) followed by interest, depreciation and maintenance, which all together accounted for 93.9% of the production cost.

CPO could also further processed into biodiesel, but in this study that further process was assumed to be

| Cost component       | Amount    | %   |
|----------------------|-----------|-----|
| Variable costs       | 58.77     | 69% |
| Maintenance          | 29.80     | 35% |
| Harvesting           | 11.20     | 13% |
| Transportation       | 14.30     | 17% |
| Wages and benefits   | 3.47      | 4%  |
| Fixed costs          | 26.18     | 31% |
| Crop depreciation    | 7.88      | 9%  |
| Non-crop depreciation| 4.14      | 5%  |
| Interest             | 14.16     | 17% |
| Total cost           | 84.94     | 100%|
conducted by other company. The biodiesel production cost, net of by product glycerol, was estimated about USD 798.95 per ton CPO and shown in detail in Table 3. 88.4% of that production cost is raw material cost (CPO cost). Total production cost of biodiesel, excluding raw material costs (CPO cost); was only USD 92.98 per ton CPO 15).

Meanwhile, the market prices of CPO and biodiesel in the year 2014 were about USD 705.97 per ton, and USD 900.89 per ton, respectively. Based on prices, costs and normal profits explained before and coupled with a productivity of 24% (the ratio of the produced CPO to the input FBB), the economic value of FFB value derived from CPO production was USD 121.82 per ton FFB as shown in Table 4. The economic value of FFB value would decrease to USD 95.21 per ton FFB if CPO was further processed into biodiesel, a 22% value decrease (Table 5). This indicates that the CPO production is economically more favorable than biodiesel production 15, 16).

In contrast, the results of the sensitivity analysis as shown in Table 6 indicate if the price of CPO decreases by more than 15%, implying at least 13% decrease in biodiesel production cost; the economic value of FFB derived from biodiesel production would be higher than that obtained from CPO production by USD 5.2 per ton FFB. This means the FFB use for biodiesel production is economically more favorable than for CPO production. Moreover, CPO price decrease by more than 15% make biodiesel price higher than CPO price by more than USD 300 per ton CPO, a fundamental price difference.

Coupled with CPO price changes, impacts of biodiesel price changes on the difference between the FFB economic values derived from biodiesel and CPO productions were shown in Table 7. At the current CPO price (USD 705.97

| Table 2  | CPO production cost |
|----------|---------------------|
| Cost component | Amount (USD/ton CPO) | % |
| Variable costs   | 344.05              | 82.4% |
| Raw material     | 323.59              | 77.5% |
| Supplies         | 3.26                | 0.8% |
| Electricity/power| 7.93                | 1.9% |
| Wages and benefits| 9.26               | 2.2% |
| Fixed costs      | 73.54               | 17.6% |
| Depreciation     | 24.05               | 5.8% |
| Maintenance      | 15.61               | 3.7% |
| Insurance        | 1.88                | 0.4% |
| Interest         | 28.96               | 6.9% |
| Tax              | 3.04                | 0.7% |
| Total cost       | 417.59              | 100.0% |

| Table 3  | Biodiesel production cost |
|----------|---------------------------|
| Cost component | Amount (USD/ton CPO) | % |
| Variable costs | 780.38                | 97.7% |
| Raw material | 705.97                 | 88.4% |
| Supplies | 55.58                  | 7.0% |
| Electricity/steam | 18.30              | 2.3% |
| Wages and benefits | 0.53                | 0.1% |
| Fixed costs | 23.49                 | 2.9% |
| Depreciation | 3.35                | 0.4% |
| Maintenance | 0.01                 | 0.0% |
| Insurance | 0.33                  | 0.0% |
| Administration | 0.11               | 0.0% |
| Marketing | 15.17                 | 1.9% |
| Tax | 4.52                 | 0.6% |
| By product (glycerol) | 4.92            | 0.6% |
| Total cost | 798.95                | 100.0% |

| Table 4  | FFB value derived from CPO |
|----------|-----------------------------|
| Item | Unit | Amount (USD/ton CPO) |
| Price of CPO | USD/ton CPO | 705.97 |
| Production cost of CPO (Excl. FFB cost) | USD/ton CPO | 94.00 |
| Normal profit (25%) CPO | USD/ton CPO | 104.40 |
| Productivity (ton CPO/ton FFB) | % | 24% |
| Economic value of FFB | USD/ton FFB | 121.82 |

| Table 5  | FFB value derived from Biodiesel |
|----------|---------------------------------|
| Item | Unit | Amount (USD/ton CPO) |
| Price of biodiesel | USD/ton CPO | 900.89 |
| Production cost of Biodiesel (Excl CPO cost) | USD/ton CPO | 92.98 |
| Normal profit biodiesel (25%) | USD/ton CPO | 199.74 |
| Production cost of CPO (Excl. FFB cost) | USD/ton CPO | 94.00 |
| Normal profit CPO (25%) | USD/ton CPO | 104.40 |
| Transportation cost of CPO | USD/ton CPO | 13.08 |
| Productivity (ton CPO/ton FFB) | % | 24% |
| Economic value of FFB | USD/ton FFB | 95.21 |
per ton CPO, the FFB use for biodiesel production would economically be more favorable than for CPO production when biodiesel price increases by at least 15% as indicated by the FFB economic value difference of USD 5.8 per ton FFB (Table 7). Further, bold numbers of the FFB economic value differences in Table 7 indicate combination of biodiesel and CPO price changes that make the FFB use for biodiesel production is economically more favorable than for CPO production.

In order to promote a development of oil palm downstream industries such as biodiesel industry in Indonesia, the Indonesia government issued the Minister of Finance Regulation No.133/PMK.05/2015 on tariff subsidy through the Oil Palm Plantation Funding Board (Badan Pengelolaan Dana Perkebunan Sawit or BPKDS). However, almost 80% of BPKDS funds were used only by three big biodiesel companies. BPKDPS also provides fund for oil palm replanting, but this supports is hardly accessed by small-holder plantations since they could not show their certificate of land ownership as required.

When the economic value of FFB as feedstock for biodiesel is higher than that FFB economic value derived from CPO production, the expansion of FFB use as bioenergy would be expected. And, this would contribute not only to the security of the energy supply but also to the national import bills savings. The government endeavour to reduce CO2 equivalent emission would also be supported.

4. Conclusion

The economic value of FFB was USD 121.82 per ton FFB. This economic value would decrease by 22% if FFB is further processed into biodiesel. The expansion of FFB use as bioenergy would be expected when the price of CPO decreases by more than 15% since the economic value of FFB derived from biodiesel production would be higher than that obtained from CPO production.

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| Table 6 | Impacts of CPO price on FFB value |
|-----------------|----------------|-----------------|
| CPO price (%)  | Economic value of FFB derived from | Difference    |
| Biodiesel       | CPO              |                 |
| 20%             | 103.7            | 879             | 15.7           |
| -15%            | 101.6            | 964             | 5.2            |
| -10%            | 99.4             | 104.9           | -5.4           |
| -5%             | 97.3             | 113.3           | -16.0          |
| 0%              | 95.2             | 121.8           | -26.6          |
| 5%              | 93.1             | 130.3           | -37.2          |
| 10%             | 91.0             | 138.8           | -47.8          |
| 15%             | 88.9             | 147.2           | -58.4          |
| 20%             | 86.7             | 155.7           | -69.0          |

| Table 7 | Impacts of Biodiesel and CPO price changes on FFB economic value differences |
|-----------------|----------------|----------------|-----------------|
| CPO price (%)  | -15%          | -10%          | -5%            | 0%             | 5%             | 10%            | 15%            |
| Biodiesel price changes (%) | -273          | -271          | -26.8          | -26.6          | -26.0          | -25.9          |
| FFB             | -16.5         | -16.2         | -16.0          | -15.8          | -15.6          | -15.4          |
| 0%              | -5.7          | -5.4          | -5.2           | -5.4           | -5.0           | -4.8           |
| 5%              | -4.8          | -4.8          | -4.8           | -4.8           | -4.8           | -4.8           |
| 10%             | -3.7          | -3.7          | -3.7           | -3.7           | -3.7           | -3.7           |
| 15%             | -2.7          | -2.7          | -2.7           | -2.7           | -2.7           | -2.7           |
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