Productivity improvement with green approach to palm oil factory productivity

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Abstract. The palm oil factory (POF) processes fresh fruit bunches into crude palm oil (CPO) and palm kernel oil (PKO) by products in the form of liquid and solid waste. One of the solid wastes produced in POF Tanjung Kasau is empty fruit bunches of palm oil (FBPO) which have been burned completely on incinerator tubes so that potentially produces pollutants that pollute the environment. If FBPO waste is managed properly, it will improve the productivity of the company. Therefore, it is necessary to conduct a study to find out how far the increased productivity of the company can reduce their impact on the environment, if FBPO is used as raw material of liquid smoke. The productivity improvement approach is done by Green Productivity concept, by looking at three aspects: environmental, social and economical. Green Productivity aims to protect the environment simultaneously by increasing the productivity of the company. One way is to turn FBPO waste into liquid smoke product is by pyrolysis process. The results showed that turning FBPO solid waste into liquid smoke will increase productivity by 18.18%. Implementation of Green Productivity can improve productivity through the improvement of FBPO waste treatment process which has been done by perfect combustion by pyrolysis process so that waste can be minimized to create environment industry POF clean and friendly environment.

1. Introduction
The palm oil industry plays an important role in the development of the national economy in general and in particular the Province of North Sumatra. Despite the obvious economic benefits from the development of palm oil-based industries, on the other hand, the industry also contributes significantly to environmental degradation, both on inputs and on the outputs of industrial activities. Palm Oil Factory (POF) processes raw materials in the form of fresh fruit bunches (FFB) and produces crude palm oil (CPO) and palm kernel oil (PKO). In addition to the main product (main product), also generated waste in the form of liquid and solid waste in the form of shells, fibers and empty bunches of palm oil (FBPO) [1]. POF Tanjung Kasau located in North Sumatra Batubara District, is one of the POF sites that still processes waste FBPO by burning perfectly through the innecrator. The remaining burning of FBPO ash is dumped into oil palm plantation area as land application. In the combustion process smoke is thrown into free air. The process of handling the FBPO has the potential to pollute the environment. On the other hand FBPO still have economic value when processed further, one alternative is to make it as liquid smoke. Liquid Smoke Rendemen from FBPO pyrolysis process reached 29.45 with selling price in the market around Rp. 30,000, - per liter [7].

Managing FBPO well in addition to contributing to revenue generation can also minimize environmental impacts to create a clean MCC industry. To see how far the improvement of
productivity and environmental improvement by processing FBPO into liquid smoke, it is necessary to conduct a study using Green Productivity (GP) approach. GP is a strategy to increase productivity and environmental performance for overall socio-economic development. It is an appropriate productivity application and environmental management of policies, tools, techniques and technologies in order to reduce the environmental impact of organizational activities that produce goods or services.

To measure GP, Hur, et al. (2004) [6] developed an economic and environmental performance measurement tool in a single index called the Green Productivity Index (GPI), as the system's productivity ratio for its environmental impact. With this index, companies can estimate economic and environmental performance at once. Adopting this index, Gandhi, et al. (2006) [5], used a weighted environmental impact. However, research related to GP measurement or GP keywords is still quite rare, the same thing as eco-efficiency and environmental productivity are more popular for use in some studies [4]. GP index is actually developed from the concept of eco-efficiency. Initially, eco-efficiency is the ratio of product or service value added to its environmental influences [3,11].

As an indicator of economic performance, the added value of a product or service is modified into productivity as a broader sense of the efficient use of resources with improved quality. To see the extent to which improvement of company productivity and environmental improvement, the study of GPI processing FBPO POF Tanjung Kasau factory as a pilot project, so it can be used as a recommendation for the management of POF industry.

2. Method
The research was conducted at Palm Oil Factory (POF) Tanjung Kasau Sub-Province of Batubara Sumatera Utara. The method used by Green Productivity by measuring and comparing Green Productivity Ratio (GPR) and Green Productivity Index (GPI) before and after processing FBPO into liquid smoke.

Three important steps in conducting analysis using Green Productivity concept include:

1. Getting Started
   The beginnings of the Green Productivity process are walk through surveys and information gathering. Walk through surveys are conducted to identify the sequence of production processes. At this stage must have determined the block diagram of the process and material balance so that known operations that produce waste including estimates or estimates of the amount of waste generated. Early productivity calculations are performed as a basis for consideration in estimating the solution to be obtained to determine whether productivity is improving or otherwise.

2. Planning
   In this planning stage, it is divided into two steps, namely:
   A. Identify the problem and its causes
      Information obtained from walk through surveys will be used to identify problems and causes.
   B. Define goals and targets
      After knowing the problems and causes, it is necessary to set goals and targets as a pointer to select solutions that can eliminate the problem.

3. Generation and Evaluation of GP Options
   This step includes developing solutions to meet the objectives and targets that have been formulated in the previous step. This includes a viewpoint on pollution prevention and planned control procedures. Options are generated and prioritized based on the Green Productivity Indicator. All of that is then synthesized into the implementation plan.
Green Productivity indicator is a strategy, where an indicator is needed that can measure the performance of the strategy quantitatively. Measurements can be made using Green Productivity Index (GPI) and Green Productivity Ratio (GPR) as indicators [6].

\[
GP_{\text{index}} = \frac{\text{productivity}}{\text{the impact is determined}} 
\]

(1)

The calculation of Green Productivity Ratio for labor, energy, material, and maintenance is done using the following formula.

\[
GPP_{\text{waste}} = \frac{\text{kg Waste}}{\text{kg input material}} 
\]

(2)

4. Results and Discussions

4.1. Existing Condition (Getting Started)

Existing condition is used to make comparisons of productivity calculations before and after processing of FBPO into liquid smoke as a solution to solve FBPO waste problem with green productivity approach. The average input and output of the company during Year 2015 with the processing of FBPO burned perfectly can be seen in Table 1.

| Table 1. Average Input and Output of POF Tanjung Kasau in 2015 |
|---------------------------------------------------------------|
| **Output** | **Value (Rp)** | **Volume (ton)** |
| Oil and Core Sales Sawit | 28,961,217,685 |
| **Input** | | |
| Material | 363,794,103 | 11,293.19 |
| Labor | 579,352,468 |
| Energy | 107,080,985 |
| Maintenance | 215,146,432 |
| Waste | 2.37 |

Based on Table 1 data, GPR calculations for each of the input and effluent are presented in Table 2.

| Table 2. GPR POF Tanjung Kasau, 2015 |
|-------------------------------------|
| **Masukan (input)** | **Green Productivity Ratio** |
| Material | 79.61 |
| Labor | 49.99 |
| Energy | 270.46 |
| Maintenance | 134.61 |
| Waste | 0.21 |

4.2. Liquid Smoke Processing (Planning)

Based on the pilot project by developing equipment that is able to process FBPO with the calculation of 40 kg of FBPO per day, the following results are obtained:

Liquid smoke produced during one year (350 days) is \(= 350 \text{ days} \times 11.82 \text{ l/day} \times \text{Rp. 30,000, -/l} = \text{Rp. 124,110,000, -} \). In addition, a by-product of FBPO ash can still be sold for around Rp. 500, - per kilogram. For every 20 kg of FBPO produced 3.36 kg or a day is generated 6.72 kg.
4.3. Generation and Evaluation of GP Options

Using the pilot project basis and potential FBPO waste if all FBPO is treated as liquid smoke, the productivity estimate of POF Tanjung Kasau for one year of production is 27.04. The calculation of productivity by processing all FBPO into liquid smoke is presented in Table 3. While the calculation of GPR and GPI for the use of all FBPO can be seen in Table 4.

| Table 3. Productivity of FBPO Processing into Liquid Smoke |
|---------------------------------------------------------|
| **Factor**                                            | **Existing Conditions** | **Application of Liquid Smoke** |
| Sales                                                  | 28,961,217,685          | 63,413,217,685                |
| Input Materials                                        | 363,794,103             | 363,794,103                  |
| Input Labor                                            | 579,352,468             | 1,239,352,468                |
| Input Energy                                           | 107,080,985             | 227,080,985                  |
| Input Maintanance                                      | 215,146,432             | 515,146,432                  |
| Total Productivity                                     | 22.88                    | 27.04                        |

| Table 4. Existing GPR Calculations and GPI            |
|-------------------------------------------------------|
| **Green Productivity Indicators**                     | **Green Productivity Ratio Existing** | **Green Productivity Ratio with liquid smoke** | **Green Productivity Index** |
| Materials                                             | 79.61                         | 170.25                           | 2.13                          |
| Labor                                                 | 49.99                         | 50.24                            | 1.00                          |
| Energy                                                | 270.46                        | 274.19                           | 1.01                          |
| Maintanence                                           | 134.61                        | 136.81                           | 1.02                          |
| Waste                                                 | 0.21                          | 0                                | 0                             |

The palm oil industry as one of the mainstay and strategic commodities in creating food and energy security is often positioned as an environmentally unfriendly industry. This is because the resulting waste has not been properly managed. Processing of FBPO which is one of solid waste into liquid smoke contribute to the improvement of company performance and also performance to environment. POF Tanjung Kasau if processing FBPO waste overall will increase the productivity of 18.18% ie from 22.88 to 27.04 and GPI to zero which means the impact of FBPO waste on the environment can be minimized. Liquid smoke produced can be used as a substitute for chemical food preservatives that have been used by many people, such as formalin. So that by doing FBPO processing into liquid smoke, impact on the improvement of company performance, create palm oil industry clean and society can use preservative which is safe for health.

5. Conclusions

Based on the result of the research through the pilot project of liquid smoke making from FBPO waste, it can be concluded that:
1. Handling of FBPO solid waste into liquid smoke will increase the productivity of the company from the previous by 22.88% to 27.04% or an increase in productivity level of 18.18%.
2. Implementation of Green Productivity can improve productivity through process improvement. With the improvement of FBPO waste treatment process which has been done perfect combustion with pyrolysis process, the waste can be minimized so that it creates a clean and environmentally friendly industrial environment POF.
3. The resulting liquid smoke can be used as a food preservative that is safe for humans, thus reducing the use of chemical preservatives.
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