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Production cost approach and material flow cost accounting as a step towards increasing responsibility, efficiency, and sustainability (RES): the case of palm oil mill in Banten Indonesia

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Abstract. Based on Indonesia Program for Pollution Control, Evaluation and Rating (PROPER), palm oil industries are more likely to care about hazardous waste management rather than resource efficiency. It is very important to balance and achieve economic and ecological targets by identifying material and energy inefficiencies with significant economic impact. The application of standard and sustainable production also plays important role for oil palm companies which so far have more than 70% of biomass energy materials such as shells, powders, fibres, and dried empty bunches. This study used the production cost approach and material flow cost accounting to reduce material consumption and waste minimization. Identifying resource efficiencies were used to determine area for improvement. The results show that palm oil company more likely to manage total waste, hazardous waste, and raw materials consumed than material efficiencies. In terms of financial factors, cost ratio and profitability are likely to affect firm decisions regarding to manage the material flow for reducing hazardous waste ratio. This could support long-term business relationships which can be established and negotiated between the palm oil industry as organic waste supplier and the bioenergy producer, revealing economic and environmental benefits for both actors while contributing to the development of responsibility, effectiveness and sustainable (RES).

1. Introduction

Based on the achievements of Environmental Pollution Control Program (PROPER) publication, inefficiency materials caused the loss of margin of revenue [1]. It is which faced by the palm oil industry in its production process. Most of input material that should be processed into products as by product and waste. To achieve the SDGs of the palm oil sector through PROPER, the processing of raw materials as final products must be followed by mitigation from losses by utilizing waste into more valuable outcomes [2]. The lack of awareness of material flow analysis and the amount of natural resources which involved in production generated more waste and by-product production [1]. Palm oil solid waste has not been used optimally and some is used for fertilizer or dumped in landfills.



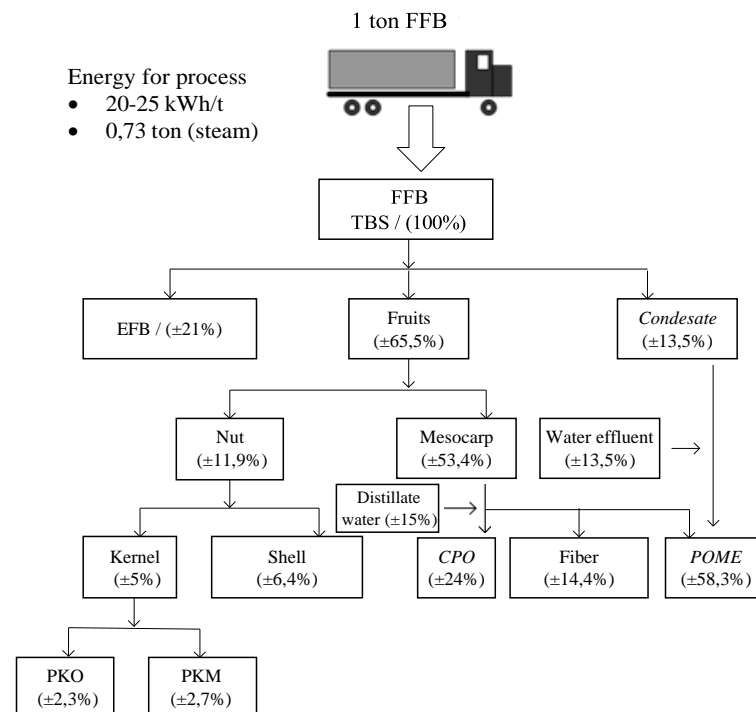


Figure 1. Proportion of Utilization and Material of Fresh Fruit Bunches (FFB) [5]

Fresh fruit bunches contain oil, fiber, shells, empty bunches, which can be converted into energy (materials bearing energy). Processing FFB to CPO can be done by utilizing the energy contained in it. In the preliminary stage, the use of by-products or materials that have not been used optimally is used as an energy source. If it is not sufficient, then the next stage can use some of the main content (oil / fat) for energy. Processing 1 (one) ton of fresh fruit bunches (FFB) of oil palm will produce waste in the form of 21-25% oil palm empty fruit bunches or 210-250 kg, 6.4% or 64 kg shells, washing water and condensate 27% or 270 kg after mixing with water and other materials, fiber 14.4% or 144 kg and liquid waste 58.3% or 583 kg (Figure 1) [5].

Table 1. Saving and Economical Value of Environmental Pollution Control Program (PROPER) Implementation

Parameter	Billion (IDR)	Value
Energy Efficiency	9.3	273.6 mil. GJ
GHG Emission Reduction	4.34	38.02 mil. ton CO ₂ eq
Water Efficiency	63.3	545 mil. m ³
Conventional Emission Reduction	5.34	18.7 mil. ton
3R hazardous Waste	10.1	16 mil. ton
3R Non-Hazardous Waste	3.91	6.8 mil. ton
Waste Water Load reduction	63.3	31.7 mil. ton

Disclaimer: Based on Data 437 Green Candidate Companies (Ministry of Environment and Forestry, 2019)

This is a challenge that must be resolved through the concept and implementation of cleaner production in the palm oil industry. The production cost approach and material flow cost accounting

(MFCA) determine how to increase effectiveness in controlling revenue leakage. This study describes the financing in the process of cultivation, processing, and handling in the palm oil industry as a basis for improvements in both physical and financial terms [3]. The material input flow during the production process is compared with the output and potential damage. Adoption of the MFCA is expected to be able to reduce waste in the production process and the basis for decision making [4].

Opportunities for economic improvement and cost reduction are expected to be in line with mitigation for environmental impacts through increased palm oil productivity. Based on production performance, the private sector industry produces the most palm oil by 26.5 million tons or 51%. Furthermore, private plantations contributed 14 million tons of CPO or 33%, while state plantations contributed only 6% or 2.5 million tons of CPO [5]. According to Directorate General of Plantation, Ministry of Agriculture Republic of Indonesia, one of the drivers of performance achievement is the accuracy of the production system and the performance of infrastructure. The efficient in material consumption required the support of mitigating activities that impede the smooth flow of material on production lines and financing.

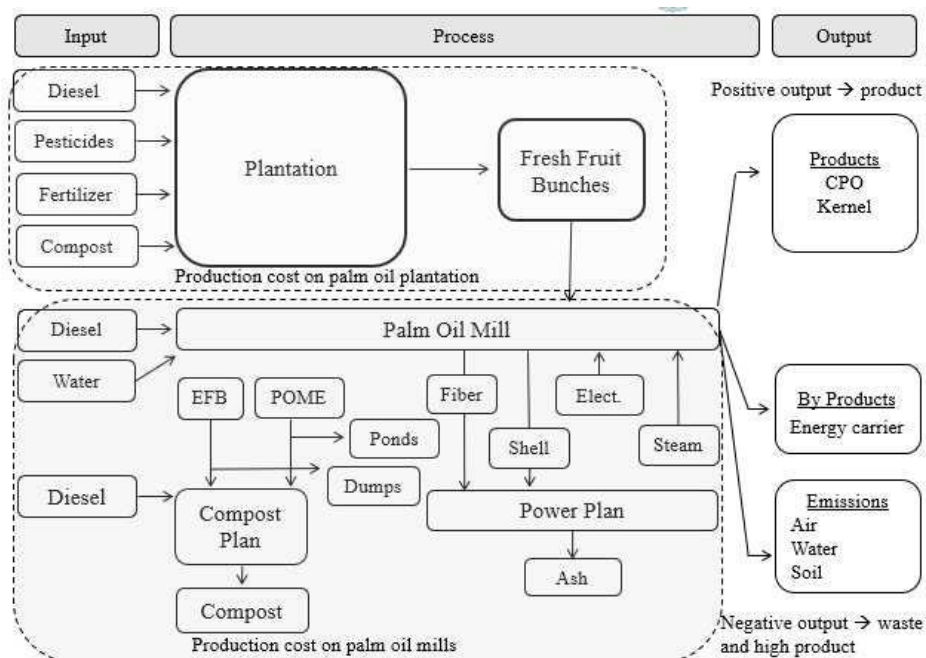


Figure 2. Palm Oil Plantation and Mills Scheme

Waste and inefficiency affect the palm oil mills performance due to their amount of by product and waste. Non-product output is usually considered an iceberg phenomenon as hidden cost in the form of waste. Mapping the areas of improvement and human resources ability building requires transparency on material and energy flow and impact to environment (Figure 2). As government company, palm oil industry seeks to increase revenue by harmonizing the company's economy through the tea, rubber, quinine, and fruits plantation sectors. They contribute each other to fulfil their lack of profit [6].

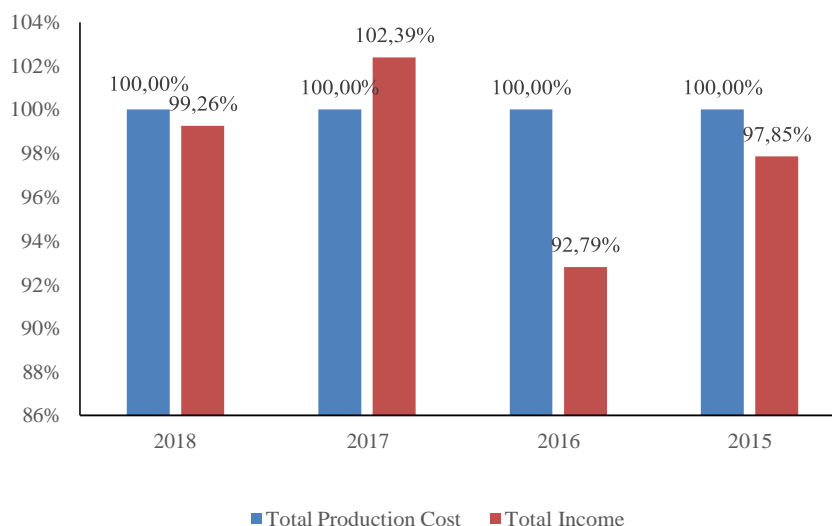


Figure 3. Total Production and Total Income Palm Oil Mill [6]

Figure 3 shows that total production costs for 2018, 2016 and 2015 are higher than total revenue and the 2017 performance ratio is only 2.39% [6]. This will cause palm oil mills get more losses. Waste generation is considered as a direct function of inefficient operations [8], so that the search description is expected to be able to improve the stakeholder knowledge, skills and awareness for better management. Transparency in production cost and material flow were enable business actors and policy makers to categorize inefficiencies in the production line as a basis for making decisions on the use of adaptive technology [9]. The integration could be performed to educate and provide social, economic and environmental sustainability.

2. Methods

This study was conducted in medium scale palm oil plantation and mills which capacity of 45 tons of fresh fruit bunches (FFB) per hour with an average of 30 tons per hour of FFB. Data collection were conducted through observation, depth interviews with factory managers, company database analysis, and focus group discussions. Identification of the main factors that affect production costs for CPO through a quantitative approach to production costs, material flow, and waste and waste materials financing is carried out to understand the process and identify components of factory hidden costs, operational data, and selection of indicators that are appropriate for this framework. The material cost flow accounting approach is carried out through the relationship of the source of waste, location, and stage of activity of each operating unit. The amount of material and energy use is mapped to determine the area of improvement (hotspot).

3. Results and Discussion

The average price of CPO last year was US \$ 595 per metric ton or 17% lower than the previous year of US \$ 714.3 per metric ton. The decline was caused by an increase in CPO stockpiles as a result of the trade war between the US and China and slower world economic growth. According to GAPKI, CPO exports contributed US \$ 20.35 billion in foreign exchange last year, slightly lower than in the previous year of US \$ 22.97 billion. Whereas for 2019, GAPKI projects Indonesia's CPO and PKO production to increase by 4-5% this year [10].

3.1. Cost Production Approach

The results of measurement and recording of production costs show costs at the plantation stage of 19.53%, harvesting and distribution costs 30.57%, crop maintenance costs 8.45%, fertilization

14.13%, and salaries and wages 0.86%. For the cost of processing fresh fruit bunches at the plant identified as processing costs 4.64%, maintenance of infrastructure 4.64%, wages and salaries 0.2%, insurance 0.06%, and depreciation 16.89%. To date, the land clearing and preparation stages have not been identified in this study. This is because there is still a change of function of rubber land into oil palm. To carry out its activities, palm oil mills require a large amount of energy. Energy requirements for operations are mostly used for boilers by utilizing fiber and shells as energy materials. With a design capacity of 45 tons FFB / hour, this palm oil mill processes an average of 30-35 tons / hour FFB. The use of fossil fuels is allocated to diesel engines in anticipation of generators and field vehicles. The company has not yet identified the financing for biomass energy and has determined the value of its utilization.

The amount of production costs and the determination of financing allocations have a process intensity that varies from one area to another [11]. The processing cost were gathered and analysed for decision making. Palm oil mill measure and record data sales for various distribution channels, yields, overhead costs, inputs, and labour.

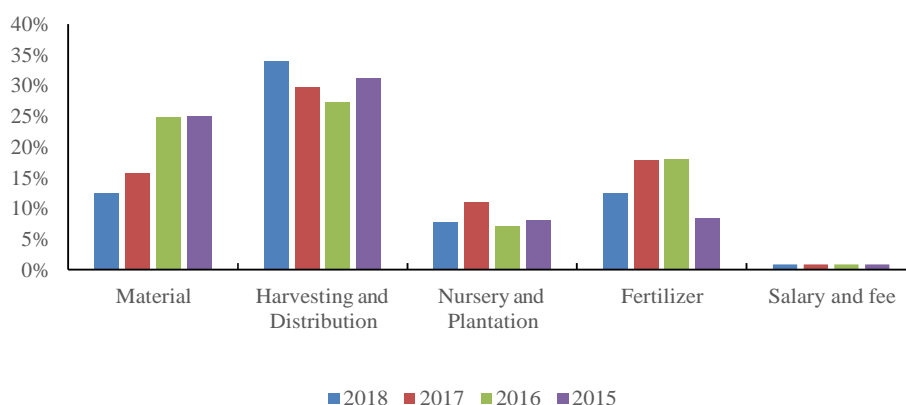


Figure 4. Cost component percentage allocation in Plantation 2015-2018 [6]

Figure 4 shows the achievement of the company during 2015 - 2018. FFB procurement costs and fertilizer costs have decreased but harvesting and distribution costs have increased. The high cost of harvesting and distribution is due to high logistics costs. Improving ability on tracing and tracking could allow for optimal resource utilization, transparency in production process as well as improved cost efficiency.

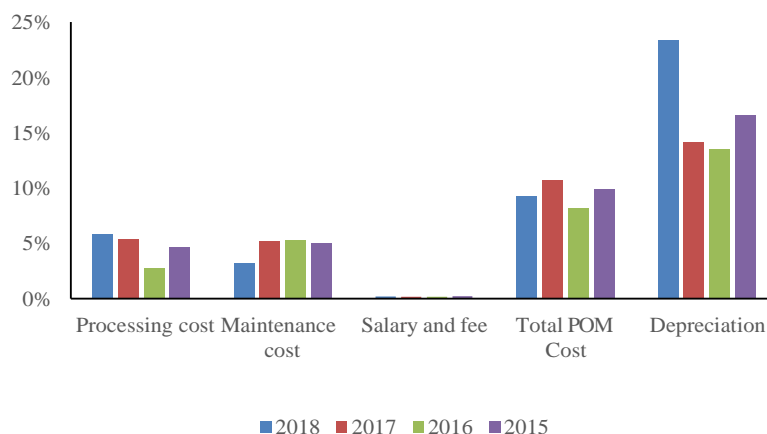


Figure 5. Cost component percentage allocation in Palm Oil Mill 2015-2018 [6]

Figure 5 shows the highest total production costs incurred in 2018 due to the high depreciation for production facilities and infrastructure. Low maintenance costs are the cause of many problems when they were operating.

Table 2. Details of Production Cost Component

Cost Component	Total (IDR)
Fixed cost	535,196,014
Variable cost	
Material	63,234,696,517
Utility	227,470,598
Packaging	
Total	63,462,167,115
Semi-variable Cost	
Labour	668,385,240
Management and Controlling	63,898,510.00
Maintenance	15,140,306,793
Operation supply	
Laboratory	148,337,650
General cost	177,687,114,934
Overhead cost	156,757,901
Total	193,864,801,028
Total Sales	503,097,279,225

Source: Observation and Annual Report [6]

Production costs components were measured by calculating the amount of material that generate cost production such as inputs, yields, and sales [7]. Maintaining macro records includes activities that relate directly or indirectly to production, labour, and other budget allocation as inputs [7]. The process of tracing and tracking of material used is associated with the most profitable and least profitable companies. Cost management were conducted to anticipate fluctuations in product prices and inputs may increase. Controlling production costs to efficiency requires accurate pricing information, including production costs, historical trends, experience, competitor capabilities, and marketing costs [12].

3.2. Material Cost Flow Accounting

Cost accounting that focuses on various activities carried out in an organization. This technique utilizes a multi-stage allocation process in palm oil plantation and palm oil mills which consists of several activity-based cost-centers. The production cost approach prevents distortion of costs resulting from conventional costing where all costs are not directly combined into a single cost pool [14]. Based on the result of detail production cost components, harvesting and distribution contribute the highest cost due to the characteristics of material. Quality control system play important role in reducing cost in harvesting, distribution, and increase revenue of industry [11]. Table 2 is a representation of the production cost approach. From the Table 1, the costs of each stage of production activity costs are identified; categorized and overhead costs charged to the respective cost center are also carried out for crude palm oil and palm kernel. Each activity cost is related to the product, which provides a view of the movement of costs in palm oil mills. This is an effective way to monitor efficiency on the production line [12].

The production cost approach with material cost flow accounting is focused on every activity that involves material, energy materials, and human resources. The mass balance and energy balance are used to identify center of activity that contain material, energy, waste, and overhead costs to be specified in product costs. Evaluate the effectiveness of the allocation of company resources identified to distribute, or support the product supporting activities [13]. Identification of monetary level in overhead costs will to show the areas of savings and prevention of accumulation of waste materials. The redesign and process improvement process were carried out using a logistics cost model to maximize company profits and minimize environmental impacts. The quality level of each product is seen as a driver of economic performance as a result of increasing environmental performance. The main obstacle is the lack of an integrated information system that impedes the collection of some accounting data for material, logistic, energy, system, and waste treatment in palm oil plantation and palm oil mill so that detailed information were insufficient.

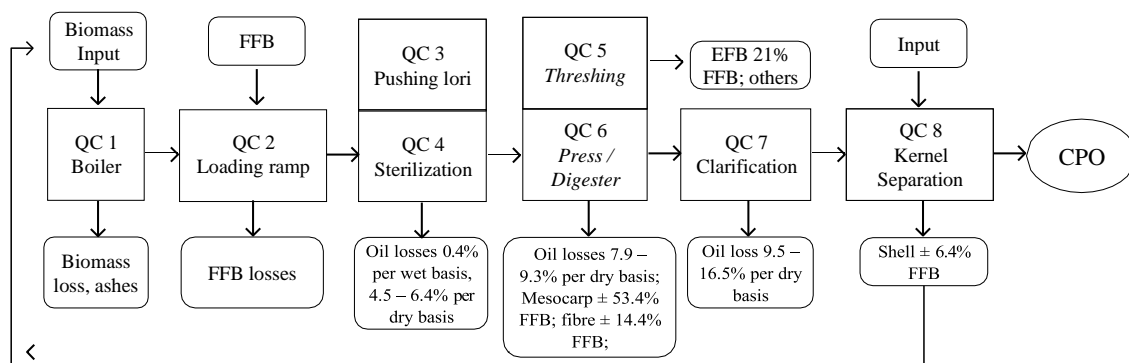


Figure 6. Material Flow Cost Accounting Approach [3], [7]

Material flow cost accounting were used to engage operators and management in environment performance based on monetary parameters. Figure 6 provides a visual representation of the input and material losses in the processing of fresh fruit bunches (FFB). The production line, product flow, and waste flow indicate areas of improvement that need to be carried out in the process of sterilization and clarification to reduce the amount of oil lost. This result identified improvement possibilities, an input-output model towards achieving more sustainable production, and lost saving approach for prioritization of evaluation. Environmental management through the flow of waste generation and availability in the threshing and pressing process requires an assessment of the financing and value of the waste produced to support eco-efficiency decisions. The amount of material involved (quantity center) and cost (cost center) connecting physical and financial information in one concept based on inputs (materials, energy, water and other inputs and outputs (products / by-products, waste, liquid waste, emissions) as a center of quantity with the calculation of the components involved MFCA relies on information on input of processed fresh fruit bunches, empty fruit bunches (EFB), fiber, shells and other amount of biomass for the cost approach needed during handling, MFCA sets out to demonstrate how operationalization is needed to change their behaviour and points at the advantage of utilizing cost as a driver for environment design. MFCA also used to integrate activities economic and environmental processes through improved processes to identify level utilization, energy and system costs incurred for products and potential output (Table 3).

Table 3. Detail and Waste Utilization

Waste and By Product	Quantity	Utilization	Level Utilization	Potential Output
Plantation				
Leaves	10 tonnes / ha	NA	Very high	Feed, green fertilizer
Trunk	80-90 tonnes/ha	NA	Very high	Charcoal briquettes, feeding boiler
Palm oil Mill				
Empty Fruit Bunch	20 - 23% from FFB	Mushroom media, Fertilizer, Biogas	Very high	Biogas digester
Fibre	12 - 13% from FFB 6 - 8% from	Boiler feeding	Very high	Charcoal briquettes Activated carbon,
Shell	FFB	Boiler feeding	Very high	Charcoal briquettespotting medium
Boiler Ash	0.4 - 0.6% from FFB	Fertilizer	Low	Fertilizer
Sterilizer concentrate	12 - 20% from FFB	Waste water treatment	Very high	Cellulose, single-cell protein
Centrifuge waste	40 - 50% from FFB	Waste water treatment	Very high	NA
Decanter effluent	30 - 40% from FFB	Waste water treatment	Very high	NA
Hydro cyclone % clay bath water	5 - 11% from FFB	Waste water treatment	Very High	NA
Factory washing	4 - 8 from FFB	Waste water treatment	High	NA
Waste Water Treatment				
Sludge cake	NA	Fertilizer and Feed	Medium to High	NA
Anaerobic solid	5 - 10 % from FFB	Fertilizer	Very High	NA
Aerobic solids	< 5% from FFB	Fertilizer	High	NA
Biogas	28 m3 / tonnes EFB	Biogas digester	Very Low	Electrical and heat

Table 3 indicates the level of utilization each part of palm oil. The needs of practical environment

management and design are the way to go to challenge existing production standard which could imply broader positive scale up effect in palm oil [3,6]. The company has not yet optimally developed waste into more valuable products and still limited to maintaining the domestic production and yield. Integration of input-output systems and educate the stakeholder for environmental impacts requires the availability of information on actual quantities and costs to be compared in positive outcomes in the form of products and negative outcomes in the form of waste that requires treatment. Transparency of

this information hold improvement of responsibility and efficient process towards to sustainable palm oil industry.

Waste generated from palm oil mills is partially returned to the cultivation and plantation areas as agricultural land fertilizer or sold to third parties for added value [14]. Utilization of solid waste, including solid waste originating from air emissions and POME deposits, actually has a high-value function by develop them more valuable. The limitation of non-production wastewater treatment technology, POME, and solid waste results in uncontrolled accumulation and imbalance in the final phase [15]. Incentives need to be given in the form of innovation and improvement to encourage consistency of results based on the material flow system. Effective communication and coordination among business actors are essential for improving productivity in the use of materials and energy for resource efficiency.

Table 4. MFCA Summary

Cost	Material (IDR)	Energy (IDR)	System (IDR)	Waste Treatment (IDR)	Total (IDR)
CPO as product	494,587,350				494,587,350
Losses	-	22,631,992,529	18,823,080,724	505,106,310	41,960,179,563
Total	494,587,350	22,631,992,529	18,823,080,724	505,106,310	42,454,766,913

The material flow cost accounting (MFCA) summary in Table 4 shows the lost cost of energy contribute the highest level based on monetary parameter [6]. Processing facilities for waste-water and solid waste into high-value products are expected be carried out to improve the sustainability of the Indonesian palm oil industry. Directed towards developing renewable energy and energy independence adopted material flow cost accounting as viable technique in identification and reduction of waste in production process play important role for effective decision making to be aware of the losses and reduce negative products. Improvement and evaluation of activities must refer to mechanisms to reduce residual waste and the use of material, enhanced quality and consistency output, linking physical and monetary information based on material flow analysis, and to curb revenue leakage on production line.

4. Conclusion

Production cost approach and material flow cost accounting provide better information on material, energy, system, and waste to enable decision makers to manage waste transparently, thereby reducing revenue leakage and increasing efficiency on production lines. Evaluation and continuous improvement are needed to adopt a tool to curb revenue leakage on the production line. The increase in production costs which reached 4.9% per year is not comparable to the increase in CPO prices which only amounted to 1.5% per year.

Acknowledgments

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