

# Evaluation of palm oil supply chain's performance, added value, and performance improvement : A case study at X Co.

Marimin<sup>1</sup> and Safriyana<sup>2</sup>

<sup>1,2</sup>Department of Agroindustrial Technology, Faculty of Agricultural Technology,  
Bogor Agricultural University, Bogor, Indonesia

Email: marimin@ipb.ac.id, marimin\_07@yahoo.com

**Abstract.** In palm oil supply chain, when the productivity and export market are being increased, usually the negative impacts to sustainability issues (economic, social, and environmental aspects) will arise. It also has direct impacts to supply chain itself, so it required to recognize the supply chain performance position. The objectives of this research were to evaluate performance, added value, and develop sustainability improvement strategies to increase performance of palm oil supply chain at X Co. Palm oil supply chain's performance measurement was obtained by SCOR (Supply Chain Operations Reference) approach. It showed the performance level of plantation was above average (91.24%) and manufacture was at average (86.19%). Added value ratio was measured by using modified Hayami method. It showed that the added value of plantation and manufacture were 21.86% and 37.55% respectively. ANP (Analytical Network Process) method with BOCR (benefit, opportunity, cost, and risk) analysis was used in selecting sustainability improvement strategies to increase performance of palm oil supply chain, the weighting results showed that production plan's improvement was the highest.

*Keywords:* Added value, ANP, palm oil, performance evaluation, SCOR

## 1. Introduction

Global palm oil production is dominated by Indonesia and Malaysia, totally produce 85-90% of world palm oil production. Currently, Indonesia is stated as the world's largest world palm oil producer and exporter with its rapid growth as seen in the amount of production and exports activities along with the area growth of palm oil plantations. With the strong global demand, the palm oil business in Indonesia is considered profitable because it generates substantial profit margins, while these commodity are easy to produce and production costs are relatively low, and resulting in high productivity levels. Driven by the growth of global demand and profits, palm oil plantations has increased significantly by both small farmers and large business parties (bring out the negative impacts on environment and decreased production of other agricultural commodities due to the transition to palm oil cultivations), it was known that there is a significant increase of palm oil productivities and exports in 2008-2016, with the amount of production increases from 19.2 million tons to 32.0 million tons in 2016. Moreover, as the domestic production rose, the amount of exports also increased by 15.1 million tons in 2008 and reached 27.0 million tons in 2016 [1].

Along with the increase in productivity and exports, sustainability issues arise as it covering economic, social, and environmental aspects. This is worth noticing because it is related to the potential impacts of the supply chain due to the economic and social changes of various supply chain actors. Therefore, it is necessary to analyze various risks that arise in palm oil supply chain activities



so that it is able to minimize any negative impact that may occur in the future. Supply chain measurements are performed through analysis of the company's business processes including supply chains performance analysis and its added value that play a role in creating conditions for improvement[2]. Based on the performance and added value analysis results, it needed to identify risk that causing unoptimum supply chain and determine the integrated palm oil supply chain improvement direction from upstream to downstream continuously, effectively, and efficiently [3]. In connection with the occurrence of risk factors in supply chain management both by internal and external factors, so that adversely affects the company's performance, the type of palm oil supply chain risks observed that often occur and are minimally notice is the operational risk factor [4], [5].

The research which includes evaluation of palm oil supply chain's performance and added value was conducted in palm oil agroindustry in West Java province by measuring the company performance which aims to ascertain the improvement direction that creates company's superiority and the using of modified Hayami method [6], [7] to ascertain the distribution of equitable profits along the supply chain. Furthermore, an intergrated formulation of palm oil supply chain sustainability performance improvement strategies using ANP was also conducted. In particular, the objectives of the research were identifying and analyzing palm oil supply chain mechanism, measuring and evaluating palm oil supply chain's performance and added value, and developing the potential sustainability improvement strategies to increase performance of palm oil supply chain at X Co.

## **2. Literature review**

### *2.1. Supply chain performance measurement*

Supply chain performance measurement is conducted to monitor and evaluate the performance of the company so that the direction of improvement in company competition can be determined. One of the performance appraisal reference models is the SCOR model developed by Supply Chain Council [8], based on business process (plan, source, make, deliver, and return) decomposed objectively in the dimensions of performance attributes and performance metric customized to corporate supply chain business processes level thus forming a common to detail structured hierarchy [9]. The implementation of SCOR in performance assessment is conducted by identifying each of hierarchy level based on business process measured by a collaborative approach using the pairwise comparison to differentiate the importance level among supply chain processes in the use of multi-criteria decision analysis as decision support in the process selection interests [10] developed by Saaty[11] through the decomposition of complex multi-criteria problems into a structured hierarchy.

### *2.2. Added value*

Added value defined as the additional value that occurs in commodity because of the process of further processing in a production process[12], [3]. Added value is the main motive for the establishment and development of business, the realization of the profit increase is the most powerful motivation that encourages a person or organization to participate in a supply chain[13]. Added value was conducted using Hayami method [14] to know the comparison of the each part added value and its relation to the acceptance of the added value difference of the whole supply chain. Through the Hayami method, the amount of added value, output value, and productivity can be measured, however Hayami method can not able to be used for long cycle production process and can not explain the by-products [6], so Hayami method was developed specifically to palm oil with the assumptions determination is related to added value calculations for years period and the value in the amount of money [6], [7].

### *2.3. ANP (Analytical Network Process)*

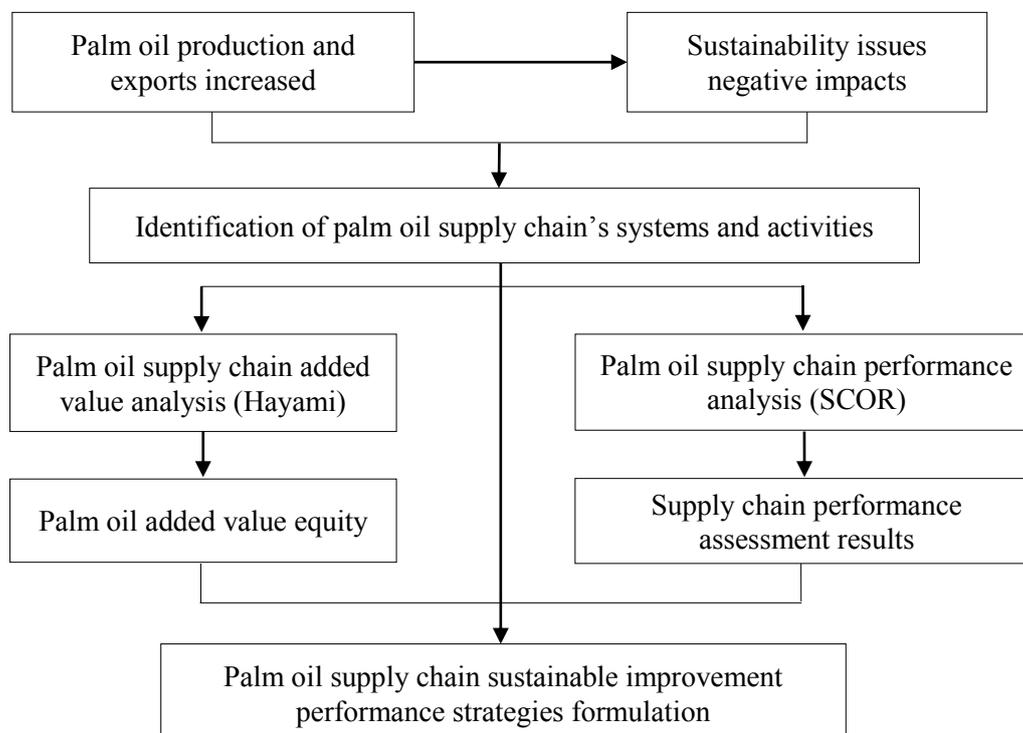
The ANP method is used for solving unstructured problem and requires dependency among the elements. The concept of ANP is a controls hierarchy or network among elements at a higher level with a lower level elements, hierarchical decision-making is determined by an alternative interest determined by the importance of the criteria to explain a cluster within the elements, the interaction form of interdependence on the same level in an analysis is indicated by the looping existence on the

cluster itself known as a level. The general use of ANP as a criterion is regulated by conducting benefit, opportunity, cost, and risk analysis [11]. The comparison of interest rates in each element/cluster is represented in a matrix by providing a pairwise comparison scale that shows the comparison interests between elements in a component with outer dependence elements or in elements of the element itself (inner dependence). The comparison matrix results is presented in the form of a stochastic matrix as a supermetric. The relationship between the elements is represented by a priority vector derived from paired comparisons as in AHP (Analytical Hierarchy Process), thus resulting priority weight results [15].

### 3. Methodology

#### 3.1. Framework

Analysis of supply chain management performance begins with the problem of increasing production and palm oil export in addition to improving Indonesia's economy, also causing negative impacts in the form of sustainable issues. It needs further study to comprehend the productivity and performance of palm oil manufacturing company; thus from the level of performance and added value, it can conclude the company performance, improvement direction, and performance improvement which can be measure according to company condition. Those things can be achieved by optimizing palm oil supply chain and to create an effective and efficient integration of upstream-downstream supply chain. The palm oil supply chain performance analysis is determined by the SCOR method with pairwise comparison weighting to obtain supply chain performance measurements. The added value analysis was conducted using Hayami method to determine the profitability level of the palm oil supply chain. The final stages is the formulation of sustainable performance improvement strategies in the palm oil supply chain. The research framework diagram strategically as in figure 1.



**Figure 1.** Research framework.

### 3.2. Data tabulation and analysis' procedure

3.2.1. *Supply chain performance analysis.* Performance measurement is based on SCOR-pairwise comparison weighted model which as a collaborative approach for work standard classification, hierarchical modelling based on five management processes, i.e. planning, material procurement, processing, delivery, and return. These five processes form the SCOR model top level, then decomposed into lower levels, including business process level, performance parameter level, performance attribute level, and performance metric level. Selection of performance metric is conducted by pairwise comparison approach through weighted hierarchy of performance metric as well as priority determination to generate priority weight.

3.2.2. *Supply chain added value analysis.* Added value can analyze the amount of income in each supply chain members [16]. In this research, added value data were obtained through stakeholder interviews and company management reports. The value added calculation procedure was analyzed following the mathematical model developed in Hayami et al. [14] modified for palm oil by Hidayat [6] as in table 1.

**Table 1.** Calculation of the added value of the modified Hayami method.

No	Variables	Values
<b>Supply Chain Interaction</b>		
1.	Material purchase (Rp/kg)	(1)
2.	Product selling price (Rp/kg)	(2)
3.	Total of added value per kg of output (Rp/kg)	(3) = (2) – (1)
<b>Outputs, Inputs, dan Costs</b>		
4.	a. Output sales volume (kg)	(4a)
	b. Output sales value (Rp)	(4b)
5.	Basic raw materials (Rp)	(5)
6.	Direct labor (DoW)	(6)
7.	Conversion factor	(7) = (4b) / (5)
8.	The coefficient of direct labor (Rp/DoW)	(8) = (5) / (6)
9.	Wage of direct labor (Rp)	(9)
<b>Incomes and Added Value</b>		
10.	a. Other input costs-production (Rp)	(10a)
	b. Other input costs-non-production (Rp)	(10b)
11.	a. Added value (Rp)	(11a) = (4b) - (5+10a+10b)
	b. Ratio of added value (%)	(11b) = (11a) / (4b)*100
12.	a. Profit (Rp)	(12a) = (11a) – (9)
	b. Profit Rate (%)	(12b) = (12a)/(4b)*100
<b>Remuneration of Production Holder</b>		
13.	Margin (Rp)	(13) = (4b) – (5+10a)
	a. Other input cost contributions (%)	(13a) = (10a+10b)/(13)*100
	b. Company's profit (%)	(13b) = (12a)/(13)*100

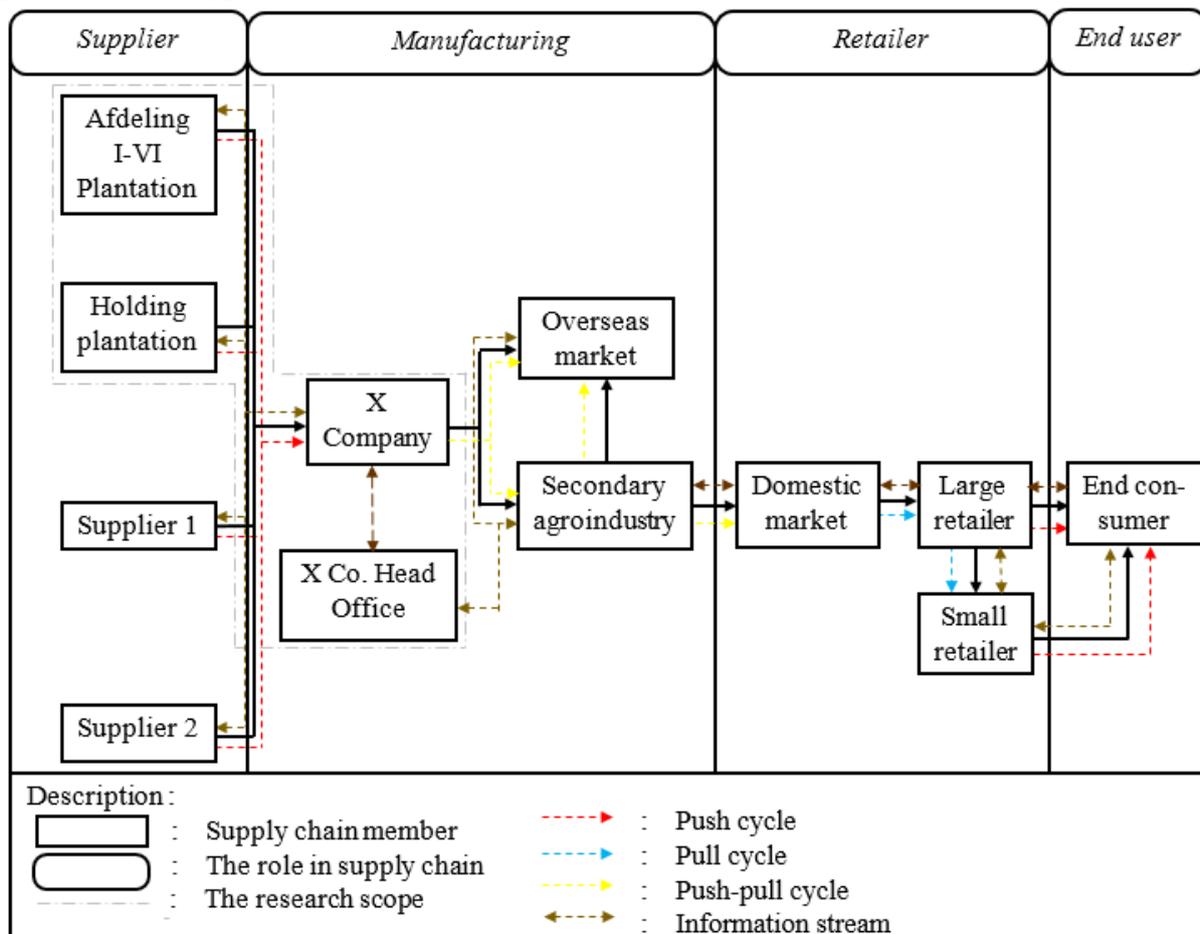
\*DoW = Days of Work

3.2.3. *Alternative selection of performance improvement strategy.* The alternative selection of sustainable palm oil supply chain performance improvement is conducted using ANP method, based on the main criteria of BOCR analysis and synthesized into technological, social, economic, and environmental aspects; from the alternatives formulation, the alternative strategies selected is the highest one to find out the importance of alternative. Data processing is obtained by pairwise comparison.

**4. Results and discussions**

*4.1. Palm oil supply chain network structure and business process*

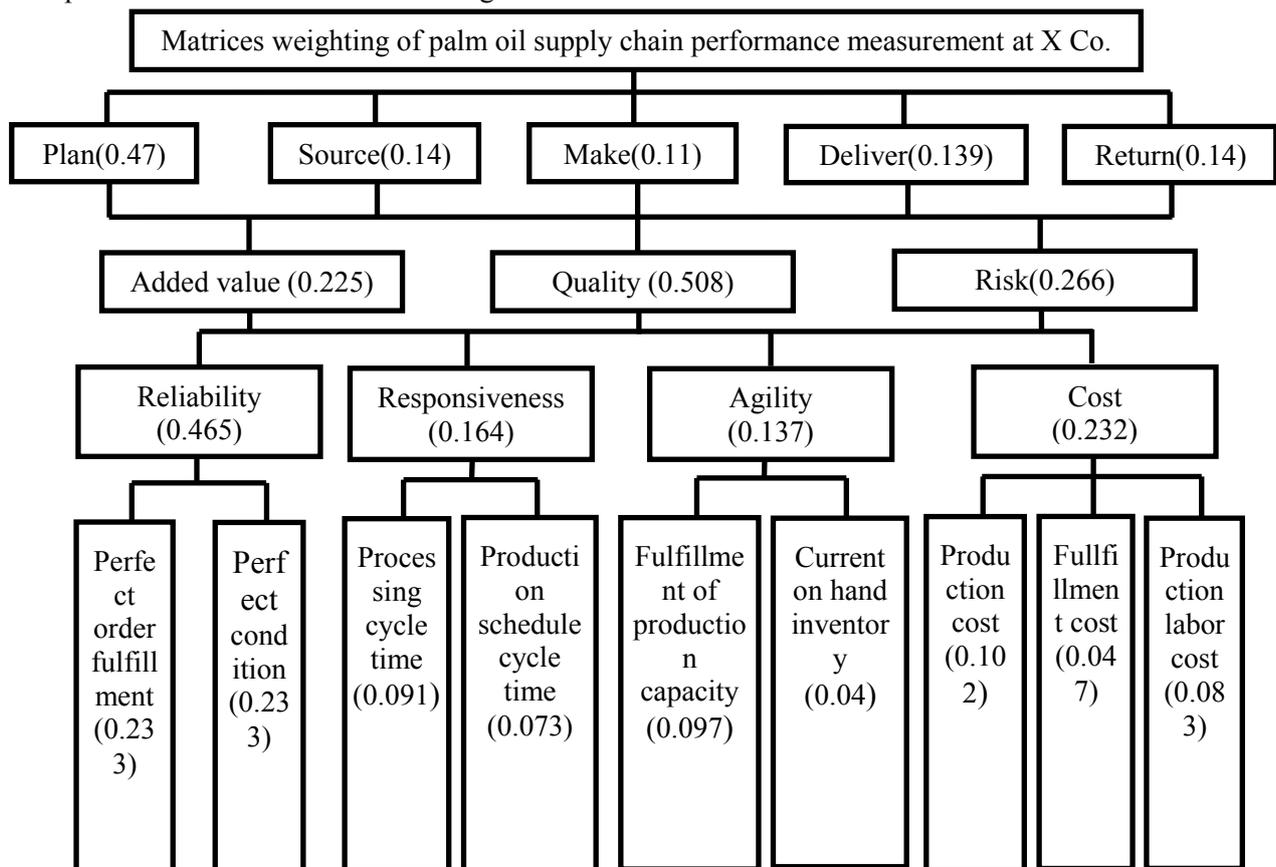
The supply chain is divided into several levels that contain units with the same function in general, the level in the supply chain is usually decomposed into supplier level, processing level, distribution level, and customer level. The general flow that occurs within these levels is divided into product flows and information flows [17]. Business processes in the supply chain, in addition to product flow and information flow, contain a flow that is reviewed through a push-pull strategy, based on operational activities in the supply chain for a sustainable flow, appropriate to the needs of the consumer. By using the push-pull strategy approach, it can delay the sudden changes of the products and processes, thus minimizing the change in business processes [17]. In general, the analysis results of the palm oil supply chain flow are shown in Figure 2. In the supply chain model structure in X Co., the integrated various parties are the stakeholders who contribute in the supply chain management unity, referred as the primary members of the supply chain. The modern supply chain is complex because there is a flow of goods and information that aims to ensure that the correct product, is delivered to the right place, with the right amount, price, time and cost [18]. Based on figure 2, it can be seen that the supply chain's primary members in X Co. consist of raw material providers (plantation business unit, holding plantation, and supplier), manufacturer, and consumer.



**Figure 2.** Palm oil supply chain flow pattern.

#### 4.2. Palm oil performance measurement

4.2.1. *Supply chain performance metric weight.* SCOR modelling aims to modelling and improving supply chain performance by combining engineering concepts and business processes [19]. Camargo et al. [9] stated that performance measurement using SCOR is preceded with modelling process to improve the relation of supply chain strategic reaction in supply chain performance with effective management system through five business process indicators i.e. plan (resource fulfillment process), source (procurement process goods/services), make (the process of adding value to commodities/goods), deliver (the demand fulfillment process), and return. Thereafter, measurements of supply chains performance metric are based on the actual performance of performance indicators compared to the company's target to improve the objective value of the company's performance, this process called the benchmarking step from the actual data of the performance metric multiplied by the percentage of company achievement. The weighting results show that the plan (weight 0.47) is the most important business process, as it's a major part of the overall process; in terms of physical, technological, capital, and human resources. For performance parameters, it's found that quality has the highest weight of 0.508, this becomes essential because it is related to the final product quality and the measure of consumer trust level. The weighting result of performance attribute shows that reliability has the highest weight with 0.465, indicating the consumer trust level to company. In the performance metric, it's known the priority of the weighted results for the perfect order fulfillment and the perfect condition with the each weight is 0.233.



**Figure 3.** Palm oil supply chain hierarchy and weighted result of performance measurement metric.

4.2.2. *Supply chain performance measurement results.* Supply chain performance measurement through pairwise comparisons results in the expert opinion weighted results is to obtain a performance metric value, then the weighting result must be multiplied with the company's

achievement in the percentage value. The results of the palm oil supply chain performance measurement conducted in the plantation and manufacturer levels are listed in table 2.

**Table 2.** Supply chain performance value at X Co.

Performance attribute	Performance Metric	Metric performance weight	Actual Value		% Metric Performance Value	
			Plan-tation	Manu-facture	Plan-tation	Manu-facture
Reliability	Perfect order fulfillment	0.233	99.89	100	23.24	23.26
	Perfect condition	0.233	94.95	100	22.09	23.26
Respon-siveness	Processing cycle time	0.091	100	81.79	9.12	7.46
	Production schedule cycle time	0.073	100	95.8	7.31	7
Agility	Fulfillment of production capacity	0.097	69.6	50.24	6.74	4.87
Cost	Current on hand inventory	0.04	99.89	72.18	4.01	2.9
	Production cost	0.102	76.2	55.14	7.79	5.64
	Fulfillment cost	0.047	79.09	93.98	3.73	4.43
	Production labor cost	0.083	87.06	88.93	7.22	7.37
<b>Supply chain performance value</b>					91.24	86.19

Based on the results of the palm oil supply chain performance at the plantation and manufacture level as shown in table 2, it is known that the supply chain performance is in level of 91.24% (above average) for the plantation and 86.19% (average) for the manufacture. The supply chain performance results are influenced by the implementation of supply chain management as a whole, from the results it's known that the level of company performance has not reached the maximum point, indicates the presence of profit lost on each attributes performance is less than optimal. Profit lost that occurs in the entire metric is categorized as opportunity lost because the target is not fulfilled, resulting impact in the loss of profit levels. Technical performance improvement in plantation and manufacture sections, lies in the attributes of agility, the company is considered not able to cope with the changes that occur, especially for the production capacity fulfillment, this is due to the gap presence between the available raw materials with the production planning, thus implicating the cost attributes on the processing section and resulting in unmaximum total value, so that improvement that can be done is increasing cooperation with raw materials suppliers to meet the capacity of the processing to achieve an effective and efficient palm oil supply chain design.

#### 4.3. Added value analysis

The added value concept is a commodities value development due to the addition of input or because of further processing, the added value in the supply chain has different values based on the inputs and treatments that occur within each level of supply chain members [3]. Hines [7] defined added value as the difference between output value and the input costs, added value concept is the increase in the value due to the growth of the value as functional input is affected to the commodity. Harjanto [7] defined functional input is the treatment and services that causes increments in the utility and the value of the commodity. Added value analysis is performed on each supply chain members in order to know the profit sharing at each level so that there is limit the imbalance profit level in the supply chain members. The added value analysis on the palm oil supply chain is performed on the plantation and manufacture sections with added value measurement based on modified Hayami method [6], [7] with the calculation of all inputs and outputs within one year for the production rate of the crop production level at plantation and total processing at the manufacture.

The result of the added value measurement in table 3 shows that the added value ratio in the plantation section of 2016 is 21.86% and the company profit is 11%. The relatively low added value ratio in the plantation is caused by the low productivity of the land due to climate and soil conditions, the condition of the plantation which has steep slopes (flat wavy to hilly mountainous) and high rainfall that is 2756 mm/year, whereas its optimum range between 2000-2500 mm/year [20], and influenced by the age of palm oil tree itself. Meanwhile, for the manufacture, it is found that the added value ratio in 2016 is 37.55% and the company profit rate is 72.71%. The low added value ratio is influenced by the conversion factor from the raw material input of production to the output of the product, which is directly influenced by the oil yield and the losses which occurs during processing and the raw materials losing due to the handling of materials carried out between processing stations, such as **palm fruits** aren't entirely separated from the bunches, **inefficient pressing process**, and various other causes. However, the profit level gained from the palm oil processing sector has a fairly high value due to the high selling price of CPO and kernel.

**Table 3.** Palm oil added value calculation.

No	Variables	Plantation	Manufacture
Supply Chain Interaction			
1.	Material purchase (Rp/kg)	839	1 082
2.	Product selling price (Rp/kg)	1 082	
	Product 1		9200
	Product 2		7500
3.	Total of added value per kg of output (Rp/kg)	243	
Outputs, Inputs, dan Costs			
4.	a. Output sales volume (kg)	38 636 830	18 583 120
	b. Output sales value (Rp)	41 805 050 060	168 062 000 000
5.	Basic raw materials (Rp)	1 264 586 349	84 881 428 480
6.	Direct labor (DoW)	310	317
7.	Conversion factor	33.058	1.979
8.	The coefficient of direct labor (Rp/DoW)	4 079 310.803	267 764 758.6
9.	Wage of direct labor (Rp)	6 503 328 000	1 232 285 400
Incomes and Added Value			
10.	a. Other input costs-production (Rp)	16 616 529 827	11 571 066 321
	b. Other input costs-non-production (Rp)	14 785 867 695	8 494 640 980
11.	a. Added alue (Rp)	9 138 066 189	63 114 648 219
	b. Ratio of added value (%)	21.859	37.554
12.	a. Profit (Rp)	2 634 738 189	37 249 489 859
	b. Profit Rate (%)	6.302	22.164
Remuneration of Production Holder			
13.	Margin (Rp)	23 923 933 884	71 609 289 199
	a. Other input cost contributions (%)	1.313	42.714
	b. Company's profit (%)	11.013	79.294

#### 4.4. Sustainability performance improvement strategies' alternative chosen

Palm oil supply chain sustainability performance improvement strategies was obtained by BOCR (benefit, opportunity, cost, and risk) analysis to choose best alternative in ANP structure, the priority select by measure the benefit-cost ratio by comparing the positive weight against the negative weight of alternatives, the selected alternative is the highest value ratio [11]. ANP (Analytic Network Process) is a multiple criteria decision-making method used to derive relative priority from individual judgements, which can deal with all kinds of dependences systematically [21]. Based on palm oil supply chain sustainability performance improvement purpose, so the criteria elements assessed are economic, social, and environmental aspects, yet at the moment there are developed sustainability

assessment that observe other various aspects expect those three pillars, some of it equipped with the addition of technology aspect [22], [23]. In addition to technology aspect, it is necessary to also include palm oil supply chain performance evaluation and risk assessment.

Palm oil supply chain sustainability performance improvement strategies alternatives, selected five alternatives that are (1). Continuity of raw material supply; production capacity fulfillment in accordance with the installed machinery capacity requires raw materials supply continuously so that the efficiency of the processing is achieved, integrated system and rapid information exchange is needed to fulfill the supply, (2). Improved cooperation among related stakeholders; cooperation needs to be done with various relevant stakeholders to meet the supply-demand associated with increasing raw material supply, thereby increasing the amount and yield of production, distribution of product, stabilize the price of raw materials and price of products and policies related to palm oil and other licensing, as well as other roles from various related parties; (3). Production plan improvement; is needed to be done by analyzing the various possibilities that directly/indirectly affect the running of production process, such as the raw materials availability that meet the requirements, disruptions that occur both before and during the production process, the labor availability; which has implications for cost design, (4). Technology recovery for production process improvement; production process undertaken in palm oil supply chain is carried out from the maintenance of palm oil crops, harvesting, and processing of palm oil into CPO and palm kernel, the process in its implementation requires a variety machinery, so the use of appropriate technology is needed in sustainability of production processes and optimization, (5). Biodiversity conservation; is done to address sustainability issues that have a critical point on the environmental aspect, and this is further fueled by a European Union resolution rejecting exports from Indonesia because palm oil plantations are considered to destroy forest and degradation of habitats, so that maintaining biodiversity to meet environmental aspects. The calculation for the overall strategy of sustainable palm oil supply chain performance improvement is synthesized in software to obtain the weight priority based on pairwise comparison results in each alternative in the subcriteria, the selected alternative priority level is obtained as in table 4.

**Table 4.** Alternative priority based on BOCR criteria.

	Continuity of raw material supply	Improved cooperation among related stakeholders	Production plan improvement	Technology recovery for production process improvement	Biodiversity conservation
Benefit	0.158	0.098	0.110	0.116	0.070
Opportunity	0.028	0.023	0.033	0.037	0.018
Cost	0.051	0.027	0.034	0.038	0.029
Risk	0.025	0.026	0.022	0.025	0.033
BO / CR ratio	3.470	3.211	4.853	4.518	1.317
Alternative priority	3	4	1	2	5

The result of alternative priority based on the expert opinion indicates that the most influential alternative priority is the production plan improvement because the alternative has an opportunity in performance and profit improvement when applied in supply chain. According to the technological point of view, the alternative is more profitable because the production technology development needs to be done for performance improvement. According to the economic point of view, the production improvement and raw materials/products quality can be achieved by improving the production design. According to the social point of view, this alternative can increase the consumers demand so that it has implications on improving workers' welfare and company image improvement. According to the environmental point of view, its' directly improves the product quality by reducing the use of

pesticides/chemicals so that the level of profit increases and can be allocated for environmental empowerment.

#### *4.5. Managerial implication*

Performance evaluation of palm oil supply chain can be done through managerial reports to run the controlling function to maintain the company efficiency and evaluating the overall business process of supply chain. Supply chain performance measurement is conducted integrally on each dimension of supply chain based on the optimal target so it can be formulated the potential alternative strategy to improve the palm oil supply chain. Improvement of supply chain performance can be generated as positive impact to company competitiveness, with the implementation of strategy formulation according to company condition and importance factor based on expert opinion. Based on the analysis results, it is known that the metric of production capacity and production cost have low value and related to productivity level in both plantation and manufacture. Improvement opportunities that can be performed based on the analysis results, among others, are increased raw materials supply to enhance the production capacity fulfillment which also imply production costs and plantation productivities so increasing yields and by cooperating with third parties as a raw materials supplier to meet production capacity. Therefore, it requires to implement harvesting strategies and preservation fruit, transportation system, and the treatment to maintain quality of FFB (which has implications in the quality of CPO). In addition, sustainable improvement of supply chain performance can be accomplished with the implementation of alternative formulations, the expert assessments result indicate the alternative production plan improvement, which can be done through improvements in the design of production capacity, tools and machinery, costs, and labor; to provide opportunities for improved performance and increased profits in the supply chain. Rainforests which pointed out that palm creates problems of deforestation, corruption, underage workers, to human rights violations [24], the research resulting on the environmental aspects of performance improvement found that there are negative opportunities (risk) potential for land fires. Based on alternative technology selection strategy, it can be applied water technology management for peat land, application of technology for fire monitoring and detection, and installation of waste processing unit to become compost.

## **5. Conclusions and recommendations**

### *5.1. Conclusions*

Palm oil supply chain's performance was really important related to the continuity and sustainability of business processes that affect the profits and constraints faced by the company. The palm oil supply chain's primary members consist of raw material providers/plantation, manufacturer, and consumer. The assessment of palm oil supply chain performance and added value was conducted in the plantation and manufacture, the results showed that there were still identified profit lost due to the level of performance (demonstrated in average and above average performances) and added value which found had a lower profit percentage influenced by low raw material productivity. The occurrence of profit lost was indicated as the existence of problems in supply chain, so it is required to formulate strategies for a performance improvement to enhance company opportunities and productivity, based on the sustainability factors. Integratedly, the ANP analysis for sustainability palm oil supply chain performance improvement suggested that production plan improvement strategy was considered more influential than other alternatives.

### *5.2. Recommendations*

The palm oil supply chain research scope should be conducted on a broader analysis substance and network, including downstream supply chain flow from CPO production to end-consumers. The performance and added value sharing along the chain in order to increase palm oil supply chain performance and productivity should be investigated. In addition, it is necessary to review the sustainability issues especially from social and environmental aspects that significantly affect the production process in particular and supply chain generally.

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