ANALISIS PENGUKURAN PRODUKTIVITAS PADA PRODUKSI CPO MENGGUNAKAN METODE OBJECTIVE MATRIX (OMAX)

TUGAS AKHIR

Diajukan Sebagai Salah Satu Syarat untuk Memperoleh Gelar Sarjana Teknik
Pada Program Studi Teknik Industri Fakultas Sains dan Teknologi
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PEKANBARU
2024

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Spektrum Industri
Vol. 21, No. 2, 2023, pp. 109-119
ISSN 1693-6590
http://journal3.uad.ac.id/index.php/spektrum

UAD Universitas Ahmad Dahlan

Analysis of Productivity Measurement in CPO Production Using OMAX Method

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ARTICLE INFO

Article history
Received July 21, 2023
Revised September, 2023
Accepted October 5, 2023

Keywords
Analytical Hierarchy Process;
CPO;
FMEA;
OMAX;
Productivity

ABSTRACT

The primary focus of this research revolves around the measurement of productivity and the factors that impact Crude Palm Oil (CPO) production which currently faces challenges in assessing whether existing productivity falls into the 'satisfactory' category. The contribution of this study is conducting a comprehensive productivity assessment, focusing on metrics and identifying the causes of productivity decline, especially potential points of failure. The measurement indicators use the Objective Matrix (OMAX) method which includes five ratios, including raw material utilization, energy consumption, labor efficiency, optimization of production targets, and production capacity utilization. The Analytical Hierarchy Process (AHP) is used to assign relative weight to factors that contribute to overall productivity. In addition, Failure Modes and Effects Analysis (FMEA) functions as a tool to determine the causes of decreased productivity by considering the potential for failure to occur. The research results show that productivity reached its highest point in March at 219.93% and the lowest in July at -67.33%. Based on the score assessment, this decline was mainly caused by the lack of optimal achievement of production targets, symbolized by a ratio of 4 to a score of 45. Potential causes for this ratio include non-compliance in selecting FFB that meets standards, and production standards that are too ambitious. targets, and mental and physical fatigue and stress. To improve overall performance, proposed improvements include the application of Internet of Things (IoT) technology, such as the use of sensors and automation systems in production processes, as well as investment in agricultural technology as a monitoring system. This increase is aimed at achieving higher production targets and overall efficiency.

1. Introduction

In the present competitive business, manufacturing industries are focusing on improving effective performance to sustain. Productivity is needed to measure production costs precisely and accurately. Productivity is needed to measure production costs precisely and accurately (Anusha & Umasankar, 2020). Productivity is defined as the ratio between input and output as well can be interpreted as a measure of effectiveness and efficiency (Adesunkanmi & Nurain, 2022). Productivity is one of the important factors that affect the performance of a company (Novianti et al., 2019). Productivity is also a major contributor as an indication of the company's ability to survive in the face of business competitiveness (Shebeb, 2018). Productivity can be used as an indicator of business success (Putra

https://doi.org/10.12928/si.v21i2.145 spektrum.industri@ie.uad.ac.id

Spektrum Industri
Vol. 21, No. 2, 2023, pp. 109-119
ISSN 1693-6590

& Mursid, 2021). Productivity is not everything, but in the long term, productivity is everything (Parravicini & Graffi, 2019).

TBS is a raw material in processing Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). Crude palm oil (CPO) is a type of vegetable oil which has very diverse derivative products, especially as food ingredients, cosmetics industry, chemical industry, etc. at case study in PT. ABC is an agroindustry that produces Crude Palm Oil (CPO). PT. ABC has set a production target of 3,050 tons/month, with a production process capacity of 30 tons/hour so that the production process runs 24 hours/day with working hours divided into 2 work shifts. Productivity is currently an important factor in company growth (Cruz-Rivero et al., 2020). PT. ABC wants to increase productivity but faces difficulties because it has never measured productivity properly. They use production target achievement as a performance assessment, but the standard production targets do not provide a satisfactory picture of whether the company's productivity is at a good or bad level. In addition, to meet Refined's annual target of 32,738 tons of CPO, the company is estimated to suffer a loss of -640 tons. One method used to measure productivity is the Objective Matrix (OMAX) method, which can measure performance aspects by considering a work unit (Hidayatullah et al., 2022). OMAX sets important criteria for increasing productivity in production line activities (Celina et al., 2022). Factors that influence the decline in productivity will be identified based on measurement results using Failure Modes and Effect Analysis by adopting potential failures that will occur. The priority The goal of corrective action in FMEA is to eliminate the occurrence of failure and enhance current control (Liew et al., 2019).

In this study, the focus extends beyond merely measuring productivity using Objective Matrix (OMAX) in the agricultural industry. It also involves identifying factors that contribute to a decrease in productivity. To identify and take action on the risks that arise using Failure Mode and Effects Analysis (FMEA) by recognizing potential failures (Atin & Lubis, 2020). This proactive approach empowers companies to take preventive measures before any adverse consequences emerge. Furthermore, using FMEA assists companies in prioritizing improvements related to potential failures with significant impact, facilitating more efficient resource allocation by company.

The study by Wahyuni & Alya (2020) applied OMAX to measure the level of productivity in producing plates, also in the manufacturing industry the study (Lesmana et al., 2020) applied productivity measurements in the assembly department. Current productivity calculations do not meet management needs, they need an additional matrix as a measurement matrix, and meanwhile in research (Yahya et al., 2019) Productivity calculations in shipbuilding projects use the Mundel and OMAX models to determine a decrease in the productivity index. Meanwhile, productivity measurements were carried out in small industries, based on a study (Mukti et al., 2021), Aceh Coffee found that there was a discrepancy in the amount of production with the specified targets, so there were deficiencies in determining the input ratio in analyzing the productivity index in substance. The contribution of this study is conducting a comprehensive productivity assessment, focusing on metrics and identifying the causes of productivity decline, especially potential points of failure. The measurement indicators use the Objective Matrix (OMAX) method which includes five ratios, including raw material utilization, energy consumption, labor efficiency, optimization of production targets, and production capacity utilization

2. Method

Productivity is an illustration of the relationship between the input used and the output produced (Basumerda et al., 2019). The data used to measure CPO production productivity is primary data obtained directly during interviews and filling out questionnaires with managers QC assistant at PT. ABC. In this study, the productivity measurement method employed is the Objective Matrix, which calculates the Crude Palm Oil (CPO) production productivity index. Weighting in the assessment of this productivity index is determined using the Analytical Hierarchy Process (AHP) methodology. Additionally, the research identifies factors contributing to decreased productivity by incorporating potential failures, utilizing the Failure Modes and Effects Analysis (FMEA) method. There are several methods for measuring productivity, the Target Matrix Method is one of the best (Basumerda et al., 2019).

2.1. Objective Matrix (OMAX)

The Objective Matrix (OMAX) serves as the chosen measurement method for monitoring productivity within the company. Employing OMAX for measurement purposes results in an abundance of data. It provides an objective set of criteria that aligns with the collective interests of the entire company and offers flexibility in the measurement process. (Sayuti et al., 2021). The Objective Matrix (OMAX) method can identify the causes of decreased productivity (Putra & Mursid, 2021). The OMAX productivity measurement model is a measurement tool that offers distinct advantages. It empowers management to assign weights to criteria based on their relative importance within the company, enhancing objectivity and flexibility in the measurement process. (Nurwantara, 2018). OMAX, as a performance measurement method, assesses various criteria by assigning weights to calculate the overall enterprise productivity index. (Lesmana et al., 2020). The Objective Matrix has a unique feature, namely by combining workgroup performance criteria into a single matrix (Mukti et al., 2021). To use the OMAX method. the stages of the process using the Objective Matrix method (Handayani & Susilowati, 2021):

a. Identification of Productivity Criteria
b. Ratio calculation
   The calculations of the ratio per criterion are divided into efficiency and effectiveness criteria.
   1) Efficiency Criteria, shows the level of use of company resources such as the number of workers, use of working hours, energy, raw materials and capital that is as efficient as possible. The ratios used in this criterion are showed in Equation (1) – (3).

$$\text{Ratio 1 (working hours productivity)} = \frac{\text{Total product}}{\text{Working Hours Used}} \quad (1)$$

$$\text{Ratio 2 (energy used productivity)} = \frac{\text{Total product}}{\text{Energy Used}} \quad (2)$$

$$\text{Ratio 3 (material used productivity)} = \frac{\text{Total Product}}{\text{Material Used}} \text{ x100\%} \quad (3)$$

   2) Effectiveness Criteria, shows how the company achieves results when viewed from the point of view of time, accuracy and quality, which are included in these criteria, among others. The ratios used in this criterion are showed in Equation (4)-(5)

$$\text{Ratio 4 (optimization of production target)} = \frac{\text{Actual Production}}{\text{Production Plan}} \text{ x 100\%} \quad (4)$$

$$\text{Ratio 5 (optimization of production capacity)} = \frac{\text{Working Hours Used}}{\text{Material Used}} \quad (5)$$

c. Determination of final targets (level 10), short-term targets (score 3) and lower score (score 0).
d. Determination of productivity intervals (scores 1 - 2 and 4 - 9)
   For an increase in productivity value adjusted by way of interpolation as shown in Equation (6)-(7).

$$\text{For Increases level 1 and 2} = \frac{\text{Level 3 - Level 0}}{3 - 0} \quad (6)$$

$$\text{For Increases level 4 and 9} = \frac{\text{Level 10 – Level 3}}{10 - 3} \quad (7)$$

e. Determination of scores, weights and value

Spektrum Industri
Vol. 21, No. 2, 2023, pp. 109-119
ISSN 1693-6590

In making the OMAX table, a weighting technique with a reliable method is needed. For weighting The Analytical Hierarchy Process (AHP) is a tool used to discover the prioritization of various decision options through pairwise comparisons of the decision elements to general criteria (Varshney et al., 2021). The score is obtained from the performance of each ratio that approaches the productivity level. To calculate value, use the following formula:

$$\text{Value} = \text{Score} \times \text{Weights} \tag{8}$$

f. Calculation of Performance Indicator

To obtain the most current measure of productivity, you sum up all the existing productivity values from each criterion. To calculate the productivity index, use the following formula:

$$IP = \frac{\text{Current} - 300}{300} \times 100\% \tag{9}$$

To calculate the previous productivity index, use the following formula:

$$\text{Previous} = \frac{\text{Current Productivity} - \text{Previous productivity}}{\text{Previous productivity}} \times 100\% \tag{10}$$

2.2. Analytical Hierarchy Process (AHP)

Many methods need to be used to determine the weight of the rating index in the assessment process. In the 20th century, Professor Saaty of the University of Pittsburgh, USA, put forward a comprehensive method of qualitative and quantitative systematic analysis. It is an analytical hierarchical process (AHP) (Qin & Kang, 2019). The analytical hierarchical process method (AHP) is introduced, which can deal with complex and immeasurable multi-objective decision-making problems (Ren et al., 2019). The Analytical Hierarchy Process (AHP) has been a favorite tool of research experts from various fields such as engineering, technology, manufacturing, production, social sciences, etc. It has proved to be a reliable and efficient technique. (Khan, 2020). The step for implementing of AHP as follows (Prasetyo et al., 2023):

a. Creating a Hierarchical Structure
b. Determine assessment criteria and alternatives
   Determining criteria and alternatives using pairwise comparisons is done with a scale of 1-9 very well in order to be able to express an idea. The pairwise comparisons can be seen in Table 1.

Table 1. Pairwise Comparison Criteria

Interest Intensity	Description
1	Both elements have the same essential value
3	Element X is slightly more essential than element Y
5	Element X is more essential than element Y
7	Element X is clearly very essential to element Y
9	Absolute X elements are more essential than Y elements
2,4,6,8	The median value between the two adjacent comparisons

c. Finding Element Priority
   When establishing the hierarchy of elements, an initial step involves the creation of a pairwise comparison matrix. This matrix is formed by systematically comparing each existing element with every other element, based on predefined criteria. Carrying out synthesis for pairwise comparison
d. Consistency Measurement
e. Calculation of the Consistency Index (CI) and Consistency Ratio checks
   If the results of the Consistency Ratio CR < 10% or 0.1 then the questionnaire must be repeated, and if the Consistency Ratio (CR) > 0.1, then the calculation results can be decided correctly.

2.3. Failure Modes and Effect Analysis (FMEA)

Failure mode and effect analysis (FMEA) aims to improve operational performance of a productor process (Liew et al., 2019). Its outcome is the RPN (Risk Priority Number), which guides recommendations for prioritizing the maintenance and improvement of the most critical risk factors. The RPN score is computed using Severity (S), Occurrence (O), and Detection (D) (Suryoputro et al., 2019). In this research, the approach was employed to detect the occurrences of failures, encompassing(Soewardi & Wulandari, 2019):

a. The extent of damage (severity), indicating the degree of harm inflicted on the process.
b. The frequency (occurrence), signifying the potential for a failure to transpire.
c. The level of detection (detection), highlighting the capacity to identify failures before they materialize.

The processes for different types of FMEA share fundamental similarities. They revolve around cause-and-effect connections, identifying the initial source of an error. This source can be found within the system or even outside it, in the vicinity where the error manifests. This approach enables the potential to influence the nature of the errors encountered. A comprehensive analysis can pinpoint the root cause of the error (Dumitrescu et al., 2016).

3. Results and Discussion

The objective potential that has been formed is arranged in the form of a questionnaire adjusting the availability of features from each objective potential with the assistant quality controller and production assistant. The results of determining the criteria as a source of performance calculations can be seen in Table 2.

Table 2. Identification of Performance Criteria

Potential Objective	Criteria
Use of Working Hours	Total Product produced (Tons) Total working hours (hours)
Energy Use Efficiency	Total Product produced (Tons) Amount of electricity used (KwH)
Efficient Use of Raw Materials	Total Product produced (Tons) Total Raw Materials (Tons)
Optimizing the achievement of Production Targets	Total Actual Production (Tons) Production Target (Tons)
Optimization of production capacity realization	Actual Production (Tons) Production Capacity (Ton/Hour)

The ratio calculation exploits CPO production data for 2022. Data from each of these criteria include working hours, energy use, raw material requirements, production targets, and optimal production capacity. Ratio data for each criterion can be seen in Table 3.

Level 0 as the lowest target indicated from the results of calculating the lowest ratio, level 3 as the standard target cause the average ratio calculation based on the ratio calculation results, and level 10 as the highest target is known from the results of estimating the highest ratio of each ratio. The results of calculating the realistic productivity value and OMAX level of CPO production from January to December can be seen in Table 4.

Levels 0, 3, and 10 serve as benchmarks for determining the OMAX level. The OMAX level is determined through an interpolation calculation, resulting in a range between levels 0 and 10. The OMAX level obtained in this process serves as the foundation for evaluating performance scores in each period. Therefore, performance indicator calculations can be carried out. You can find the OMAX levels in the Table 5.

Table 3. Recapitulation Input of Productivity

Working Hours Used (Hours)	Electricity Used (Kwh)	Raw Materials Used (Tons)	Actual Production (Tons)
365.00	176,496	10,372	2,130
482.50	199,782	13,665	2,802
500.50	205,399	14,138	2,923
584.83	212,856	15,305	3,137
652.58	219,044	12,913	2,013
720.33	227,420	11,429	2,124
788.08	233,882	9,591	1,786
855.83	243,940	13,379	2,473
923.58	248,209	15,002	3,014
991.33	254,665	15,851	3,140
1,059.08	271,309	13,648	2,797
1,126.83	295,856	18,326	3,759

Table 4. Result of Calculation The Performance Ratio and OMAX Level

Period	Ratio 1	Ratio 2	Ratio 3	Ratio 4	Ratio 5
January	5.836	0.012	20.536	69.836	28.416
February	5.807	0.014	20.505	91.869	28.321
Mach	5.840	0.014	20.675	95.836	28.248
April	5.364	0.015	20.497	102.853	26.170
May	3.085	0.009	15.589	66.000	19.788
June	2.949	0.009	18.584	69.639	15.866
July	2.266	0.008	18.622	58.557	12.170
August	2.890	0.010	18.484	81.082	15.633
September	3.263	0.012	20.091	98.820	16.243
October	3.167	0.012	19.809	102.951	15.990
November	2.641	0.010	20.494	91.705	12.887
December	3.336	0.013	20.512	123.246	16.263
Max (Level 10)	5.840	0.015	20.675	123.246	28.416
Average (Level 3)	3.870	0.012	19.533	87.699	19.666
Min (Level 0)	2.266	0.008	15.589	58.557	12.170

The process of ascertaining the performance score involves aligning the outcomes of ratio calculations in each time frame with the OMAX level found in Table 6, which serves as a performance benchmark. This approach enables the performance scores for each measured period to reflect the productivity level associated with each ratio. The recapitulation of performance score in the Table 6.

To establish the weight, we evaluate each of these criteria through pairwise comparisons, assessing their relative importance using the AHP (Analytical Hierarchy Process) method, based on the questionnaire responses from both the manager and production assistant. The results of weighting using AHP after calculation using software Microsoft excel 2021 like in Table 7.

The results of the AHP calculation to determine the consistency index (CI) has a result of 0,10283, then testing the consistency or consistency ratio (CR), from the results of the consistency calculations carried out, it is obtained CR = 0,09. The comparison value can be determined to be consistent, if <0,10 or below 10%, therefore the determination of the weight comparison value on the productivity ratio is consistent.

Table 5. Level of Objective Matrix

Performance	Criterion				
	Ratio 1	Ratio 2	Ratio 3	Ratio 4	Ratio 5
10	**5.840**	**0.015**	**20.675**	**123.246**	**28.416**
9	5.559	0.014	20.512	118.168	27.166
8	5.277	0.014	20.349	113.090	25.916
7	4.996	0.013	20.186	108.012	24.666
6	4.714	0.013	20.022	102.934	23.416
5	4.433	0.012	19.859	97.856	22.166
4	4.152	0.012	19.696	92.778	20.916
3	**3.870**	**0.012**	**19.533**	**87.699**	**19.666**
2	3.336	0.010	18.218	77.985	17.167
1	2.801	0.009	16.904	68.271	14.669
0	**2.266**	**0.008**	**15.589**	**58.557**	**12.170**

Table 6. The Recapitulation of Performance Score

Period	Score					Total
	Ratio 1	Ratio 2	Ratio 3	Ratio 4	Ratio 5	
January	10	4	9	1	10	34
February	10	8	9	4	10	41
Mach	10	9	10	5	10	44
April	8	10	9	6	8	41
May	2	1	0	1	3	7
June	1	1	2	1	1	6
July	0	0	2	0	0	2
August	1	2	2	2	1	8
September	2	4	6	5	2	19
October	2	5	5	6	2	20
November	1	2	9	4	0	16
December	2	6	9	10	2	29
Total	49	52	72	45	49	267

Through the evaluation of productivity performance for the 2022 period, it is evident that the peak performance occurred in March with a value of 959,79. Furthermore, when analyzing the productivity index growth by comparing the most recent index with the preceding one (Previous IP), the highest increase was observed in September, amounting to 161,09%. The lowest accretion from the latest productivity to the previous period's productivity occurred in the May period with a decrease in productivity of -88.05%. CPO productivity index like in the Table 8.

Table 7. Result of AHP

Criterion	Eigenvector	Eigen Value
Ratio 1	0.0969	1.098088
Ratio 2	0.1466	1.148278
Ratio 3	0.49	0.935141
Ratio 4	0.0511	0.919423
Ratio 5	0.2154	1.310422
Total	1	5.41135

In the 2022 period, the peak of the productivity index was reached in March at 219,93%. This increase was due to the calculation of the ratio performance score of 3, namely the productivity of raw material utilization which was very high until it reached level 10. This underlined that the efficiency of material utilization plays an important role in increasing productivity, based on the relative importance of each ratio. In contrast, the lowest CPO (Crude Palm Oil) production productivity occurred in July with a decrease of -67,33% because, based on the calculation of performance scores, all ratios in this period were below the set performance standards. Meanwhile, based on the score calculation, the factor that influenced the decline in CPO production productivity was the performance of ratio 4, namely optimizing production targets, evidenced by a ratio of 4 having the lowest score calculation result with a performance score of 45. The growth of the CPO productivity index is shown in Figure 1.

Table 8. Productivity of CPO Production

Period	Current Performance	Indicator Productivity	Previous Indicator Productivity
1	817.05	172.35%	0.00 %
2	891.02	197.01%	9.05%
3	959.79	219.93%	7.72%
4	868.1	189.37%	-9.55%
5	103.77	-65.41%	-88.05%
6	149	-50.33%	43.59%
7	98	-67.33%	-34.23%
8	168.77	-43.74%	72.21%
9	440.65	46.88%	161.09%
10	411.42	37.14%	-6.63%
11	500.45	66.82%	21.64%
12	642.52	114.17%	28.39%

Identify factors that cause a decrease in productivity while striving to achieve production targets set through risk evaluation using the FMEA (Failure Modes and Effects Analysis) method. During the application of this method, potential failures and their causal factors are detected through the development of questionnaires, in collaboration with managers and quality control assistants as exemplified in Table 9.

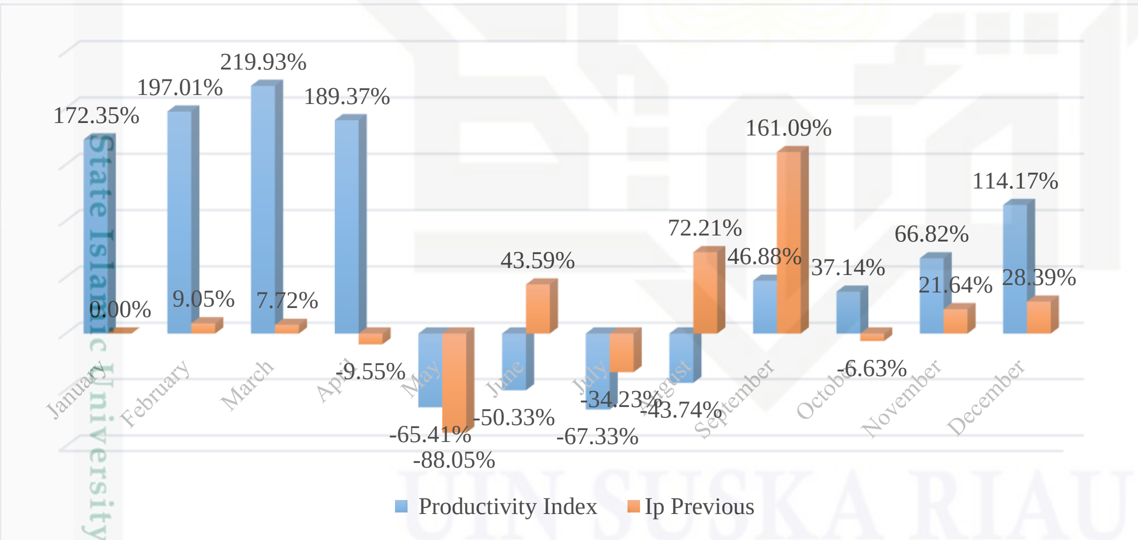

Fig 1. Current Indicator Productivity against Indicator Productivity Previous

Table 9. Failure Mode and Effect Analysis

Criteria	Potential Failure Mode	Potential Effect	Potential Cause	S	O	D	RPN
Optimizing production target (ratio 4)	Declined in CPO Quality	The possibility of obtain penalties or trade restrictions Diminishing the Company's competitiveness on the global stage.	The processed Fresh Fruit Bunches (FFB) do not meet the quality criteria established and Inadequate monitoring and supervision within the Quality Control (QC)	8	5	2	80
	Excessive workload for employees	Elevated staff turnover rate Declined in labor efficiency	Resulting in mental and physical exhaustion and stress Limited scope for workplace innovation due to continuous task-focused routines without breaks	5	4	4	80
	Unsuccessful production planning resulting in unmet production targets	Falling short of the production objectives A decrease in the productivity of Fresh Fruit Bunches (FFB)	The company has set overly ambitious production standard targets The material choice of which will be processed FFB varieties with oil content below 20%	7	6	6	252

The factors that influence the failure to meet production targets have adjusted to the risks that are the main priority for improvement, including failure in planning to set standard targets, which is the company's priority to increase optimization of production targets, then decreasing CPO quality and excessive workload. These causal factors are assessed by the plant manager based on their severity, frequency, and detectability, resulting in the calculation of Risk Priority Numbers (RPN). The suggested enhancements include integrating Internet of Things (IoT) technology through sensors and automation for the production process, upgrading workplace facilities with a focus on Occupational Health and Safety (K3) equipment at every workstation, providing ongoing training to boost operator creativity, and investing in agricultural technology as a monitoring system. These measures aim to attain higher production targets and enhance overall efficiency.

4. Conclusion

The highest CPO production productivity index in 2022 was in the March period with an index of 219.93%. The lowest productivity level occurred in the July period with an index of -67.33%. Based on the score calculation, the performance ratio that has the lowest performance score is ratio 4, namely optimizing production targets, which is the cause of the decline in CPO production productivity at PT. A B C. The factors that influence the failure to meet production targets have adjusted to the risks that are the main priority for improvement, including failure in planning to set standard targets, which is the company's priority to increase optimization of production targets, then decreasing CPO quality and excessive workload. Recommended improvements include investing in agricultural technology as a monitoring system, integrating Internet of Things (IoT) technology through sensors and automation in production processes and improving workplace facilities with a focus on Occupational Health and Safety (K3) equipment at each workstation, providing continuous training to increase operator creativity. These steps aim to achieve higher production targets and improve overall efficiency.

Author Contribution: All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest.

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