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Design of Plantation and Palm Oil Mill Monitoring System to Improve Palm Oil Production at PTPN IV

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Abstrak

Penelitian ini bertujuan untuk merancang sistem pemantauan antara manajemen perkebunan dan pabrik kelapa sawit di PT Perkebunan Nusantara IV (PTPN IV) guna meningkatkan produksi minyak sawit mentah (CPO). Masalah utama yang diidentifikasi meliputi ketidakhadiran sistem pemantauan data kualitas tandan buah segar (FFB), pelacakan waktu pengangkutan FFB yang tidak memadai, serta pemantauan operasional pabrik dan tingkat kerugian yang kurang memadai. Metode Problem Identification Corrective Action (PICA) digunakan untuk mengidentifikasi akar masalah, sementara metode Rapid Application Development (RAD) diterapkan untuk merancang solusi digital. Hasil penelitian menunjukkan bahwa sistem pemantauan digital antara perkebunan dan pabrik dapat menyediakan informasi yang transparan, akurat, dan real-time mengenai kualitas buah, jadwal pengangkutan, dan kondisi mesin pabrik. Implementasi dashboard digital mempercepat pengambilan keputusan, meminimalkan sisa FFB di lapangan, dan membantu menjaga kualitas produksi CPO sesuai dengan target korporat. Studi ini merekomendasikan pengembangan dan implementasi lebih lanjut sistem digital untuk meningkatkan efisiensi operasional dan mencapai kinerja berkelanjutan di sektor perkebunan kelapa sawit.

Keywords: Sistem Pemantauan Perkebunan dan Pabrik; Minyak Sawit; Digitalisasi; PICA; RAD; Produksi CPO

Abstract

This study aims to design a monitoring system between plantation management and palm oil mills at PT Perkebunan Nusantara IV (PTPN IV) to enhance crude palm oil (CPO) production. The main issues identified include the lack of a monitoring system for fresh fruit bunch (FFB) quality data, inadequate tracking of FFB transportation times, and insufficient monitoring of mill operations and loss levels. The Problem Identification Corrective Action (PICA) method is used to identify the root causes, while the Rapid Application Development (RAD) method is employed to design a digital solution. The results of the study show that a digital monitoring system between plantations and mills can provide transparent, accurate, and real-time information on fruit quality, transportation schedules, and mill machinery conditions. The implementation of a digital dashboard accelerates decision-making, minimizes leftover FFB in the field, and helps maintain CPO production quality in accordance with corporate targets. The study recommends further development and implementation of digital systems to improve operational efficiency and achieve sustainable performance in the palm oil plantation sector.

Keywords: Plantation and Mill Monitoring System; Palm Oil; Digitalization; PICA; RAD; CPO Production

1. Introduction

PalmCo manages 434,597 hectares of oil palm plantations, making it the company's largest commodity. Rubber is the next major commodity, covering 46,534 Ha, followed by tea with 6,255 Ha and coffee with 501 Ha. PalmCo processes its raw materials through its own facilities, which include 54 palm oil mills, 12 rubber factories and 4 tea factories. The PalmCo work/business

units are spread across 8 provinces, with a total of approximately 62,700 employees. According to the Articles of Association, PalmCo's business fields include agribusiness, agro-industry and other related sectors.

Palmco's current palm oil digitalization project is *Digital Farming*, namely an application for recording palm oil production results holistically, which is carried out at the plantation level, including harvesting and transportation activities. In contrast, *the Mill Indicator Monitoring System* and IoT factory monitoring (temperature, pressure, pH *water treatment* and *lab samples*) are carried out by the Palm Oil Mill including the FFB processing process. Specifically, for its main commodity, namely palm oil, there is a primary process, namely harvesting activities. During the harvesting stage, it is essential for management to monitor both the quality of fresh fruit bunches (FFB) and the efficiency of transportation to ensure optimal processing at the palm oil mill (PKS). These activities can be used as indicators to ensure that palm oil production meets established standards and achieves optimal quality and potential.

During the 2019–2023 period, the performance of PKS PTPN IV Regional II consistently fell short of the company's expected targets. Although the company targeted an average CPO yield of 23.49% over the last five years, the actual achievement was only 22.87%, or 97.34% of the intended target. Regional II of PT Perkebunan Nusantara IV has 29 Core Plantations, 1 Plasma Plantation and 16 Palm Oil Mills (PKS). The Company's average CPO yield from 2019 to 2023 was 22.87%, equivalent to 97.34% of the target set in the RKAP (Work Plan and Corporate Budget).

Achieving company targets requires strong coordination between Plantation and Factory Management, especially in ensuring that the delivered fresh fruit bunches (FFB) meet quality standards and arrive on time for processing on the same day. Effective coordination requires transparent communication and prompt dissemination of information between management, especially concerning fruit quality issues and the transportation of FFB. To support this, a solution is required to enable fast and accurate decision-making. The author proposes accelerating access to effective, accurate, and up-to-date information for Plantation Managers and PKS by leveraging digital technology.

At present, digital technology has been implemented in Regional Work Unit II of PTPN IV through the MyPalmco Dashboard, which provides data on the company's performance in both on-farm (plantation) and off-farm (palm oil mill/PKS) operations. However, the application technology has not been integrated in an updated manner between the Plantation and PKS, so it is still focused on each work unit's performance target only. A digitalization technology is needed so that there is integration between Plantation Management and PKS Management so that they have the same target, namely palm oil production (CPO).

Based on the performance data of the Regional II Palm Oil Mill (PKS) of PT Perkebunan Nusantara IV for the period 2019–2023, the average CPO yield reached only 22.87%, or 97.34% of the company's target of 23.49%. This 0.62-point shortfall, when converted into oil volume, indicates that the potential production loss could amount to thousands of tons of CPO annually.

Through business process analysis, three main phenomena have been identified as the likely causes of this production gap:

1. **Unsynchronized TBS Quality**
The reported quality of fresh fruit bunches (FFB) in the plantation is recorded through the Digital Farming application. However, the sorting data received at the palm oil mill (PKS) often differs by 5–10% when compared to the data reported from the field. This mismatch hinders the evaluation of material quality standards and complicates the setting of daily FFB (Fresh Fruit Bunch) processing volumes.
2. **TBS Delivery Time *Tracking Is Not* Comprehensive**
The SPB document records the truck departure and weighing times at the palm oil mill (POM), but does not capture the arrival time. Consequently, both plantation and mill managers lack accurate information regarding the actual travel duration of FFB transportation. This is critical, as delivery delays exceeding three hours may reduce crude palm oil (CPO) yield by up to 0.5%.
3. **Machine Condition and *Losses* Reporting Not Yet *Real-Time***
Although the MyPalmco dashboard displays data on damage and losses, updates are only available on an H+1 basis. Consequently, decision-making for machine damage handling is often delayed, resulting in an average downtime of 4–6 hours per incident.

The problem in this research can be formulated as follows:

1. Does real-time integration of FFB quality data between plantation management and the palm oil mill improve the accuracy of sorting reports?
2. How does the implementation of a comprehensive FFB delivery time tracking system (from departure to arrival) impact oil yields at the PKS?
3. How can developing a *real-time dashboard* to monitor PKS machine conditions and losses accelerate damage handling and support the achievement of palm oil production targets?

The objectives of this study are as follows:

1. Developing a system that can monitor Fresh Fruit Bunch (FFB) quality reports in real time between plantation management and the palm oil mill (POM) to improve the accuracy of sorting reports and support daily FFB processing scheduling.
2. Developing a tracking module/system that records all stages of truck movement, from departure to arrival, to ensure transparency in delivery duration and reduce the decline in raw material quality.
3. Designing a dashboard-based monitoring system that visualizes machine operational status and loss levels in real time, enabling technical teams to intervene more quickly and improve the efficiency of palm oil extraction processes.

2. Literature Review

The implementation of supply chain management can accelerate the production process by minimizing the time between customer orders and product shipment. In this way, companies can ensure timely product availability and satisfy customers. Furthermore, supply chain management can reduce production costs by optimizing inventory, transportation, and distribution processes efficiently (Kristian, 2023).

The primary objective of supply chain management is to enhance operational efficiency while minimizing costs across the entire system. The system in question encompasses all activities and components involved in the process, ranging from transportation to distribution, as well as from the procurement of raw materials to the production of finished goods. The supply chain is an integrated system encompassing suppliers, manufacturing facilities, warehouses, and retail stores. It includes activities at every level of the company, starting from strategic planning to operational implementation. (Simchi Levi and Kaminsky, 2008).

Objectives can be established at both the group level, encompassing the entire supply chain, and the individual level, focusing on specific members. However, the objectives of the two sets should be coordinated for effective performance measurement for the supply chain. This may require common goals from members so that supply chain objectives can be met (Charu Chandra, Sameer Kumar 2000).

Productivity is a process measured by comparing output with input, which is often referred to as operational productivity. The concept of productivity differs significantly from that of production. Since production is tangible and can be measured directly, productivity is often mistakenly equated with production. Production refers to the act of generating goods and services, whereas efficiency is closely related to how effectively assets are utilized to produce those goods and services (Yamit, 2007).

According to Heizer (2005), three factors determine the level of efficiency, particularly in relation to work, which refers to both the quantity and the nature of the work performed within the organization. Education, workforce knowledge, improvement of the work environment, and the availability of adequate labor are key factors in enhancing the capabilities of the workforce.

Operational management has undergone three theoretical stages, each with its own distinctive designation. It was initially referred to as Manufacturing Management, later evolved into Production Management, and is currently known as Operations Management (Sisca et al., 2020).

The concept of operational management refers to the activities undertaken by a company to create goods and services that are offered to consumers. With the concept of operational management, all company income will be integrated to produce output that has added value, whether in the form of finished goods, semi-finished goods or services. Operational management refers to a systematic activity aimed at creating value through the production of goods and services by transforming various inputs into outputs (Lavari, 2016).

Data recorded in the blockchain can also include important information about product quality, production methods and standards and regulations followed, helping to ensure that palm oil products meet established standards and comply with responsible practices. Blockchain technology uses strong encryption and cryptographic mechanisms, so that data in the supply chain is safe from theft or manipulation. By providing a decentralized and open platform, *blockchain technology* encourages cooperation between various stakeholders in the palm oil supply chain, facilitating better communication and more effective collaboration (Iqbal, 2024).

In an era of increasingly intense business competition, companies must continuously improve efficiency across all business processes (Priansa, 2017; Asikin & Fadilah, 2024). Optimal business process efficiency is crucial to ensure business continuity and sustainable growth (Zuhro & Suwitho, 2016; Suastini et al., 2016). One important factor that supports business process efficiency is the implementation of effective quality management (Setiawan & Setiyadi, 2017). Management itself is the process of achieving organizational goals through the efforts of others (Kurniawan & Martadisastra, 2022). To achieve these objectives, management functions include planning, organizing, leading, and controlling. In addition, management also involves specific managerial roles that must be performed to ensure organizational effectiveness (Aisyah, 2021).

Rapid Application Development (RAD) is a process model for developing applications. device software that is incremental in nature especially for time short work. (Sukamto & Shalahudin, 2016).

3. Methods

3.1 Model or Framework

Palm Oil Production in Regional Area II is responsible for two functional sections, namely the Plantation Section and the Engineering and Processing Section. Problem identification in this study was conducted using the Problem Identification and Corrective Action (PICA) method, which serves as a management control tool for monitoring the Plan–Do–Check–Act (PDCA) cycle. Problem identification aims to analyze factors that cause planned activities not to be implemented effectively. Since 2020, Regional Area II management has implemented harvest monitoring using a Digital Farming application. Activities at the palm oil mill (POM) include weighing Fresh Fruit Bunch (FFB) trucks and conducting sorting and sampling processes.

Another method used in problem solving is the *Rapid Application Development (RAD)* method. This method is the preparation of a system to replace the old system as a whole or improve the existing system. Stages in Rapid Application Development (RAD), namely:

- 1) *Business Modeling (Business Modeling)*
 - Understanding the flow of information within an organization and how that data is used by various business processes.
 - The development team works closely with stakeholders to define business goals and key workflows.
- 2) *Data Modeling*
 - Data identified at this stage are modelled to support business requirements.
 - This includes creating data schemas, relationships between data and how the data will be used.
- 3) *Process Modeling*
 - Processes involving data are designed for support channel business.
 - This stage includes defining the business processes, logic and rules that must be implemented in the application.
- 4) *Application Generation*
 - Using automation tools or code generators to create applications based on previously designed models.
 - This stage often involves creating *prototypes* that can be tested and reviewed directly by users.
- 5) *Testing and Turnover*
 - Testing is done on *prototypes* to ensure the application meets user needs.
 - After all feedback is implemented, the final application is prepared for production.

3.2 Design Results (RAD Method)

Rapid Application Development (RAD) method, data processing is done iteratively and collaboratively so that applications are developed quickly and directly according to user needs. Here are stages data processing in RAD context:

1. Quick analysis focuses on identifying user needs, visualizing workflows, and defining input and output requirements.
2. Making Prototype: Build prototype (wireframe, mockup or testable system).
3. Trial & Evaluation Prototype: Users try prototypes and provide feedback.
4. Design and Development Iterations: System improved repeatedly based on feedback.
5. Finalization System & Implementation: System built fully, data migration, testing & deployment.

3.3 Analysis and Evaluation (PICA Method)

Using the PICA framework, the steps for root cause analysis in the Plantation-factory integration case are as follows:

1. Problem Identification
 - Symptoms: Average CPO yield is only 22.87%.
 - Supporting data: Reports TBS sorting, truck time logs and engine downtime.
2. Root Cause Analysis
 - The quality of TBS is not Sync → No validation system and automation of TBS quality data transfer.
 - There is no tracking of TBS delivery time → Absence of mechanism capture timestamp moment arrived at PKS.
 - Engine condition and losses are not monitored real time → Data pipeline not optimized for real-time.
3. Corrective Action Planning
 - CA1: digital form-based TBS quality input module.
 - CA2: end-to-end tracking with QR-code/GPS.
 - CA3: real-time IoT machine sensor dashboard.
4. Implementation & Evaluation
 - PICA module runs parallel with RAD prototype. Each CA is tested based on KPI “synchronization quality of TBS”, “accuracy time delivery” and “reporting PKS conditions.”

3.4 Validation of Results

Validation is carried out to ensure that the design of the integrated system of the Plantation and factory that has been prepared can

be applied logically, technically and operationally in the PTPN IV work environment. This validation does not use observation or respondent methods, but is based on workflow simulations, functionality tests and implementation feasibility analysis.

1. Functional Validation

- Cycle time can be shortened from 6–7 hours to around 4–5 hours.
- The system identifies delays and potential queues.
- Recording and reporting functions run consistently.

2. Process Logic Validation

- Roles do not overlap, no data duplication, ERD covers key entities.
- Validation of Implementation Feasibility
- Technical: uses lightweight, web-based platform.
- Economy: no large hardware investments.
- Organization: structure can be adopted without major restructuring.

3. Validation Conclusion

- System feasible technically and logically; able to provide operational efficiency and yield increase.

3.5 Comparison Before and After System Design

- a) Scheduling Transportation of TBS: Manual → automatic Auto Scheduler.
- b) Harvest Data Input: Manual → real-time mobile input.
- c) Fleet Monitoring: Only departure & weighing → end-to-end GPS tracking.
- d) TBS Queue: Congested → arranged by SLA system.
- e) TBS Quality Feedback: H+1 → direct sync automatically.
- f) Daily Performance Evaluation: Weekly → real-time KPI dashboard.
- g) Coordination: Less intensive → real-time data integration.
- h) Efficiency: 6–7 hours → 4–5 hours
- i) CPO yield: 21% → potential 22.5%.

3.6 System Design Cost Estimates

Total Estimate Cost: Rp. 1,250,100,000.

Includes: IoT Hardware & Tracking, Software Development, Cloud Services, Implementation & Training, Maintenance & Support, Reserve (Contingency 10%).

4. Conclusion

Based on the results of the analysis and design that have been carried out and referring to the research objectives, the following conclusions can be drawn:

- a) A prototype of an integrated Fresh Fruit Bunch (FFB) quality monitoring system was developed between plantation management and the palm oil mill (POM), enabling real-time exchange and consolidation of FFB quality data. This integration allows sorting activities at both the plantation and the mill to operate synchronously, resulting in more accurate and consistent quality reports. Furthermore, the integrated data support more effective daily processing scheduling at the mill in accordance with the quality profile of the available raw materials.
- b) A GPS- and timestamp-based FFB delivery tracking system was designed and evaluated to record all stages of truck journeys, from departure at the plantation to arrival at the palm oil mill (POM). This system provides transparency in delivery duration, enables direct identification of delays, and supports better decision-making in harvest and FFB logistics management. Furthermore, its implementation has the potential to reduce fruit quality deterioration caused by excessively long delivery times.
- c) A system in the form of a machine operational and loss monitoring dashboard was designed to present real-time data through sensor (IoT) integration and visual dashboards. The displayed information includes machine operating status, temperature, pressure, and loss values. This dashboard enables the technical team to intervene quickly when process anomalies occur, thereby improving oil extraction efficiency and reducing the risk of machine damage caused by delayed response.

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References

- [1] Aisyah. (2021). *Management in Organizations*. Jakarta: Mitra Wacana Media.
- [2] Asikin, M., & Fadilah, A. (2024). *Business Process Efficiency in Modern Companies*. Journal Management and Innovation, 8(1), 1–10.
- [3] Charu, C., & Kumar, S. (2000). *Managing the Supply Chain as a Strategic Asset: Theory and Practice*. International Journal of Logistics.
- [4] Heizer, J. (2005). *Operations Management*. 8th Edition. New Jersey: Pearson Prentice Hall.
- [5] Iqbal, T. (2024). *Application of Blockchain Technology in the Palm Oil Supply Chain*. Journal of Applied Agricultural Technology, 12(2), 45–60.
- [6] Christian. (2023). *Supply Chain Management and Production Efficiency*. Journal of Economics and Management, 7(2), 55–66.
- [7] Lavari, S. (2016). *Operational Management in Modern Perspective*. Bandung: Alfabeta.
- [8] Nur Aini, F., et al. (2021). Controlling Reject Value of Goods Using PICA Method at PT Astra Otoparts Tbk. *Journal of Industrial Engineering*, 5(2), 23–29.
- [9] Nurul Hidayati, et al. (2022). Implementation of the PICA Method in the Maintenance Document Delivery Improvement Process at PT GMF AeroAsia Tbk. *Journal of Operational Management*, 10(1), 66–73.
- [10] Priansa, DJ (2017). *Human Resource Planning and Development*. Bandung: Alfabeta.
- [11] Pristianingrum, Y. (2017). *Total Quality Management: Concept and Implementation*. Yogyakarta: Deepublish.
- [12] Purba, S., & Siswono, H. (2022). *Implementation of Quality Management in Increasing Company Competitiveness*. Journal of Business and Management, 14(3), 45–55.
- [13] Sedarmayanti. (2016). *Total Quality Management*. Bandung: Refika Aditama.
- [14] Setiawan, R., & Setiyadi, A. (2017). *Implementation of Quality Management in Industrial Companies*. Surabaya: Surabaya State University Press.
- [15] Simchi-Levi, D., & Kaminsky, P. (2008). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. 3rd Edition. Boston: McGraw-Hill.
- [16] Sisca, R., et al. (2020). *Development of Operational Management Theory*. Journal of Economics, 9(1), 21–30.
- [17] Sukanto, R., & Shalahudin, M. (2016). *Software Engineering*. Yogyakarta: Informatics.
- [18] Suastini, NM, et al. (2016). *Production Process Efficiency and Human Resource Productivity*. Journal Indonesian Management, 6(2), 123–132.
- [19] Wolfert, S., et al. (2017). *Big Data in Smart Farming – A Review*. *Agricultural Systems*, 153, 69–80.
- [20] Yamit, Z. (2007). *Production and Operations Management*. Yogyakarta: Ekonomi UMY Press.
- [21] Zuhro, S., & Suwitho, S. (2016). *Business Process Optimization in Industry*. Journal Accounting and Management, 11(1), 77–88.