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Implementation of Key Performance Indicators in the Palm Oil Harvest Monitoring Information System

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ABSTRACT: Manual management of palm oil harvest data often resulted in data inconsistencies, low operational efficiency, and financial losses for plantation companies. To address these challenges, this study aimed to implement the Key Performance Indicator (KPI) method within a harvest monitoring information system at PT Perkebunan Nusantara (PTPN; Nusantara Plantation Company, Ltd) IV Regional II Unit Adolina, with the goal of enhancing data accuracy, transparency, and managerial effectiveness. A quantitative research approach was employed, utilizing data collection techniques such as observation, interviews, and document analysis. Five out of ten afdeling units were selected as research samples. The performance was assessed using three primary indicators: total harvest yield (weighted at 40%), labour productivity (35%), and monthly harvest frequency (25%). The results revealed significant variations in KPI achievement across afdeling units, with several units exceeding the established targets. Furthermore, the developed system featured an interactive visual dashboard that enabled managers to monitor performance in real time and supported data-driven decision-making. Compared to traditional monitoring tools, this system offered enhanced integration of performance metrics, automated data processing, and real-time analytics, addressing previous limitations such as delayed reporting and fragmented data sources. In conclusion, the integration of KPI into the harvest monitoring information system proved to be effective in providing objective and measurable performance evaluation. This approach offered a strategic solution for improving operational efficiency and productivity in palm oil plantation management.

KEYWORDS: Key Performance Indicator; information system; harvest result; palm oil; monitoring

1. Introduction

In the era of globalization, information technology evolved rapidly over time [1]. This development was widely adopted by institutions and companies to shift from manual processes to digital systems in order to enhance effectiveness and efficiency [2, 3]. However, not all sectors were able to utilise this advancement effectively and appropriately [4–6]. Information technology functioned to streamline tasks, making them easier and more timely to execute [7, 8], and aimed to simplify human work from various perspectives [9]. Companies employed

information systems to improve operational effectiveness in data management [10, 11], enabling information to be presented in a more complete, fast, efficient, and accurate manner to support decision-making processes.

One such company that needed to adopt information technology in its management was PTPN IV Medan, a state-owned enterprise engaged in the plantation sector based in Medan, focusing on agro-industrial activities [12, 13]. Its business operations included the cultivation and processing of oil palm and rubber, with main products such as crude palm oil (CPO), palm kernel, and rubber derivatives [14]. Traditional palm oil plantation management, although organised, faced challenges in monitoring transportation and reporting harvest results due to manual data recording. This process was prone to discrepancies, financial risk, reduced product quality, and increased potential for inaccuracies in fresh fruit bunch (FFB) sales [4]. The use of information technology enhanced productivity, operational efficiency, and the accuracy of harvest data management. Therefore, PTPN IV required a transparent, objective, and efficient system to support harvest data processing, field monitoring, and data-driven decision-making in an optimal and productive manner.

As a solution, implementing a monitoring information system was proposed. This study proposed the implementation of a monitoring information system integrated with the KPI method. While previous studies had focused either on system development or general performance tracking, they had rarely combined both approaches in the context of harvest monitoring. This system was designed to collect, process, and present data in real time with the objective of tracking performance, processes, or specific activities within an organisation or project [15–17]. Monitoring systems also played a crucial role in supporting planning and strategy for more effective plantation management [4, 18, 19]. In this context, the use of the KPI method was introduced [20]. KPIs were measurable indicators that provided insights into the extent to which strategic objectives were achieved [21]. They served to determine how effectively an organisation reached its goals. Within monitoring systems, KPIs were essential for tracking and evaluating relevant performance aspects [18]. Moreover, KPIs could be applied to assess the effectiveness of monitoring systems in promoting agricultural sustainability [20]. They also supported data-driven decision-making, allowing managers to respond more accurately and promptly to current conditions.

This study was grounded in prior research that had implemented similar KPI-based approaches. Lindberg and Tan [22] showed that KPIs delivered quantitative data that could support strategic decisions, including process optimisation and improved operational efficiency. Ghufroni and Kurniawan [23] highlighted that KPIs offered measurable insights into how well strategic objectives were being achieved. Erlina and Amanda Putri [4] demonstrated that integrated monitoring systems significantly reduced fraud potential and improved operational effectiveness in palm oil harvest management. Similarly, Khalilah Dulay and Santoso [18] asserted that monitoring systems simplified the tracking of harvest data and production, enabling managers to assess the alignment between reported and actual yields.

The objective of this research was to implement Key Performance Indicators within a harvest monitoring information system at PTPN IV Adolina in order to optimise efficiency, operational accuracy, and data validation. The research gap lay in the chosen methodology: whereas previous studies focused solely on system development, this study proposed the integration of the KPI method specifically within harvest monitoring systems. The KPI approach facilitated the identification of challenges in manual data collection, transport, and

reporting, and allowed for evaluating the effectiveness of the KPI-based system in resolving these issues. Additionally, the system supported measurable operational performance tracking, enhanced decision-making processes, and contributed to improved productivity and efficiency across the palm oil supply chain.

2. Materials and Methods

In research methods, a scientific approach was used to collect data to understand, solve, and anticipate problems, as well as to develop knowledge and theory [24]. The aim of research was to determine answers to questions through the application of scientific procedures. Thus, research methods played an important role in producing valid and accountable findings, so that they could contribute to the development of science and systematic problem-solving [25, 26]. The research stages were as follows:

2.1. Problem identification.

Problem identification aimed to recognise and understand the issues or gaps that needed to be addressed. It also served to determine priorities and select appropriate alternative solutions [27]. Once the problem had been identified, data were collected to support analysis and the selection of suitable methods. A needs analysis was then conducted to explore the essential elements required for resolution. This process formed the basis for formulating the research objectives and approach. Subsequently, an appropriate method was chosen to ensure the solution was effective, relevant, and objective.

2.2. Data collection.

Data collection was a crucial aspect of this research [28]. The methods used in this study included observation, interviews, and literature review. Observation involved directly examining the relevant objects, while interviews relied on direct interaction with respondents to obtain in-depth information about their experiences or perspectives. The literature review was conducted to explore and analyse written sources such as books, journals, and reports, which supported the theoretical framework and provided relevant background information. These three methods complemented each other to obtain valid and comprehensive data. At PTPN IV Adolina, the plantation was divided into 10 divisions (afdelings) comprising a total of 318 blocks, based on data obtained from the crop division of PTPN IV Adolina. From these, 5 out of 10 afdelings and 125 blocks were randomly selected as samples for this study. The data used corresponded to the monthly harvest periods, which served as the basis for analysing the Key Performance Indicators (KPI).

2.3. KPI method.

KPI was defined as a series of measurable key indicators that provided insight into the extent to which the strategic objectives assigned to an organisation had been achieved [23]. The key elements of KPIs included strategic goals, relevant performance indicators aligned with those goals, benchmark targets, and related metrics [29]. In practice, KPIs were designed to be specific, measurable, relevant to organisational objectives, and time-bound to allow for regular evaluation.

Several key characteristics were considered when determining KPIs within an organisation, including the following [23]: KPIs played a critical role in assessing organisational performance and had to be managed with methodological precision. Firstly, KPIs were subject to regular monitoring to ensure the continuous evaluation of progress and the timely identification of performance gaps. It was imperative that these indicators remained within the scope of control of the organisation's management, thereby allowing for strategic decision-making and operational adjustments. Moreover, the methods for measuring performance, as well as the corresponding corrective actions, had to be comprehensively understood by all relevant personnel to promote consistency, transparency, and effective implementation. The assignment of responsibilities related to each KPI was clearly defined to enhance accountability and role clarity within the organisational structure. Additionally, KPIs were designed to exert a significant influence on key operational or strategic outcomes, thus ensuring their relevance and value. Finally, it was essential that the implementation of KPIs led to demonstrable positive outcomes that supported the organisation's objectives and long-term sustainability.The following were the steps used in KPI assessment [30]:

2.3.1. Determining the KPI attribute categories.

The performance assessment indicators were categorised as follows:

- Palm Oil Harvest Data (Indicator 1): This indicator represented the amount of palm oil harvested during a harvest period and the target output to be achieved. According to Untung Prastio, harvest yield was one way to measure the level of productivity in agricultural cultivation, aiming to implement innovations to maximise output through efficient cultivation techniques and optimal nutrient provision [31].

- Labour Productivity in Harvesting (Indicator 2): Harvesting labour played a vital role in determining the productivity level of palm oil plantations, which depended on how effectively the harvesters performed their tasks [32, 33]. This indicator was calculated based on the number of kilograms harvested per worker during a given period. It was crucial in evaluating the efficiency of human resource usage in the field and in planning the required workforce in line with production capacity.

- Harvest Frequency per Month (Indicator 3): This referred to how many times harvesting took place within one month on a plantation. The frequency was influenced by factors such as the type of crop, fruit ripeness level, weather conditions, and plantation management practices.

2.3.2. Determining the weight of each KPI indicator.

Each KPI indicator value was derived based on the importance of its associated performance target. More critical performance targets were assigned higher weight values, with the total weight summing up to 100%. The performance assessment was based on three key indicators, each weighted according to its relative importance. Indicator 1 carried the highest weight at 40%, reflecting its critical role in evaluating overall performance. Indicator 2 contributed 35%, indicating its substantial influence in the assessment process. Lastly, Indicator 3 was assigned a weight of 25%, representing its supporting role in the overall evaluation.

2.3.3. Determining the value of KPI indicators.

The following formula was used to calculate the percentage value of each KPI indicator:

$$KPI\ Item\ Percentage = \frac{REALISATION}{TARGET}\ X\ 100\% \quad (1)$$

2.3.4. Calculating the weighted value of KPI indicators.

The following formula was used to calculate the percentage value of each KPI indicator:

$$Indicator\ Score = Indicator\ Value\ x\ Indicator\ Weight \quad (2)$$

2.3.5. Determining the overall KPI score.

The total KPI score was obtained by summing all individual indicator scores:

$$KPI\ Score = Total\ Sum\ of\ All\ KPI\ Indicator\ Scores \quad (3)$$

2.3.6. Determining the final evaluation quality.

The final stage in this calculation was determining the quality of the evaluation. This step aimed to assess whether the evaluation met the expected outcomes.

3. Results and Discussion

3.1.Problem analysis.

Problem analysis in this study was conducted to gather information regarding the issues faced by PTPN IV Regional II Unit Adolina and to identify the system requirements necessary to improve the performance of palm oil harvest monitoring [20]. This improvement was achieved through the implementation of an integrated KPI system based on a web application. During this stage, direct data collection was carried out at PTPN IV Regional II Unit Adolina through interviews and observations. A needs analysis was also conducted to evaluate the shortcomings of the existing system at PTPN IV Regional II Unit Adolina, which then served as a reference for developing a system tailored to the requirements of palm oil harvest monitoring activities in the unit.

3.2.Data collection.

Data collection in this research employed a quantitative method through documentation and direct observation [8]. The data collected included palm oil harvest yields, the number of workers involved in the harvesting process, and the monthly harvest frequency over a specific period. The data sources consisted of plantation administrative records and daily operational reports managed by the plantation's management. The collected data were then analysed to evaluate the productivity and effectiveness of the palm oil harvesting process (Table 1).

Table 1. Harvest data.

No	Afdeling	Planting Year	Block	Harvest Result (Kg)	Harvest Target (Kg)	Labour Productivity (kg/ Worker)	Target Labour Productivity (kg/ Worker)	Harvest Frequency per Month	Target Harvest Frequency per Month
1	One (I)	2006	A	25.487	27.000	1.961	2.000	5	4
2	Two (II)	2010	A	11.915	18.000	993	1.200	4	4
3	Three (III)	2008	AM	35.682	30.000	1.622	1.500	4	4
4	Four (IV)	2017	S	30.913	21.000	1.546	1.400	4	4
5	Five (V)	2010	AH	24.210	20.000	1.100	1.200	4	4

3.3.Analysis.

After the required data was obtained, the KPI calculation was carried out through several evaluation steps.

3.3.1. KPI attribute categories.

The KPI assessment was based on three main indicators:
- Palm oil harvest data (Indicator 1)
- Labour productivity in harvesting (Indicator 2)
- Harvest frequency per month (Indicator 3)

3.3.2. KPI indicator weights.

Each indicator was assigned a specific weight to reflect its importance:
- Indicator 1: 40%
- Indicator 2: 35%
- Indicator 3: 25%

3.3.3. Calculation of KPI indicator values.

The percentage values for each KPI indicator were obtained for all five afdelings:
- Palm Oil Harvest Data: Afdeling 1 (94%), Afdeling 2 (66%), Afdeling 3 (118.94%), Afdeling 4 (147.20%), Afdeling 5 (121.05%).
- Harvest Labour Productivity: Afdeling 1 (98.05%), Afdeling 2 (82.75%), Afdeling 3 (108.13%), Afdeling 4 (110.43%), Afdeling 5 (91.67%).
- Monthly Harvest Frequency: Afdeling 1 (125%), Afdeling 2 (100%), Afdeling 3 (100%), Afdeling 4 (100%), Afdeling 5 (100%).

3.3.4. Calculation of KPI indicator weights.

The KPI indicator values were then multiplied by their respective weights:
- Palm Oil Harvest Data: Afdeling 1 (37.60%), Afdeling 2 (26.40%), Afdeling 3 (47.57%), Afdeling 4 (58.88%), Afdeling 5 (48.42%).
- Harvest Labour Productivity: Afdeling 1 (34.32%), Afdeling 2 (28.96%), Afdeling 3 (37.85%), Afdeling 4 (38.65%), Afdeling 5 (32.08%).
- Monthly Harvest Frequency: Afdeling 1 (31.25%), Afdeling 2 (25%), Afdeling 3 (25%), Afdeling 4 (25%), Afdeling 5 (25%).

3.3.5. Determination of total KPI score.

The final KPI score for each afdeling was obtained by summing the weighted scores of all three indicators (Table 2).

Table 2. Final score determination.

No	Afdeling	Planting Year	Block	Palm Oil Harvest Result	Harvest Labour Productivity	Monthly Harvest Frequency
1	One (I)	2006	A	37,6%	34,32%	31,25%
2	Two (II)	2010	A	26,4%	28,96%	25%
3	Three (III)	2008	AM	47,57%	37,85%	25%
4	Four (IV)	2017	S	58,88%	38,65%	25%
5	Five (V)	2010	AH	48,42%	32,08%	25%

Table 2 provides a comparative overview of the performance achievements of each division based on three main indicators. This structured presentation of data makes it easier for readers to examine differences in performance between units and provides an objective basis for understanding areas that have been optimized and those that still require further attention. This information is expected to support more targeted evaluation and decision-making processes in harvest management. Table 3 presents the final evaluation quality.

Table 3. Final evaluation quality.

Scor Range	Description
50>	Far exceeds expectations
40-50	Exceeds expectations
30-40	Meets expectations
20-30	Nearly meets expectations
<20	Does not meet expectations

3.4. System analysis.

This system was designed using several integrated software development tools (Figure 1). The system design began with the use of Unified Modeling Language (UML) as a modeling tool to visually depict the process flow and system structure.

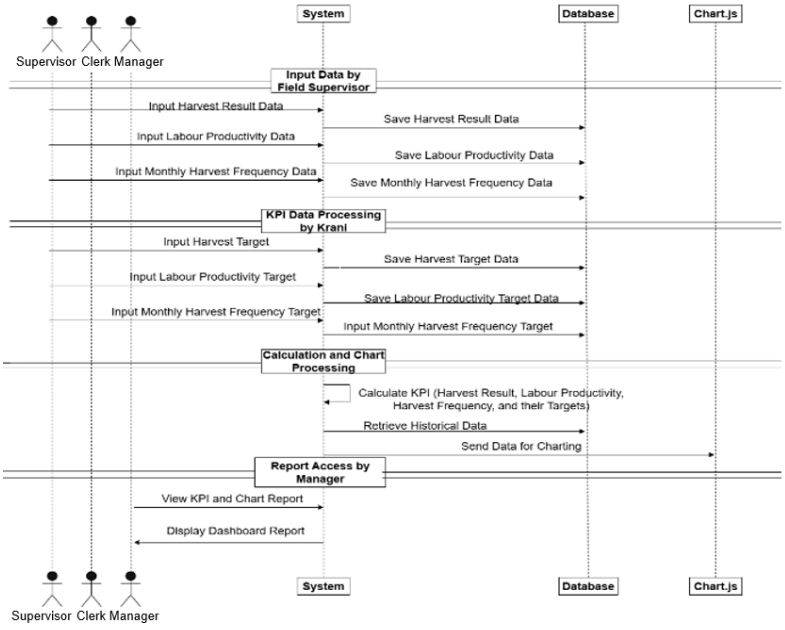

Figure 1. Sequence diagram.

This sequence diagram illustrated the data processing flow of palm oil harvest KPI [4]. The Field Supervisor entered the actual data for harvest results, labour productivity, and monthly harvest frequency, which were then stored in the database. Next, the Admin Staff entered the target data for each of these indicators and saved them accordingly. The system then calculated the KPI based on the stored actual and target data and retrieved historical data for further analysis. The calculation results were sent to Chart.js for visualization in graphical form. Finally, the Manager accessed the KPI report through the system dashboard to monitor overall harvest performance.

3.5.System implementation.

In interface development, HTML and CSS were used to create responsive and structured page displays. The PHP programming language was used as server-side scripting to manage system logic and data interactions. The coding process was carried out using Visual Studio Code as the primary text editor, which supported various web development extensions. For local development needs, XAMPP was used as a local server that provided an Apache and MySQL environment. Meanwhile, MySQL acted as a database management system to store, manage, and process all harvested data and performance indicators generated by the system. This combination of tools supported an efficient, flexible, and structured system development process. Figure 2 shows the oil palm harvest dashboard of PTPN IV Regional 2, with a total harvest of 391,736 kg over 68 days and a productivity of 1,516.80 kg per workday. The chart illustrated that the peak harvest, frequency, and productivity occurred in the second month before declining in the third month.

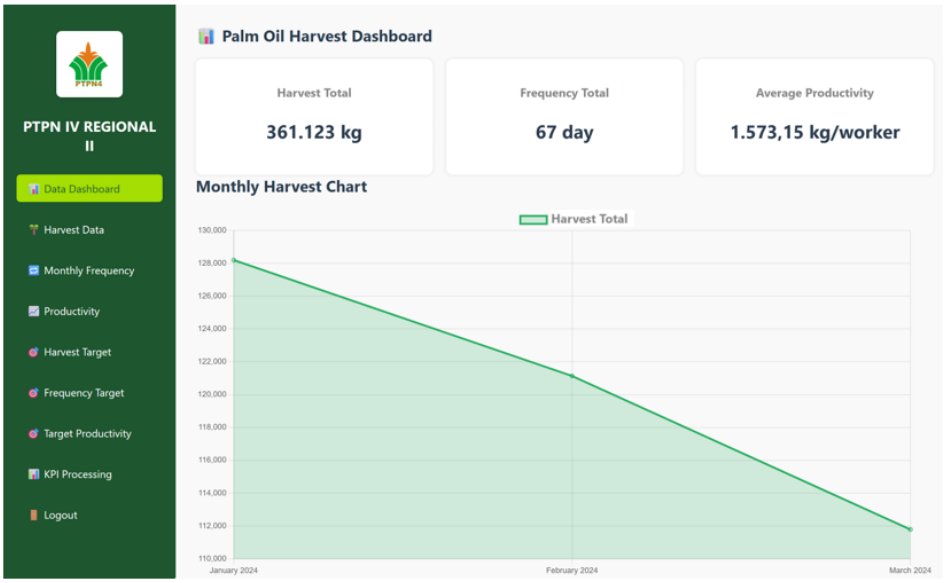

Figure 2. Dashboard page.

Figure 3 presents the "Add Harvest Data" input form on the harvest information system of PTPN IV Regional 2. This form required the field supervisor to enter harvest data based on the date, block, afdeling, planting year, and harvest quantity (kg).

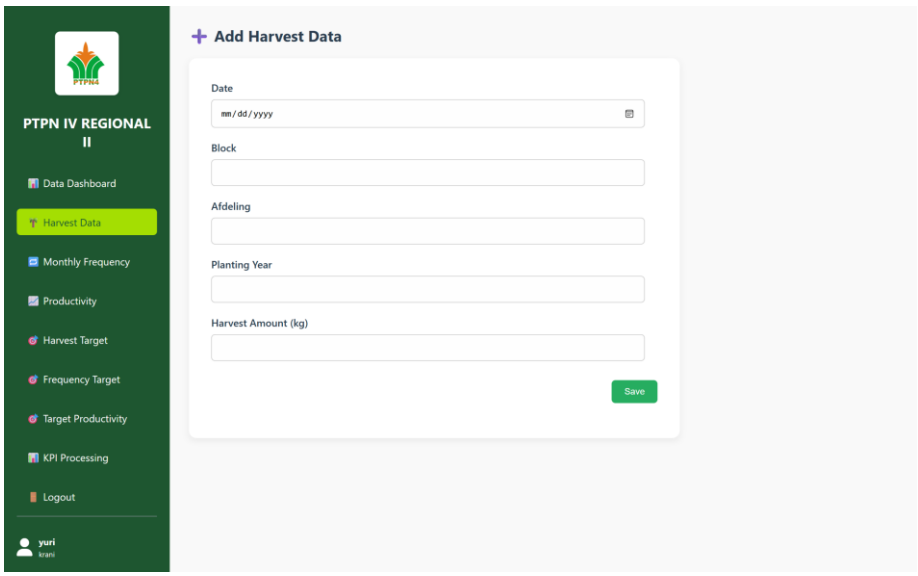

Figure 3. Harvest data input page.

Figure 4 displays the “Harvest Results Data” on the PTPN IV Regional 2 system. The figure recorded harvest data based on the date, block, afdeling, planting year, harvest quantity (kg), and the responsible officer (Field Supervisor).

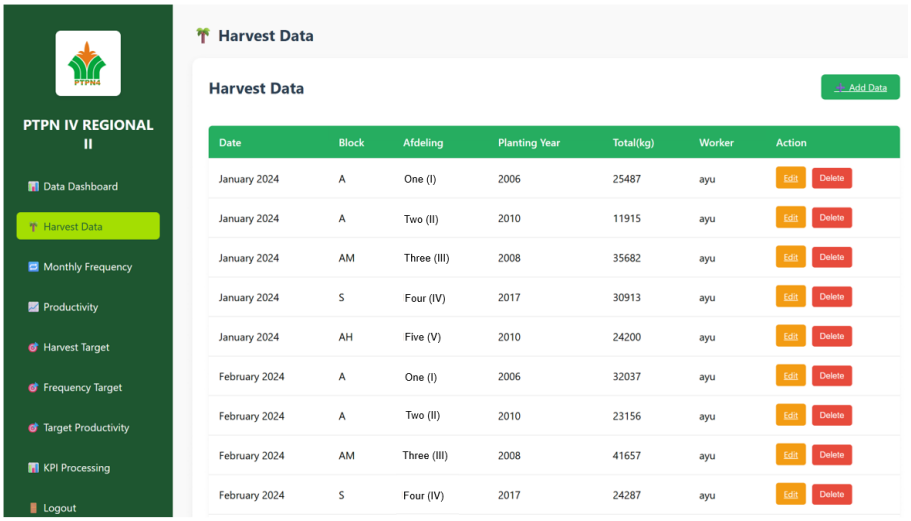

Figure 4. Harvest results data page.

Figure 5 shows the “Harvest Target” section of the PTPN IV Regional 2 system. The figure presented target harvest data per afdeling and block for a specific month, with columns for date, afdeling, block, and target (kg). Figure 6 illustrates the "KPI Processing" page of the PTPN IV Regional 2 system, which presented KPI related to oil palm harvest, harvest frequency, and labour productivity. The fgure included columns for month, block, KPI type, target, actual result (realisasi), KPI percentage, KPI score, and status. Status indicators were color-coded to reflect achievement levels, such as “Meets Expectations,” “Exceeds Expectations,” and “Almost Meets Expectations.” This page helped monitor and evaluate performance based on set targets across different blocks and time periods.

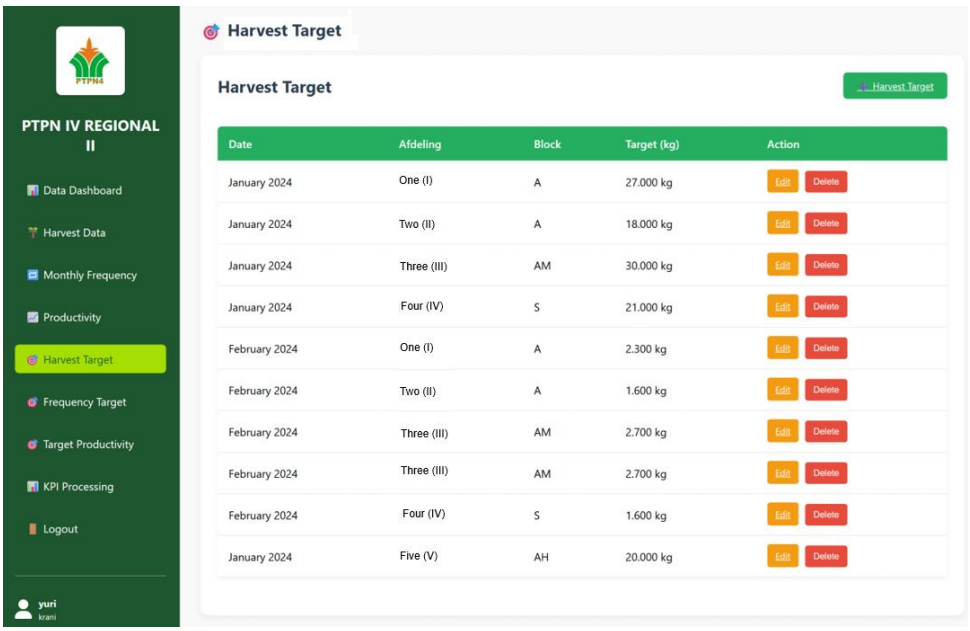

Figure 5. Harvest target data page.

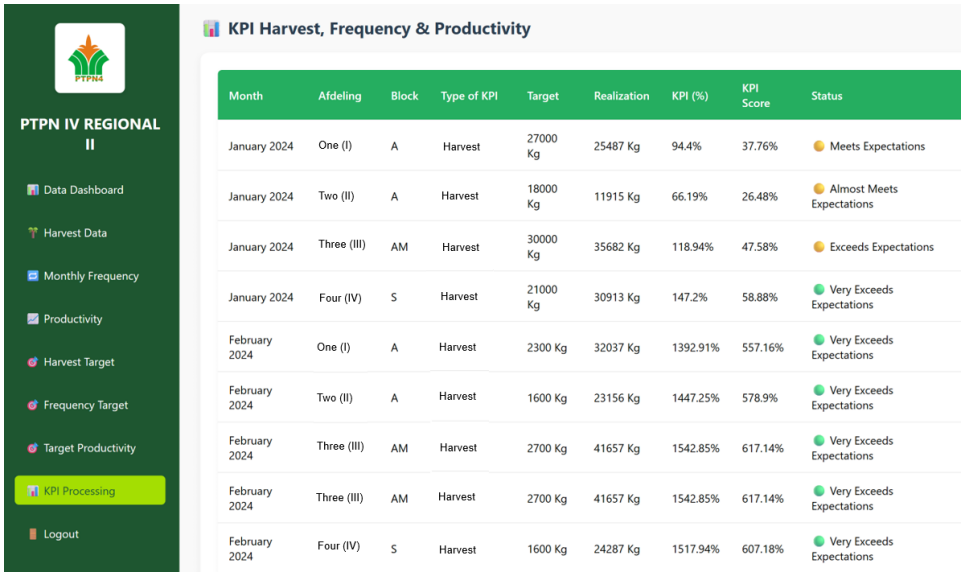

Figure 6. KPI Processing page for harvest, frequency, and productivity.

Table 4 presents the system testing results. All tested features, including login, dashboard display, harvest data input, KPI target input, KPI calculation, data editing/deletion, and logout functions, passed their respective test cases, demonstrating that the system operated as intended.

Table 4. System testing results.

No	Feature	Test Case	Expected Result	Status
1	Login Page	Enter valid username and password	Redirected to dashboard page	Passed
2	Dashboard Display	Open dashboard after login	KPI graphs are displayed	Passed
3	Harvest data input	Submit valid harvest data	Data saved and listed	Passed
4	KPI target inout	Submit KPI targets for afdeling/ block	Target stored sucessfully	Passed
5	KPI calculation	System calculates KPI from actual vs target	KPI is calculated accurately	Passed
6	Edit & Delete Data	Edit or delete existing harvest data	Data is updated or deleted	Passed
7	Logout Function	Click “Logout” button	Redirected to login page	Passed

Based on previous studies, this research shared similarities with earlier works in the development of monitoring information systems. For instance, the study by Erlina and Amanda

Putri [4] also aimed to reduce the potential for fraud and improve operational effectiveness through a monitoring system. However, this study offered added value by integrating the KPI method, which enabled objective performance evaluation based on measurable indicators such as labour productivity, harvest yield, and harvest frequency. Likewise, the research conducted by Khalilah Dulay and Santoso [18] emphasized the importance of monitoring systems in facilitating harvest data tracking, but it did not explicitly implement KPI as a structured performance evaluation method. Therefore, the integration of the KPI approach in this study was expected to support more effective and data-driven decision-making processes.

4. Conclusions

The implementation of the KPI in the harvest monitoring information system at PTPN IV Regional II Unit Adolina provided a more measurable, objective, and efficient performance evaluation. By utilising three main indicators—total harvest yield, labour productivity, and monthly harvest frequency—the system enabled management to monitor target achievement and enhance data-driven decision-making. The findings showed that some afdeling units exceeded their performance targets, while others required improvement. The system was also effective in minimising data recording errors and accelerating information access through an easy-to-understand dashboard. This study contributes to the advancement of monitoring systems in plantation management by demonstrating how KPI integration can improve transparency, accuracy, and operational efficiency. While the system proved effective in its current scope, its application was limited to a single regional unit. Future research could expand the implementation across multiple regions, integrate real-time data acquisition, and incorporate predictive analytics to further support strategic decision-making.

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Author contribution

he authors confirm the following contributions to the paper: study conception and design: Diah Ayu Rina Sari, Muhammad Dedi Irawan; data collection: Diah Ayu Rina Sari; analysis and interpretation of results: Diah Ayu Rina Sari, Muhammad Dedi Irawan; draft manuscript preparation: Diah Ayu Rina Sari, Muhammad Dedi Irawan. All authors reviewed the results and approved the final version of the manuscript.

Competing Interest

The authors declare that they have no competing interests, whether financial or non-financial..

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