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Streamlining the Process of Sample Registration to a Paperless System

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Abstract

The purpose of this paper is to improve the sample registration management at the Central Analytical Laboratory (CAL) of Johor Plantations Group Berhad by introducing a change in the existing system from a manual to a paperless system. The primary aim is to enhance operational efficiency, accuracy, and customer satisfaction. The PDCA (Plan-Do-Check-Act) method incorporates Lean and Kaizen strategies to eliminate waste in the current manual system. The team also utilized other tools such as Ishikawa Diagrams, Multi-Voting, and Value Stream Mapping (VSM) in problem identification and solution development. After some pilot studies, the Excel-based digital registration system was implemented and tested through a pilot trial, followed by training and feedback collection from the users. The transition to a digital system significantly improved process efficiency, reducing the Value-Added Time (VAT) from 151.32 minutes to 64.35 minutes and Non-Value-Added Time (NVAT) from 2643.18 minutes to 0.92 minutes, achieving a Process Efficiency (%PE) increase from 5.41% to 98.59%. User feedback indicated high satisfaction with the new system, citing improvements in data accuracy, turnaround time, and overall operational efficiency. The implementation of a paperless sample registration system at CAL has led to substantial improvements in operational efficiency and customer satisfaction. The study demonstrates the effectiveness of digital transformation in laboratory settings, aligning with sustainability goals and contributing to cost savings and corporate social responsibility. The findings underscore the importance of continuous improvement and the potential for further enhancements through integration with advanced laboratory information systems.

Keywords
Lean, Six Sigma, kaizen, value steam mapping, process efficiency

1. Introduction
Central Analytical Laboratory (CAL) operates within the R&D Agricultural Services Division of Johor Plantations Group Berhad (JPG), providing a comprehensive array of laboratory services to both internal and external customers, focusing on supporting the company and agricultural community in achieving their objectives.

CAL provides exceptional services to its customers. To achieve and maintain customer expectations, CAL is integrating the Kaizen philosophy into its operations. Kaizen emphasizes continuous improvement through small, incremental changes and active employee involvement, which has proven to enhance operational efficiency and quality. Brunet & New (2003) highlighted that implementing Kaizen can lead to significant improvements in productivity, waste reduction, and overall organizational performance. By adopting these principles, CAL ensures that it remains at the forefront of operational excellence, consistently delivering superior value to its customers and fostering a culture of continuous improvement.

Turnaround time (TAT) has become the major key performing index for CAL's customers. This prompt feedback is essential for making informed decisions regarding crop management practices, maintaining the quality of products, and ensuring compliance with local regulations and acts. CAL to maintain satisfactory TAT, as it will influence the overall customer satisfaction with the laboratory's services, ultimately impacting its reputation and continued support from the customers (Hailu et al., 2020; Zawawi & Justinia, 2017).

CAL faces challenges with its current manual samples registration system in terms of operation efficiencies to manage approximately 20,000 samples and over 120,000 analyses annually. These samples are categorized by the type of samples that will be registered into individual intake books which are foliar, fertilizer, water, effluent, and palm oil. The existing system relies on standardized forms compiled into books for each sample type, resulting in hundreds of pages by year-end, leading to issues such as human errors, material damage, methodological inefficiencies, equipment shortages, and environmental concerns.

This manual system introduces inefficiencies and difficulties in processing customer test requests, managing payment processing and outstanding payments, and summarizing monthly productivity. Additionally, the increased potential for errors further hinders overall laboratory performance and data management. Transitioning to a Laboratory Information System (LIS) appears to be an ideal solution to address these issues as it can significantly address the challenges highlighted above. This is supported by the findings from Alenazi & Bugis (2023), that implementation of LIS can improve patient care, reduce human error, and lower operating costs by standardizing laboratory tests, procedures, and workflows. However, the high cost of acquiring the LIS has been a major obstacle for CAL, necessitating the search for more affordable alternatives.

The project on streamlining the sample registration process to a paperless system is necessary for enhancing operational efficiency, accuracy, and customer satisfaction. The current manual system is inefficient and prone to errors, impeding the laboratory's ability to handle a large volume of samples effectively. Implementing a paperless system would streamline workflows, enhance data management, and ensure timely feedback, thereby benefiting agricultural stakeholders significantly.

Improved TAT directly correlates with higher customer satisfaction, essential for maintaining CAL's reputation and customer support (Jaffar & Ismail, 2023). Additionally, transitioning to a paperless system aligns with JPG's sustainability goals leading to cost savings and corporate social responsibility (Kulim (Malaysia) Berhad, 2023). This project contributes to the field by introducing cost-effective solutions and establishing alternative practices that improve industry standards, particularly in agricultural laboratory services. By promoting customer-centric approaches and utilizing widely available basic software, the project ensures that advanced data management systems are accessible to a broader range of users, enhancing operational efficiency and customer satisfaction.

1.1 Scope and limitations

This paper focuses on improving the sample registration management at the Central Analytical Laboratory (CAL) of Johor Plantations Group Berhad (JPG) by transitioning from a manual to a paperless system. The primary aim is to enhance operational efficiency, accuracy, and customer satisfaction. The study employs the PDCA (Plan-Do-Check-Act) method, incorporating Lean and Kaizen strategies to eliminate waste in the current manual system. The scope includes the implementation of a digital registration system, process efficiency analysis, user satisfaction assessment, and alignment with sustainability goals. The study explores the transition from manual logbooks to an Excel-based digital registration system, including pilot testing, training, and feedback collection. It evaluates the impact of the digital system on process efficiency, specifically focusing on Value-Added Time (VAT), Non-Value-Added Time (NVAT), and Process Efficiency (%PE). Additionally, the study assesses user satisfaction with the new system through feedback mechanisms and surveys and examines how the digital transformation aligns with JPG's sustainability goals, contributing to cost savings and corporate social responsibility.

However, the study has several limitations. The sample size is limited to the CAL of JPG, and the findings may not be generalizable to other laboratories or industries. The technological constraints of relying on Microsoft Excel for the digital registration system are acknowledged, as Excel may not offer the same level of functionality and integration as more advanced Laboratory Information Systems (LIS). The study highlights the cost-effectiveness of the Excel-based system but does not provide a detailed cost-benefit analysis compared to other potential solutions, such as cloud-based or open-source LIS. Human factors, such as resistance to change and varying levels of digital literacy among staff, may impact the effectiveness of the new system. Additionally, the paper does not extensively address data security and privacy concerns associated with the digital registration system. Future studies should explore these aspects to ensure compliance with regulatory requirements and protect sensitive information.

1.2 Problem Statement and Objectives

The problems highlighted by the CAL's team are the operational efficiencies and limitations of the current laboratory sample registration process, the logbook. Operating a manual sample registration process is inefficient and susceptible to errors. CAL's manual sample registration system is less efficient and error-prone in managing a high volume of samples and analyses, complicating data management and processing.

The current system of maintaining five individual sample registration logbooks for different sample types (foliar, fertilizer, water, effluent, and palm oil) results in significant operational inefficiencies and challenges. This manual process leads to common problems such as human errors, data redundancy, and difficulty in data retrieval. Producing monthly reports on laboratory progress is particularly challenging, as data from all logbooks must be manually extracted and summarised, which is time-consuming and prone to errors. Additionally, monitoring laboratory performance, tracking sample and payment progress, and ensuring timely updates are difficult tasks under this system. Transitioning to a LIS would help, however, the high cost requires more affordable alternatives.

The objective of this paper is to share the experience and outcomes of a team from a medium-sized plantation laboratory that applied the PDCA method to investigate the challenges of the work process and develop paperless intake books by streamlining the sample registration process to a paperless system.

2. Literature Review

In the competitive and fast-paced environment of laboratory services, turnaround time (TAT) is a critical metric that directly impacts customer satisfaction and operational efficiency. TAT is defined as the total time from sample receipt to result delivery. TAT is crucial across clinical, research, and industrial laboratories, significantly enhancing customer satisfaction, especially in clinical settings where timely results are critical for effective patient care (Hawkins, 2007; Pati & Singh, 2014).

Findings by Lowe et al. (2014) and Zawawi & Justinia (2017) have shown that leveraging a Laboratory Information System (LIS) is crucial for achieving targeted TAT. An LIS is a software solution designed to manage and streamline laboratory work and data by facilitating seamless sample processing management from receipt to result delivery, thereby optimizing workflow efficiency and minimizing delays. It encompasses the handling of sample data, tracking of samples, management of test results, and integration with various laboratory instruments and external systems. It was also reported by Blaya et al. (2007) and Prasad & Bodhe (2012) that LIS has assisted in increasing laboratory productivity by improving turnaround time, optimizing resource utilization, and improving quality assurance and control.

The cost of owning and maintaining an LIS is often prohibitively high for small to medium-scale laboratories. Implementing a full-scale LIS involves significant expenses related to software acquisition, hardware requirements, system customization, and ongoing maintenance and support. Consequently, these laboratories must explore more economical data management solutions, such as cloud-based systems or open-source alternatives, to achieve efficient and reliable operations without incurring the substantial financial burden associated with traditional LIS implementations (Prasad & Bodhe, 2012).

Excel's intuitive interface and extensive help resources make it accessible even to beginners. The software offers a range of templates and built-in functions that simplify complex tasks, such as data analysis and visualization. According to Formby et al. (2017), Excel's user-friendly nature significantly enhances productivity and efficiency in data management tasks. Affordability compared to other specialized data analysis tools; Excel is relatively inexpensive. It is often included in Microsoft Office bundles, which are commonly available at discounted rates, particularly for students and educational institutions. This affordability makes it an attractive option for individuals and organizations with limited budgets. Mota et al. (2021) have shown that the cost-effectiveness of Excel contributes to its widespread use in various sectors.

Open-source Laboratory Information Systems (LIS) are increasingly available due to their cost-effectiveness and flexibility, making them accessible to a wide range of laboratories, especially those with limited budgets. These systems promote transparency by allowing users to inspect and modify the source code, which can enhance customization and adaptability to specific laboratory needs. However, the open-source nature also introduces significant risks, particularly in terms of cybersecurity. The lack of dedicated support and the potential for unpatched vulnerabilities can expose laboratories to cyber threats, including data breaches and ransomware attacks. Therefore, while open-source LIS offer substantial benefits in terms of availability and customization, they require robust cybersecurity measures to mitigate associated risks (Patel et al., 2023).

3. Methods

The approach of this project was using the PDCA method. The PDCA method is highly beneficial in Kaizen projects as it fosters continuous improvement by providing a easy-to-understand structured framework for identifying, implementing, and evaluating incremental changes. According to a study by Singh & Singh (2015), the PDCA cycle enhances problem-solving efficiency, ensures systematic process control, and promotes employee involvement in quality improvement initiatives, ultimately leading to sustained operational excellence and increased organizational agility .

To summarize, the approach taken during this project is as in Figure 1.

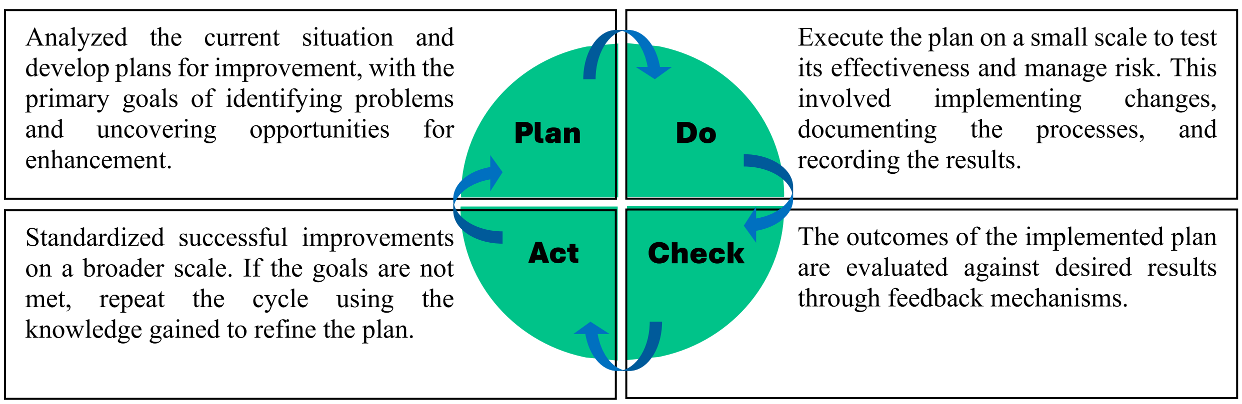

Figure 1. PDCA Method

3.1 Plan

Recognizing current challenges is the first step in understanding the root causes, setting clear objectives, and formulating actionable strategies to achieve desired outcomes. This stage lays the groundwork for the subsequent phases in the PDCA cycle (Realyvásquez Vargas et al., 2023). Figures 2 to 5 are examples of the previous procedures for recording sample registration.

Figure 2. Sample registration book for each sample type

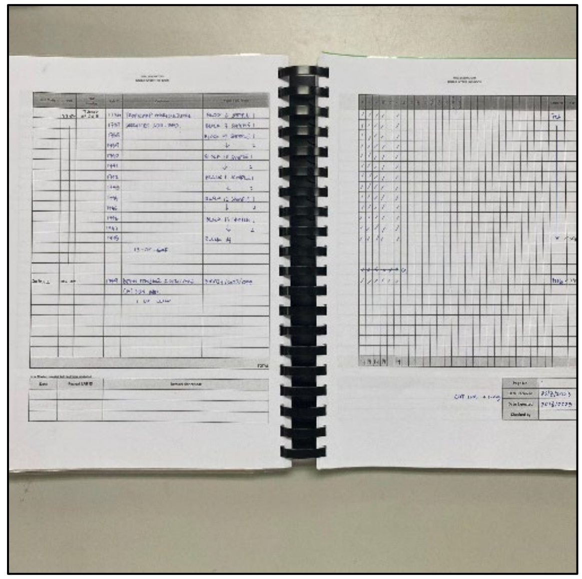

Figure 3. Sample registration record

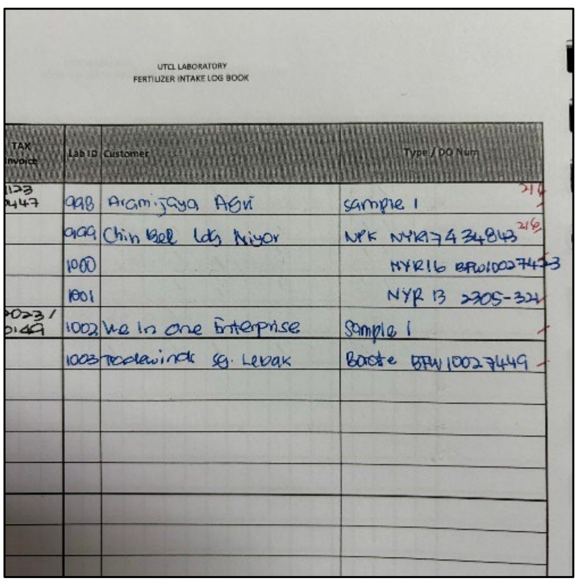

Figure 4. Example of bad handwriting

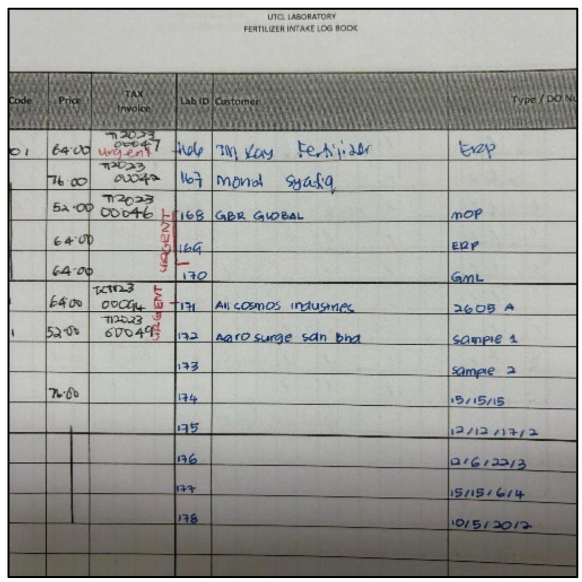

Figure 5. Manual fees calculation

i. Ishikawa Diagram

The Plan phase began the Kaizen process that the team pursued. This crucial stage involves a thorough analysis of the current process, identifying key challenges and opportunities for enhancement through comprehensive problem diagnosis. The team used an Ishikawa Diagram, also known as a fishbone diagram, with the problem or effect at the "head" and the causes extending as "bones" from the spine. Each bone represents a category of potential causes. It is a versatile graphical tool for problem-solving and quality management by identifying and categorizing the potential cause to determine the root causes (Coccia, 2018).

The team applied the 5M approach (Mother Nature, Machine, Material, Method, and Man) to brainstorm by category and find possible causes for the inefficiency of the sample registration process as illustrated in Figure 6.

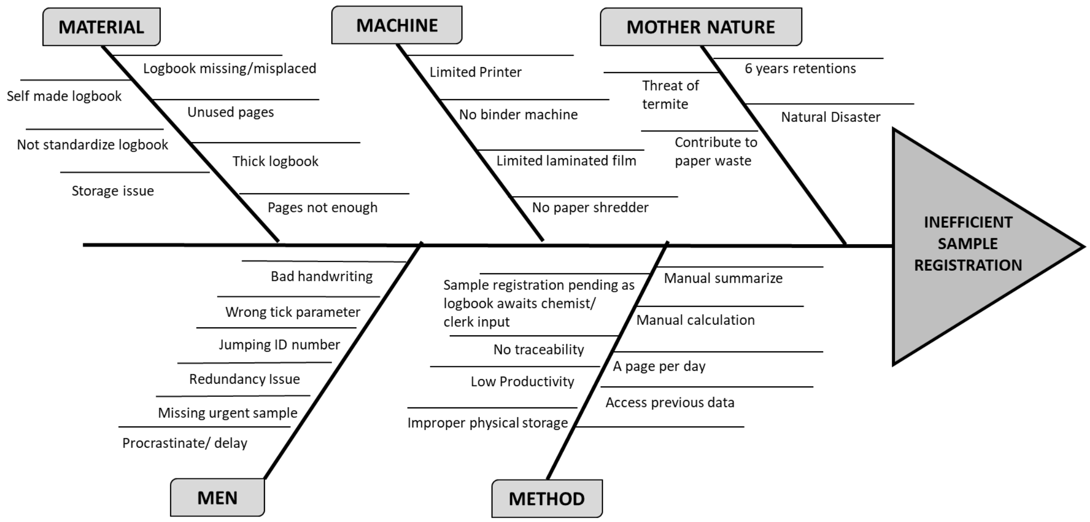

Figure 6. Ishikawa diagram of the possible causes of inefficiency of the sample registration process

ii. Multi-Voting

The likely reason was narrowed down and analyzed utilizing multi-voting. This method is subjective and relies on the team's understanding of the problem's most probable to least likely causes (Desai et al., 2015). The team was asked to

No	Problems	Criteria								Total marks	Ranked	To Do?
		Cost implication		Time implication		Frequency happen		Critical implication				
		× 4		× 3		× 2		× 1				
1	Bad handwriting	8	32	8	24	9	18	8	8	82	2	No
2	Wrong tick parameter	8	32	5	15	4	8	4	4	59	15	No
3	Jumping ID number	2	8	5	15	3	6	4	4	33	23	No
4	Redundancy issue	1	4	4	12	2	8	4	4	28	26	No
5	Missing urgent sample	7	28	7	21	1	6	6	6	61	14	No
6	Procrastinate/Delay	1	4	4	12	2	4	5	5	25	27	No
7	Logbook missing/ Misplace	3	12	2	8	1	2	2	2	24	28	No
8	Damaged logbook	5	20	9	27	3	6	6	6	86	1	Yes
9	Unused pages	1	4	1	3	2	4	1	1	12	29	No
10	Thick logbook	2	8	3	9	6	12	6	6	35	22	No
11	Pages not enough	3	12	7	21	5	10	7	7	50	18	No
12	Self made logbook	4	16	8	24	8	16	9	9	65	8	No
13	Not standardized logbook	1	4	4	12	4	8	5	5	29	25	No
14	Storage Issue	7	28	6	18	6	12	7	7	65	9	No
15	Manual summarizes	6	24	8	24	8	16	7	7	71	4	No
16	Manual calculation	7	28	8	24	8	16	8	8	76	3	No
17	A page per day	7	28	2	24	8	16	3	3	71	5	No
18	Access previous data	3	12	9	27	9	18	6	6	63	10	No
19	Limited access between department	4	16	8	24	8	16	7	7	63	11	No
20	Sample registration pending as logbook awaits Chemist/Clerk Input	5	20	7	21	5	10	6	6	57	16	No
21	No traceability	3	12	6	18	3	6	3	3	39	20	No
22	Low productivity	7	28	7	21	4	8	5	5	62	12	No
23	Improper physical storage	6	24	8	24	4	8	6	6	62	12	No
24	Limited printer	7	28	6	18	3	6	3	3	55	17	No
25	No binder machine	3	12	6	18	3	6	3	3	39	21	No
26	Limited laminated film	4	16	5	15	4	8	4	4	43	19	No
27	No paper shredder	2	8	5	15	2	4	2	2	29	24	No
28	6 years retentions	7	28	6	18	6	12	8	8	66	6	No
29	Natural Disaster	1	4	1	3	0	0	1	1	8	31	No
30	Threat of termite	7	28	7	28	3	6	4	4	66	7	No
31	Contribute to paper waste	2	8	2	6	5	10	1	1	15	30	No
Scale				1-3			4-7			8-10		
Description				Very low (less good)			Moderate			Veru high (best)		

Figure 7: Multi-voting on the possible cause of inefficiency of the sample registration process

vote on each likely cause based on four criteria: cost effect, time impact, frequency of occurrence, and crucial impact. The team voted on the causes, as shown in Figure 7, on a scale of 1 to 10, with 10 being the likely reason with the most influence on the problem and 1 representing the least impact on the problem. Only one probable reason was selected at this moment to tackle the urgency and time-consuming nature of the issue.

iii. Value Stream Mapping

Value Stream Mapping (VSM) is a lean-management method used to visualize and analyze the flow of materials and information required to bring a product or service from its inception to the customer. Originating from the Toyota Production System, VSM is a fundamental tool in lean methodology, aimed at identifying and eliminating waste, thereby improving process efficiency and effectiveness (Forno et al., 2014). It involves creating a visual representation of every step in a process, allowing organizations to see the entire value stream and pinpoint areas where improvements can be made (Noto & Cosenz, 2021).

In the context of CAL, VSM was used to improve the manual sample registration system. VSM helped the team understand the current situation (Current State) and plan for future improvements (Future State). Figure 8 shows the current state of the sample registration process. Value-Added Time (VAT) refers to the time spent on activities that directly contribute to meeting the activities' product while Non-Value-Added Time (NVAT) refers to the time on activities that do not add value to the product. On the other hand, Process Efficiency (PE) is a matrix used to evaluate the efficiency of a process by comparing the value-added time to the total lead time. The higher the %PE value, the more efficient the process (Ahmad et al., 2022). The sample registration process took 151.32 minutes of VAT, and 2643.18 minutes of NVAT, with a %PE of 5.41%.

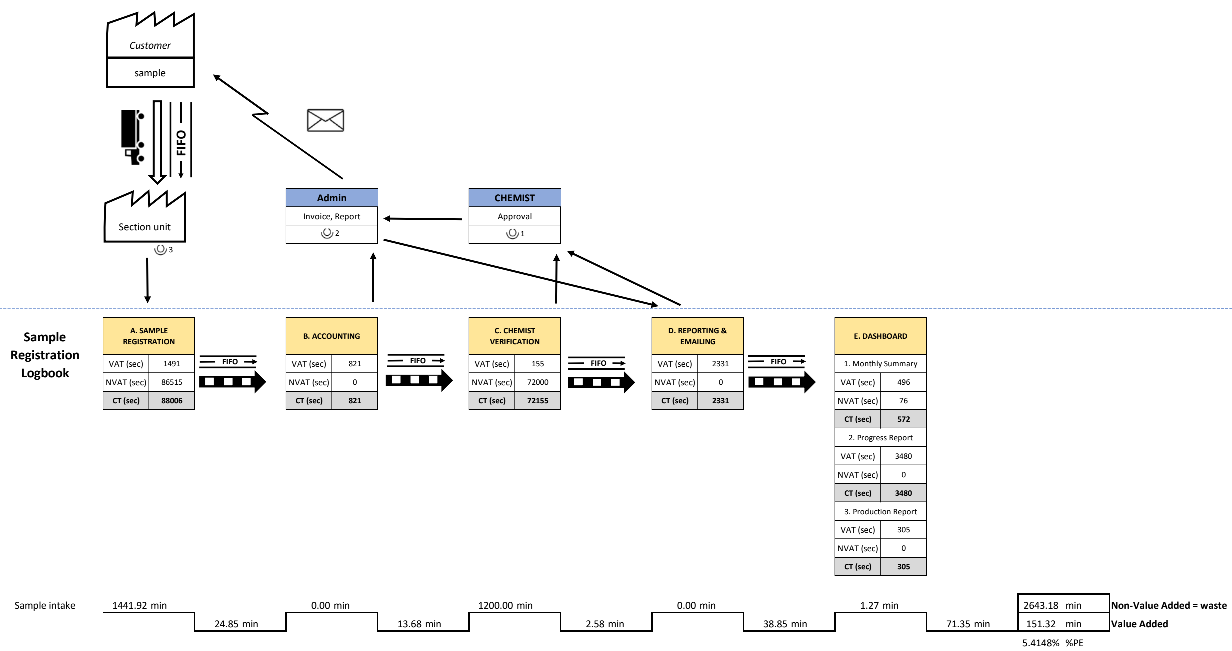

Figure 8. Value Stream Mapping of Sample Registration (Current State)

3.2 Do

In the "Do" phase of the PDCA cycle, the team implemented the planned changes on a small scale to test their effectiveness and manage potential risks. This phase involved several key activities:

i. Implementation of Digital Registration System:

The team adopted a digital registration system using Microsoft Excel to replace the manual sample registration logbooks. This system was chosen for its accessibility and ease of use, which significantly reduces the likelihood of human errors and improves data accuracy. According to Formby et al. (2017), Excel provides an interface and built-in functions that facilitate productivity in data management. In Figure 9, each team accesses sample Excel files through controlled cloud sharing via Microsoft SharePoint. Using Excel automates the calculation of customer fees, thereby minimising errors as shown in Figure 10.

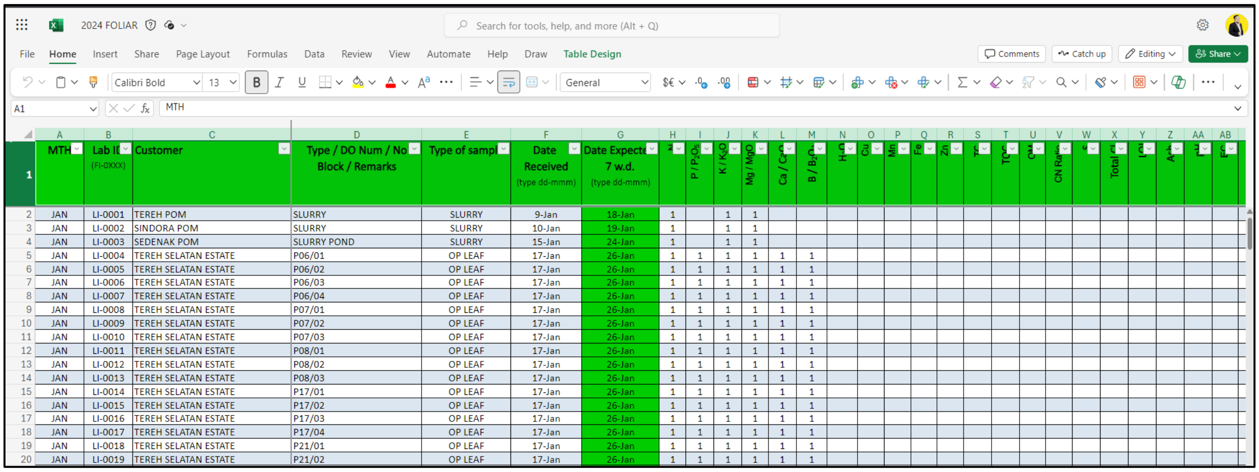

Figure 9. Access to MS Excel for Foliar Sample Registration System via limited access cloud sharing Microsoft SharePoint

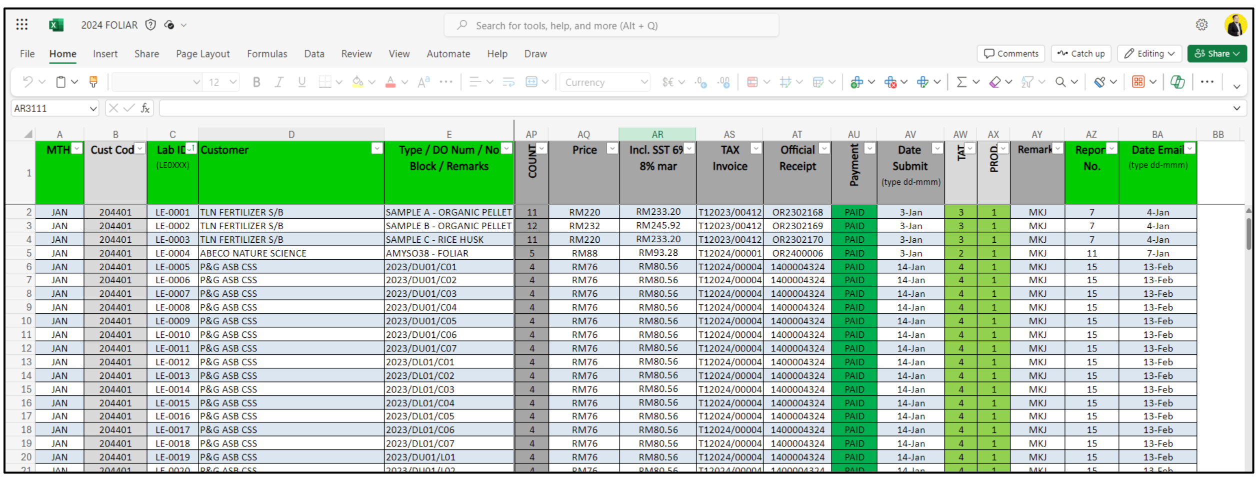

Figure 10. Automated calculating of analysis fees and samples turnaround time progress

ii. Pilot Testing

A pilot test was carried out to assess the new system's performance, focusing on a single section responsible for handling one type of sample. The objective was to test the new procedure and compare the outcomes with the manual process. This pilot phase helped identify any issues and offered insights for further refinements before implementing the system across other sections and ensuring the system meets operational requirements (Blaya et al., 2007).

iii. Training and Capacity Building:

The team members were trained on the new digital system to ensure smooth adoption and minimize resistance to change. Training sessions focused on the functionalities of Excel, data entry protocols, and troubleshooting common issues. Effective training is crucial for successful implementation, as highlighted by Singh & Singh (2015), who emphasize the importance of employee involvement in quality improvement initiatives. Figure 11 exhibits staff undergone training on the new digital sample registration system.

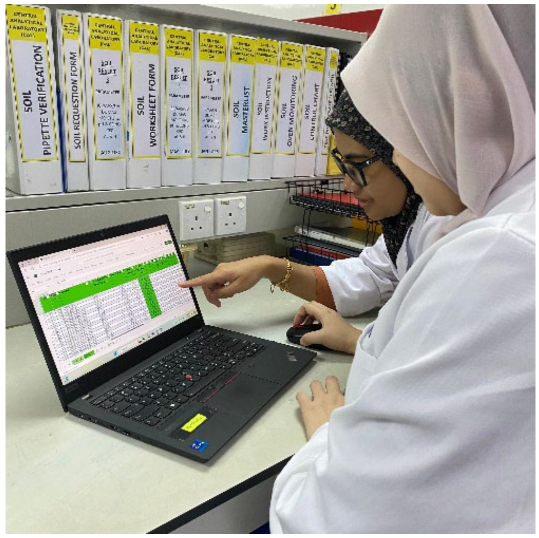

Figure 11. Training on new sample registration system

4. Results and Discussions

a. Check

In the "Check" phase of the PDCA cycle, the team evaluated the effectiveness of the implemented changes and assessed whether the desired outcomes were achieved. The following steps were undertaken:

i. Feedback Mechanisms:

Feedback from the users was collected to assess the new system's effectiveness and identify areas for improvement. This feedback was crucial for making necessary adjustments and ensuring the system met user needs. Incorporating user feedback is vital for the successful implementation of new systems in laboratory settings (Prasad & Bodhe, 2012). A questionnaire using Microsoft Forms was used to collect the feedback. It was critical to understand the user experience and identify any challenges faced during the transition. According to Zawawi & Justinia (2017), incorporating user feedback is vital for implementing and continuously improving new systems. Figure 12 presents the survey results on the new digital registration system.

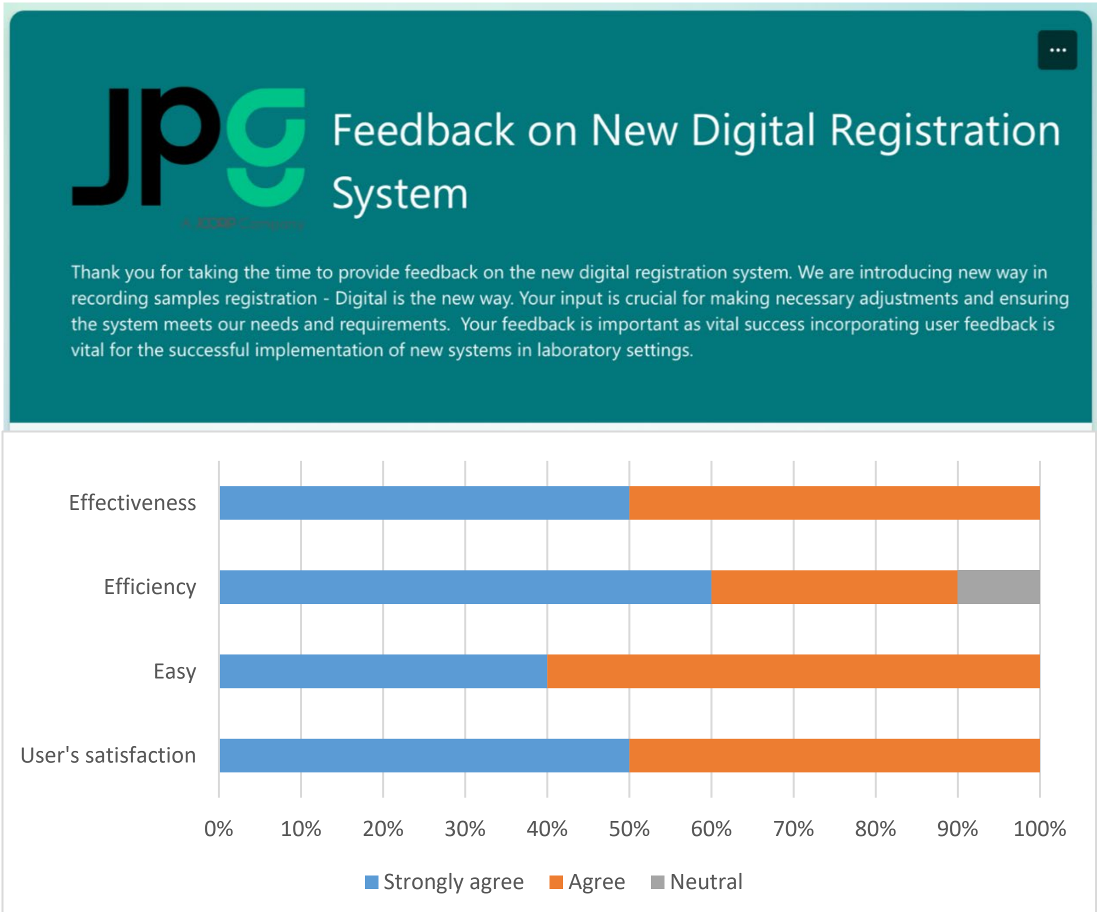

Figure 12. Feedback results on the new digital registration system

The feedback on the new digital registration logbook indicates a generally positive reception, with a significant proportion of users expressing strong satisfaction and agreement regarding its ease of use, efficiency, and effectiveness. Specifically, 50% of respondents strongly agree that the logbook meets their satisfaction, 40% find it easy to use, 60% believe it is efficient, and 50% feel it is effective. Additionally, another 50% of respondents agree on its user satisfaction, 60% on ease of use, 30% on efficiency, and 50% on effectiveness. However, a small percentage of users remain neutral about its efficiency, suggesting potential areas for improvement. Overall, the data highlights the logbook's success in meeting user expectations while also pointing to opportunities for further enhancement.

ii. Review of Documentation and Processes:

The team reviewed all documentation and processes related to the new system to ensure they were comprehensive and up-to-date. This review included checking the accuracy of data entries, the effectiveness of training materials, and the clarity of procedural guidelines. Effective documentation is essential for maintaining system integrity and ensuring compliance with regulatory requirements (Prasad & Bodhe, 2012).

b. Act

In the "Act" phase of the PDCA cycle, the team focused on standardizing successful improvements and making necessary adjustments based on the evaluation results. The following steps were undertaken:

i. Standardization of Processes:

The team documented the new digital registration processes and established standard operating procedures (SOPs) to ensure consistency and reliability. These SOPs were disseminated to all relevant staff members to ensure uniformity in the sample registration process. According to Realyvásquez Vargas et al. (2023), standardizing processes is crucial for maintaining quality and efficiency in laboratory operations. Figure 13 exhibits the operator registering samples into the sample registration system.

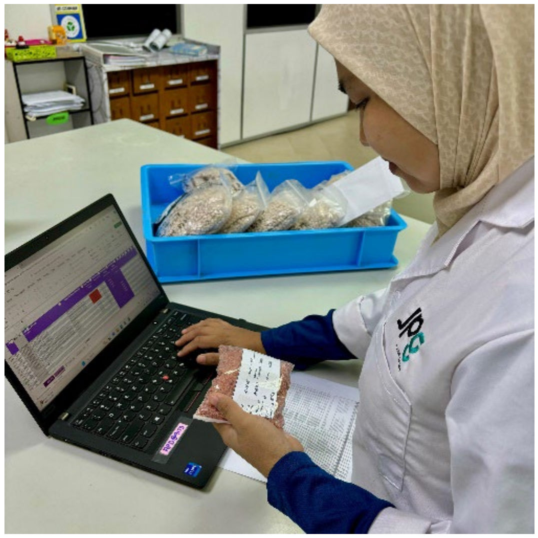

Figure 13. Sample registration into the Sample Registration System by the operator

ii. Full-Scale Implementation:

Following the successful pilot phase for the sample registration system for the first section, the digital registration system was rolled out across the entire section. This full-scale implementation included continuous support and troubleshooting to address any issues that arose during the transition. As noted by Singh & Singh (2015), providing ongoing support is essential for the successful adoption of new systems. Each sample registration system for fertilizer, effluent, soil, and water is shown in Figures 14 to 17.

The laboratory introduced a colour-coded sample registration system to differentiate sample types for easy identification. A study by Ozcelik et al. (2009)showed that this system improved efficiency in finding related information.

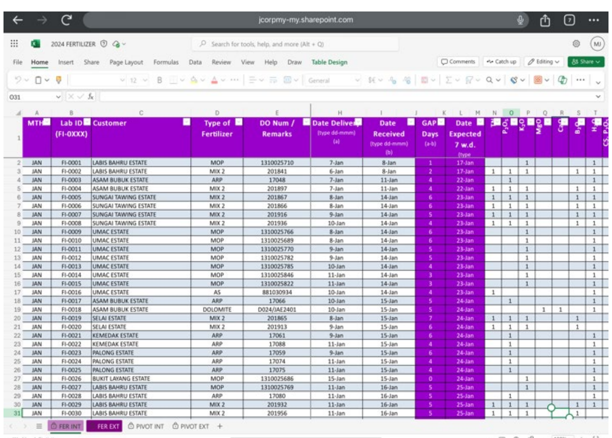

Figure 14. Example of the new Fertilizer Sample Registration System

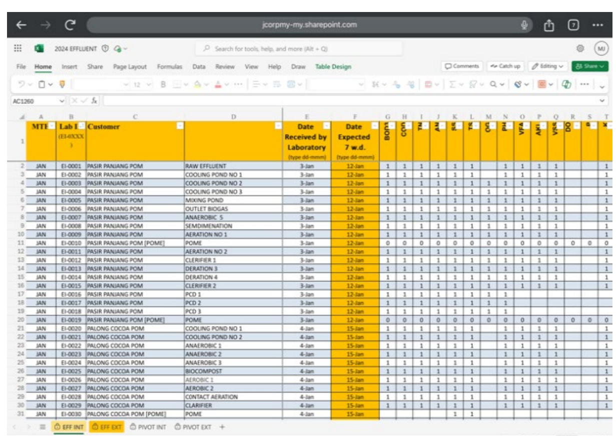

Figure 15. Example of the new Effluent Sample Registration System

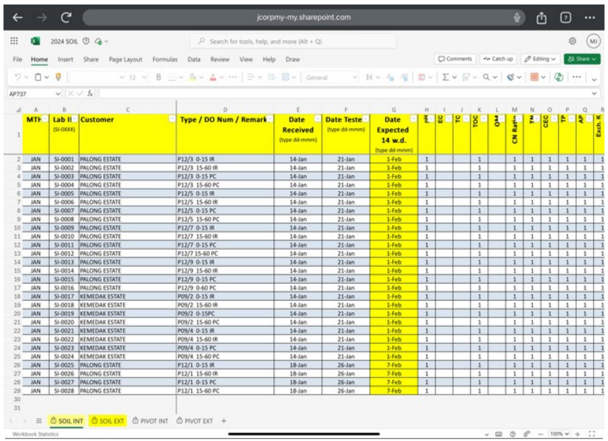

Figure 16. Example of the new Soil Sample Registration System

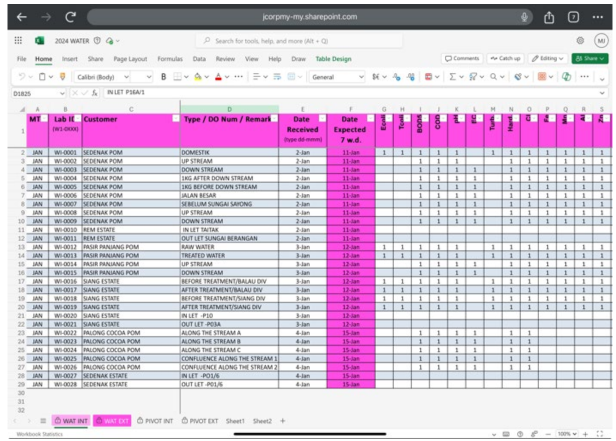

Figure 17. Example of the new Water Sample Registration System

A dashboard display is being established to sync all logbooks from the five sections in the cloud. Cloud sharing ensures automatic data synchronization from all five sample registration books. This data is then summarised to monitor the overall progress of the laboratory as shown in Figure 18. In Figure 19, details on laboratory progress are also calculated concurrently, allowing the laboratory manager to be aware of any pending operational issues. The financial aspects of the laboratory are now more easily monitored. Aging receivables can be tracked more efficiently against the established key performance index (KPI) due to the concurrent synchronization of data with other relevant information, as illustrated in Figure 20.

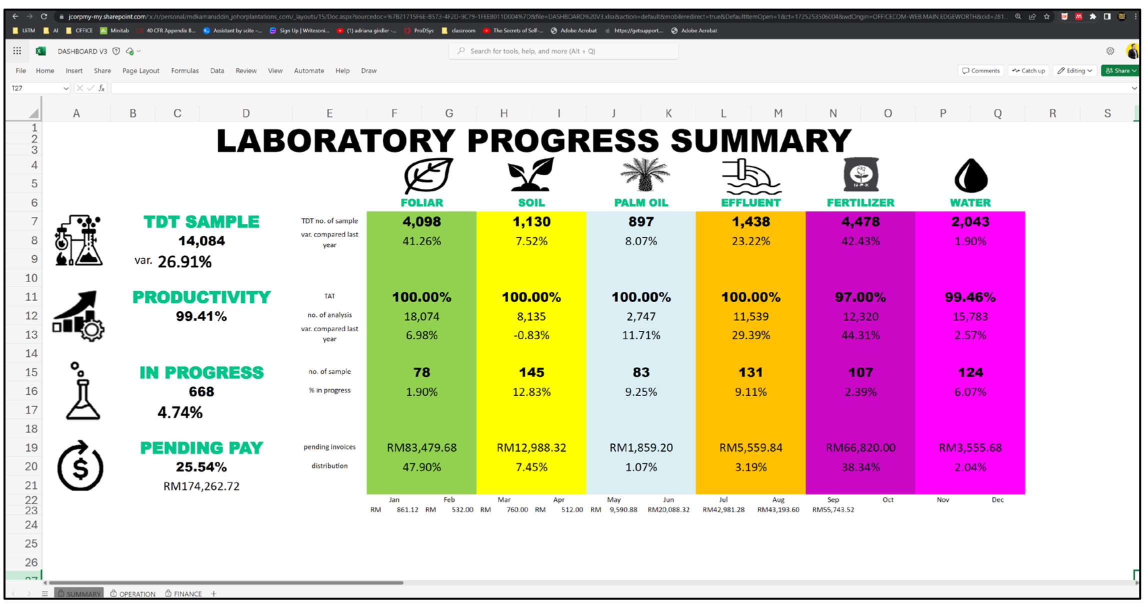

Figure 18. Dashboard summary on overall laboratory status

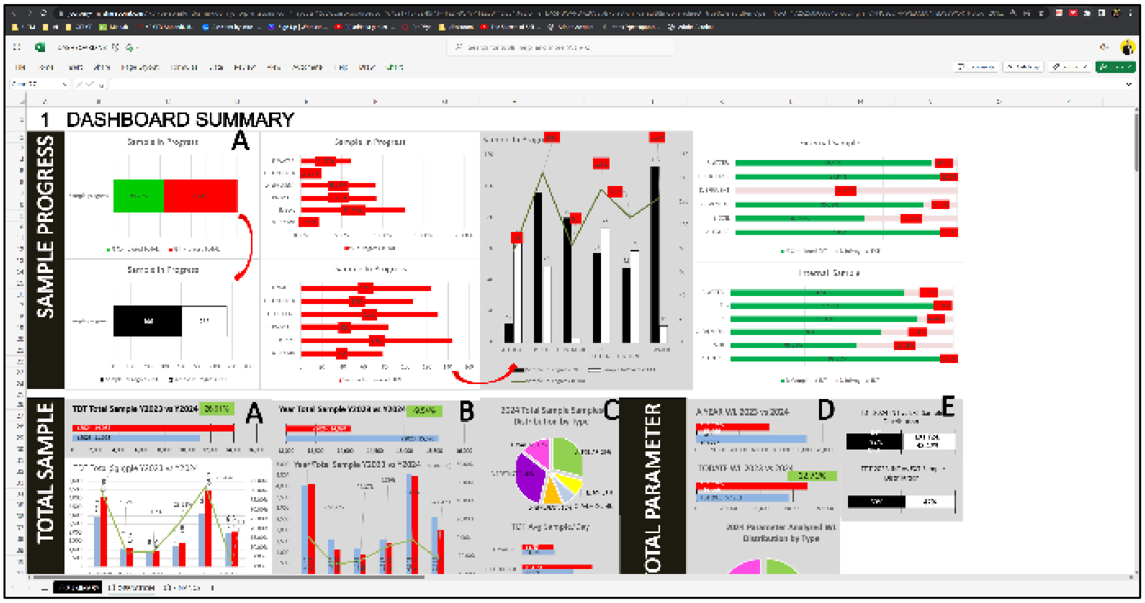

Figure 19. Summary on operation status

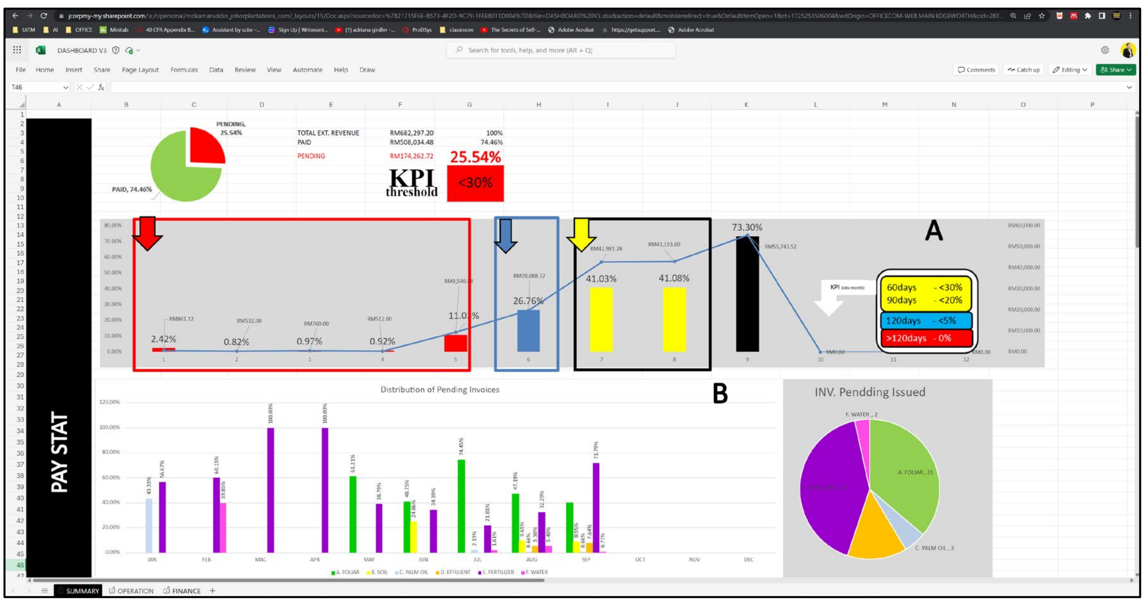

Figure 20. Summary on financial status

iii. Monitoring and Evaluation:

The team set up a monitoring system to regularly evaluate the performance of the digital registration system. Regular evaluations helped in identifying any areas for further improvement and maintaining high standards of operation (Hawkins, 2007). The VSM after implementation of the digital sample registration book was drawn. Figure 21 shows that the sample registration process took 64.35 minutes of VAT, and 0.92 minutes of NVAT, with a %PE of 98.59%.

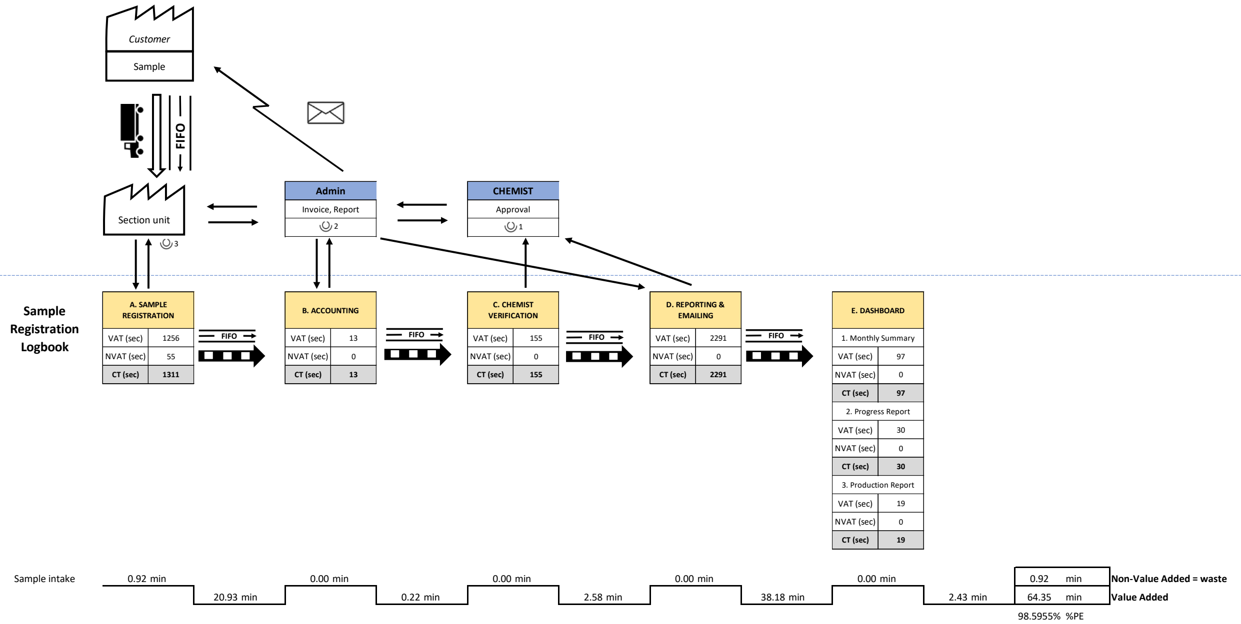

Figure 21. Value Stream Mapping of Sample Registration (Future State)

iv. Comparison with Benchmarks:

The performance of the new system was compared with the previous procedure to ensure it met the required quality and efficiency levels. This comparison helped in identifying any gaps and areas for enhancement. Pati & Singh (2014) emphasize the importance of benchmarking in maintaining high standards in laboratory operations.

The implementation of the new digital sample registration system has significantly reduced operating inefficiencies by eliminating the need for physical movement of logbooks. As detailed in Table 1, the total distance traveled by staff for logbook-related tasks decreased from 370 feet to 0 feet, representing a 100% reduction. This change not only saves time and reduces physical strain on staff but also improves accuracy, enhances accessibility, streamlines processes, and supports environmental sustainability. These improvements underscore the system's effectiveness in optimizing operational workflows and reducing inefficiencies, thereby contributing to a more efficient and sustainable organizational environment.

Table 1. Distance travel by staff to carry the logbook

Steps	Details	Before (ft)	After (ft)
1	After sample registration, staff bring the logbook intake to the admin area for sample charging	92	0
2	Admin returns the logbook to the section	92	0
3	Staff bring the logbook intake along with the report to the chemist's room for the verification process	71	0
4	Chemist sends the logbook intake to the admin area for reporting and summary	23	0
5	Admin returns the logbook intake to the section for sample registration	92	0
	TOTAL	370	0

5. Conclusion

The transition from a manual to a digital sample registration system at the Central Analytical Laboratory (CAL) of Johor Plantations Group Berhad has been a significant beginning step towards enhancing operational efficiency and accuracy. The manual system was exposed to issues such as human errors, material damage, methodological inefficiencies, equipment shortages, and environmental concerns. These challenges necessitated a shift to a more reliable and efficient system.

In the "Plan" phase, the team identified the key issues and developed a comprehensive strategy to address them. The "Do" phase involved implementing a digital registration system using Microsoft Excel, integrating it with existing laboratory instruments, and conducting extensive staff training. Pilot testing and feedback collection were crucial in refining the system before full-scale implementation.

The "Check" phase focused on evaluating the system's performance through data analysis, user feedback, and comparison with industry benchmarks. This evaluation helped identify successes and areas for further improvement. Finally, in the "Act" phase, the team standardized the new processes, rolled out the system across the laboratory, and established continuous training and feedback mechanisms to ensure ongoing improvement.

The adoption of the digital registration system has led to significant improvements in data accuracy, turnaround time, and user satisfaction. By standardizing processes and incorporating continuous feedback, CAL has created a more efficient and user-friendly sample registration process by standardising processes and incorporating continuous feedback. This transition not only enhances operational efficiency but also aligns with the organization's sustainability goals, contributing to cost savings and corporate social responsibility. The Value-Added Time (VAT) was reduced by 57.47% from 151.32 minutes to 64.35 minutes and the Non-Value-Added Time (NVAT) by 99.96% from 2643.18 minutes to 0.92 minutes. CAL enhanced percentage process efficiency from 5.41% to 98.59%. Physical activity also has been removed, saving time, decreasing strain, increasing accuracy, boosting accessibility, simplifying procedures, and promoting sustainability.

Through the adoption of the Kaizen mindset, CAL is committed to implementing lean operating principles. Ongoing discussions with JPG's Digital Division team aim to enhance the sample registration system to new levels. Additionally, discussions have begun on developing an in-house Laboratory Information System (LIS). This new system will be integrated with existing ecosystems, such as SAP S/4HANA (financial planning, budgeting, and reporting), SAP Ariba (purchasing and contract management), and KPlant (operation data platform), among others. This initiative highlights CAL's and JPG's commitment to continuous improvement and operational excellence.

Overall, the successful implementation of the digital registration system at CAL demonstrates the importance of embracing digital transformation in modern laboratories. It highlights the benefits of systematic planning, thorough evaluation, and continuous improvement in achieving long-term operational excellence.

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References

Ahmad, R., Amin, R. F. M., & Mustafa, S. A., Value Stream Mapping with Lean Thinking Model for Effective Non-value Added Identification, Evaluation and Solution Processes. *Operations Management Research*, *15*(3–4), 1490–1509, 2022. https://doi.org/10.1007/s12063-022-00265-9

Alenazi, S. M., & Bugis, B. A., The Role of Laboratory Information System in Improving the Delivery of Laboratory Services: A Recent Systematic Review. *Combinatorial Chemistry & High Throughput Screening*, *26*(8), 1451–1460, 2023. https://doi.org/10.2174/1386207325666220914112713

Blaya, J. A., Shin, S. S., Yagui, M. J. A., Yale, G., Suarez, C. Z., Asencios, L. L., Cegielski, J. P., & Fraser, H. S. F., A Web-based Laboratory Information System to Improve Quality of Care of Tuberculosis Patients in Peru: Functional Requirements, Implementation and Usage Statistics. *BMC Medical Informatics and Decision Making*, *7, 2007*. https://doi.org/10.1186/1472-6947-7-33

Brunet, A. P., & New, S., Kaizen in Japan: An Empirical Study. *International Journal of Operations and Production Management*, *23*(11–12), 1426–1446, 2003. https://doi.org/10.1108/01443570310506704

Coccia, M., The Fishbone Diagram to Identify, Systematize and Analyze the Sources of General Purpose Technologies. *Journal of Social and Administrative Sciences*, *4*(4), 291–303, 2018. https://ssrn.com/abstract=3100011

Desai, D. A., Kotadiya, P., Makwana, N., & Patel, S., Curbing Variations in Packaging Process through Six Sigma Way in a Large-scale Food-processing Industry. *Journal of Industrial Engineering International*, *11*(1), 119–129, 2015. https://doi.org/10.1007/s40092-014-0082-6

Formby, S. K., Medlin, B. D., & Ellington, V., Microsoft Excel®: Is It An Important Job Skill for College Graduates? In *Information Systems Education Journal (ISEDJ)* (Issue 3), 2017. http://www.isedj.org;http://iscap.info

Forno, A. J. D., Pereira, F. A., Forcellini, F. A., & Kipper, L. M., Value Stream Mapping: A Study about the Problems and Challenges Found in the Literature from the Past 15 Years about Application of Lean Tools. *International Journal of Advanced Manufacturing Technology*, *72*(5–8), 779–790, 2014. https://doi.org/10.1007/s00170-014-5712-z

Hailu, H. A., Desale, A., Yalew, A., Asrat, H., Kebede, S., Dejene, D., Abebe, H., Gashu, A., Yenealem, D., Moges, B., Yemanebrhane, N., Melese, D., Gurmessa, A., Mohammed, A., Getu, Z., Ayana, G., Kebede, A., & Abate, E., Patients' Satisfaction with Clinical Laboratory Services in Public Hospitals in Ethiopia. *BMC Health Services Research*, *20*(1), 2020. https://doi.org/10.1186/s12913-019-4880-9

Hawkins, R. C., Laboratory Turnaround Time. *The Clinical Biochemist Reviews*, *28*, 179–194, 2007.

Jaffar, M. K., & Ismail, A., Six Sigma Application to Reduce Variance In Turnaround Time for Fertilizer Analysis. *Proceedings of the 4th Asia Pacific Conference on Industrial Engineering and Operations Management*, 367–378, 2023. https://ieomsociety.org/proceedings/2023vietnam/112.pdf

Kulim (Malaysia) Berhad., *Integrated Report 2022, 2023*. www.kulim.com.my

Lowe, G. R., Griffin, Y., & Hart, M. D. (2014). Analysis of STAT Laboratory Turnaround Times Before and After Conversion of the Hospital Information System. *Respiratory Care*, *59*(8), 1275–1280, 2014. https://doi.org/10.4187/respcare.01814

Mota, M., Manuela Sá, C., & Cecília Guerra, Systematic Literature Review Using Excel Software: A Case of the Visual Narratives in Education. *Computer Supported Qualitative Research*, 325–340, 2021.

Noto, G., & Cosenz, F., Introducing a Strategic Perspective in Lean Thinking Applications through System Dynamics Modelling: the Dynamic Value Stream Map. *Business Process Management Journal*, *27*(1), 306–327, 2021. https://doi.org/10.1108/BPMJ-03-2020-0104

Ozcelik, E., Karakus, T., Kursun, E., & Cagiltay, K., An Eye-tracking Study of How Color Coding Affects Multimedia Learning. *Computers and Education*, *53*(2), 445–453, 2009. https://doi.org/10.1016/j.compedu.2009.03.002

Patel, A. U., Williams, C. L., Hart, S. N., Garcia, C. A., Durant, T. J. S., Cornish, T. C., & McClintock, D. S., Cybersecurity and Information Assurance for the Clinical Laboratory. *The Journal of Applied Laboratory Medicine*, *8*(1), 145–161, 2023. https://doi.org/10.1093/jalm/jfac119

Pati, H. P., & Singh, G., Turnaround time (TAT): Difference in Concept for Laboratory and Clinician. *Indian Journal of Hematology and Blood Transfusion*, *30*(2), 81–84, 2014. https://doi.org/10.1007/s12288-012-0214-3

Prasad, P. J., & Bodhe, G. L., Trends in Laboratory Information Management System. *Chemometrics and Intelligent Laboratory Systems*, *118*, 187–192, 2012. https://doi.org/10.1016/j.chemolab.2012.07.001

Realyvásquez Vargas, A., García Alcaraz, J. L., Satapathy, S., & Díaz-Reza, J. R., Plan-Do-Check-Act Cycle (PDCA) and Auxiliary Tools for Troubleshooting Manufacturing Processes. In *In The PDCA Cycle for Industrial Improvement: Applied Case Studies* (pp. 1–22), 2023. Springer. https://doi.org/10.1007/978-3-031-26805-2_1

Singh, J., & Singh, H., Continuous Improvement Philosophy – Literature Review and Directions. *Benchmarking*, *22*(1), 75–119, 2015. https://doi.org/10.1108/BIJ-06-2012-0038

Zawawi, R., & Justinia, T., Laboratory Information Systems and Analytical Turnaround Time. *Global Journal of Research and Review*, *4*(1), 2017. https://doi.org/10.21767/2393-8854.10005

Biographies

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Aziah Azri began her chemistry career in 1998, specializing in plant, fertilizer, soil, palm oil, effluent, water, and latex analysis. Her experience with Six Sigma led her team to win several awards, including a 3-Star Gold at the National Team Excellence Convention in 2015. She also earned first place in an Innovation and Creative project under the Kuntum Programme by the Malaysia Productivity Corporation (MPC). Currently, she is a laboratory specialist at the Central Analytical Laboratory, focusing on the ICP-OES Spectrometer, AAS, Total Chloride Analyzer, UV-Vis Spectrometer, and Dumas CNS Analyzer.

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