

Integrating Value Stream Mapping and Business Process Reengineering to Improve Operational Efficiency in Sustainable Teak Forest Production

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ABSTRACT

The purpose of this research is to identify inefficiencies in the sustainable teak forest production process and to optimize the business process by integrating Value Stream Mapping (VSM) and Business Process Reengineering (BPR). This research is important because improving production efficiency is essential to support sustainable forest management and enhance the effectiveness of business operations. The approach used in this research is an embedded mixed-methods case study, with data collected through observations, interviews, and documentation of operational activities within the company. The findings indicate that the major causes of inefficiency are time wasted due to waiting, overprocessing, and lack of coordination between work units, particularly during the legality verification process and the distribution of information. These conditions result in delays and reduce the overall efficiency of the production process. The use of VSM was successfully carried out to identify bottlenecks and non-value-added activities, while the implementation of BPR was able to reduce process complexity and integrate business processes. The redesign process resulted in an improvement in flow efficiency from 47.4% to 74.2% and a reduction in production lead time. These findings demonstrate that the integration of VSM and BPR can provide a systematic approach to improving production flow, reducing waste, and supporting more efficient and sustainable business processes.

Keywords: Business Process Reengineering; Value Stream Mapping; Operational Efficiency;

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi ketidakefisienan dalam proses produksi hutan jati berkelanjutan dan mengoptimalkan proses bisnis melalui integrasi Value Stream Mapping (VSM) dan Business Process Reengineering (BPR). Penelitian ini penting karena peningkatan efisiensi produksi diperlukan untuk mendukung pengelolaan hutan yang berkelanjutan serta meningkatkan efektivitas operasional bisnis. Pendekatan yang digunakan dalam penelitian ini adalah studi kasus mixed-methods tertanam (embedded mixed-methods case study), dengan pengumpulan data melalui observasi, wawancara, dan dokumentasi terhadap kegiatan operasional perusahaan. Hasil penelitian menunjukkan bahwa penyebab utama ketidakefisienan berasal dari pemborosan waktu akibat aktivitas menunggu, overprocessing, dan kurangnya koordinasi antarunit kerja, terutama pada proses verifikasi legalitas dan distribusi informasi. Kondisi tersebut menyebabkan keterlambatan dan menurunkan efisiensi keseluruhan proses produksi. Penggunaan VSM berhasil mengidentifikasi bottleneck dan aktivitas yang tidak memberikan nilai tambah, sedangkan penerapan BPR mampu mengurangi kompleksitas dan mengintegrasikan proses bisnis. Proses perancangan ulang menghasilkan peningkatan efisiensi aliran dari 47,4% menjadi 74,2% serta mengurangi waktu tunggu produksi.

Temuan ini menunjukkan bahwa integrasi VSM dan BPR dapat menjadi pendekatan sistematis untuk meningkatkan aliran produksi, mengurangi pemborosan, serta mendukung proses bisnis yang lebih efisien dan berkelanjutan.

Kata Kunci : Rekayasa Ulang Proses Bisnis; Pemetaan Aliran Nilai; Efisiensi Operasional.

INTRODUCTION

Presently, there are rising complexities associated with the sustainable forestry sector since there is increasing pressure in terms of improving efficiency, legal requirements, and sustainable operations. While companies need to achieve increased production output, it is also necessary for them to ensure legality, accountability, and efficient utilization of resources in a sustainable way. For forestry companies, the situation is particularly challenging since their production process is greatly dependent on natural conditions, geographical distribution, and cross-functional coordination, which makes their operational process less effective structurally (Norrman & Prataviera, 2023; Vukman et al., 2024). The matter of efficiency in this sense is therefore not only a question of technological improvement in production but also a strategic one for the competitive advantage of the modern forestry industry.

In today's operations management context, efficiency can be defined as how well an organization can generate efficient value flows by minimizing non-value activities. According to lean management theory, waste like waiting time, excess processing, excessive movement, and excess inventory are among the primary issues that impede the process flow and affect the productivity of organizations (Memari et al., 2022). Nevertheless, most implementations of lean management remain in the manufacturing industry due to its more predictable and less complex production process. In contrast, implementing lean management in the forestry industry presents multiple constraints, as its production process entails numerous complexities in terms of the environment, timber legality, and other aspects (Roux et al., 2025).

These conditions demonstrate that inefficiency in the forestry industry cannot be understood solely as a result of weak operational controls but also because of fragmented business processes. Many organizations still operate a function-based work system, where coordination between units is partial and administrative in nature. Therefore, information and resource flow become asynchronous, leading to bottlenecks and thus increasing cycle times of production. In reality, waste is systemic and a result of a lack of integration of organizational practices, rather than being caused by mistakes in operations (Noto & Cosenz, 2020). It indicates that any effort aimed at improving efficiency must be transformative in nature.

One possible solution that can be deemed relevant to solving this problem is business process reengineering (BPR). The BPR technique differs from the incremental continuous improvement strategy as it focuses on making dramatic changes in process design within an organization for better performance (Raffak et al., 2024; Vera & Zapata, 2022). The technique allows organizations to design their workflows, enhance coordination, and bring together activities that have traditionally been separate functions in an organization. In the case of the forestry sector, BPR becomes crucial due to the fact that inefficiency is largely attributed to other factors besides production processes (Monferdini & Bottani, 2024).

Nevertheless, the application of BPR without diagnostic tools may cause wrong actions. This scenario is why the combination of BPR and value stream mapping (VSM) has become an essential part of the development of advanced production processes. VSM makes it possible to map all materials and information flows in the process and, thus, identify waste, bottlenecks, and other factors that have no added value for the company (Ahmad et al., 2022). As applied to lean operations management, VSM visualizes

processes and acts as a tool for analyzing the interdependencies of operations.

A few recent research studies show that combining VSM and BPR may result in improved effectiveness of operations through simpler processes, shorter lead time, and higher flow efficiency (Silva et al., 2026). Nevertheless, the focus of the above research is on manufacturing activities and industries centered around production facilities. Few studies have examined the combination of VSM and BPR in industries based on natural resources, especially forestry and its sustainability. The lack of research on this topic, although forestry industries have specific operational features because of their dependence on ecology, environment, and geography, is understandable (Forzieri et al., 2024; Xie et al., 2023).

Apart from the constraints associated with the research framework, the operational efficiency concept tends to be considered a technical problem rather than being viewed from other perspectives. Specifically, the past research has not taken into account the external factors, including legislation, environmental governance, and timber legality (Abbas & Kumari, 2021; Obiki-Osafiele et al., 2024). This perspective results in an efficiency model that is overly mechanical and lacks relevance to the context of sustainable forestry business operations. The reality is that legislation such as the Timber Legality Assurance System (SVLK) becomes another element contributing to waiting time and bureaucracy if not incorporated into the design of processes and organizational systems. Therefore, operational efficiency in the forestry sector should be regarded as a complex phenomenon requiring the interplay between process structure, organizational systems, and external factors.

Based on these conditions, this research identifies three main gaps in the existing literature. First, empirical studies on the integration of business process reengineering and value stream mapping are still limited in the context of the sustainable forestry industry. Second, few studies simultaneously link operational efficiency with regulatory complexity and natural resource characteristics. Third, previous studies tend to separate waste identification and strategic intervention, thus failing to produce an integrative and systematic process transformation model. Therefore, this research seeks to develop an approach that serves not only as an operational analysis tool but also as a framework for organizational transformation that is more adaptive to sustainability demands.

In light of this gap, the objective of this study is to examine the reality of the teak forest production process and re-engineer business processes using the combination of BPR and value stream mapping techniques to enhance the efficiency of the business processes of the organization. The contribution of this study in theory lies in its expansion of the use of lean and BPR models in the highly complex environment of sustainable forestry management. Additionally, the practical contribution of this study lies in its development of a process transformation model for use by forestry firms in eliminating waste and improving flow efficiency.

THEORETICAL REVIEW

Efficiency in the Sustainable Forestry Industry. Operational efficiency, in terms of contemporary management, can no longer be viewed as the extent to which an organization can cut back on its production cost; rather, operational efficiency should be considered in terms of how capable an organization is at generating a responsive, flexible, and sustainable process flow (Cosa & Torelli, 2024; Setyadi et al., 2025). The issue of efficiency in the forestry sector has become a more complicated matter recently. The geographical specifics of production, extended chains, and significant amounts of paperwork render the

efficiency of forestry operations susceptible to waste that is caused by waiting time, redundant documents, and information dissemination lags (Sun & Gong, 2026). Hence, efficiency becomes dependent not only on the actual production process but also on the system of organizing processes in companies.

Several empirical studies recently conducted have revealed that many forest organizations continue to experience difficulties between their objectives for sustainable development and their ability to operate internally (Cyfert, 2026; Kaipainen et al., 2026). Classical concepts of efficiency cannot provide adequate solutions to this problem since they concentrate exclusively on production outcomes while ignoring issues of inter-departmental coordination and external control. Thus, most businesses adopt inefficient work models characterized by a bureaucratic nature, lack of speed, and poor adaptability to environmental shifts. Efficiency failure does not result from technical problems but rather from organizational technology mismatch, according to socio-technical systems theory (Govers & van Amelsvoort, 2023; Herrmann & Pfeiffer, 2023). Consequently, improving the efficiency of the forestry industry requires an approach that would enable effective optimization of business processes in the entire organization.

Lean Management and Identification of Waste. Over time, lean management has developed into a strategy with the objective of maximizing the value delivered to customers through the elimination of non-value-added activities within organizational processes. As lean management has been developing, lean is not viewed as just a method for cost reduction but rather as a philosophy that focuses on ensuring continuous flow, integrating processes, and making organizations more responsive to the changing environment (Qureshi, 2024; Rupp et al., 2024). This concept is important because many organizations today operate under conditions in which there are invisible sources of waste due to inadequate coordination, high bureaucracy, and inefficient flow of information.

However, the introduction of lean practices in natural resources-related industries is not an easy task compared to manufacturing industries. According to Ince et al. (2025), the implementation of lean practices in industries associated with natural resources, specifically those associated with wood, is associated with challenges related to high variability in the production process and the influence of external variables, including material and environmental regulations. In addition, existing lean practices only emphasize operational efficiency but overlook the sustainability issues and the complicated nature of institutional arrangements within organizations (Ooi et al., 2023). As a result, lean practices in many instances have failed in achieving systemic change since they are associated with efforts aimed at reducing waste without tackling its root cause within organizations.

Value Stream Mapping (VSM) as a Process Diagnostic Tool. Value Stream Mapping (VSM) is one of the fundamental tools applied in lean management that is utilized to document the flow of materials and information throughout the business processes. Value stream mapping helps businesses to identify and analyze both value-added and non-value-added activities within their operations to perform an effective source analysis. In particular, besides being a means for documenting process flows, VSM can be considered a valuable analytical tool that helps businesses understand relationships between activities, performance bottlenecks, and flow imbalances (Seth et al., 2017).

However, several researchers point out that contexts characterized by stable and standardized manufacturing processes are more prevalent when it comes to implementing VSM practices. In the context of its application to the forestry sector, for instance, VSM is associated with various challenges, including

difficulties caused by the complexity of supply chains, their geographic location, and significant regulation. Another limitation of the tool in question is linked to the fact that traditional VSM practices are often based on internal aspects of business operations and are therefore ineffective in terms of considering the dynamics of sustainability and external relationships (Heydarzade et al., 2025; Santos et al., 2019). Thus, to address the shortcomings described above, some researchers started creating the notion of sustainable value stream mapping that combines environmental and sustainability metrics into business process analysis.

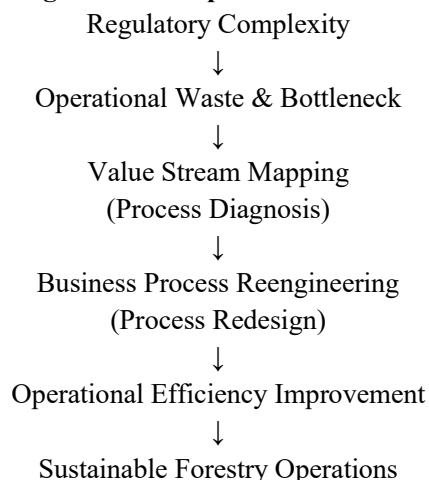
Business Process Reengineering (BPR) in Organizational Transformation. The concept of Business Process Reengineering (BPR) can be defined as an innovative strategy in which emphasis is placed on radical changes in designing business processes, thus resulting in substantial performance improvements. Unlike continuous improvement, BPR involves making radical changes by simplifying workflow, functional integration, and reduction of non-value-added activities (Kaur et al., 2022). The BPR strategy was devised in response to shortcomings associated with traditional organizations characterized by bureaucracy and fragmentation, thus reducing the agility of decisions made by organizations.

The organization's ability to systematically understand the root causes of inefficiencies greatly influences the success of BPR during its implementation. Most organizations tend to be unsuccessful in the implementation of BPR since they concentrate on the restructuring of the organization rather than process diagnosis (Yi et al., 2025). Most BPR research focuses on industries currently operating in the manufacturing and service sectors. However, the forest industry is an example of a sector where the use of BPR has been ignored despite the industry being faced by complicated organizational features such as interaction with production processes, environmental concerns, and legal issues.

Integration of VSM and BPR from a Sustainability Operations Perspective. It is becoming apparent that the adoption of VSM and BPR will lead to a more integrated strategy for creating modern operations systems. VSM is the ability to provide diagnoses as a way of uncovering problems in processes, while BPR acts as a change that will completely revolutionize the way work is done in an organization. Together, these two tools allow companies to discover where inefficiencies exist, as well as provide the means through which strategies can be implemented to improve the process design (Larsson et al., 2026). This process is especially important when considering sustainability operations since organizations are expected to become more efficient while still being sustainable and environmentally compliant.

A few empirical pieces of research found recently prove the usefulness of the integration of VSM and BPR in terms of improving flow efficiency, cycle time, and cross-functionality in an organization (Tezel et al., 2023). However, empirical studies on the integrated implementation of these two approaches in the sustainable forestry industry are still very limited. Most sustainability operations studies still position sustainability as an additional variable, rather than a core element in organizational process design. As a result, developed efficiency models often fail to capture the relationship between regulation, operational complexity, and long-term sustainability. Based on these conditions, this study positions the integration of VSM and BPR as a strategic framework for simultaneously building a more efficient, adaptive, and sustainable forestry production system.

Figure 1. Conceptual Framework



METHODS OF RESEARCH

The current research employs an embedded mixed-methods case study design to understand and improve business processes in a sustainable teak forest production system. The reason for using this approach is that problems concerning the operational efficiency of the forestry industry cannot be addressed through numerical or textual data alone; they need to be analyzed by combining both types of information. Case study design offers an opportunity for researchers to study the dynamics of business processes within the context of operations in an organizational setting, which are impacted by such factors as the regulatory environment, inter-departmental cooperation, and features of supply chain management systems associated with natural resource industries (Yin, 2018).

The research focused on the sustainable teak forest production process at a forestry company that implements a timber legality system and sustainable forest management standards. The location was selected purposively, considering three main criteria: the complexity of the production process, the involvement of the sustainability regulatory system, and indications of operational inefficiencies in the production and administration flow. The study was carried out for four months using direct observation of manufacturing operations, document distribution, and coordination processes within different work units. The emphasis during the observation was on the total process, from the acquisition of raw materials and processing of wood through legality checks to product delivery to customers.

Data collection was done using triangulation methods involving participant observation, semi-structured interviews, and documentation research. Interviewing was done using key informant interviews with operational managers, production supervisors, staff in the legal department, and field operators involved in the business's operations. The purposive sampling method was used during data collection to ensure that the informants were knowledgeable about the processes that took place in the field (Campbell et al., 2020). Apart from interviewing, there was also the use of organizational documents like production reports, lead time records, SOPs, and distribution processes.

Analysis of the operational processes was performed based on Value Stream Mapping (VSM). The first step in implementing the VSM method is conducting a current state map analysis to identify all value-added and non-value-added elements of the business process (Rother & Shook, 2003). Thereafter, a few

indicators such as cycle time, wait time, processing time, and flow efficiency are estimated to discover potential process bottlenecks and dominant waste types (Horsthofer-Rauch et al., 2024). This method helped the researchers analyze the relationships between processes and view inefficiencies not only as technical problems but also as results of ineffective organizational process management.

Following the identification process for waste, the next step in conducting the research was to carry out the Business Process Reengineering (BPR) phase as an initiative towards changing business processes. The researchers analyzed the operational processes to identify areas for improvement, combination, or streamlining. In doing so, the key areas where reengineering took place included streamlining the administration, minimizing the number of approvals, and enhancing coordination between production and legal processes. This method was chosen because it could make process improvements deeper than other methods (Ho et al., 2023).

Qualitative data analysis was done using thematic analysis approaches via the processes of data reduction, classification, interpretation, and conclusion-making. The interview data and the observations were coded to highlight patterns of waste, coordination problems, and structural elements that affect the efficiency of operations within the organization. In contrast, the quantitative data were analyzed using descriptive methods where the situation before and after business process reengineering was compared. The combination of qualitative and quantitative data helped provide an understanding of the change in process efficiency and its implications for the entire operations process within the organization (Creswell & Clark, 2017).

To ensure the quality of the research, the researcher implemented validity and trustworthiness strategies through source triangulation, member checking, audit trails, and peer debriefing. Triangulation was used to compare the results from the company's observation, interviews, and operational documents to ensure consistency. On the other hand, member checking was performed in the confirmation of the interpretation of the researcher by the informants to make sure that the data produced would be reflective of the true situation in the organization. Moreover, the application of an audit trail ensured that the research was able to attain sufficient levels of dependability and confirmability (Nowell et al., 2017). Through this procedure, this research aims to obtain practical yet methodologically sound results in sustainable operations management research.

RESULT AND DISCUSSION

Result

Based on the findings of this study, the sustainable teak forest production process in the company under study is still facing some inefficiencies structurally and cross-functionally. The study found that the production process is affected by both the technical wood processing and the flow of legal documents and coordination. Due to this problem, there is no synchronization between material and information flow. The problem results in delays in operational processes at particular points of operation. From the above findings, it can be seen that operational waste is not caused by one particular problem but by a systemic lack of integration of the business process design.

Observations of three production cycles revealed a total production lead time of 18.4 days, with an effective processing time of only 8.7 days. What it implies is that more than 50% of the company's operation time is spent on non-value-adding activities like waiting, rework checking, administrative transfers, and internal approvals. The flow efficiency analysis conducted revealed an initial value of 47.4%, which shows

that the flow efficiency of the company process is quite low. This revelation implies a significant disparity between value-adding activities and non-value-adding activities.

Current state value stream mapping results indicate that the main bottlenecks occur at the timber legality verification stage and the coordination of production document distribution. Currently, several different units repeatedly carry out the verification process without an adequate data integration system. This means that there is a need to go through the same paperwork several times before moving on to the next step in the process of production. Not only does this situation make people wait for longer periods, but it also causes a backlog of work, which then results in delays in the delivery of products to customers.

Along with administrative issues, the study also identified wastage in terms of material handling activities and coordination among production departments. Observations conducted at the site indicated that the process of transferring wood from one work point to another is yet unstructured, leading to wastage of transportation and idle time for production operators. At times, production operators need to get an instruction from the administration department to start the process of cutting and distribution. Such a condition leads to disruption in the rhythm of the work process among the production operators, thus extending their cycle time.

Interviews with operational managers revealed that the company has focused more on achieving production targets than on evaluating the overall process flow. Most operational decisions are still based on individual experience and informal coordination between work units. This situation makes it difficult for the company to systematically identify sources of waste because performance evaluations focus more on final output than process effectiveness. It was mentioned by one informant that production delays were often seen as the expected outcome of the legal process, whereas, in reality, most of the hindrances were caused by repetition of internal administrative processes.

Based on waste identification using a lean approach, four dominant types of waste were identified in the company's operational system: waiting, overprocessing, transportation, and unnecessary motion. The waiting waste is a result of the document queues and delays in approval processes between departments. The overprocessing waste occurs because of excessive administrative verification of legal documents that have already been verified before. Transportation and motion wastes are a result of improper coordination of production and distribution processes. These observations demonstrate that inefficiencies of the company have their origin not in its technical capabilities but in its process management.

To solve these issues, business process reengineering is carried out using a combination of business process reengineering and value stream mapping. The process of redesign involved streamlining the approval procedure, consolidating the verification process for legality, and minimizing the manual transfer of documents between departments. In addition to that, a coordination process based on the process flow was developed to ensure that the communication between the departments is not dependent on administrative hierarchy anymore. At this point, several separate processes have been combined into one.

The results of the future state map simulation showed a significant improvement in the company's operational performance. Total production lead time was reduced from 18.4 days to 11.2 days, while waiting time decreased by almost 52%. The flow efficiency rose from 47.4 percent to 74.2 percent following the process redesign. Such an increase is largely attributed to the elimination of repetitive inspections, faster dissemination of information, and easy coordination across functions. The above results show combining VSM and BPR can lead to more effective process improvements than partial or incremental approaches. Process Redesign Implementation: Improvement in Performance of the above results shows that process redesign implementation resulted in improved performance, as shown in Table 5.

Table 1. Comparison of Before vs. After Improvement

Indicators	Before	After	Change
Lead Time	18.4 hari	11.2 hari	↓39.1%
Flow Efficiency	47.4%	74.2%	↑26.8%

On the other hand, the process of implementing the redesign was not free of internal organizational difficulties. Interviews found that certain employees exhibited initial reluctance towards work procedure changes because of their knowledge of old-fashioned administrative practices. Moreover, process integration implied that the work culture of units that used to operate in a sectoral fashion had to be changed. In particular, cross-functional coordination faced difficulties in its initial stages because of the absence of common communication standards. Thus, the results obtained show that business process reengineering success depends not only on system design but also on organizational readiness to manage work changes together.

In summary, the findings from this research have indicated that the problem of inefficiency in the sustainable forestry sector is a multifaceted one that entails interrelationships between the structures of process, regulatory regimes, and coordination practices. The integration between value stream mapping and business process reengineering facilitates a more comprehensive approach to waste identification and the creation of process designs that can better adapt to sustainability requirements. This demonstrates that any improvements in efficiency in the forestry industry cannot be achieved solely through optimization of production processes but also through changing business process designs and organizational governance.

Discussion

Based on the research results, the inefficiency of the sustainable forestry industry can no longer be associated with the technical underperformance of the productive capabilities of enterprises; rather, it is determined by the fragmentation of business processes and poor integration of information flows between departments. The study proves that the operational inefficiencies in forestry companies have a structural character due to the fragmented process coordination systems, administrative processes, and legislative measures. In light of the lean management paradigm, this evidence implies the lack of balance between value-added activities and non-value-added activities, thereby extending the duration of processes in the company (Singh et al., 2020). Thus, process interactions must be managed properly, not just sped up.

These research findings support the socio-technical systems theory, which explains that organizational performance is influenced by the simultaneous interaction between social structures, work systems, and organizational technology. In the context of the forestry company studied, production delays arose not only from operational technical limitations but also from unintegrated administrative coordination patterns. This situation causes the flow of information to move slower than the flow of materials, thus creating bottlenecks at several stages of production. According to Noto & Cosenz (2020), companies that do not manage to align their information systems and processes have hidden waste that cannot be easily detected by means of conventional evaluation methods. Hence, efficiency can be achieved only through complete process design re-engineering and not through optimization of production processes.

This study also found that the dominant waste in the production process, in the form of waiting, overprocessing, transportation, and unnecessary motion, occurs more in administrative activities than in technical production activities. This finding broadens the understanding of lean management, which has been more frequently applied in manufacturing environments, with a focus on physical waste in the production area. In the context of sustainable forestry, waste arises through repeated legal mechanisms and document coordination. These findings align with research by Hartini et al. (2020), which states that the nature of waste generated in wood-based industries is complex. Therefore, in the case of forestry, waste is both an operational and administrative concept.

The findings on long waiting time in the legality verification stage indicate that regulations may create operational paradoxes if not well integrated into the business process design of the organization. Regulations are meant to ensure effective governance and accountability along the entire value chain. However, where regulations are enforced through fragmented administrative processes, the regulations

themselves are a source of long cycle times and lack of flexibility within the organization. The finding is consistent with Anderson's (2017) claim that compliance systems employed in the forestry sector lead to non-value-added activities because there is no mechanism for process coordination in the organization. Therefore, the organization derives operational sustainability from both regulations and effective management.

It can be observed that the findings obtained through this research reveal that value stream mapping can not only act as a process visualization technique but also serve as a strategic diagnostic tool for identifying areas where the organization becomes inefficient as a whole. Through material and information flow mapping, it was revealed that most of the bottlenecks associated with the operations of an organization occur due to asynchronous process activity and document duplication. These findings align with the work conducted by Wang et al. (2024) as per this piece of literature, VSM holds the potential of revealing hidden waste that cannot be identified using conventional evaluation methods. This is because VSM allows organizations to realize that the largest waste is not generated through primary production processes but through inter-process integration.

Nevertheless, what this research proves is that VSM application alone cannot bring about substantial operational improvements without being combined with transformational changes within the organization's process design. The company in question had undergone a waste identification stage during its early days, but it had failed to make any fundamental changes to the processes responsible for the generation of waste. Such an example brings into light the weaknesses of a lean management strategy based only on continuous improvement and ignoring structural business process redesign. In such a case, BPR becomes an important tool because it allows organizations to streamline and integrate their functions (Li & Nazif, 2021).

The implementation of BPR in this study resulted in significant reductions in lead times and waiting times through streamlined approval procedures and the integration of legality verification into a single process coordination system. Based on these results, it can be concluded that the major factor contributing to the organizational inefficiency is the presence of excessive bureaucracy within the organization rather than its inability to produce effectively. The above conclusions can be validated with the findings of Vukman et al. (2024), who state that reengineering of the business processes in the timber and forestry sector should include information systems integration and cross-functional cooperation for greater responsiveness. Therefore, increased efficiency of the forestry sector will greatly depend on the organization's capability to redesign interrelationships between work units.

The increase in flow efficiency from 47.4% to 74.2% after the redesign implementation demonstrates that the integration of VSM and BPR can produce more substantial operational changes than a partial improvement approach. From a lean operations perspective, flow efficiency is a crucial indicator because it reflects the proportion of time actually spent creating value for the organization. The considerable improvement in flow efficiency in this study suggests that minimization of redundant administrative efforts plays a more important role than maximization of productive technical effort. This result supports the findings of Freitas et al. (2024), which confirmed that sustainable value stream mapping can improve process effectiveness by reducing cross-functional waste and streamlining workflows within the organization.

The current research also highlights the role of social readiness of the organization as one of the factors affecting the success of business process transformation addition to the design of operational systems. The employees' reluctance to follow the new process highlights the threat posed by business process changes to existing work processes. From the perspective of organizational change, this situation is quite typical, as business process transformation does not only involve changes in the workflow but also in communication, distribution of authorities, and organizational culture. According to Balzer et al. (2019), failure of lean implementation and process redesign is more often associated with psychological and behavioral rather than technical characteristics of work.

Apart from organizational internal factors, the present study reveals that the complexity of the forestry industry can also be explained by the need for sustainability and global governance. The companies operating within the forestry sector today must not only be efficient in producing goods but also must ensure the legality, transparency, and accountability of their supply chains. The problem results in the fact that organizations face dual pressures regarding efficiency and sustainability. In terms of sustainability operations, organizations that manage to meet both of these challenges will enjoy a more advantageous position in comparison with other firms that are focused on efficiency alone (Queiroz et al., 2022). Thus, the efficiency of the forestry industry must be viewed through the prism of organizational capacity to balance performance and sustainability legitimacy.

The findings of this study also provide theoretical contributions to the development of lean management and BPR studies in the context of natural resource-based industries. Most previous studies have focused on lean and BPR within relatively stable and standardized manufacturing environments. From this study, it is clear that in the forestry industry, wastage results from the relationship between regulatory processes, administrative processes, and complexity in the process distribution. Therefore, the current study contributes to the literature on lean operations in showing that waste need not necessarily be in the form of production activities but may result from institutional and organizational processes as well. This makes the case for lean operations to be a more holistic one encompassing process integration (Thomas, 2018).

In addition to its theoretical contributions, this study also yields practical implications for forestry companies and other natural resource-based organizations. The combination of VSM and BPR can serve as a strategic approach to detect process bottlenecks and create flexible work systems under sustainability conditions. The organizations should have coordination systems based on the management of process flow, automate their legal documentation, and improve cross-functional communication so that they can save substantially through administrative efficiency. In a digitized industry, the ability of organizations to integrate their operational and decision-making processes is vital in enhancing efficiency and competitiveness (Pozzi et al., 2022).

Although this study has managed to illustrate the effectiveness of VSM and BPR integration in enhancing efficiency, there are certain limitations that need to be discussed. First of all, this study has been carried out in one forestry organization only; hence, other organizational features and legislation might bring different implications. Moreover, this study has concentrated rather on the operational process changes for the short term than on the effect of VSM and BPR integration on long-term organizational sustainability. It means that further research should be devoted to implementing a multi-case study design along with carrying out longitudinal analysis to investigate VSM, BPR, and sustainability operations integration in the forestry sector.

CONCLUSION

The results from this study indicate that inefficiencies in sustainable teak forest production are not only related to production technique constraints but are also majorly attributed to business process fragmentation, redundancy in administration, and poor integration of information flow between work units. Using the value stream mapping method, it was possible to identify different types of waste that are causing the company to take longer to complete tasks. Waste of this kind includes waiting, overprocessing, transportation, and motion. The business process redesign technique has also proved very effective in enhancing efficiency, legality checking, and coordination among various departments within the firm. Redesigned results show that flow efficiency has been improved from 47.4% to 74.2% as well as production waiting time decreased. It is clear that value stream mapping and business process reengineering techniques have proven useful for improving operations in the sustainable forestry industry.

Conceptually, this study contributes to the development of research in lean management and business process reengineering in natural resource-based industries characterized by high levels of regulation. It has been shown that waste in the forestry sector is not only created in terms of non-value-added activities carried out in the production departments but also as a result of bureaucratic processes, legal frameworks, and organizational inefficiencies. As such, operational efficiency should be defined as an organization's ability to balance business processes, information systems, and sustainability governance. Nevertheless, this study has limitations related to its narrow scope since it was carried out in one particular forestry firm, which means that organizational features and regulations will vary in different organizations. Moreover, this study focuses on short-term changes in business operations so that it does not cover the issue of long-term sustainability.

Based on these limitations, future research is recommended to develop a multi-case study approach across various forestry companies and other natural resource-based industries to gain a more comprehensive understanding of lean and BPR implementation in a sustainability context. Future studies can also incorporate the use of digital transformation, ERP, and sustainability performance measurement to analyze the link between efficiency and organizational readiness for technology. Further, it is important that future research be conducted longitudinally in order to determine the impact of business processes on organizational adaptability and sustainability performance.

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