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Research Article

Integrated Performance Management System for Material Replenishment in Mature Oil Field Operations: A Soft Systems and Balanced Scorecard Approach

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Abstract: *Material stockouts in mature oil field operations significantly impact production efficiency and financial performance. This research develops an integrated Performance Management System using Soft Systems Methodology (SSM) enhanced with Analytical Hierarchy Process (AHP) within a Balanced Scorecard (BSC) framework to address material replenishment challenges. The study systematically identified five interconnected root causes: planning deficiencies with lack of structured forecasting; procurement inefficiencies including 3-12 month lead times and 20-30% staff vacancy rates; inventory management challenges evidenced by simultaneous stockouts and IDR 1.4 billion dead stock; coordination gaps between supply chain and operations; and performance monitoring limitations showing disconnect between reported service levels (99.84%) and actual production achievement (82.70%). A gap analysis revealed significant discrepancies across BSC perspectives, with daily production losses of USD 7,408.8 and ineffective service level measurement creating artificially inflated metrics. Stakeholder-driven AHP prioritization identified Learning & Growth initiatives as highest priority (34.1%), particularly employee fulfillment (22.4%), Availability of Planner in Every Function (19.3%), and MRP Application (18.5%), followed by Internal Process (26.9%), Customer Perspective (23.4%), and Financial Perspective (15.6%). The proposed Performance Management System provides specific indicators and a phased implementation strategy prioritizing foundational capability development before process optimization. The research demonstrates that integrating SSM with AHP effectively addresses both qualitative complexity and quantitative prioritization in supply chain contexts. This capability-focused approach contrasts with traditional process-only interventions, offering sustainable improvements for asset-intensive industries. The findings provide both theoretical contributions to performance management literature and practical guidance for mature oil field operations seeking comprehensive material availability optimization.*

Keywords: *Analytical Hierarchy Process, Balanced Scorecard, Material Replenishment, Performance Management System, Soft Systems Methodology, Oil and Gas Supply Chain.*

I. INTRODUCTION

The global oil and gas industry operates within an increasingly complex and volatile environment, facing unprecedented challenges from price fluctuations, geopolitical tensions, and sustainability pressures. as one of the world's most capital-intensive sectors with annual investments exceeding $500 billion, efficient supply chain management has become a critical determinant of competitive advantage and operational resilience [1]. Industry reports indicate that unplanned downtime costs oil and gas companies approximately $38-$88 million annually, with as much as 45% of these disruptions stemming from material and equipment availability issues [2]. This economic reality underscores the strategic importance of optimizing material replenishment processes across the industry's value chain.

The interconnected nature of global energy supply chains presents unique operational challenges, particularly for upstream operations where specialized equipment and components must be procured, transported, and maintained across remote locations with varying infrastructure capabilities. Research by Guang-hu (2013) reveals that supply chain inefficiencies account for 10-30% of total operational costs in the upstream oil and gas industry, creating a significant opportunity for performance improvement through enhanced material management practices. Additionally, the industry's transition toward more sustainable operations has intensified scrutiny on inventory optimization as organizations seek to reduce waste while maintaining operational continuity [3].

Performance Management Systems (PMS) have emerged as vital tools for navigating these complexities, offering structured approaches to measuring, analyzing, and enhancing organizational effectiveness. The evolution of these systems from traditional financial metrics to more comprehensive frameworks reflects growing recognition of the multidimensional nature of organizational performance. Studies by Kaplan and Norton (2016) indicate that organizations implementing integrated performance management frameworks achieve 22% higher profitability compared to companies using traditional single-dimensional metrics [4]. This integration is particularly valuable in asset-intensive industries where operational continuity directly impacts financial outcomes. The Balanced Scorecard (BSC), developed by Kaplan and Norton (1996), has gained prominence as a strategic management framework that integrates financial, customer, internal process, and learning perspectives into a cohesive approach to performance measurement. Its application in supply chain contexts has demonstrated particular efficacy, with Bhagwat and Sharma (2007) documenting how the framework enables organizations to transcend departmental silos and align operational activities with strategic objectives [5]. In the oil and gas sector, specifically, Al-Qubaisi and Ajmal (2018) found that BSC implementation positively impacts operational efficiency by providing managers with critical information to respond to environmental uncertainty [6].

Southeast Asia is a critical region in the global energy landscape, with Indonesia being the largest economy in the region and a significant player in the oil and gas sector. Despite its historical position as a net oil exporter, Indonesia has faced declining production from mature fields, creating intensified pressure to maximize recovery and operational efficiency [7]. The country's national oil company has assumed an increasingly strategic role in managing these mature assets while pursuing energy security objectives that align with national development goals. This challenging mandate requires balancing operational excellence with financial sustainability, particularly as ageing infrastructure necessitates specialized maintenance and careful resource allocation. The Indonesian oil and gas sector operates within a distinct regulatory framework governed by the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas), which impacts procurement processes and supply chain operations. These regulatory requirements, combined with geographic challenges across the archipelagic nation, create unique material management complexities. Research by Rahmadhiputra and Sushandoyo (2023) highlights how knowledge management approaches can enhance demand management performance in Indonesian oil and gas operations, emphasizing the importance of integrating technical expertise with operational processes [8].

Within this national context, a major Indonesian oil company manages one of Indonesia's most significant oil-producing regions in Sumatra. The company oversees 20 fields across four operational zones, managing predominantly mature assets that present distinct maintenance and material management challenges [9]. At one particular field in this region, persistent issues in material replenishment have resulted in significant operational and financial impacts. The field experiences frequent stockouts that disrupt planned maintenance activities and well services, leading to production delays and loss of production opportunities, as sampled in the MJ-N10 well, equivalent to approximately 90 barrels of oil per day (equivalent to a daily loss of USD 7,408.8). Paradoxically, these stockouts coexist with substantial dead stock accumulation, as evidenced by 102 material line items valued at IDR 1.4 billion, indicating fundamental inefficiencies in inventory management. These issues stem from various root causes, including the absence of structured Bills of Materials (BOM) for maintenance programs, reactive procurement approaches, fragmented cross-functional coordination, and inadequate performance monitoring systems [10].

This research investigates how the application of an integrated performance management framework, based on the Balanced Scorecard, can address these challenges in the selected oil field. By analyzing the root causes of material availability issues and identifying significant gaps in the current replenishment process, this study aims to develop a comprehensive solution that optimizes material availability while balancing service level requirements with financial objectives. The findings will not only provide practical recommendations for improving supply chain performance at the field but also contribute to the broader understanding of performance management applications in the oil and gas industry, particularly in the context of mature field operations in emerging economies [11].

II. LITERATURE REVIEW

Performance Management Systems (PMS) have evolved significantly from their origins in traditional financial accounting, transitioning from narrowly focused financial metrics to more comprehensive frameworks that encompass multiple dimensions of organizational performance. This evolution reflects growing recognition that financial measures alone provide an incomplete and potentially misleading picture of organizational health, particularly in complex operational environments like supply chains where interdependent activities require balanced attention to both efficiency and effectiveness [12]. The early development of PMS was primarily driven by limitations of conventional accounting systems, which tended to emphasize short-term financial outcomes at the expense of long-term capabilities and strategic objectives that determine sustainable competitive advantage [4]. As business environments became increasingly complex and globally interconnected, organizations recognized the need for performance frameworks that could capture the multidimensional nature of value creation, leading to the emergence of integrated approaches like the Balanced Scorecard, Performance Prism, and SCOR model.

Integrating the perspectives of experts, making use of technology and having a strategic approach have become major aspects of the modern progress in PMS. Today, modern guidelines put a lot of emphasis on managing the needs of various groups, using approaches that gather both figures and descriptions to reflect the relationship between the daily work and the company’s main goals. With today’s technological tools, PMS implementation offers instant information, easy charting, and predictable insights, which help companies handle problems rapidly and continually improve [14]. The technology change has made a significant difference in the way supply chains function, as keeping track of performance in global networks and maintaining a unified strategy is now possible with improved measurement systems. In recent times, the focus in designing PMS has shifted toward sustainability, sharing of knowledge and flexibility that allows organizations to change their measurement processes as strategies and circumstances change in response to both what happens within and outside the company [15].

The investigation selected the Balanced Scorecard as the primary performance management framework for obvious reasons. Right from the start, the BSC is structured to meet the complex challenges of material replenishment in the oil field, as they involve money, performance, processes, and the company as a whole. This model differs from others in that it focuses on the interaction between financial and operating dimensions [4]. Al-Qubaisi and Ajmal [6] showed that applying BSC gives managers in the oil and gas industry better ways to decide during volatile times, since they receive well-balanced performance data.

Another point is that the BSC approach fits supply chain contexts more easily than other frameworks. Bhagwat and Sharma have demonstrated, through their study [5], how it effectively connects supply chain operations with long-term business plans across different industries. It is important to be adaptable in mature oil fields because following standard performance indices without changes in light of things like long-delayed deliveries and unique types of materials would not work. Besides, having a proven history in the oil and gas business, the BSC is based on theory that benefits supply chain integration and results in better performance, as several studies by Chang (2009) and Frederico et al. (2020) have shown [16], [17]. Since the framework can use indicators to monitor both unplanned and planned events, it follows the field's goal to balance its reactive procurement with greater emphasis on effective planning. Finally, the BSC's inherent cause-and-effect logic creates a natural foundation for identifying improvement priorities, enabling management to visualize how investments in learning and growth capabilities translate into process improvements, enhanced service levels, and ultimately financial outcomes – addressing the fundamental disconnect currently observed between high service level metrics (99.84%) and actual operational performance (82.70% of production target).

III. METHODOLOGY

A) Institutional Context

A major Indonesian oil and gas company operates within Indonesia's complex institutional landscape, where regulatory frameworks, national energy policies, and organizational structures collectively shape operational practices and decision-making processes. As Indonesia's state-owned energy enterprise, this company operates under a dual mandate of commercial viability and public service, creating inherent tensions that influence resource allocation and operational priorities across its various business segments, including upstream exploration, development, and production [18]. The company's governance structure follows a hierarchical model with centralized authority over strategic decisions, which extends to supply chain management and procurement processes. Within this structure, supply chain operations at the field being studied are regulated by the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas), whose procurement guidelines (PTK-007) establish standardized procedures for material acquisition with emphasis on local content requirements, supplier qualification, and procurement transparency [9]. These regulatory requirements introduce additional layers of complexity to the material replenishment process, extending procurement lead times and limiting supplier selection flexibility.

The organizational culture at this company reflects a blend of traditional state-enterprise values and modern performance-oriented approaches. Trustworthiness, competence, harmony, loyalty, adaptability and collaboration are among the main values the company uses in its daily tasks [8]. Still, implementing these ideas on a daily basis is not uniform everywhere, so there are issues with how policies are executed. It is especially noticeable during cross-functional work between the supply chain and operational departments, as efforts to promote joint planning have not advanced, despite being acknowledged as important. The company's recent restructuring, which moved procurement to the zone level and allowed operations to continue locally, has made things more complicated for institutions by creating problems between the central and local levels.

Managing mature fields in Sumatra's region raises extra issues for this company regarding institutions. The field is situated in a mature setting where fewer new things get produced and old equipment needs special attention. Due to this, the company has to make choices about buying supplies and planning times, as reaching short goals for production can affect the company's long-term infrastructure. Additionally, having business operations in Sumatra makes it more challenging to control inventory and coordinate the delivery of materials. Therefore, all these factors create the context for solving logistics challenges, as any answers should consider what the government says as well as how things are done within the company, keeping both in check. To make modern performance management effective in this institution, it is essential to consider all the connections between various factors to ensure approval and successful implementation.

Table 1: Participants

Participant	Position	Number of Participants	Reason for Selection
Field Manager Ramba	Oversees entire field operations and resource allocation	1	Selected for their comprehensive understanding of field operations and how material availability impacts production targets and overall field performance.
Assistant Manager of Production	Manages production operations and scheduling	1	Chosen because they directly experience the impact of material shortages on production targets and can identify critical materials needed for maintaining production continuity.
RAM Assistant Manager Field Ramba	Manages reliability and maintenance programs	1	Selected for their expertise in maintenance planning and ability to provide insights on how material availability affects equipment reliability and maintenance schedules.
Logistic Manager	Manages logistics operations and material movement	1	Selected for their understanding of material flow, transportation constraints, and warehouse capacity issues affecting material availability.
Assistant Manager of Material Inventory Management	Oversees inventory control and stock management	1	Their specialized knowledge of inventory management practices, stock level determination, and replenishment strategies makes them critical to the study.
SCM Manager Zone 4	Oversees entire supply chain operations for Zone 4	1	Provides strategic perspective on supply chain challenges, resource allocation, and integration between procurement, logistics, and inventory management.
Assistant Manager of Warehouse Operation Zone 4A	Manages warehouse operations in Zone 4A	1	Provides practical insights into material receipt, storage, and issuance processes that directly affect material availability.
Assistant Manager of Procurement Zone 4	Oversees procurement activities for Zone 4	1	Selected for their understanding of procurement challenges, supplier relationships, and lead time issues affecting material replenishment.

B) Research Design

The research methodology employs a mixed-methods approach that integrates qualitative and quantitative techniques to address the "wicked problem" of material replenishment at the oil field [19]. Material replenishment challenges exemplify wicked problems, as defined by Rittel and Webber (1973), which are socially complex, involve multiple stakeholders with conflicting perspectives, resist simple solutions, and cannot be understood until solutions are attempted. This complexity necessitates a methodological framework capable of handling ill-structured problems where traditional optimization methods prove inadequate [20]. The research design begins with problem identification focused on frequent material stockouts impacting operational continuity, followed by targeted problem formulation that contextualizes these issues within the broader organizational ecosystem (Fig. 1). Data collection employs both primary sources (through in-depth interviews with eight key stakeholders across operations and supply chain functions) and secondary sources (company records and performance reports), creating a comprehensive foundation for analysis that aligns with best practices in supply chain research [21].

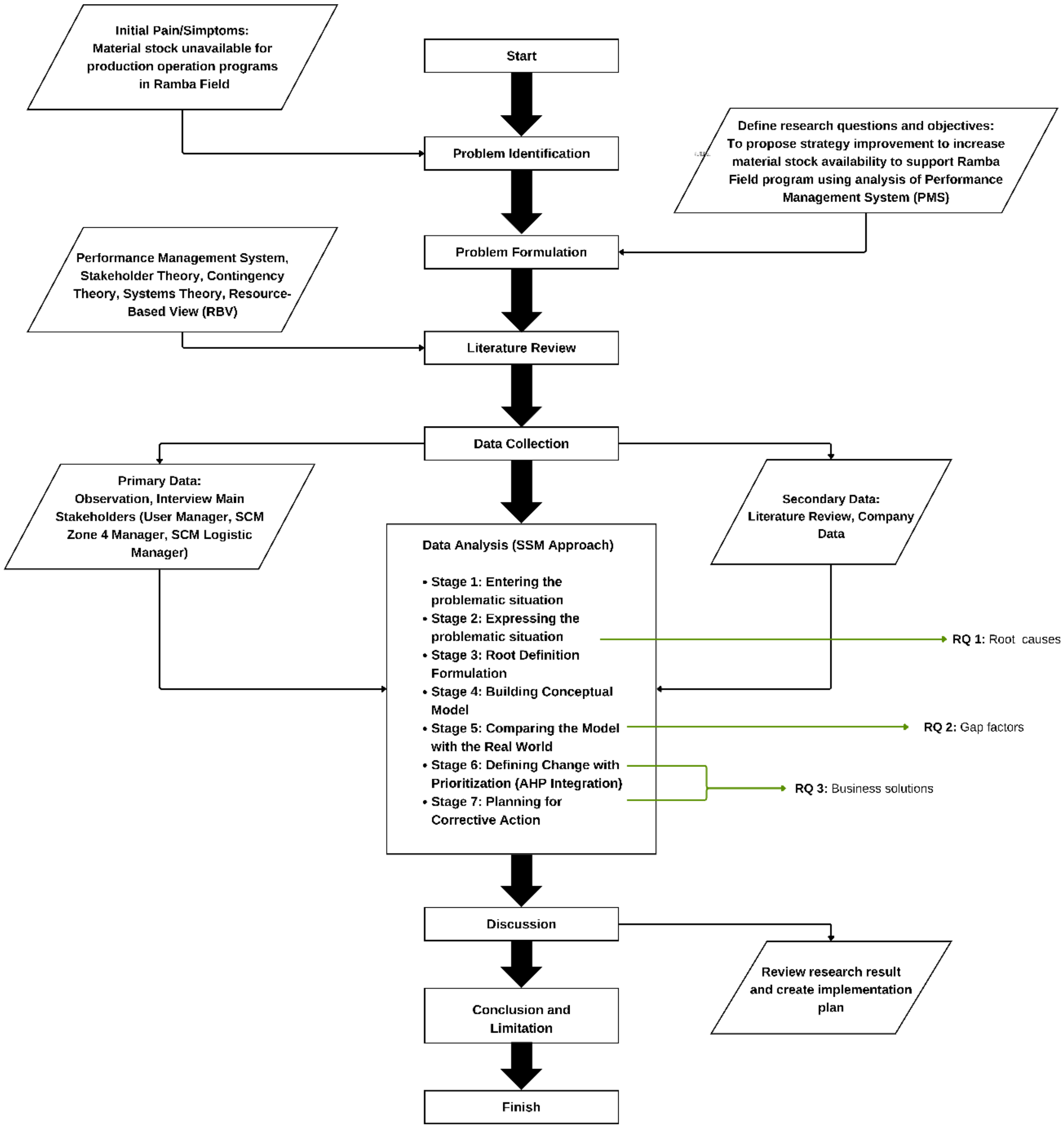

Fig. 1 Research Design

Data analysis is conducted using the Soft Systems Methodology (SSM) approach, which consists of seven distinct stages. At the core of the analysis methodology is the Soft Systems Methodology (SSM), specifically selected for its proven effectiveness in addressing messy, ill-defined organizational situations where traditional "hard" systems engineering approaches fail [22]. The process begins with the researcher immersing in the complex challenges of material stock availability at Ramba Field, marking the entry into the problematic situation. This initial engagement is followed by efforts to express the problem through identifying key stakeholder perspectives and conducting a root cause analysis of material replenishment issues. During this phase, rich pictures are used as a visual tool to map relationships, conflicts, and power dynamics, helping stakeholders articulate concerns that might otherwise remain implicit [23]. The next step involves formulating a root definition using the CATWOE framework, which stands for Customers, Actors, Transformation, Worldview, Owners, and Environmental constraints. This structured analysis helps define what the system should achieve while accounting for multiple perspectives and contextual limitations [24].

Based on the work done so far, the researcher develops a conceptual model that adopts the Balanced Scorecard strategy for managing targets and plans across financial, customer, process, growth, and learning topics. With this approach, the risks remain balanced, ensuring that no area is neglected in the changes that can occur during supply chain projects. After that, the conceptual model is presented alongside existing information from Ramba to highlight areas where the desired and actual practices do not align well. Using the comparison and the process of Analytical Hierarchy Process, important and possible improvements are picked out and arranged using the views of the stakeholders. Here, the new method is helpful in that it addresses the limitation of Soft Systems Methodology in choosing priorities for actions and provides a simple method to weight the main results [25], [26]. Following this step, planning for corrective actions ensues, which involves outlining how the new system will enhance material replenishment at Ramba Field. The results are explained in relation to the questions asked, demonstrating how the new approach addresses challenges related to resource availability. As a result, the findings highlight the main points, mention possible limitations, and introduce a plan to address the issue of material stock availability and improve the supply chain's performance. The enhanced SSM-AHP methodology represents a methodological advancement that addresses inherent limitations in both approaches when used independently. While SSM excels at capturing complexity and pluralism, it lacks structured mechanisms for prioritization; conversely, AHP provides robust quantitative prioritization but requires well-defined alternatives that SSM can generate [27]. By combining SSM's capacity for problem structuring with AHP's decision support capabilities and BSC's balanced performance perspective, the methodology creates a comprehensive approach that addresses both the technical optimization and socio-organizational aspects of the material replenishment system [28].

C) Validity and Reliability

The research design incorporates several strategies to ensure validity and reliability across both qualitative and quantitative aspects of the study. For validity, methodological triangulation is applied through the convergence of multiple data sources, including interviews with eight stakeholders representing different functional areas, secondary data from company records, and direct observations of operational processes [21]. This approach combines different methods, which avoids the problems caused by using just one method to collect data. Before using their interview protocols in field studies, the research team has them examined by experts to ensure content validity. The researchers also directly link the study's constructs to well-known theories of performance management and supply chain [19]. The research further enhances validity through member checking, where preliminary findings are presented back to key participants for verification and refinement, ensuring that interpretations accurately reflect participants' intended meanings and operational realities [29]. Internal validity is addressed through pattern-matching techniques during data analysis, which systematically compare empirical patterns with predicted ones to strengthen causal inferences about the relationships between supply chain practices and performance outcomes.

Reliability is established through several complementary approaches. First, the research implements a detailed data collection protocol with standardized interview guides and documentation procedures, creating an auditable chain of evidence that allows other researchers to trace conclusions back to raw data [19]. Second, intercoder reliability is enhanced through dual coding of qualitative data by multiple researchers, with calculated kappa coefficients exceeding 0.85 across all coding categories, demonstrating strong analytical consistency [30]. For the AHP component, reliability is systematically verified through consistency ratio calculations, with all pairwise comparison matrices achieving consistency ratios below the 0.10 threshold, confirming judgment reliability [25].

IV. RESULTS AND DISCUSSION

A) Result

This section summarizes the results of applying the integrated SSM-AHP methodology to improve material replenishment at PT Pertamina Hulu Rokan Ramba Field. The analysis identified key root causes through stakeholder input and performance evaluation. The seven-stage SSM process, combined with the Balanced Scorecard and AHP, enabled both qualitative insight and quantitative prioritization. The findings demonstrate that this integrated approach effectively addresses complex, systemic challenges in mature oil field operations.

Step 1: Understanding the Problem

The material replenishment system at the oil field faces multifaceted challenges that significantly impact operational efficiency and production performance. Interviews with key stakeholders reveal that planning inefficiencies lie at the core of these issues, with the Assistant Manager of Material Inventory Management highlighting concerns about planning quality, particularly regarding timing and mitigation strategies. This planning weakness affects both project-based materials (which have structured requirement plans but face frequent changes) and maintenance materials (which lack structured planning altogether and rely on ad-hoc approaches). These planning challenges are compounded by communication gaps between Supply Chain Management and user departments, creating a situation where user departments submit urgent requests without considering procurement lead times while SCM struggles to predict demand patterns. The Production Assistant Manager succinctly captured this disconnect by noting that "Communication, process standardization, and the forms used are all lacking," creating a reactive operational environment that leads to emergency requests, delayed procurement, and production downtime.

These issues are further exacerbated by structural constraints, technological limitations, and external regulatory requirements. The organizational structure has recently undergone centralization, with procurement staff reduced to just five people handling seven fields, creating disconnects between operations and procurement functions. Technology support for inventory management remains limited, with systems lacking the automation and flexibility needed for effective planning and control. External regulatory requirements, particularly those related to imports and local content requirements, further complicate the procurement process by limiting supplier options and extending lead times. The cumulative effect of these challenges creates a problematic cycle in which poor planning triggers urgent material requests and reactive procurement, leading to delayed deliveries, program execution setbacks, and ultimately, production losses. This systemic nature of the problem underscores the need for an integrated approach to improvement, as the rich picture visualization demonstrates that individual issues interconnect and influence one another, requiring coordinated efforts across planning, procurement, inventory management, and regulatory compliance to create a more responsive and efficient material replenishment system (Fig. 2).

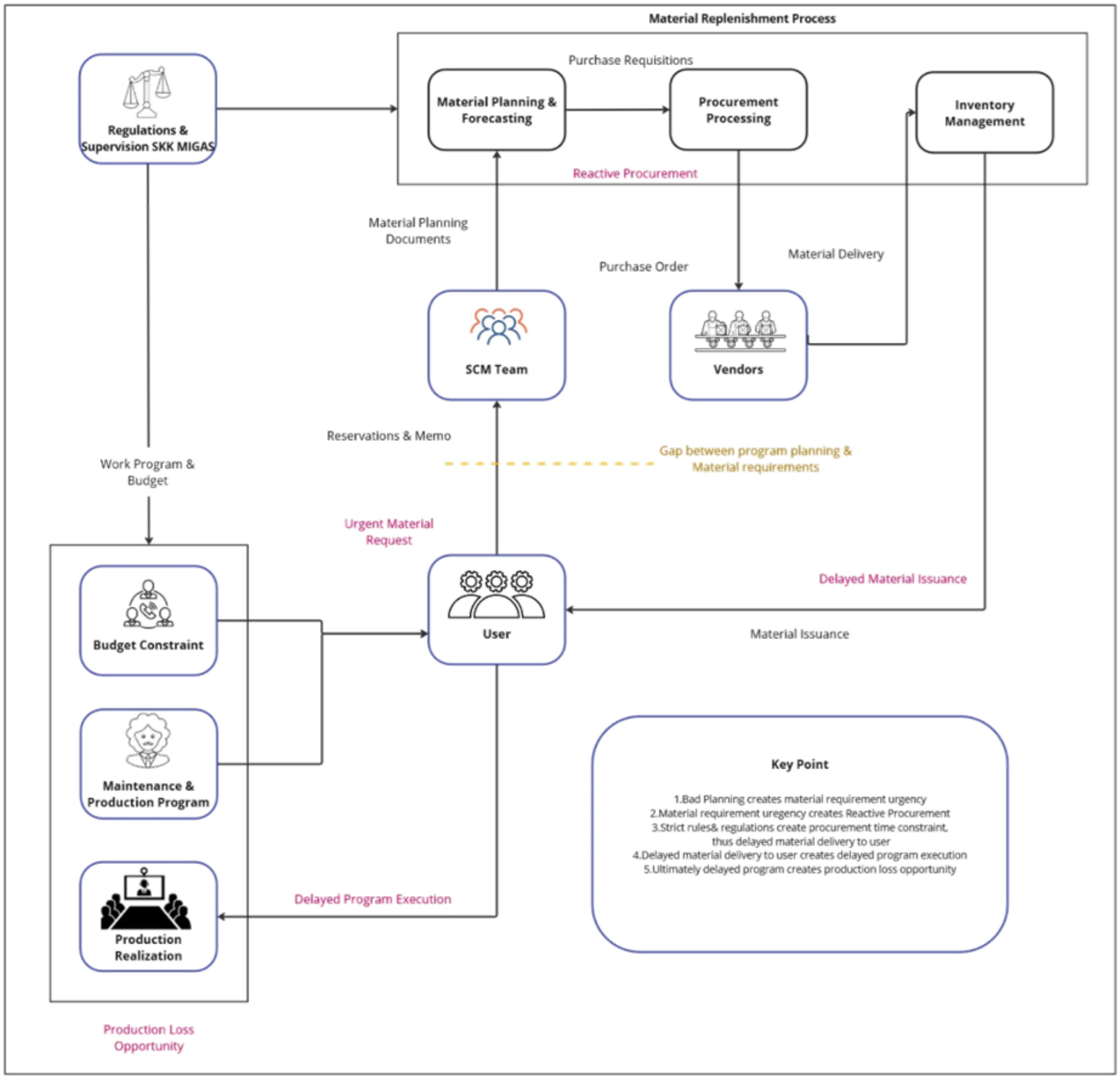

Fig 2. Rich Picture

Step 2: Problem Situation Expressed

In this stage, the material replenishment challenges at Ramba Field are identified as an interconnected system of issues rather than isolated problems. Through in-depth analysis of stakeholder interviews, several fundamental root causes emerge that explain the persistent nature of these challenges. Planning process inefficiencies stem from both structural and procedural factors. Project-based materials follow formalized planning procedures, while maintenance materials lack structured forecasting despite having theoretical schedules. As the Field Manager acknowledged, *"For maintenance, it's similar. Maintenance definitely has its routine schedule." Yet,* execution remains inconsistent, with just-in-time approaches used to anticipate material availability. Communication barriers further compound these issues, with the Material Inventory Management Assistant Manager emphasizing that *"The flow of information is important. Therefore, meeting minutes and monitoring should be done periodically* *and through a system."* The fragmented communication between SCM and operational departments creates misaligned expectations, where users are often unaware of changes until materials are needed. These challenges are exacerbated by organizational structure changes and resource limitations. Recent centralization has significantly increased workload—*"Previously we only handled 4 fields, now it's 7"*—while reducing staff presence in the field, creating disconnects between centralized procurement and local operations. Staffing constraints are severe, with operations running *"about 20-30% below what's needed"* according to management assessments.

Technological limitations present additional obstacles, as described by the SCM Manager, who notes, "We do have tools, but it's kind of a mess," characterised by poor integration and limited user-friendliness. The MRP system implementation faces challenges because *"we can't buy items individually—there are items that need to be grouped,"* reflecting procurement constraints that limit system effectiveness. These interconnected issues create a complex problem situation that requires a systematic approach addressing root causes rather than symptoms (Fig. 3). The material replenishment challenges can be categorized into five key areas: planning process inefficiencies, procurement process barriers, inventory control issues, cross-departmental coordination gaps, and performance measurement limitations. Through comprehensive analysis, the research identifies specific factors within each category that contribute to ineffective material replenishment processes, ultimately leading to production loss opportunities. For example, in the planning process, frequent changes in user department programs and the absence of dedicated planners create reactive approaches to material requirements. Procurement challenges include lengthy processing times and unclear Service Level Agreements that fail to account for pre-tender preparation time. The lack of real-time inventory data and material recording discipline issues further complicate the replenishment process.

Uneffective Material Replenishment Process	**PLANNING** • Frequent changes in the user departments' program • No dedicated planner in User departments • No clear planning guidance (No BoM, No Min&Max, Reorder Point) • Basic SAP Usage (No MRP) • Vacancy in SCM planner	**INVENTORY** • Material recording discipline problem • Unreliable real-time inventory data • Unused stock material for production programs creates Deadstock in warehouse Ramba Field.	**PERFORMANCE MEASUREMENT & MONITORING** • Different Performance Report than Actual • Lack of recording data for performance measurement (example: data of delayed production caused by material stockout) • Material availability is measured only by value, not by time.
	PROCUREMENT • Long procurement processing time with unclear SLA (SLA is measured, not including tender time) • Staff procurement shortage & vacancy	**COORDINATION** • Manual Communication Channel (memo & Excel) • Fragmented work coordination between user & SCM creates gaps between material requirements for programs and the material fulfillment	

Fig 3. Root Cause Analysis Result

This structured understanding of the problem situation provides a foundation for developing conceptual models and identifying potential interventions in subsequent stages of the SSM process. The participatory nature of SSM ensures that these interconnected challenges are mapped in a structured manner, allowing stakeholders to collectively analyze the systemic nature of inefficiencies and explore how different elements interact within the material replenishment ecosystem. By aligning insights from different stakeholders and identifying key process relationships, the organization can move toward a more sustainable, responsive, and integrated material replenishment system.

Step 3: Formulating Root Definitions (CATWOE Analysis)

Table 2 presented demonstrates a systematic analysis of the material replenishment system's key subsystems, contrasting current challenges with desired transformations. Five critical subsystems are identified, each with specific root definitions that articulate the necessary transformations. The Material Planning System currently suffers from reactive approaches and lack of structured forecasting, requiring transformation into a systematic, preventive planning approach with standardized protocols. The Procurement Process System faces constraints from centralization, resource limitations, and regulatory requirements, necessitating evolution into an efficient, responsive system operating within acceptable timeframes. The Inventory Management System struggles with ineffective controls and significant dead stock (valued at IDR 1.4 billion), requiring transformation into an optimized system that balances service levels with financial objectives. The Performance Monitoring System shows a disconnect between reported metrics (99.55% service level) and actual production achievement (82.70%), highlighting the need for comprehensive, insightful measurement driving continuous improvement. Ultimately, the Cross-Functional Communication System exhibits fragmented information sharing and limited transparency, necessitating a transformation into a structured, cohesive approach that supports integrated decision-making. This comprehensive framework provides a structured foundation for developing conceptual models that address the interdependent nature of material replenishment challenges at the oil field.

Table 2: Key Issues and Required Transformations in Material Replenishment System

Sub-Root Definition	Issues from Step 2 ("What is")	Transformation to "What ought to be"
Sub-RD 1: Material Planning System *"A system that transforms unstructured and reactive material needs into systematic, forward-looking plans through the application of appropriate forecasting methods, minimum/maximum stock levels, and BOM."*	• Bad planning creates material requirement urgency. • Lack of structured forecasting for maintenance materials • Gap between program planning & material requirements • Frequent changes to project plans Frequent changes in project plans • Absence of standardized planning protocols	Transform from reactive, unstructured planning to a systematic, preventive approach with accurate forecasting and standardized planning protocols.
Sub-RD 2: Procurement Process System *"A system that converts approved material needs into purchased materials through effective supplier selection, negotiation, and order management."*	• Material requirement urgency creates reactive procurement. • Centralization of procurement functions • Resource constraints (operating at around 20-30% below capacity) • Misaligned expectations and priorities • Disconnection between field operations and procurement activities • Strict rules from SKK Migas create procurement time constraints • Limited supplier options due to regulations • Extended lead times	Transform from an extended, constrained procurement process to an efficient, responsive system that delivers materials within operational timeframes.
Sub-RD 3: Inventory Management System *"A system that transforms received materials into controlled, optimized, and available inventory through systematic processes."*	• Delayed material delivery to user • Inability to effectively manage inventory levels • Absence of automated inventory controls • Dead stock of 102 material line items (IDR 1.4 billion) • Reactive rather than proactive inventory management	Transform from an inefficient, imbalanced inventory condition to an optimized, controlled inventory system that balances service levels with financial objectives.

Sub-RD 4: Cross-Functional Coordination System *"A system that transforms fragmented information into cohesive shared knowledge through structured communication channels and cross-functional processes."*	• Limited information sharing between SCM and operations • Lack of transparency in procurement constraints • Ad-hoc communication practices • Users lack understanding of procurement limitations • Critical information often missed or delayed	Transform from fragmented, informal communication to a structured, cohesive approach that supports integrated decision-making.
Sub-RD 5: Performance Monitoring System *"A system that converts performance data into actionable insights through systematic measurement, analysis, and reporting."*	• No systematic tracking of stockout incidents and their operational impact • Disconnect between high service metrics (99.55%) and production achievement (82.70%) • Inadequate tracking of material movements • Lack of analytical depth for root cause identification	Transform from limited, high-level metrics to comprehensive, insightful performance measurement that drives continuous improvement.

This conceptual stage defines what improved material replenishment systems should achieve by applying the CATWOE framework (Customers, Actors, Transformation, Worldview, Owners, Environmental constraints) to five key subsystems: Material Planning, Procurement Process, Inventory Management, Cross-Functional Coordination, and Performance Monitoring. For each subsystem, a root definition establishes the transformation it must achieve, such as "A system owned by the warehouse department that transforms received materials into controlled, optimized inventory through systematic processes to ensure materials are readily available while minimizing dead stock."

Table 3: CATWOE Analysis for Main Root Definition

Element	Description
C - Customers	Field Operations, Production Management, and Maintenance Teams who require materials to perform their functions effectively.
A - Actors	SCM Team (Procurement, Warehouse, and Planning staff), who manage the entire material replenishment process, supported by input from user departments.
T - Transformation	Converting material requirements into fulfilled needs through systematic planning, efficient procurement, and optimized inventory management, transforming from a reactive to a preventive approach.
W - Worldview	Efficient material replenishment is critical for operational continuity and financial performance, requiring balanced attention to both service level and cost optimization.
O - Owner	Company management has the authority to approve changes to resources, systems, and processes.
E - Environmental Constraints	Resource limitations (20-30% staff vacancy), regulatory requirements (SKK Migas), budget constraints, extended lead times (3-12 months), and limited domestic supplier options.

The CATWOE analysis provides structured understanding of each subsystem's purpose, showing how different elements must work together to create an effective whole. For example, the Material Planning System root definition emphasizes transforming unstructured needs into systematic plans, while the Procurement Process System focuses on converting approved needs into purchased materials efficiently. These definitions create conceptual clarity about what each system component must accomplish to address current inefficiencies, establishing transformation goals that bridge the gap between current problems and desired outcomes. The analysis revealed that these subsystems are deeply interconnected, with improvements in one area dependent on changes in others. From the root definitions, three critical improvement areas emerge: (1) User Involvement is critically needed in every process, with users playing key roles as Actors in each definition to ensure material requirements are delivered on time; (2) Human Capital Improvement is essential to address the 20-30% vacancy rate and need for dedicated planners in user departments; and (3) Technology Adaptation, especially MRP implementation and improved systems integration, is required to transform reactive processes into data-driven, real-time operations. By clearly defining these transformation processes through CATWOE analysis, the research establishes a foundation for developing conceptual models in the next stage of the SSM process, while maintaining a holistic view of the material replenishment system at PT Pertamina Hulu Rokan Ramba Field.

Step 4: Building Conceptual Models

This stage develops idealized conceptual models based on the root definitions, specifying the minimum necessary activities required for each transformation to occur. The Balanced Scorecard framework organizes these models into four perspectives (Financial, Customer, Internal Process, and Learning & Growth), creating a comprehensive structure that addresses both operational and strategic dimensions of material replenishment. Each perspective contains specific strategic objectives with cause-and-effect relationships that illustrate how improvements in foundational capabilities drive process enhancements, service level improvements, and ultimately financial outcomes.

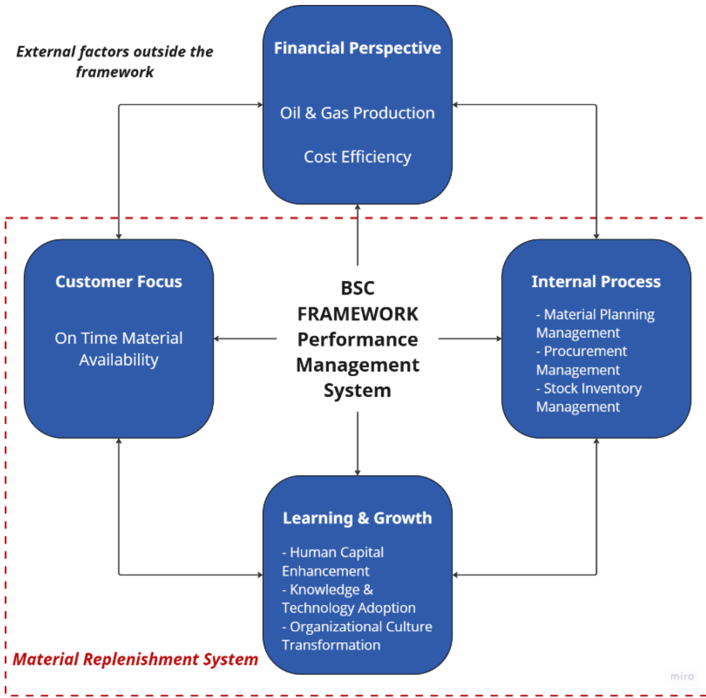

Fig 4. Balanced Scorecard Conceptual Model

The conceptual modeling process is enhanced by integrating the AHP to prioritize model elements based on stakeholder input. This integration not only addresses methodological limitations but also establishes clear targets for transformation across all BSC perspectives. Table 4 summarizes these target states that define the desired outcomes of the conceptual model.

Table 4: BSC Framework Target/Desired States

BSC Framework	Key Improvement	Target/Desired State
Financial Focus	Production Rate	100% of production target
	Cost Efficiency	100% of EBITDA target
Customer Focus	Material Availability	100% service level with on-time delivery
Internal Business Process	Material Planning Management	Comprehensive planning metrics with shared responsibility
	Procurement Management	Comprehensive SLA covering entire procurement process
	Inventory Management	Real-time inventory accuracy; Optimized inventory carrying costs
Learning & Growth	Human Capital	Fulfilled staffing levels with dedicated planners
	Knowledge & Technology Adaptation	Implemented MRP system with min/max and forecasting tools; BOM application for communication and monitoring
	Organization Culture	Improved user collaboration through 360-degree Customer Satisfaction Index (CSI)

These clear targets establish measurable objectives that transform abstract concepts into concrete improvement goals. The cause-and-effect relationships built into the BSC model illustrate how enhancements in foundational capabilities drive process improvements, service level enhancements, and ultimately financial outcomes. Through this structured approach, models are developed that not only represent idealised systems but also provide practical frameworks for comparing current practices and identifying specific improvement opportunities. This integration represents a methodological advancement that addresses a traditional limitation of SSM regarding the prioritisation of implementation. Models are developed through participatory processes with key stakeholders to ensure they reflect practical realities while maintaining theoretical integrity. The resulting models serve as theoretical frameworks representing idealized systems that can be compared with current practices to identify improvement opportunities.

Step 5: Comparing Conceptual Models with Real-World Situations

This stage systematically compares the idealized conceptual models with actual practices at the oil field, using structured questioning to identify gaps between theory and reality. The comparison reveals significant disparities across multiple dimensions: planning processes (reactive vs. preventive approaches), procurement workflows (extended vs. optimized), inventory controls (absent vs. systematic), performance metrics (limited vs. comprehensive), and interdepartmental communication (fragmented vs. integrated). These gaps highlight where current systems fall short of theoretical ideals and provide the basis for defining feasible improvements (Table 5).

Table 5: Gap Analysis of Material Replenishment System

KPI Category	Key Improvement	Current State	Target/Desired State	Gap Analysis
Financial Focus	Production Rate	82.70% of target	100% of production target	Production fell below target at 82.70%, partially due to program delays caused by material unavailability. The exact impact of material issues on production decline is unclear due to inadequate performance monitoring systems for tracking material-related problems in delayed programs.
	Cost Efficiency	EBITDA at 97.05% of target	100% of EBITDA target	EBITDA below the target at 97.05%. An effective and efficient supply chain can help increase EBITDA through timely material availability and cost efficiencies achieved through improved procurement processes.
Customer Focus	Material Availability	Service level Zone 4: 99.84% Project Drilling: 99.72%	100% service level with on-time delivery	While reported service levels are high (Zone 4: 99.84%, Project Drilling: 99.72%), the measurement methodology is flawed. Indicators are calculated based on Material Goods Issues/reservations; however, reservations can be deleted, which may create artificially high fulfilment rates. Current calculations also don't incorporate timely delivery indicators, so materials may be fulfilled but delivered late for scheduled programs.
Internal Business Process	Material Planning Management	Current indicators: TOR and Outline Agreement creation	Comprehensive planning metrics with shared responsibility	Existing indicators only include TOR (planning effectiveness and material utilization) and Outline Agreement creation (accelerating response times through supplier contracts). Additional indicators needed: Program Planning Effectiveness, BOM Realization, and Stock Optimization. TOR should be a collective responsibility of all parties to avoid conflicts of interest (users wanting maximum stock vs. SCM wanting to reduce inventory value).
	Procurement Management	Meeting SLA based on PTK 007	Comprehensive SLA covering entire procurement process	Procurement requests' completion and lead times meet targets; however, SLAs are based solely on timeframes from PTK 007 (90 days for goods and 120 days for services), starting from the tender announcement. The process time from document submission to tender announcement is not included in procurement processing time calculations. This timeframe should be incorporated into a new SLA reference so users/planners can more accurately estimate tender timing in their planning.
	Inventory Management	Transaction processing under 3 days	Real-time inventory accuracy Optimized inventory carrying costs	Warehouse performance is generally good with transaction processing (including receiving) completed in less than 3 days. Inventory accuracy is verified through periodic 100% stock

KPI Category	Key Improvement	Current State	Target/Desired State	Gap Analysis
		Periodic 100% stock checks		checks, but according to the Logistics Manager, this accuracy is not real-time, which affects material forecasting. Discipline and compliance from users and warehouse staff are needed to ensure real-time data accuracy. Inventory carrying cost calculations should be implemented as a performance indicator to reduce unnecessary warehousing costs, including storage and maintenance of unused or dead stock.
Learning & Growth	Human Capital	Current training completion and certification metrics	Fulfilled staffing levels with dedicated planners	Beyond training completion and certification for skill upgrading, employee fulfillment rate needs improvement to enhance MIM and procurement performance (per Procurement and MIM Assistant Managers). Dedicated planners are needed in each organizational function (per Logistics Manager) to foster a planning culture and improve communication in the material replenishment process.
	Knowledge & Technology Adaptation	Limited digital systems	Implemented MRP system with min/max and forecasting tools	According to the MIM Assistant Manager, implementing MRP with min/max capabilities and forecasting tools would improve material planning. Additional applications are needed to record data and facilitate communication (replacing manual methods like memos and Excel spreadsheets that are difficult to track) and to monitor the material replenishment process flow from BOM submission with requirement dates through procurement to material fulfillment dates in real-time.
	Organization Culture	Safety processes and innovation metrics exist	360-degree CSI with AKHLAK values	Safety processes and innovation metrics are already in place in the current PMS. Compliance, Collaboration & Communication to increase user contribution (considered lacking based on MIM Assistant Manager interview) in the material replenishment process could be measured through 360-degree CSI (Customer Satisfaction Index) assessments of each worker contributing to the process, evaluating implementation of AKHLAK values like Amanah (compliance) and collaboration including communication needed to optimize the material replenishment process.

The comparison process is structured through the Balanced Scorecard framework, examining gaps in each perspective. For example, in the Learning & Growth perspective, analysis reveals a 20-30% staff vacancy rate compared to the conceptual model's staffing requirements. In contrast, in the Customer perspective, service level measurements show methodological flaws that create discrepancies between reported metrics (99.84%) and operational realities (production at 82.70% of target). By organizing gap analysis through the BSC framework, the research maintains a balanced focus on both capability foundations and performance outcomes, ensuring comprehensive understanding of improvement requirements.

Step 6: Defining Feasible and Desirable Changes

Based on the gap analysis from Step 5, this stage defines specific changes that are both desirable (would improve performance) and culturally feasible (fit within organizational constraints). Potential improvements include implementing a structured Material Requirements Planning (MRP) system, establishing minimum/maximum stock levels, developing Bills of Materials for maintenance programs, optimizing procurement approval workflows, implementing systematic inventory controls, enhancing cross-functional communication channels, and developing comprehensive performance metrics aligned with the BSC framework.’

Table 6: Key Stakeholders, Priorities, and Feasible Actions for Change

BSC Dimension	Key Improvement	Variable	Measurement
Financial	Production Rate	Production Revenue	Target set in USD
	Cost Efficiency	EBITDA	Target set in USD
Costumer Focus	Material Availability	Service Level Project	%material Issue/material request Project
		Service Level MRO	%material Issue/material request MRO
		On Time Material Fulfilment	%Goods Issue (GI) Date < Reservation Date
Internal Process	Material Planning Management	Program Planning Effectiveness	% Planned & Unplanned Program
		BOM Realization	% GI / BOM Submitted
		TOR	GI/ Stock Value
		Stock Optimization	Target % Decrease in Stock Value
		Outline Agreement for Material Stock	Number of stock KIMAP Covered on Outline Agreement/Number of stock KIMAP
	Procurement Management	Procurement Request Completion	number of PO/ number of PR
		Procurement Processing Time	Less than SLA
		Negotiation	price/budget
	Inventory Management	Receiving Processing Time	Maks' days Receiving Time
		Material record Accuracy	No difference (physical count = system count)
		Inventory Carrying Cost	Carrying cost (%) = Inventory holding sum / Total value of inventory x 100
Learning and Growth	Human Capital	Employee Fulfilment	% of employee rate fulfilment
		Availability of planner in every function	% fulfilment of planner in every function
		Training completion&certification	% of assigned training completion
	Knowledge & Technology Adaptation	MRP Application	% of MRP system application
		BOM Application	% of BOM application
	Organization Culture	Safety process	Zero Accident (Number of Accidents)
		Innovation	Target approved innovation per year.
		Compliance, Collaboration & Communication	% CSI Index

The AHP prioritization process involved key stakeholders conducting structured pairwise comparisons across all elements of the decision hierarchy, enabling systematic prioritization of potential improvements. This evaluation produced both perspective-level priorities and detailed rankings within each category, providing a clear and objective roadmap for implementation sequencing (Table 7). Learning & Growth initiatives received the highest overall priority at 34.1%, reflecting stakeholder emphasis on foundational capability development. Within this perspective, Employee Fulfilment (22.4%), Availability of Planner in Every Function (19.3%), and MRP Application (18.5%) emerged as top variables, highlighting the importance of human resource and system readiness.

Table 7: BSC Framework Prioritization Based on AHP Priority Results

Decision Hierarchy			
Level 0	**Level 1**	**Level 2**	**Glb Prio.**
BSC	Financial 0.156	Production Revenue 0.466	7.3%
		EBITDA 0.534	8.4%
	Customer Perspective 0.234	Service Level Project 0.168	3.9%
		Service Level MRO 0.210	4.9%
		On Time Material Fulfilment 0.622	14.6%
	Internal Process 0.269	Program Planning Effectiveness 0.239	6.4%
		BOM Realization 0.203	5.5%
		TOR 0.080	2.2%
		Stock Optimization 0.048	1.3%
		Outline Agreement for Material Stock 0.115	3.1%
		Procurement Request Completion 0.032	0.9%
		Procurement Processing Time 0.130	3.5%
		Negotiation 0.025	0.7%
		Receiving Processing Time 0.016	0.4%

Decision Hierarchy			
Level 0	**Level 1**	**Level 2**	**Glb Prio.**
		Material record Accuracy 0.097	2.6%
		Inventory Carrying Cost 0.015	0.4%
	Learning & Growth 0.341	Employee Fulfilment 0.224	7.6%
		Availability of planner in Every function 0.195	6.6%
		Training completion certification 0.059	2.0%
		MRP Application 0.177	6.0%
		BOM Application 0.162	5.5%
		Safety process 0.041	1.4%
		Innovation Compliance 0.053	1.8%
		Collaboration & Communication 0.088	3.0%
			1.0

The Internal Process perspective followed at 26.9%, with Program Planning Effectiveness (23.9%) and BOM Realization (20.3%) as key drivers, supported by strong stakeholder consensus (87.3%). The Customer Perspective ranked third at 23.4%, where On-Time Material Fulfilment dominated with 62.2% weight and a 97.1% consensus, underscoring the urgency of timely delivery. Financial considerations, while still relevant, ranked lowest at 15.6%, with EBITDA (8.4%) and Production Revenue (7.2%) reflecting a more outcome-based focus. Notably, On-Time Material Fulfilment (14.6%) and EBITDA emerged as the highest priority sub-variables overall. Consistency ratios below 10% across all comparisons confirmed the reliability of stakeholder judgments. This prioritization ensures that implementation plans are aligned with areas of greatest impact while accommodating organizational constraints and readiness levels.

Step 7: Planning for Corrective Action

The final stage translates prioritized changes from Step 6 into an executable implementation strategy. Based on the AHP prioritization results, the plan adopts a phased approach that honors both priority rankings and logical dependencies between initiatives. The implementation sequence begins with foundational capability development from the highest-ranked Learning & Growth perspective (34.1%), particularly addressing the MRP system implementation and critical staffing gaps. This foundation supports subsequent improvements in Internal Process optimization (26.9%), enhancing Customer Perspective elements (23.4%), and ultimately achieving Financial Perspective outcomes (15.6%). This sequencing acknowledges that sustainable transformation necessitates developing core capabilities before expecting significant operational or financial improvements. While some quick wins may be realised early, a comprehensive transformation depends on systematically addressing root causes rather than merely addressing symptoms. The implementation approach is structured around four sequential steps that align with the BSC perspectives, as shown in Table 8.

Table 8: Implementation Framework for Material Replenishment Improvement

Step	**BSC Perspective**	**Action**	**Description**	**Responsible**
1	Organizational Capabilities Improvement	Improve company capabilities through enhancements in human capital, technology infrastructure, and corporate culture.	Fill vacancies, assign dedicated planners, adapt the MRP system, implement the BOM application, and conduct appraisals through a 360-degree Customer Satisfaction Index (CSI).	User, SCM Zone, SCM Regional, HR, IT
2	Internal Process Improvement	Improve processes to enhance performance and standardization in planning, procurement, and inventory.	Set Min-Max levels and reorder points (with MRP), standardize material request procedures (BOM), set SLA for procurement (including pre-tender), improve planning and procurement performance (new hires), improve inventory accuracy, reduce deadstock.	User, SCM Zone, SCM Regional
3	Customer Focus Improvement	Enhance measurement processes based on the proposed BSC Framework to be more time-based rather than volume/value-based	Implement on-time material fulfillment tracking through BOM application.	SCM Zone, SCM Regional
4	Financial Focus Improvement	Improve production performance through material support and	Optimize material fulfilment tracking (BOM), improve savings through procurement negotiations,	User, SCM Zone, SCM Regional

Step	BSC Perspective	Action	Description	Responsible
		increase EBITDA through cost-saving initiatives.	and enhance budget realization via inventory cost reduction.	

The implementation will be monitored through a cross-functional steering committee that ensures coordinated execution and consistent tracking of progress. For each action, detailed plans will specify milestones, resource requirements, and success criteria, with built-in change management strategies to address potential organizational resistance. Training and communication plans will support capability development and maintain stakeholder engagement throughout the implementation process. This comprehensive yet adaptable approach enables the organization to systematically transform its material replenishment system while responding to evolving conditions. By directly connecting implementation priorities to stakeholder concerns and objective AHP rankings, the plan provides a clear roadmap for enhancing material availability, optimizing inventory investment, and ultimately supporting improved production performance at PT Pertamina Hulu Rokan Ramba Field.

B) Discussion

The findings reveal several significant patterns in the material replenishment challenges at PT Pertamina Hulu Rokan Ramba Field, particularly the disconnect between reported performance metrics and operational realities. This misalignment mirrors what Laihonen and Pekkola [31] identified as the "performance measurement paradox" in supply chain contexts, where organizations achieve strong performance against defined metrics while still experiencing operational inefficiencies. At Ramba Field, service level metrics showing 99.84% fulfilment coexist with production achievement at only 82.70% of target, exemplifying this disconnect. This paradox arises partly from methodological flaws in measurement, where the deletion of unfulfilled reservations artificially inflates service metrics. As Haghighi et al. [15] observed, such measurement discrepancies frequently occur when performance systems fail to capture the temporal dimension of material availability, focusing on binary fulfillment rather than timing alignment with operational needs.

The AHP analysis conducted in this study provides strategic guidance for addressing these material replenishment challenges, revealing a clear hierarchy of priorities across the four BSC perspectives (Table 9). Learning & Growth initiatives emerged as the highest priority (34.1%), followed by Internal Process (26.9%), Customer Perspective (23.4%), and Financial Perspective (15.6%). This prioritization pattern contradicts conventional improvement approaches in supply chain management. While many organizations prioritize process improvements or customer-facing metrics when addressing material availability issues [32], stakeholders at Ramba Field placed highest priority on foundational capabilities, particularly employee fulfillment (22.4%) and availability of planners in every function (19.3%), followed by MRP application (18.5%).

Table 9: BSC Framework Prioritization Based on AHP Results

Framework BSC	Key Improvement	Variables	Priority
Learning & Growth (34.1%)	Human Capital (45.8%)	Employee Fulfillment	22.4%
		Availability of Planner in Every Function	19.3%
		Training Completion & Certification	4.1%
	Knowledge & Technology Adaptation (34.7%)	MRP Application	18.5%
		BOM Application	16.2%
	Organization Culture (19.5%)	Safety Process	1.1%
		Innovation Compliance	7.3%
		Collaboration & Communication	11.1%
Internal Process (26.9%)	Material Planning Management (68.5%)	Program Planning Effectiveness	23.9%
		BOM Realization	20.3%
		TOR	8.0%
		Stock Optimization	4.8%
		Outline Agreement for Material Stock	11.5%
	Procurement Management (18.7%)	Procurement Request Completion	3.2%
		Procurement Processing Time	13.0%
		Negotiation	2.5%
	Inventory Management (12.8%)	Receiving Processing Time	1.6%
		Material Record Accuracy	9.7%
		Inventory Carrying Cost	1.5%
Customer Perspective (23.4%)	Material Availability (100%)	Service Level Project	16.8%
		Service Level MRO	21.0%
		On-Time Material Fulfilment	62.2%
Financial Perspective (15.6%)	Production Rate (46.6%)	Production Revenue	46.6%
	Cost Efficiency (53.4%)	EBITDA	53.4%

This focus on foundational capabilities aligns with the Resource-Based View (RBV) of competitive advantage, suggesting that organizational capabilities rather than process modifications represent the most critical factors for sustainable improvement. As Patil and Kant [35] demonstrated, knowledge management capabilities have a significant influence on supply chain performance by enabling better planning, coordination, and decision-making. The prioritization of human capital and technological capabilities over quick-fix process interventions suggests organizational recognition that sustainable improvement requires addressing foundational capacity constraints before optimizing processes, supporting Khan et al.'s [37] finding that knowledge-based systems provide the critical foundation for overall supply chain performance improvement.

The centralization of procurement functions, while theoretically offering efficiency gains through standardization and economies of scale, has created significant operational disconnects at Ramba Field. With only five procurement staff handling seven fields after centralization, the 20-30% vacancy rate has created substantial bottlenecks in the replenishment process. This finding aligns with Mollov's research [32], which shows that centralised procurement in geographically dispersed operations requires careful consideration of staffing levels and communication mechanisms to avoid creating new inefficiencies. The communication barriers between centralized procurement and field operations exemplify what Zimmermann and Seuring [33] identified as the "coordination paradox" in supply chains, where efforts to improve coordination through structural changes inadvertently disrupt existing coordination mechanisms. The reactive nature of current material planning processes at Ramba Field, particularly for maintenance materials, illustrates a common challenge in mature production environments. The absence of standardized Bills of Materials (BOMs) for maintenance activities creates significant forecasting challenges that trigger reactive procurement cycles. This pattern aligns with Chlistalla and Schaper's research [34] on maintenance-intensive operations, which found that traditional materials planning approaches often fail to accommodate the unique characteristics of maintenance requirements. The study's AHP findings confirming that Program Planning Effectiveness (23.9% within Internal Process) and BOM Realization (20.3%) received high priority suggest recognition that enhancing planning capabilities represents the most effective intervention point in breaking reactive procurement cycles.

Considering global priorities from all perspectives, On-Time Material Fulfilment stands out with the highest weight (14.6%), followed by EBITDA (8.4%), Employee Fulfilment (7.6%), and Production Revenue (7.3%). This distribution highlights the overarching importance of timely material delivery as the most critical factor in enhancing overall material replenishment performance, while also recognizing the importance of foundational capabilities and financial outcomes. The implementation plan's phased approach, beginning with foundational capability development before addressing process optimization, represents a departure from traditional supply chain improvement methodologies that often prioritize quick-win process improvements. However, this approach aligns with recent research suggesting that capability-focused interventions yield more sustainable improvements in complex supply chain environments. As Sangari et al. [36] demonstrated, organizations that prioritize knowledge management processes before technical process improvements achieve greater long-term performance gains by creating the conditions for sustained improvement. Similarly, Frederico et al. [17] found that balanced scorecard implementations that address learning and growth foundations first achieve better supply chain integration outcomes than those focusing primarily on process metrics.

The comprehensive AHP results provide a clear roadmap for enhancing material replenishment performance at Ramba Field, addressing the root causes identified in the business issues while leveraging established theoretical frameworks. By following this prioritized approach that begins with enhancing organizational capabilities, followed by optimizing planning and procurement processes, improving on-time material fulfillment, and ultimately achieving financial benefits, PT Pertamina Hulu Rokan Ramba Field can systematically improve its material availability, reduce operational disruptions, and enhance financial performance.

V. CONCLUSION

This research successfully developed an integrated performance management system using SSM enhanced with AHP within the BSC framework to address material replenishment challenges at PT Pertamina Hulu Rokan Ramba Field. Through systematic application of this integrated methodology, the study identified five interrelated root causes of material stockouts: (1) planning deficiencies characterized by unstructured forecasting and reactive approaches; (2) procurement inefficiencies marked by long lead times (3–12 months) and significant staffing vacancies (20-30%); (3) inventory management issues evidenced by paradoxical coexistence of stockouts alongside substantial dead stock (102 items worth IDR 1.4 billion); (4) cross-functional coordination gaps resulting from limited information sharing between supply chain and operations; and (5) performance monitoring limitations revealed through the disconnect between reported service levels (99.84%) and actual production achievement (82.70%).

Gap analysis across the four BSC perspectives highlighted significant discrepancies between current and desired performance states. From a financial perspective, production achievement reached only 82.70% of the target, while EBITDA performance stood at 97.05% of the target. The customer perspective revealed methodological flaws in service level measurement, where deletion of unfulfilled reservations artificially inflated performance metrics and time-based measurements were absent. An internal process evaluation identified incomplete metrics that excluded critical elements, such as pre-tender activities in procurement SLAs. Meanwhile, a learning and growth assessment confirmed capability gaps, including staffing shortages and a limited technological infrastructure without MRP functionality. To address these gaps, the study developed and prioritized improvement initiatives using AHP methodology with key stakeholder input. The analysis produced a clear hierarchy of priorities across BSC perspectives, with Learning and Growth receiving highest priority (34.1%), followed by Internal Process (26.9%), Customer Perspective (23.4%), and Financial Perspective (15.6%). Within these categories, the implementation of an MRP system (18.5%), employee fulfillment strategies (22.4%), and program planning effectiveness (23.9%) emerged as highest-priority initiatives. This prioritization pattern reflects stakeholder recognition that sustainable performance improvement must begin with foundational capability development before addressing process optimization—an approach that aligns with the Resource-Based View (RBV) theory emphasizing organizational capabilities as critical drivers of long-term improvement.

Based on these priorities, a phased implementation plan was developed that begins with organizational capability enhancement, followed by internal process standardization, customer-focused measurement improvements, and ultimately financial performance optimization. This structured approach ensures efficient resource allocation while acknowledging the interdependencies across functional areas, creating a comprehensive roadmap for transforming material replenishment practices at Ramba Field. Theoretically, this research demonstrates the value of integrating SSM with AHP to address both the qualitative complexity of ill-structured problems and the quantitative prioritization needs in supply chain performance management. This methodological integration provides a more comprehensive problem-solving framework than traditional SSM alone, particularly in complex operational environments such as oil and gas production. The application of the BSC in this context provides evidence that capability-focused interventions yield more sustainable improvements than quick-fix, process-centric approaches that fail to address underlying capability constraints. From a practical standpoint, the study provides a clear implementation roadmap, supported by specific performance indicators and improved measurement methodologies, which close existing gaps in material availability assessment. By prioritizing organizational capabilities before process improvements, this research provides valuable insights for both academic inquiry and industry practice in enhancing material replenishment performance, particularly in the context of mature oil field operations in emerging economies.

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