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Inventory Control of Main Distribution Material (MDU) PB PD 1 Phase at PT PLN UP3 Banten Selatan

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Abstrak. PT PLN UP3 Banten Selatan faces material shortages that delay customer connections, impacting service quality and regulatory compliance. This study aims to optimize inventory control for Main Distribution Unit (MDU) materials, focusing on 1-phase New Installation (PB) and Capacity Upgrade (PD) requests. The research compares current inventory practices with continuous review (s,S) and periodic review (R,s,S) systems to identify optimal inventory parameters. Risk management is addressed using the Multi-Criteria Decision Making (MCDM) framework, specifically the Analytical Hierarchy Process (AHP), to prioritize and mitigate risks in inventory control. Data from PLN's Executive Information System (EIS)—including demand history, material BoQ, and procurement costs—were analyzed to calculate inventory parameters for each method. The AHP method, supported by expert input, was used to weigh and rank risk criteria and subcriteria. Results show the continuous review system achieves a 100% service level and reduces costs, saving Rp 738,736,538 compared to the periodic review method. Financial risk emerged as the top priority, followed by supply and demand risks. Eight high-risk subcriteria were identified, such as rising storage costs and inaccurate demand forecasts. Proposed mitigation strategies include strict budget planning and vendor diversification. This study provides actionable recommendations for PLN to enhance inventory efficiency, reduce financial risks, and improve service delivery, while also contributing to academic literature on inventory control and risk management in the utility sector.

Keywords: Bill of Quantity Material, Continuous review, Periodic Review, MCDM – AHP.

INTRODUCTION

In accordance with the government mandate to PT PLN (Persero), as stipulated in the Decree of the Minister of Energy and Mineral Resources No. 185.K/TL.04/DJL.3/2024 regarding Service Quality Standards for the Java, Madura, and Bali regions, PLN must accelerate service connections: four working days for new low-voltage connections and five for capacity upgrades without network expansion; fourteen working days for connections and upgrades with network expansion; and twenty-five working days for those involving transformer addition. This regulation requires PLN to always be prepared to respond to customer requests, with the availability of Main Distribution Unit (*MDU*) materials being crucial. Essential materials for 1-phase New Connection (*PB*) and Capacity Upgrade (*PD*) requests include electricity meters (*KWh* meters), circuit breakers (*MCB*), and *HL/SR* cables (minimum 25 meters per customer).

PLN UP3 *Banten Selatan* has experienced material shortages, causing delays and failure to meet service targets mandated by the Ministerial Decree. Despite implementing a System Analysis and Product in Data Processing (*SAP*) for real-time monitoring, key inventory control features—such as material classification, safety stock, and reorder points—are not optimally used. These constraints impact unit performance, service levels, and financial outcomes, including delayed revenue.

This study determines MDU requirements by converting PB and PD requests into material needs based on the Bill of Quantity (*BoQ*), and calculates inventory parameters using current practices, continuous review (*s,S*), and periodic review (*R,s,S*) methods. Risk management analysis is conducted using the Multi-Criteria Decision-Making (*MCDM*) approach with the Analytical Hierarchy Process (*AHP*), enabling prioritization and mitigation of risks. The objectives are to determine optimal inventory parameters and implement risk mitigation to prevent financial and non-financial impacts from stockouts or supply chain issues, ultimately improving planning, revenue, and customer satisfaction.

METHOD

In the preliminary stage, the research began by formulating the problem and defining the research objectives. This was followed by a field study that involved in-depth interviews and observations within the Procurement Division to gain a comprehensive understanding of the material procurement process. Subsequently, a literature review was conducted using sources such as academic journals, books, theses, and articles related to inventory control methods under fluctuating demand, inventory forecasting, and cost calculations. The final step in this phase was designing a research methodology that aligned with the identified problems and research objectives.

The next stage was data collection. In this phase, several essential data sets were gathered, including demand data for New Installations (*Pasang Baru – PB*) and Power Upgrades (*Perubahan Daya – PD*) for single-phase connections over the past three years (2021–2023), retrieved from PLN's Executive Information System (*EIS*); the Bill of Quantity (*BoQ*) for materials according to PLN construction standards; the 2023 Material Purchase Orders (*SPB*) for *MDU*; *MDU* lead time data; and data on ordering costs, storage costs, and stockout costs. These datasets formed the foundation for the subsequent data processing stage.

Once the data had been collected, it proceeded to the data processing stage. Here, the focus was on calculating inventory control parameters and identifying the most effective and efficient inventory control strategy. The analysis included applying inventory control models such as periodic review (*R,s,S*) and continuous review (*s,S*), followed by a comparison of their performance in terms of total inventory costs and service level outcomes.

A critical component of the data processing phase was the risk management analysis using the Multi-Criteria Decision-Making (*MCDM*)–Analytical Hierarchy Process (*AHP*) method. This analysis aimed to identify and evaluate potential risks arising from material stockouts, encompassing both financial and non-financial risks. *AHP* was used to assign weights to each risk based on its severity, allowing for the formulation of appropriate mitigation strategies and preventive measures.

Referring to the study by Min Lyu et al. (2023) on flood risk assessment using *AHP*, the implementation of *AHP* in this research began with defining the problem and objectives. In this context, the objective was to assess risks arising from errors in material control. The scope and focus of the risk assessment were clearly established as the foundation of the hierarchical structure.

The next step was to construct a hierarchical structure consisting of three levels. The first level was the overall goal, which was to assess the risks of material control failure. The second level comprised the key risk criteria such as environmental factors, infrastructure, human resources, and procedural methods. The third level consisted of specific sub-criteria under each main criterion, providing a detailed and structured framework for evaluation.

Pairwise comparisons were then conducted between criteria and sub-criteria to determine their relative priorities, using a scale from 1 (equal importance) to 9 (extremely important). The results of these comparisons were used to build a comparison matrix, which was then processed to calculate the priority weights for each element. Consistency was checked by calculating the Consistency Ratio (*CR*), where a $CR \leq 0.1$ indicated that the matrix was consistent and acceptable.

After obtaining all the priority weights, the final step was to aggregate these weights to derive an overall score for each risk alternative. These scores were then used to support decision-making in risk management, leading to effective mitigation strategies. Through this structured and data-driven approach, the material procurement risk management process was implemented systematically, improving the efficiency and reliability of inventory control in the Procurement Division.

RESULTS AND DISCUSSION

Company Overview

PT PLN (Persero) UP3 South Banten is one of the Customer Service Implementation Units (UP3) under PT PLN (Persero) Main Distribution Unit (UID) Banten. PT PLN (Persero) UP3 South Banten is located in the southern part of Banten Province, covering 2 districts, namely Lebak Regency and Pandeglang Regency. Pandeglang Regency has an area of 2,746.90 square km, consisting of 35 sub-districts, while Lebak Regency has an area of 3,305 square km, consisting of 28 sub-districts (Banten Provincial Government Bureau, 2018). PT PLN (Persero) UP3 South Banten itself has a total of 885,129 customers spread under the auspices of 4 Customer Service Units (ULP), namely ULP Rangkasbitung, ULP Pandeglang, ULP Malingping and ULP Labuan. In addition to maintaining the stability and reliability of electrical energy to customers, of course UP3 South Banten has the responsibility to serve the needs of New Installation (PB) and Power Change (PD) applications. In the following sub-chapter, the types of power for New Installation and Power Change, the need for Main Distribution Materials (MDU) and non-Main Distribution Materials (non-MDU) will be described.

Risk Assessment

Identify Risk Criteria and Sub criteria

In a supply chain management system, inventory control plays a crucial role in maintaining smooth operations and cost efficiency. However, this process is inseparable from various risks that can disrupt material availability, cause excess or understock, and increase the cost burden. Therefore, a systematic approach is needed to identify and evaluate the various risks associated with inventory control.

The first step in managing this risk is the identification of relevant risk criteria and subcriteria. These criteria include key aspects that can cause disruptions to the supply system, such as demand, supply, operational, and external factors. Each of these criteria can be further elaborated into more specific subcriteria to facilitate analysis and decision-making.

In determining these criteria and subcriteria, a focus group discussion (FGD) was held with the Subscription Service Unit Manager, Construction Assistant Manager, Planning Assistant Manager and Procurement Planning Officer. The selection of expret in the FGD process is a critical factor that determines the validity and relevance of the results obtained, as well as in identifying risks that can result in poor inventory control of a unit. In the context of this research, the selected experts consider three main criteria, namely having at least 15 years of work experience at PT PLN (Persero), occupying structural positions, and coming from fields or divisions that are directly related to the invemtory control process. The criteria of this expert reflect a purposive sampling strategy that aims to get input from parties who have knowledge, in-depth experience, and operational responsibility for the inventory control process.

After the FGD was carried out with experts, the results were obtained that there are 5 risk criteria that may occur in the inventory control process, including demand risk, supply risk, operational risk, financial risk and external risk. From the 5 criteria, a breakdown is carried out again into several subcriteria where among the demand risk there are 3 subcriteria, namely demand variability, inaccurate predictions, and market trends. For supply risk, there are 4 subcriteria which include delivery delays, failure of suppliers to meet quantity and quality,

dependence on one supplier (single sourcing) and logistics or transportation crises. For operational risks, there are 4 subcriteria which include stock recording errors, damage or loss of goods, failures in the inventory information system and lack of storage capacity. For financial risk, there are 4 sub-criteria, including increased storage costs, fluctuations in the price of goods, wastage due to overstock, and stockout costs. For external risks, it is divided into 4 sub-criteria, including changes in government regulations, natural disasters, geopolitical and social conditions, pandemics or global crises.

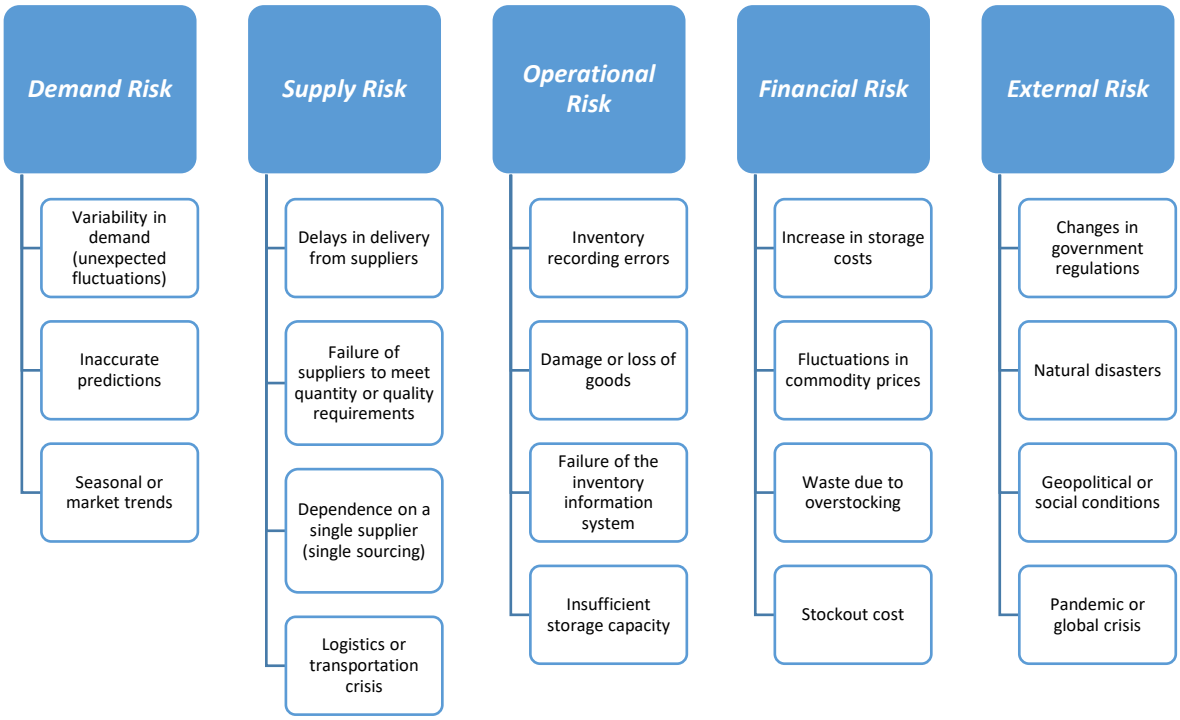

Figure 1. Criteria and Sub-criteria After FGD

Determination of Weighting Criteria and Subcriteria

In determining the weight of criteria and subcriteria, it is carried out using the Analytical Hierarchy Process (AHP) method. Where the criteria and subcriteria that have been set previously are compared in pairs through a questionnaire. The results of this questionnaire are entered into the software, namely Expert Choice™. The number of respondents from the questionnaire in determining the weight of this criterion was 4 people. These four respondents are experts at PT PLN (Persero), namely Subscription Service Unit Managers, Construction Assistant Managers, Planning Assistant Managers, and Procurement Planning Officials. So later the results of the questionnaire from each respondent will have the same weight. Before filling out the questionnaire, these four respondents were each explained the criteria and subcriteria to be weighed, the procedure for filling out the questionnaire, and the impact of filling out this questionnaire. The results of the questionnaire from each respondent are listed in the Appendix. Furthermore, the results of the questionnaire are entered into the AHP Expert Choice™ software. Weighting of vendor performance evaluation criteria obtained from AHP Expert Choice™ software.

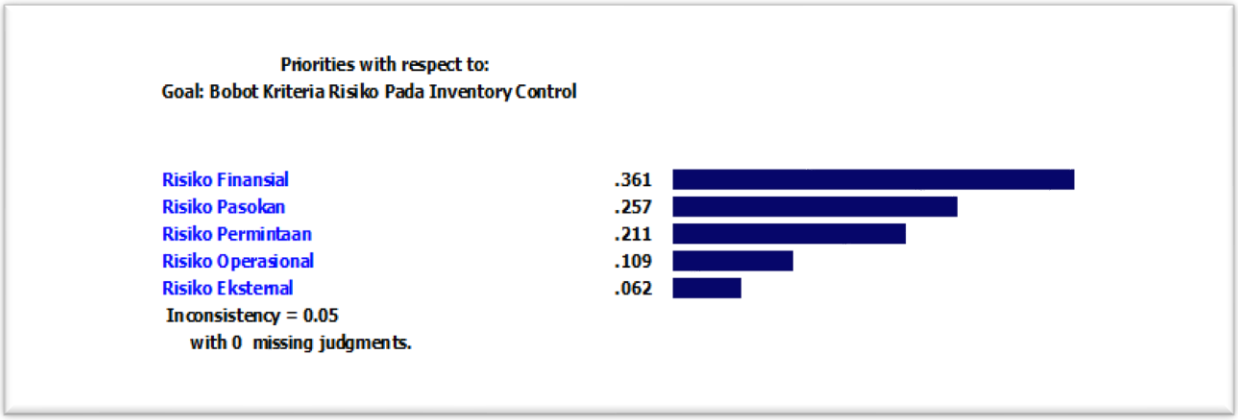

Figure 2. Weight of Risk Criteria in *Inventory Control*

Based on Figure 2, the weight of the criteria of risk in *inventory control* shows that in order, financial risk has the highest weight with a weight value of 0.361, followed by supply risk which has a weight of 0.257, then the demand risk criterion with a weight of 0.211, then operational risk with a weight of 0.109n and finally external risk with a weight of 0.062. The *consistency ratio* value obtained is 0.05, which is smaller than the standard score that has been set, which is 0.1. Thus, the data is declared consistent and usable. Next, the weight value for the subcriteria of each criterion is calculated. The following results of the calculation of the weight of the demand *risk* subcriteria are seen in Figure 3 as follows:

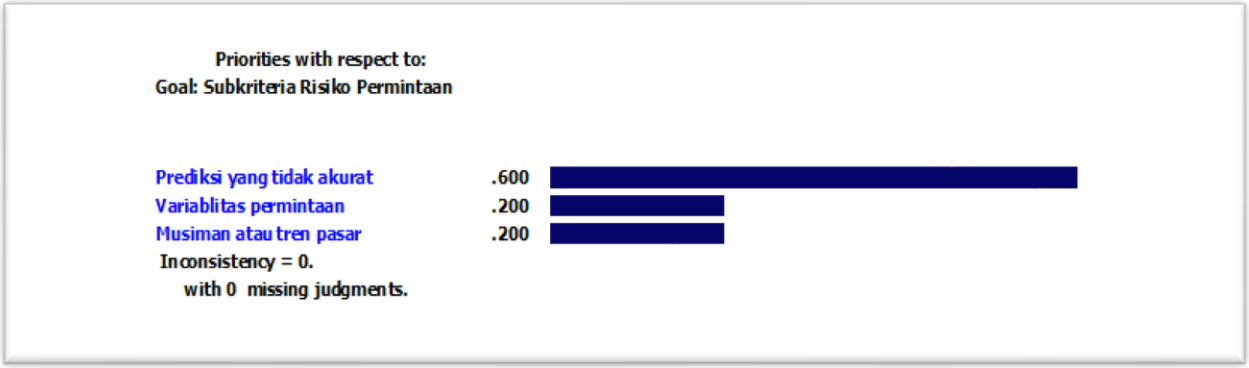

Figure 3. Sub criteria Weights of Demand Risk

Based on Figure 3 above, the results of the subcriteria are obtained from demand risk for inaccurate predictions with the highest weight value of 0.600, then the subcriteria of demand variability with a weight value of 0.200 and seasonal or market trends with a weight value of 0.200. The *consistency ratio* value obtained is 0.000 which is smaller than the standard value that has been set, which is 0.1. Thus, the data is declared consistent and usable. Next, the weight value is calculated for the subcriteria of *supply risk*. The following results of the calculation of the weight of the supply risk subcriteria are seen in Figure 4 as follows:

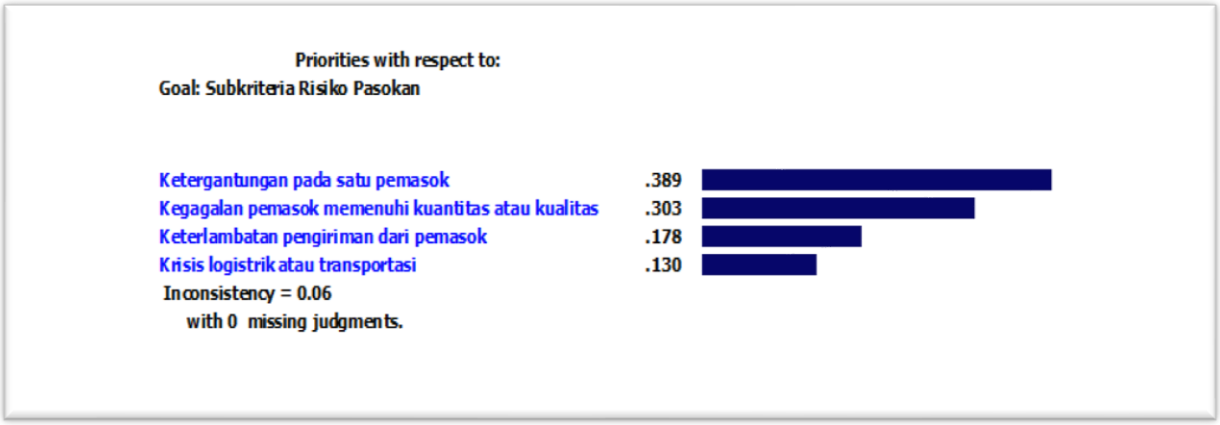

Figure 4. Sub criteria Weights of Supply Risk

Based on Figure 4 above, the results of the subcriteria of supply risk for dependence on one supplier have the highest weight value of 0.389, then the subcriterion of supplier failure to meet quantity and quality with a weight value of 0.303, then for delivery delays from suppliers get a weight value of 0.178, and the best for the subcriteria of logistics and transportation crises get a weight value of 0.130. The *consistency ratio* value obtained is 0.060 which is smaller than the standard value that has been set, which is 0.1. Thus, the data is declared consistent and usable. Furthermore, the weight value is calculated for the subcriteria of operational *risk*. The following results of the calculation of the weight of the operational risk subcriteria are seen in Figure 5 as follows:

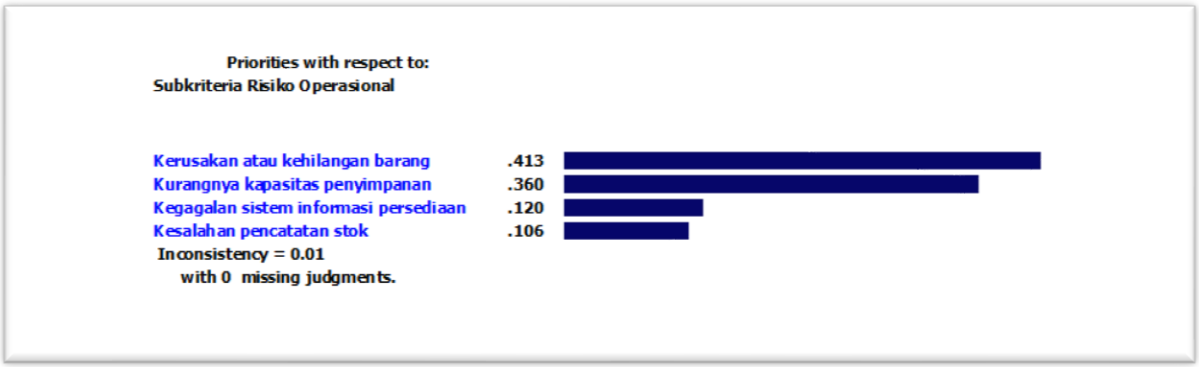

Figure 5. Underlying Weight of Operational Risk

Based on figure 5, the results of the subcriteria of operational risk were obtained, where the sub-criterion of damage or loss of goods received the highest weight result with a weight value of 0.413, then followed by the subcriterion of lack of deviation capacity with a weight value of 0.360, then the subcriterion of inventory information system failure obtained a weight value of 0.120, and the last subcriterion of stock recording error with a weight value of 0.106. The *consistency ratio* value obtained is 0.010 which is smaller than the standard value that has been set, which is 0.1. Thus, the data is declared consistent and usable.

Next, the weight value is calculated for the subcriteria of financial risk. The following results of the calculation of the weight of the financial risk subcriteria are seen in Figure 6. as follows:

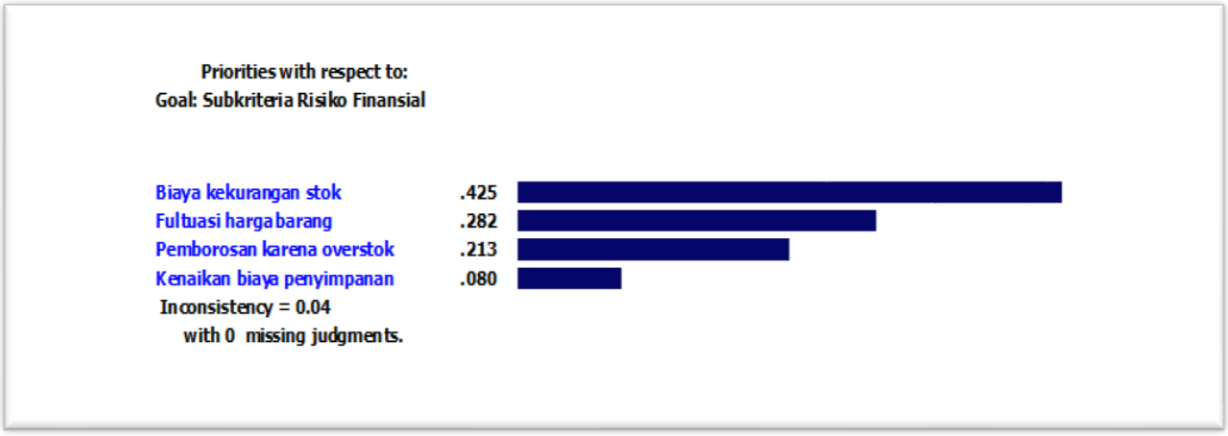

Figure 6. The Underlying Weight of Financial Risk

Based on Figure 6, the results of the subcriterion of financial risk were obtained, where the sub-criterion of the cost of stock shortage got a weight value of 0.425, then followed by the subcriterion of fluctuation in the price of goods in second place with a weight value of 0.282, then the subcriterion of waste due to overstock which got a weight value of 0.213, and the last subcriterion of increasing storage costs with a weight value of 0.080. The *consistency ratio* value obtained is 0.040 which is smaller than the standard value that has been set, which is 0.1. Thus, the data is declared consistent and usable. Next, the weight value was calculated for the subcriteria of external *risk*. The following results of the calculation of the weight of the external risk subcriteria are seen in Figure 7 as follows:

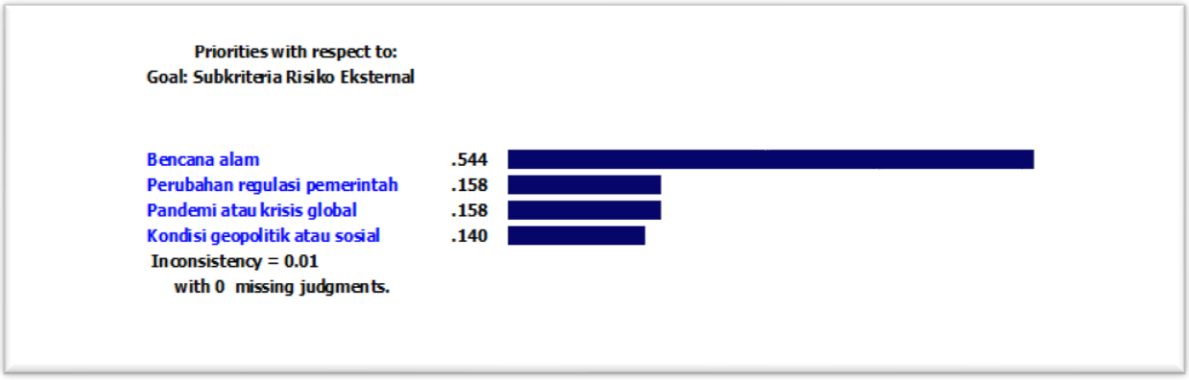

Figure 7. Sub criteria Weight of External Risks

Based on Figure 7, the results of the subcriteria of external risk were obtained, where the subcriteria of natural disasters entered the order with the highest weight value with a weight value of 0.544, then the subcriterion of changes in government regulations with a weight value of 0.158, then the subcriterion of pandemic or global crisis with a weight value of 0.158, and finally for the subcriterion of geopolitical or social conditions with a weight value of 0.140. The *consistency ratio* value obtained is 0.010 which is smaller than the standard value that has been set, which is 0.1. Thus, the data is declared consistent and usable. The final criteria and subcriteria after weighting using the AHP method in *the Expert Choice*™ software can be seen in Figure 8.

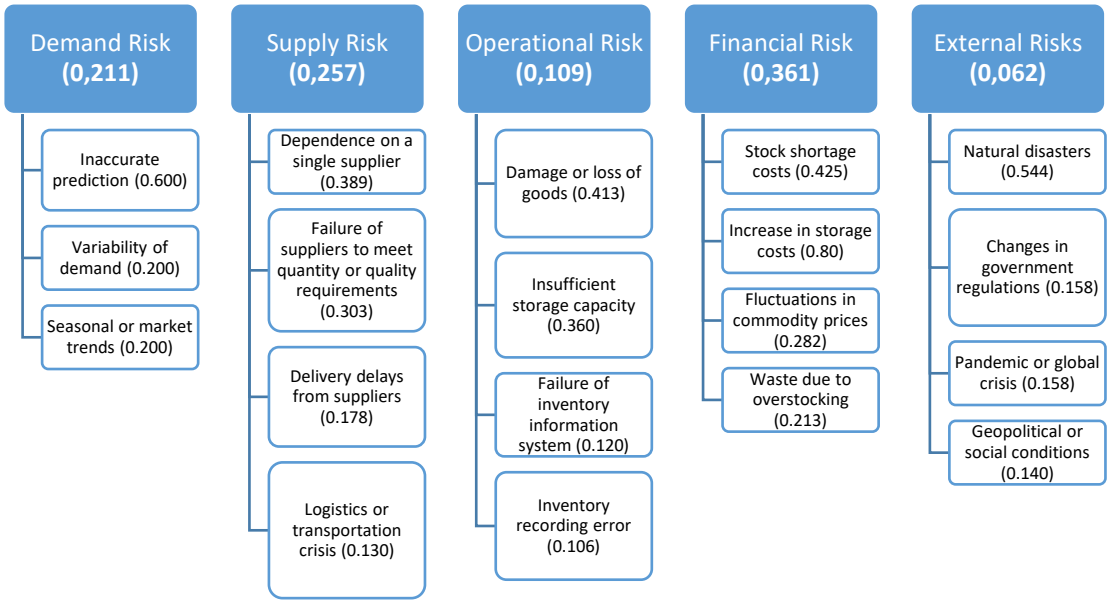

Figure 8. Final Criteria and Sub criteria After Weighting

Consistency Ratio Value

If the *consistency ratio* (CR) value < 0.1 or 10%, then the paired comparison in the criteria matrix is considered consistent. On the other hand, if *the consistency ratio* (CR) value is > 0.1 or 10%, the comparison is considered inconsistent (Saaty, 1990). Therefore, if inconsistencies are found, then the filling in of the values on the criteria and subcriteria must be repeated. The following table 4.1 presents the overall CR values.

Table 1. *Consistency Ratio* Between Criteria and Sub criteria

Pairwise Comparison	Consistency Ratio (CR)	Remarks
Between Criteria	0.05000	Consistent
Between Subcriteria of Demand Risk	0.00000	Consistent
Between Subcriteria of Supply Risk	0.06000	Consistent
Between Subcriteria of Operational Risk	0.01000	Consistent
Between Subcriteria of Financial Risk	0.04000	Consistent
Between Subcriteria of External Risk	0.01000	Consistent

Based on Table 1 regarding the *consistency ratio* between criteria and subcriteria, the results of the questionnaire from the four respondents who are *experts* at PT PLN (Persero), namely the Subscription Service Unit Manager, Construction Assistant Manager, Planning Assistant Manager and Procurement Planning Officer, show consistent results. Thus, no repetition is required in filling out the questionnaire.

Risk Level and Mitigation Measures Category

In risk analysis using the AHP method, risk grouping into categories such as "high", "medium", and "low" based on priority weights is often done to facilitate interpretation and decision-making. However, it should be noted that there is no universal standard that sets specific numerical limits for the category. Instead, many studies and practices use context-adjusted approaches and the resulting weight distribution.

Some studies have applied risk classification based on AHP weights by setting specific thresholds. For example, in a study by Rabihah Md.Sum (2015), risk was categorized based on the priority weights obtained from the AHP, although no specific numerical limitations were mentioned. This approach emphasizes the importance of flexibility and adaptation to the specific context of risk analysis.

The classification of AHP risk weights taken in this study is:

Height > 0.30
Medium 0.10–0.30
Low < 0.10

Table 2. Risk Categories of Risk Criteria

Risk	Weight Value	Risk Category
Demand Risk	0.211	Medium
Supply Risk	0.257	Medium
Operational Risk	0.109	Medium
Financial Risk	0.361	High
External Risk	0.062	Low

From the table above, financial risk is a risk criterion with a type of high-risk category, in responding to this, mitigation measures are needed that must be taken. Mitigation measures are made through FDG (*Forum Group Discussion*) with *experts* consisting of Subscription Service Unit Managers, Construction Assistant Managers, Planning Assistant Managers and Procurement Planning Officials. The mitigation steps obtained for the financial risk criteria in the FGD activities are:

Strict Material Budget Planning

Carry out strict material budget planning by making purchase planning based on demand forecasts and historical data. Then also use methods such as *Material Requirements Planning* (MRP) to avoid overbuying or under-purchasing materials.

Discipline in filling in material availability in the AGO application.

Updating materials in real time, not just waiting collectively because it is feared that there will be errors in the update process caused by *human error.*

Periodic Material Evaluation and Audit.

Conducting regular physical and administrative audits, especially in service units (ULP/ULP3). Then also focus on materials where there is often a difference between physical stock and the system, as this can lead to financial losses.

Material Management HR Training.

Improve the competence of procurement, warehouse, and distribution staff in terms of:

1) PLN logistics information system
2) Material risk management
3) Prevention of administrative irregularities

Table 3. Risk Categories of Risk Sub criteria

Risk	Weight Value	Category Risk
Inaccurate predictions	0.600	Tall
Demand variability	0.200	Keep
Seasonal or market trends	0.200	Keep
Dependence on a single supplier	0.389	Tall
Failure of suppliers to meet quantity or quality	0.303	Tall
Delay in delivery from the supplier	0.178	Keep
Logistics or transportation crisis	0.130	Keep
Damage or loss of goods	0.413	Tall
Lack of storage capacity	0.360	Tall
Inventory information system failure	0.120	Keep
Stock recording errors	0.160	Keep
Cost of stock shortage	0.425	Tall
Rising storage costs	0.800	Tall
Fluctuations in the price of goods	0.282	Keep
Waste due to overstock	0.213	Keep
Natural disasters	0.544	Tall
Changes in government regulations	0.158	Keep
Pandemic or global crisis	0.158	Keep
Geopolitical or social conditions	0.140	Keep

If sorted from highest to lowest weight, the results are obtained as shown in table 4 below:

Table 4. Risk Category Ranking of Risk Sub criteria

Risk	Weight Value	Category Risk
Rising storage costs	0.800	Tall
Inaccurate predictions	0.600	Tall
Natural disasters	0.544	Tall
Cost of stock shortage	0.425	Tall
Damage or loss of goods	0.413	Tall
Dependence on a single supplier	0.389	Tall
Lack of storage capacity	0.360	Tall
Failure of suppliers to meet quantity or quality	0.303	Tall
Fluctuations in the price of goods	0.282	Keep
Waste due to overstock	0.213	Keep
Demand variability	0.200	Keep
Seasonal or market trends	0.200	Keep
Delay in delivery from the supplier	0.178	Keep
Stock recording errors	0.160	Keep
Changes in government regulations	0.158	Keep
Pandemic or global crisis	0.158	Keep
Geopolitical or social conditions	0.140	Keep
Logistics or transportation crisis	0.130	Keep
Inventory information system failure	0.120	Keep

From the table above, the 19 risk subcriteria are a type of high-risk category, in response to this, mitigation measures are needed that must be taken. Mitigation measures are made through FDG (*Forum Group Discussion*) with *experts* consisting of Subscription Service Unit Managers, Construction Assistant Managers, Planning Assistant Managers and Procurement Planning Officials. The mitigation steps obtained for the 8 subcriteria in the FGD activities are:

Table 5. Mitigation Measures of High Category Sub criteria

Risk	Common Causes	Mitigation Steps
Rising storage costs	Overstock, storage of unused goods, obsolete materials	- Apply *just-in-time* (JIT) to non-critical materials
		- Use ABC analysis for stock efficiency
		- Optimize warehouse utilization
Inaccurate predictions	Forecast based on assumptions or old data	- Use forecasts based on historical data and actual projects
	Sudden change in project needs	- Regular planning updates
		- Close collaboration between engineering and procurement teams
Natural disasters	Floods, earthquakes, fires that damage warehouses or materials	- Use insurance for critical materials
		- Store in a warehouse with K3 standards and is disaster-resistant
		- Have an emergency recovery plan (DRP) in place
Stockout costs	Planning errors, procurement delays, unexpected requests	- Calculate and set *safety stock* and *reorder points* based on demand and *lead time*
		- Monitor stock in real-time via ERP
Damage or loss of goods	*Poor handling*, inaccurate recording, weak warehouse security	- Train warehouse staff according to SOP
		- Increase surveillance and CCTV
		- Routine physical audits and *barcode systems*
Dependence on a single supplier	Only 1 *vendor* with quota or high price	- Diversify *vendors*
		- Create long-term contracts with strict terms
		- *Periodic vendor* evaluation with a scoring system
Lack of storage capacity	Warehouse planning is not in line with the growth of material needs	- Warehouse *layout* optimization
		- Use vertical racking or *racking systems*
		- Consider renting additional warehouses during *peak season*
Supplier failure (quantity/quality)	Suppliers are unable to meet specifications or delivery times	- Use *a vendor performance evaluation system*
		- Apply penalties in contracts
		- Prepare *alternative vendors* in the approved *vendor list*

These mitigation measures are expected to be implemented to avoid risks that may occur in material inventory control activities, especially New Installation and Power Change 1 Phase materials for PT PLN (Persero) UP3 South Banten. The implementation of each mitigation effort is of course adjusted to the situation or conditional.

CONCLUSIONS

This study concluded that optimizing inventory control for *MDU* materials at PT PLN UP3 *Banten Selatan* is best achieved by implementing the continuous review (*s,S*) method, which surpassed the periodic review (*R,s,S*) in both service level (100% demand fulfillment) and cost efficiency (saving IDR 738,736,538). Financial risk emerged as the most critical factor, prompting mitigation strategies such as strict budget planning and real-time stock monitoring. The AHP-based risk assessment identified eight high-risk subcriteria—including supplier dependence and storage costs—for which targeted actions like vendor diversification and warehouse optimization were recommended. These results highlight the necessity of combining robust inventory control with proactive risk management to improve operational efficiency and regulatory compliance. For future research, it is suggested to expand the analysis to include multi-phase power demands and dynamic demand forecasting models, as well as to explore the integration of machine learning for real-time risk prediction and blockchain technology for enhanced supply chain transparency. Comparative studies across different PLN units are also recommended to validate the scalability of the proposed framework.

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