Volume 4, No. 9 September 2026
p-ISSN 3031-5786 | e-ISSN 3032-3037

ADVANCES IN SOCIAL HUMANITIES RESEARCH

Improving Construction Performances and Reducing Delay Through Lesson Learned and Project Management Office (PMO) Implementation: A Case Study of Kucing Liar Fan 7, PT. Freeport Indonesia

Rega Rinaldo Johnjudika*, Gatot Yudoko
Institut Teknologi Bandung, Indonesia
Email: regarinaldoj@gmail.com*, gatot@sbm-itb.ac.id

Keywords: Construction; Construction Performance; Project Delay; Lesson Learned; Project Management Office.

Abstract

The Kucing Liar Fan 7 project is an underground ventilation construction project within the Central Services Division of PT Freeport Indonesia. The problems arose not from a single cause but from the interaction of management, construction method, material availability, people and communication, equipment, and the underground working environment. This study aims to identify and evaluate the key lessons learned from the Kucing Liar Fan 7 project, determine how these lessons can be institutionalized through a Project Management Office (PMO), and develop an implementation roadmap to improve future construction performance. A mixed-method approach was used, combining a five-point Likert questionnaire distributed to 27 project stakeholders across six factors (Management, Method, Material, People, Environment, Equipment) with historical project data, interviews, observation, and two sessions of Focus Group Discussion (FGD). The questionnaire results were analysed using mean scores, Relative Importance Index (RII), Cronbach's alpha, and Pareto analysis. The analysis identified Management, Method, Material, People, and Environment as the prioritized factors, jointly accounting for 84.93% of the cumulative relative importance, with root causes concentrated in design readiness, change control, material planning, communication, and constrained underground working space. The lessons learned were translated into a Lesson Learned Register and a phased Controlling PMO implementation roadmap consisting of organizational assessment, pilot implementation, organizational integration, and continuous improvement. The proposed PMO does not replace the existing balanced-matrix structure but strengthens governance, standardization, coordination, monitoring, and knowledge management to reduce the recurrence of delays in future underground ventilation construction projects.

INTRODUCTION

The mining industry plays a strategic role in Indonesia's economic development through mineral resource production, employment generation, infrastructure development, and government revenue contributions. Mining contributed approximately IDR 237 trillion to Indonesia's Gross Domestic Product (GDP) in 2025, making it one of the country's largest economic contributors. Mining operations are characterized by high capital requirements, complex project execution, and significant operational risks, including geological uncertainty, safety hazards, logistical challenges, environmental constraints, and commodity price fluctuations, so that effective project management, cost control, risk management, and operational efficiency are required to maintain profitability and sustainable operations (Hobbs & Aubry, 2007, 2008) .

PT Freeport Indonesia is one of Indonesia's largest mining companies and a major producer of copper and gold, operating in the Grasberg mineral district in Central Papua. As surface reserves declined, the company transitioned from the Grasberg open-pit mine to large-scale underground mining operations, which significantly increased project complexity, particularly in underground infrastructure development, construction scheduling, logistics management, and stakeholder coordination. To support future underground production, PT Freeport Indonesia is developing the Kucing Liar Mine, which includes fixed mining facilities, crushers, conveyor systems, and ventilation systems. Among these, the Ventilation Auxiliary Fan facilities are critical for maintaining safe underground working conditions by exhausting contaminated air and supplying fresh air to mining operations.

One of these facilities, Kucing Liar Fan 7, commenced construction in January 2025 following the handover of the work area from the Underground Division to the Central Services Division, with construction scope covering the Fan Chamber, Compressor Area, PCR3, and PFCC Area. The project was originally scheduled for completion on 19 October 2025. During execution, however, the project experienced construction performance issues that resulted in schedule delays and required project re-baselining. Historical performance records show that the Project Performance Factor (PF) declined markedly from early April 2025 onward, when the project entered a more complex phase involving structural steel installation, mechanical-piping installation, and multidisciplinary coordination, with an average PF of approximately 0.82 across the observed period (see Figure 1). The 8% management contingency initially allocated for the project was fully consumed and exceeded by approximately 10% due to the cumulative effect of engineering changes, procurement adjustments, material replacement, and additional construction activity.

These challenges highlight the importance of establishing an effective Project Management Office (PMO) within PT Freeport Indonesia's construction environment. In underground mining construction, where activities involve complexity, multidisciplinary coordination, and dynamic operational risk, the absence of standardized project governance and integrated control mechanisms can significantly affect project performance. A PMO can enhance organizational project performance through standardized project management methodologies, lesson learned integration, performance monitoring, risk management, and decision-making support, while enabling systematic documentation and reuse of lessons learned from previous projects.

This research offers novelty in three respects: (1) it integrates lesson-learned capture with PMO design in a single empirical case, bridging the diagnosis–solution gap identified above; (2) it applies the PMBOK framework to underground mining ventilation construction, a context underrepresented in project management literature; and (3) it proposes a phased Controlling PMO roadmap that respects existing balanced-matrix authority — a governance model rarely documented in mining construction. The purpose of this research is to identify and evaluate the key lessons learned from the Kucing Liar Fan 7 project, determine how these lessons can be institutionalized through a PMO, and develop an implementation roadmap to improve future construction performance. The research objectives are: (1) to identify and analyse the lessons learned from the Kucing Liar Fan 7 project; (2) to evaluate how the identified lessons learned can be implemented within a PMO framework; and (3) to develop a roadmap for PMO implementation aimed at improving construction performance and reducing project delay. The contribution of this research is twofold: theoretically, it extends PMBOK-based knowledge management and PMO literature into the underground mining construction domain; practically, it provides PT Freeport Indonesia's Central Services Division with a Lesson Learned Register and a phased PMO implementation roadmap that can be replicated across future ventilation and underground infrastructure projects. The benefits include improved project governance, reduced schedule slippage, enhanced cost control, and strengthened organizational learning capability.

This research focuses on the Kucing Liar Fan 7 project and its activities in analysing project constraints and problems to establish the lesson learned, drawing on interviews, questionnaires, and historical project data, and selecting improvement priorities using the PMBOK framework (6th edition). The main data covers project activity from the Approval for Expenditure (AFE) phase through planning and execution between January 2025 and September 2025, prior to the project's re-baselining; commissioning activity and the June 2025 underground mine natural-disaster event are excluded, and equipment-related data could not be displayed due to access restrictions. The questionnaire and Focus Group Discussion respondents were limited to internal Central Services Division stakeholders with direct or indirect involvement in, and decision-making authority over, the Kucing Liar Fan 7 project, with the questionnaire distributed between January and February 2026.

This study adopts the Project Management Body of Knowledge (PMBOK) developed by the Project Management Institute, 2017) (Institute, 2017, 2019) as the primary theoretical foundation for analysing project management practice on the Kucing Liar Fan 7 project. PMBOK was selected for its comprehensive, structured approach covering Institute (Project Management initiation, planning, execution, monitoring and controlling, and closure, and for its emphasis on knowledge areas such as scope, schedule, risk, communication, procurement, stakeholder, and knowledge management, all of which are relevant to the construction delay issues examined in this research. Project performance monitoring in this study is also informed by earned value management practice standards (Boonsripitayanon & Jearasatit, 2017).

Prior studies on construction delay consistently identify multi-causal patterns rather than single dominant causes. (Assaf & Al-Hejji, 2006) found that owner-, contractor-, and consultant-related factors jointly drive large project delays; Sambasivan (Sambasivan & Soon, 2007) and Soon (2007) and (Doloi et al., 2012) reported comparable patterns of financial, planning, and coordination-related causes; (Sweis et al., 2008) and (Enshassi et al., 2009) similarly linked construction performance deterioration to material availability, change orders, and workforce and equipment constraints. These findings are consistent with the pattern observed on the Kucing Liar Fan 7 project, where design change, material readiness, and coordination gaps interacted to reduce productivity below the planned baseline.

Lesson learned is a component of the PMBOK Project Knowledge Management area and refers to the structured capture, validation, and reuse of project experience so that future projects need not begin from zero (Eken et al., 2020; Jugdev, 2012) Without formal documentation, project knowledge tends to remain tacit and is lost as personnel and projects change; a formally maintained Lesson Learned Register instead allows an organization to convert individual experience into institutional knowledge that can inform planning, estimation, integration, and communication on subsequent projects.

A Project Management Office (PMO) is an organizational structure that standardizes governance, provides project-related decision-support, and facilitates the sharing of resources, methodologies, tools, and techniques across projects ((Aubry et al., 2007, 2008). (Desouza & Evaristo, 2006) characterize PMOs as knowledge-based archetypes whose value lies in organizational learning as much as administrative control, while (Unger et al., 2012) show that a portfolio-level PMO can materially improve execution and success through governance, standardization, and coordination roles rather than by taking over project managers' direct authority. This study adopts a Controlling PMO archetype, positioned to strengthen governance and knowledge management within the existing balanced-matrix organization without displacing project managers' and functional managers' existing authority (Kerzner, 2022; Oakland, 2014).

This study applies several established analysis tools. The Ishikawa (fishbone) diagram is used to visually map potential causes of the observed performance decline into major categories. The Relative Importance Index (RII) converts Likert-scale questionnaire responses into a relative importance score per factor, interpreted using the scale of (Baruch & Holtom, 2008), while the underlying Likert mean scores are interpreted following (Boone Jr. & Boone, 2012). Pareto analysis (the 80/20 principle) is then used to prioritize the factors that jointly explain the majority of perceived importance, rather than to estimate an exact causal contribution to delay. Internal consistency of the questionnaire constructs is assessed using Cronbach's alpha (Cronbach, 1951). These quantitative tools are combined with a mixed-methods research design (Creswell & Creswell, 2018, 2022) that triangulates the questionnaire results against historical project records, interviews, and Focus Group Discussion (FGD) findings.

METHOD

Research Design and Object of Study

This research adopts a mixed-method design that integrates quantitative and qualitative data to provide a comprehensive analysis of the construction performance issues on the Kucing Liar Fan 7 project, an underground ventilation fan construction project of PT Freeport Indonesia's Central Services Division. Table 1 summarizes the project's key milestones, from the initial concept and cost estimate stage through the planned construction completion date, illustrating the sequence in which design, procurement, and construction activities were intended to proceed before the performance decline occurred.

Table 1. Major Project Milestones of Kucing Liar Fan 7

Milestone	Description	Date
Finish concept, project control and cost estimate	Initial project phase	19 Oct 2022
Approval for Expenditure (AFE)	Project financial approval	8 Jul 2023
Area handover, Underground to Central Services	Fan 7 chamber area handed over	30 Dec 2024
Kick-off meeting	Scope and deliverables defined with stakeholders	16 Jan 2025
Construction started	Execution phase begins	20 Jan 2025
All Issued-for-Construction (IFC) drawings completed	Engineering completes drawings	10 Jun 2025
Planned finish of construction scope	Original construction completion target	19 Oct 2025

Source: Project document of Kucing Liar Fan 7

Data Collection Method

Quantitative primary data were obtained from two sources: (1) historical project records, including schedule reports, progress-tracking records, baseline schedules, delay records, and cost/time performance indicators; and (2) a structured, five-point Likert-scale questionnaire distributed to 27 project stakeholders representing engineers, supervisors, planners, project controllers, and management personnel across the six investigated factor groups: Management, Method, Material, People, Environment, and Equipment. Qualitative primary data were collected through semi-structured interviews with selected project personnel and key stakeholders, direct observation, and two sessions of Focus Group Discussion (FGD). The first FGD session involved the Kucing Liar Project Manager, Project Control, Engineering, Technical Experts, and Procurement; the second involved the Project Manager, Project Control, Cost Estimator, Construction team, Construction Technical Experts, Functional and Senior Management, Field Engineering, and QA/QC. Secondary data were obtained from an extensive review of relevant academic journals, books, and industry reports related to project management, construction delay, and lesson learned systems, used to strengthen the theoretical foundation and triangulate the field findings.

Data Analysis Technique

The current project performance was first examined using historical performance and cost data, and potential root causes of the performance decline were mapped using an Ishikawa (fishbone) diagram. A questionnaire developed from the identified potential causes was then processed using mean scores, interpreted according to the scale in Table 2, and the Relative Importance Index (RII), interpreted according to the scale in Table 3. Pareto analysis was applied to the resulting RII contribution values to prioritize the factors requiring the most attention, and Cronbach's alpha was calculated to assess the internal consistency of each factor's questionnaire items. The two FGD sessions were then used to validate the quantitative findings, explore practical improvement measures, and identify the underlying causes in more depth. Findings from all sources were mapped against PMBOK knowledge areas to identify governance gaps, and were subsequently synthesized into a Lesson Learned Register and a phased PMO implementation roadmap.

Table 2. Likert Mean Score Interpretation

Likert Mean Score	Interpretation
1.00 – 1.80	Strongly Disagree
1.81 – 2.60	Disagree
2.61 – 3.40	Neutral
3.41 – 4.20	Agree
4.21 – 5.00	Strongly Agree

Source: Boone & Boone (2012)

Table 3. Relative Importance Index (RII) Interpretation Scale

Relative Importance Index Score	Importance
0.80 – 1.00	Very High
0.60 – 0.79	High
0.40 – 0.59	Moderate
0.20 – 0.39	Low
< 0.20	Very Low

Source: Holt (2014)

RESULTS AND DISCUSSION

Current Project Performance

Historical project records indicate that the overall performance of Kucing Liar Fan 7 did not achieve its planned schedule and productivity objectives. As shown in Figure 1, the Project Performance Factor (PF) remained below the target value of 1.00 for most of the execution period, with an average of approximately 0.82. A PF below 1.00 indicates that construction execution required more time and resources than originally estimated for the same scope of work. Performance deteriorated markedly from early April 2025, when the project entered a more complex phase involving structural steel installation, mechanical-piping installation, and multidisciplinary coordination, resulting in continuous schedule slippage that ultimately required the project schedule to be re-baselined.

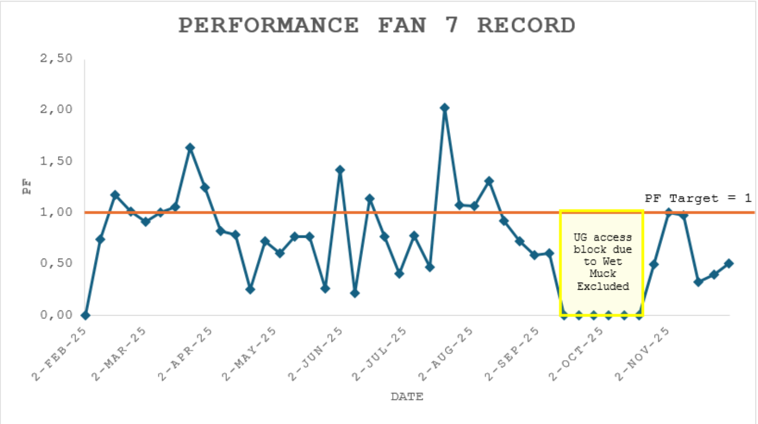

Figure 1. Project Performance Factor (PF) of Kucing Liar Fan 7
Source: Project historical performance record

The project's cost performance reflects the same decline in construction productivity (Figure 2). The management contingency was initially set at 8% of the baseline budget to accommodate unforeseen risk. However, the cumulative effect of engineering changes, procurement adjustment, material replacement, and additional construction activity resulted in cost exceeding the available contingency by approximately 10%, placing the project in an over-budget condition and indicating that the contingency reserve was insufficient to absorb the disturbances experienced during execution.

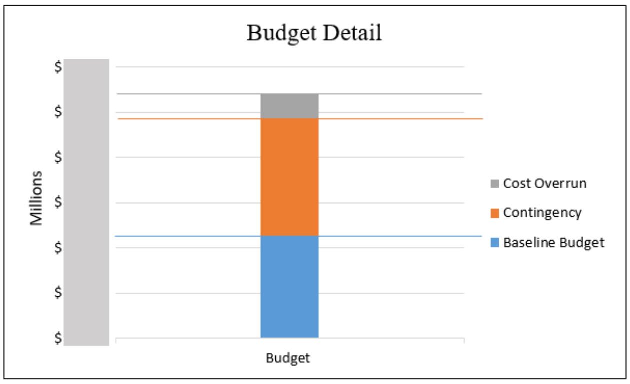

Figure 2. Budget, Baseline, Contingency, and Cost Overrun of Kucing Liar Fan 7
Source: Project historical cost record

Root Cause Identification

Potential causes of the declining construction performance and schedule delay were mapped using an Ishikawa (fishbone) diagram across the six factor categories of Management, Method, Material, People, Environment, and Equipment, as presented in Figure 3. The diagram groups causes such as frequent design changes and rework under Management, inadequate communication method and planning sequencing under Method, weak delivery priority and quality control under Material, coordination and supervisory gaps under People, limited underground working and storage space under

Environment, and limited equipment availability and utilization under Equipment. This structured mapping formed the basis for developing the questionnaire items used in the subsequent quantitative analysis.

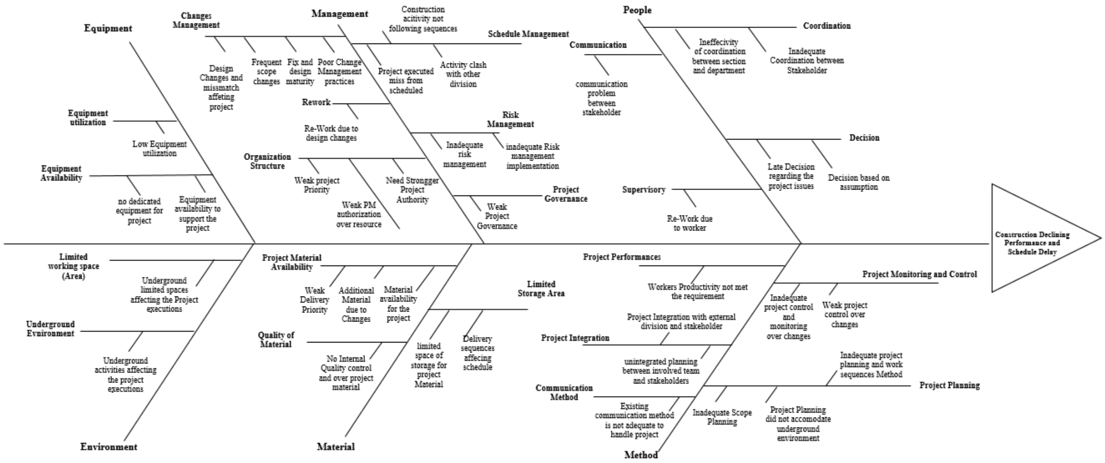

Figure 3. Ishikawa (Fishbone) Diagram of Construction Performance Decline
Source: Author, developed from project historical data and Focus Group Discussion

Questionnaire Results

The average mean score for each factor, presented in Table 4, shows that all six factors fall within the "Agree" range (3.41–4.20), with Management obtaining the highest mean score (4.153) and Equipment the lowest (3.518), indicating that respondents consistently perceived all six factor groups as contributing to the project's performance issues.

Table 4. Average Mean Score for Each Factor

Factor	Average Mean Score
Management	4.153
Method	4.017
Material	3.983
People	3.970
Environment	3.711
Equipment	3.518

Source: Author, processed from questionnaire data

The Relative Importance Index (RII) for each factor and its percentage contribution to the total RII are shown in Table 5. Management obtained the highest RII (0.831), representing 17.79% of the total normalized contribution, followed closely by Method (17.19%), Material (17.06%), and People (17.00%), while Environment (15.89%) and Equipment (15.07%) contributed the least.

Table 5. Relative Importance Index (RII) and Contribution per Factor

Factor	RII	Total RII	RII Contribution
Management	0.831	4.671	17.79%
Method	0.803	4.671	17.19%
Material	0.797	4.671	17.06%
People	0.794	4.671	17.00%
Environment	0.742	4.671	15.89%
Equipment	0.704	4.671	15.07%

Source: Author, processed from questionnaire data

The reliability of the questionnaire constructs was tested using Cronbach's alpha (Table 6). Management (0.91) and Method (0.84) show strong internal consistency, People (0.72) and Equipment (0.81) are acceptable, while Material and Environment (each 0.6) show only marginal internal consistency, likely reflecting the heterogeneous nature of underground material- and environment-related constraints. These values are considered usable for this exploratory case study but were interpreted with caution and triangulated through the FGD sessions.

Table 6. Cronbach's Alpha Value per Factor

Factor	Cronbach's Alpha
Management	0.91
Method	0.84
Material	0.60
People	0.72
Environment	0.60
Equipment	0.81

Source: Author, processed from questionnaire data

Pareto Prioritization of Factors

Pareto analysis was applied to the RII contribution values to prioritize the factors for further discussion and improvement (Table 7 and Figure 4). Management, Method, Material, People, and Environment jointly account for 84.93% of the cumulative relative importance, while Equipment contributes the remaining 15.07% and was therefore excluded from the detailed lesson-learned discussion. The prioritized order of discussion is accordingly Management, Method, Material, People, and Environment.

Table 7. Pareto Prioritization of Contributing Factors

Factor	RII Contribution	Cumulative %
Management	17.79%	17.79%
Method	17.19%	34.98%
Material	17.06%	52.04%
People	17.00%	69.04%
Environment	15.89%	84.93%
Equipment	15.07%	100.00%

Source: Author, processed from questionnaire data

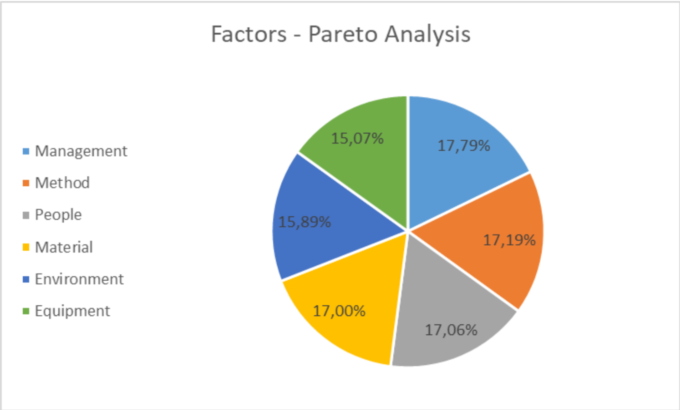

Figure 4. Pareto Distribution of Contributing Factors
Source: Author, processed from questionnaire data

Discussion of Prioritized Factors

Management factors were the largest contributor to the project's performance issues, arising mainly from design change and design immaturity, which subsequently generated Field Change Notices (FCN), Scope Change Notices (SCN), additional procurement, and rework. The balanced-matrix organizational structure used on Kucing Liar Fan 7 provided access to multidisciplinary expertise, but shared authority slowed decision-making when governance mechanisms were insufficient: design changes, procurement adjustment, and resource prioritization required approval from several functional departments, reducing the appointed Project Manager's ability to enforce timely corrective action. From a PMBOK perspective, these findings point to gaps in Project Integration Management, Risk Management, and Schedule Management.

People-related issues manifested mainly as rework arising from inadequate supervision and coordination between stakeholders and construction teams; documented cases from the project change log (Table 8) show rework on the bulkhead structure, sealant replacement, and the motor platform, each requiring 10–22 additional days to repair. These cases were traced to insufficient constructability verification and communication gaps between engineering and field supervision, corresponding to weaknesses in Project Communication and Project Quality Management.

Table 8. Documented Rework Cases Attributed to People Factors

No	Change Type	Description	Days to Repair
1	Rework	Rework on bulkhead structure	12
2	Rework	Rework: sealant replacement	22
3	Rework	Rework: motor platform	10

Source: Project change log

Material-related issues (Table 9) included rebar shortages that halted concreting for seven days, a UPS unit found broken during transportation with a two-week replacement lead time, and a corroded impeller rotary part caused by improper packaging and site storage that required a two-month re-procurement lead time. Although the direct material cost was relatively small compared with the overall project budget, the resulting construction disruption and rework were significant, reflecting gaps in Project Resource Management and quality control during transport and storage.

Table 9. Material-Related Issues on Kucing Liar Fan 7

Issue	Explanation	Impact on Project
Rebar availability	Shortage of rebar for concrete foundation work	7-day wait, disturbing construction activity
UPS system broken	Found broken during transportation to site	2-week lead time for supplier replacement
Impeller corroded	Internal impeller part corroded due to improper packaging/storage	2-month lead time, additional procurement
Compressor broken	Broken due to improper packaging	Additional procurement, construction disturbance

Source: Project historical data

Method-related findings indicate that project planning relied heavily on analogous estimation from previous fan projects, and that existing communication channels were not adequate to handle the project's coordination demands; this corresponds to gaps in Project Integration and Project Communication Management. Environmental findings centred on the limited underground working and storage area, which restricted material staging and movement while requiring multiple disciplines to work concurrently in the same space, so that a disruption in one activity created additional interfaces, rework, and schedule disruption for others. Both sets of findings were consistently validated in the two FGD sessions, which further confirmed that design readiness, integrated change control, material planning integration, and cross-functional communication were the most urgent areas for improvement.

Lesson Learned Register

The lessons learned identified through historical data, questionnaire results, and the two FGD sessions were compiled into a Lesson Learned Register (summarized by factor in Table 10) to convert individual project experience into organizational knowledge for future ventilation fan projects. The register captures the business issue observed, the resulting lesson, the recommended improvement, and the responsible function for each of the five prioritized factors.

Table 10. Summary of the Lesson Learned Register from Kucing Liar Fan 7

Factor	Business Issue	Lesson Learned	Recommended Improvement
Management	Design readiness and change control	Design was not fully mature before construction due to late supplier/client input, and change control was not formally integrated	Establish design readiness/constructability review and formal engineering change-control notification before construction authorization
Method	Planning and communication method	Planning relied heavily on analogous estimation; existing communication channels were inadequate for project coordination needs	Adopt detailed WBS-based planning and a standardized project communication/coordination platform
Material	Procurement, packaging, and storage	Material delivery, packaging, and storage practices were not synchronized with construction milestones	Integrate material planning with engineering deliverables and strengthen incoming-material quality inspection
People	Supervision and coordination	Field supervision focused mainly on progress monitoring; design verification and coordination were insufficient, causing rework	Strengthen field supervision competency and constructability verification before execution
Environment	Limited underground working space	Concurrent multidisciplinary activity in a confined area created interface conflicts and schedule disruption	Improve work-area sequencing and space-allocation planning for concurrent underground activities

Source: Author, compiled from project historical data, questionnaire, and Focus Group Discussion

Proposed Project Management Office and Implementation Roadmap

To institutionalize the lessons learned above, this study proposes a Controlling PMO under the Central Services Division. The proposed PMO does not replace the existing balanced-matrix organizational structure or take over the responsibilities of Project Managers and functional departments; instead, it provides governance, standardization, cross-functional coordination, performance monitoring, and knowledge-management support, while existing technical and functional authorities remain within the organization. The PMO is considered organizationally feasible because Central Services Division already possesses engineering, project control, cost estimating, and construction functions, so implementation can focus on integrating and standardizing existing practices rather than creating an entirely new organization or data system.

Implementation is proposed to proceed progressively through four phases, as illustrated in Figure 5 and summarized in Table 11: organizational assessment and preparation (0–6 months), PMO development and pilot implementation (6–12 months), organizational integration (Year 1–2), and continuous improvement and organizational maturity (Year 2–3). This progressive approach is intended to strengthen project governance, improve coordination and decision-making, enhance consistency of project execution, and reduce the recurrence of delays in future underground ventilation construction projects at PT Freeport Indonesia.

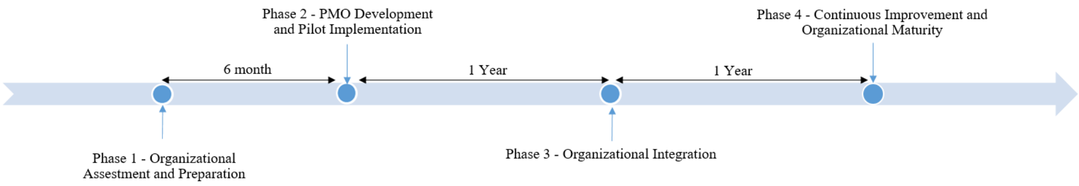

Figure 5. Proposed Project Management Office (PMO) Implementation Roadmap
Source: Author

Table 11. Summary of the PMO Implementation Roadmap

Phase	Timeframe	Key Deliverables	Primary Responsibility
1. Organizational Assessment and Preparation	0–6 months	PMO Charter, PMO Governance Framework, Standard Project Management Practices, Organizational Readiness Assessment	Central Services Division Management
2. PMO Development and Pilot Implementation	6–12 months	Standardized WBS, Design Readiness Checklist, Integrated Change Control Procedure, Risk Register Standardization, Lessons Learned Register, Standard Dashboard and EVM Reporting	Project Control, Engineering, and PMO
3. Organizational Integration	Year 1–2	Cross-functional governance meetings, portfolio performance reporting, competency development, project audits, knowledge management, standard review gates	Central Services Division Management and PMO
4. Continuous Improvement and Organizational Maturity	Year 2–3	PMO performance evaluation, continuous lessons learned update, benchmarking, PMBOK maturity assessment, digital project dashboard	Central Services Division Management

Source: Author

CONCLUSION

This research concludes that the declining construction performance and schedule delay of the Kucing Liar Fan 7 project, reflected in an average Project Performance Factor of 0.82 and a cost overrun of approximately 10% beyond the available contingency, resulted from the interaction of design readiness, change control, material planning, communication and coordination, supervisory competency, and constrained underground working space rather than from a single cause, with Management, Method, Material, People, and Environment jointly accounting for 84.93% of the prioritized relative importance among the six investigated factors. These lessons were compiled into a Lesson Learned Register and translated into a proposed Controlling Project Management Office (PMO), to be implemented through a four-phase roadmap consisting of organizational assessment and preparation, PMO development and pilot implementation, organizational integration, and continuous improvement, without displacing the existing balanced-matrix authority of Project Managers and functional departments. It is recommended that PT Freeport Indonesia's Central Services Division prioritize design readiness and constructability review before construction authorization, strengthen project planning beyond analogous estimating through detailed work breakdown structures and integrated risk assessment, adopt earned-value-based monitoring and standardized dashboards, and formally establish the proposed PMO to standardize governance, communication, and knowledge management across future underground ventilation construction projects. Future research is recommended to evaluate PMO performance after organizational adoption, compare PMO maturity across other underground mining projects, and examine the integration of digital project management technologies such as Building Information Modelling and predictive analytics into project governance.

REFERENCES

Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management*, *24*(4). https://doi.org/10.1016/j.ijproman.2005.11.010

Aubry, M., Hobbs, B., & Thuillier, D. (2007). A new framework for understanding organisational project management through the PMO. *International Journal of Project Management*, *25*(4), 328–336. https://doi.org/10.1016/j.ijproman.2007.01.004

Aubry, M., Hobbs, B., & Thuillier, D. (2008). Organisational project management: An historical approach to the study of PMOs. *International Journal of Project Management*, *26*(1), 38–43. https://doi.org/10.1016/j.ijproman.2007.08.009

Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. *Human Relations*, *61*(8), 1139–1160.

Boone Jr., H. N., & Boone, D. A. (2012). Analyzing Likert data. *Journal of Extension*, *50*(2).

Boonsripitayanon, W., & Jearasatit, V. (2017). Earned value management system for construction project performance evaluation. *International Journal of Construction Engineering and Management*, *6*(4), 141–149.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed., Ed.). Sage Publications.

Creswell, J. W., & Creswell, J. D. (2022). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (6, Ed.). SAGE Publications.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555

Desouza, K. C., & Evaristo, J. R. (2006). Project management offices: A case of knowledge-based archetypes. *International Journal of Information Management*, *26*(5), 414–423. https://doi.org/10.1016/j.ijinfomgt.2006.07.002

Doloi, H., Sawhney, A., Iyer, K. C., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, *30*(4), 479–489. https://doi.org/10.1016/j.ijproman.2011.10.004

Eken, G., Bilgin, G., Dikmen, I., & Birgonul, M. T. (2020). A lessons learned tool for organizational learning in construction. *Automation in Construction*, *112*, 103117.

Enshassi, A., Mohamed, S., & Abushaban, S. (2009). Factors affecting the performance of construction projects in the Gaza Strip. *Journal of Civil Engineering and Management, 15*(3), 269–280. https://doi.org/10.3846/1392-3730.2009.15.269-280

Hobbs, B., & Aubry, M. (2007). A multi-phase research program investigating project management offices (PMOs): The results of phase 1. *Project Management Journal*, *38*(1), 74–86. https://doi.org/10.1177/875697280703800107

Hobbs, B., & Aubry, M. (2008). An empirically grounded search for a typology of project management offices. *Project Management Journal*, *39*(S1), S69–S82. https://doi.org/10.1002/pmj.20072

Institute, P. M. (2017). *Project management body of knowledge (PMBOK guide)* (6th ed., Ed.). PMI.

Institute, P. M. (2019). *Practice standard for earned value management* (3rd ed.). Project Management Institute.

Jugdev, K. (2012). Learning from lessons learned: Project management research issues. *Project Management Journal*, *43*(2), 6–10.

Kerzner, H. (2022). *Project management: A systems approach to planning, scheduling, and controlling* (13th ed.). Wiley.

Oakland, J. S. (2014). *Total quality management and operational excellence: Text with cases* (4th ed.). Routledge.

Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management*, *25*(5), 517–526. https://doi.org/10.1016/j.ijproman.2006.11.007

Sweis, G., Sweis, R., Hammad, A. A., & Shboul, A. (2008). Delays in construction projects: The case of Jordan. *International Journal of Project Management*, *26*(6), 665–674. https://doi.org/10.1016/j.ijproman.2007.09.009

Unger, B. N., Gemunden, H. G., & Aubry, M. (2012). The three roles of a project portfolio management office: Their impact on portfolio management execution and success. *International Journal of Project Management*, *30*(5), 608–620. https://doi.org/10.1016/j.ijproman.2012.01.015