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Analysis of Key Performance Indicator (KPI) Effectiveness through Variance Analysis as A Performance Monitoring Tool in Nickel Mining Company at PT XXX

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Abstract

The nickel mining industry operates as an integrated system in which downstream performance depends heavily on the effectiveness of upstream activities. PT XXX, a laterite nickel mining company, has implemented Key Performance Indicators (KPIs) across production, exploration, sales, finance, occupational safety and health, and environmental dimensions since 2023. However, KPI evaluations have primarily focused on the numerical achievement of individual targets without systematically assessing overall operational performance. This study aimed to evaluate operational performance based on KPI achievement through variance analysis between targets and actual performance during the 2023–2025 period. A quantitative descriptive method with an evaluative approach was applied to 35 KPIs, consisting of 6 lagging indicators and 29 leading indicators across six operational dimensions. Achievement rates were calculated by accounting for performance direction, namely higher-is-better and lower-is-better indicators, and were capped at 100% to prevent overachievement in one indicator from offsetting underachievement in another. The results were then aggregated into variance scores (SVs) at both dimensional and overall levels. The analysis produced an aggregate SV of 92.85%, with Finance (99.86%) and Occupational Safety and Health (97.53%) achieving the highest scores, followed by Production (94.99%), Sales (94.52%), Exploration (88.39%), and Environment (81.81%). Although overall performance was relatively high, notable gaps remained in overburden removal (83.48%), exploration drilling (80.00%), low-grade ore (LGO) shipping (76.27%), recontouring (74.52%), and topsoil distribution (73.13%). These findings indicated that although final operational outcomes were generally strong, several upstream readiness activities still required tighter control. The study concluded that KPI evaluation should extend beyond aggregate performance scores to include detailed assessment of leading indicators, thereby enabling more precise identification of operational improvement priorities and strengthening the company's performance-monitoring system.

INTRODUCTION

In the mining industry, operational success is determined not only by the quantity of mineral resources and reserves but also by the company's ability to control a series of interdependent mining activities. In laterite nickel mining, exploration and drilling activities support increased geological confidence and the availability of mineable reserves. Furthermore, overburden removal, ore exposure, compliance with the mine sequence, grade control, and mining recovery determine mine readiness, production continuity, and ore quality. Production output is subsequently linked to stock availability, shipping, sales, revenue, and costs, while all activities must continue to comply with occupational safety, health, and environmental management standards (Hartman & Mutmansky, 2002; Hustrulid et al., 2013).

These characteristics indicate that mining operations function as an integrated system in which underperformance in upstream activities can affect downstream processes. Delays in drilling can reduce the availability of geological information, failure to achieve overburden removal targets can limit ore exposure, and inconsistencies in mine sequencing and low mining recovery can affect production, ore quality, reserve utilization, and operating costs. Similarly, delays in recontouring and topsoil placement can hinder revegetation targets. Therefore, mining companies require performance measurement and control systems capable of monitoring operational conditions and providing early indications of deviations before they affect final operational outcomes (Hustrulid et al., 2013; Darling, 2011).

One widely used approach to evaluating operational performance is the Key Performance Indicator (KPI) system, which consists of quantitative indicators used to assess progress toward organizational objectives. KPIs help companies identify deviations between targets and actual performance and support data-driven decision-making (Armstrong, 2006). In general, KPIs serve to measure target achievement, monitor performance trends across periods, and support alignment between leading and lagging indicators (Kaplan & Norton, 1996). In mining operations, this function is particularly important because each KPI occupies a different position within the operational value chain. An effective KPI system should therefore not only indicate whether final targets have been achieved but also show whether the operational activities that contribute to those outcomes have progressed according to plan (Gackowiec et al., 2020).

Several studies have examined KPI implementation in the mining industry. Gackowiec et al. (2020) classified mine KPIs into operational, safety, and maintenance categories. Sorychta-Wojsczyk and Jamrozy (2014) examined KPIs using the Balanced Scorecard framework, while Dos Reis and Nader (2023) showed that a structured performance indicator system could support mine operation planning. In the Indonesian context, Wulandari et al. (2021) used variance analysis to measure deviations between KPI targets and actual performance in mining companies, Suryadi et al. (2022) applied trend analysis, and Rasyid and Amri (2023) examined the relationship between leading and lagging KPIs in nickel mining. Meanwhile, Hidayat and Fauzi (2023) evaluated KPI implementation in nickel mines in Sulawesi using a qualitative descriptive approach, whereas Kurniawan et al. (2022) focused on operational efficiency through a data-driven KPI dashboard.

A review of previous studies indicates that KPI evaluation in Indonesian nickel mining companies remains limited and has generally relied on qualitative descriptive approaches (Hidayat & Fauzi, 2023) or focused on a single operational dimension (Kurniawan et al., 2022). However, nickel mining operations involve the simultaneous interaction of exploration, production, sales, finance, occupational safety and health, and environmental performance. Therefore, a quantitative evaluation is required to assess operational performance across dimensions using all implemented KPI indicators, including not only lagging indicators that reflect final outcomes but also leading indicators that represent operational readiness and process control.

PT XXX is a laterite nickel mining company holding a mining business license (Izin Usaha Pertambangan [IUP]) and has implemented KPIs across production, exploration, sales, finance, occupational safety and health, and environmental dimensions since 2023. The company’s operational performance is strongly influenced by the integration of technical activities. Production, for example, depends not only on equipment capability but also on the availability of mineable reserves, drilling achievement, exposed ore availability, compliance with the mine sequence, grade control, mining recovery, and material readiness for shipping. Failure to achieve any of these activities can affect production volume, ore quality, costs, and sales. Based on internal company data, operational performance changed after KPI implementation. Before KPI implementation, during 2020–2022, average nickel ore production was 1.18 million wet metric tons (WMT) per year, with an average production target achievement of 79%. During 2023–2025, after KPI implementation, average production increased to 2.21 million WMT per year, with an average target achievement of 99% (PT XXX Production Report 2020–2025).

This increase indicated an improvement in performance achievement; however, it could not be attributed solely to KPI implementation because mining performance is also influenced by equipment condition and availability, weather, geology, reserve quality and availability, mine sequencing, and business strategy. Furthermore, high production achievement does not necessarily indicate that all production-supporting activities have been consistently controlled. Production targets may still be achieved despite deviations in drilling, overburden removal, mine sequencing, mining recovery, or other operational indicators. In addition, the company’s KPI evaluation has primarily focused on the numerical achievement of individual indicators, making it difficult to systematically and quantitatively assess overall operational performance at both the dimensional and system levels.

Based on this background, the research problem focused on the level of operational performance achievement at PT XXX based on KPI indicators during the 2023–2025 period. Accordingly, this study aimed to analyze mine operational performance through variance analysis between targets and actual performance across six operational dimensions: production, exploration, sales, finance, occupational safety and health (K3), and environment.

Nickel is one of Indonesia’s strategic mineral commodities and plays an important role in supporting metal-based industries, including stainless steel production and electric vehicle battery manufacturing. Along with Indonesia’s mineral downstreaming policy, demand for nickel ore has increased, strengthening the role of nickel mining within the national mining industry (Ministry of Energy and Mineral Resources, 2024). Indonesia possesses some of the world’s largest nickel reserves, most of which occur as laterite nickel deposits distributed across Sulawesi, Maluku, and Papua. Laterite nickel deposits are formed through prolonged weathering of ultramafic rocks, generally producing profiles characterized by an upper limonite zone and a lower saprolite zone. Variations in nickel grade within these profiles require careful grade control to ensure that mined ore meets processing and market specifications (Hartman & Mutmansky, 2002).

Laterite nickel mining is generally conducted using open-pit mining methods. The operational sequence typically includes exploration, land clearing, overburden removal, ore extraction, hauling, stockpiling, and ore shipment to processing facilities or smelters (Hartman & Mutmansky, 2002; Darling, 2011). These activities are interdependent, meaning that disruptions at one stage can affect subsequent operations. Nickel mining operations are complex because they are influenced by geological and geotechnical conditions, variations in ore grade, weather conditions, and the need for coordination among mining, hauling, stockpiling, and barging activities. Therefore, mining companies require a performance management system capable of systematically monitoring and evaluating operational activities to ensure that production is conducted effectively, efficiently, and safely.

Operational performance reflects the extent to which an organization successfully carries out its activities to achieve established objectives effectively and efficiently (Armstrong, 2006). Neely, Gregory, and Platts (1995) defined effectiveness as the extent to which predetermined objectives are achieved, whereas efficiency refers to the economical use of resources in achieving those objectives. In this study, the primary focus was the effectiveness of target achievement, particularly the extent to which actual operational performance met the targets established by the company. In the mining industry, operational performance can therefore be assessed through the achievement of production and supporting operational targets while maintaining efficiency, safety, and regulatory compliance (Hartman & Mutmansky, 2002).

Mine operational performance is multidimensional. According to Armstrong (2006), organizational performance measurement encompasses aspects such as productivity, efficiency, quality, and occupational safety. In mining operations, these aspects can be reflected in six major dimensions: production, sales, finance, occupational safety and health (K3), environmental performance, and exploration, which supports the continuity and reliability of mineral resources and reserves (Hartman & Mutmansky, 2002; Gackowiec et al., 2020).

Mine operational performance is influenced by several technical and managerial factors. These include geological and geotechnical conditions, such as variations in ore grade, mineralized zone thickness, and ground conditions, which can affect productivity and operational efficiency (Hartman & Mutmansky, 2002); mine planning, because inadequate planning may result in deviations between targets and actual performance (Darling, 2011); equipment availability and productivity, particularly the performance and utilization of loading and hauling equipment; human resource management, including employee competence, discipline, and coordination among operational units (Armstrong, 2006); and performance management systems, in which structured measurement frameworks, including KPIs, support continuous monitoring, evaluation, and improvement (Parmenter, 2015; Neely et al., 1995).

Key Performance Indicators (KPIs) are selected performance measures that focus on aspects of organizational performance considered critical to current and future success (Parmenter, 2015). Parmenter (2015) distinguished four categories of performance measures: Key Result Indicators (KRIs), which summarize overall outcomes; Result Indicators (RIs), which reflect completed activities and results; Performance Indicators (PIs), which indicate operational actions requiring attention; and KPIs, which focus on the most critical drivers of organizational performance, as summarized in Table 1.

Table 1. Four Types of Performance Measures according to Parmenter (2015)

Size Type	Focus	Examples in the Context of Mines
Key Result Indicator (KRI)	Combined results of many activities	Profitability, customer satisfaction
Result Indicator (RI)	Summary of the results of an activity	Total monthly production, daily sales
Performance Indicator (PI)	Actions to take	Realization of preventive maintenance
Key Performance Indicator (KPI)	The most critical aspects of success	Ore production volume, LTIFR, cash cost

Source: Adapted from Parmenter (2015)

To be effective, KPIs should meet the SMART criteria: Specific, Measurable, Attainable, Relevant, and Time-bound (Ishak et al., 2019). Domínguez et al. (2019) developed a KPI taxonomy that incorporates the indicator life cycle, measurement dimensions, and metadata, thereby supporting more systematic KPI management in complex operational systems such as mining.

KPIs can be classified into two categories based on their temporal relationship with performance outcomes: leading indicators and lagging indicators (Reiman & Pietikäinen, 2012; Parmenter, 2015; Yorio et al., 2020; Dyreborg, 2009). Leading indicators reflect processes, activities, or intermediate outputs that precede and are expected to contribute to key outcomes, allowing management to identify potential deviations before final results are realized (Reiman & Pietikäinen, 2012; Parmenter, 2015). Lagging indicators, in contrast, reflect final outcomes achieved after supporting processes and activities have been completed (Reiman & Pietikäinen, 2012; Yorio et al., 2020). In nickel mining operations, drilling, overburden removal, compliance with the mine sequence, grade control, mining recovery, and other operational readiness activities can function as leading indicators, while production realization, shipping volume, financial performance, safety outcomes, and revegetation achievement can function as lagging indicators.

KPIs perform three main functions that support the selection of methods for evaluating KPI effectiveness: measuring goal attainment, driving continuous improvement, and promoting strategic alignment (Parmenter, 2015; Kaplan & Norton, 1996). The goal-attainment function provides the basis for variance analysis between targets and actual performance (Wulandari et al., 2021), as summarized in Table 2. Neely et al. (1995) emphasized that effectiveness is fundamentally concerned with the extent to which predetermined objectives are achieved. Therefore, comparing target values with actual performance provides a fundamental basis for evaluating KPI effectiveness and constitutes the primary focus of this study.

Table 2. The Relationship of KPI Functions with Effectiveness Analysis Methods

Functions/Objectives of KPIs	Description	Analysis Method	Supporting References
Goal Attainment	Measure the fulfillment of targets by actual realization	Analysis of Variance (Target vs Actual)	Parmenter (2015); Neely et al. (1995)
Continuous Improvement	Monitor performance growth between periods	Trend Analysis (Year-over-Year Growth)	Kang et al. (2016); Suryadi et al. (2022)
Strategic Alignment	Align operations through leading-lagging linkages	Correlation Analysis (Leading vs Lagging)	Vukomanović et al. (2010); Rasyid & Amri (2023)

Source: Author's compilation from Parmenter (2015); Neely et al. (1995); Kang et al. (2016); Suryadi et al. (2022); Vukomanović et al. (2010); and Rasyid & Amri (2023)

Variance analysis is used to evaluate the difference between the performance targets that have been set and the actual realization of each KPI. In this study, the results of the comparison of the target and actual were quantified using the achievement rate to show the extent to which the realization met the set targets. The actual comparison approach to the target is part of performance evaluation through variance analysis (Masschelein, 2024).

The achievement rate calculation is adjusted to the performance direction of each KPI (performance direction) so that all indicators have a consistent interpretation, namely the higher the achievement rate value indicates the better performance achievement. For higher-is-better KPIs, i.e. indicators that show better performance when the actual value is higher, the achievement rate is calculated with the following equation:

$$ARi = (AI/Ti) \times 100\% \text{ ... } (1)$$

Description: ARi = achievement rate of KPI i; Ai = the actual value of the ith KPI; Ti = the target value of the ith KPI.

In contrast, for lower-is-better KPIs, i.e. indicators that show better performance when the actual value is getting lower, such as production cost per ton or work accident rate, the achievement rate is calculated using the following inverse ratio:

$$ARi = (Ti / Ai) \times 100\% \text{ ... } (2)$$

Description: ARi = achievement rate of KPI i; Ti = the target value of the ith KPI; Ai = the actual value of the ith KPI. This approach is used as a form of directional normalization to align the direction of interpretation of all KPIs before aggregation, so that higher achievement rate values consistently indicate a better level of performance achievement, both for higher-is-better and lower-is-better KPIs.

Furthermore, the Aggregate Variance Score (SV) is calculated as the average level of achievement of all KPIs in a measurement period, with the following equation:

$$SV = (1/n) \Sigma ARi \text{ ... } (3)$$

Remarks: SV = Aggregate Variance Score indicating the level of achievement; ARi = achievement rate of the ith KPI; n = total number of KPIs; i = KPI index, where i = 1, 2, ..., n. In the aggregation process, the achievement rate value is limited to a maximum of 100% (capping) to prevent achievements that exceed the target on one KPI from compensating for the non-achievement of other KPIs, while the actual value is maintained according to the company's data. Setting the direction of KPIs (higher/lower-is-better) before the average calculation is a mandatory procedure to prevent aggregation bias, as affirmed in the composite index construction guidelines (OECD & JRC, 2008).

METHOD

Types and Research Approaches

This study employed a quantitative descriptive method with an evaluative approach. The quantitative approach was used to measure and analyze the company's operational performance by comparing target values with actual performance based on historical data from the 2023–2025 period. The evaluative approach was applied to assess the extent to which actual performance met the established targets across each of the company's operational dimensions.

Research Location and Time

This research was carried out at PT XXX which is located in the Matarape area, North Konawe Regency, Southeast Sulawesi Province. The selection of the research location is based on the consideration that the company has implemented a comprehensive KPI system to assess the operational performance of the mine since 2023, both in terms of production, finance, occupational safety, environment, and exploration, but has not been systematically evaluated for performance achievements during the 2023-2025 period. The research uses historical data, so most data collection is done through access to the company's Performance Management system and related internal documents. The research implementation period lasts for three months, including preparation, data collection, data processing and analysis, to the preparation of scientific reports and publications.

Research Data and Variables

The data analyzed consisted of 35 actual KPIs, namely 6 lagging KPIs and 29 leading KPIs which were grouped into six operational dimensions, including Production, Exploration, Sales, Finance, Occupational Safety and Health (K3), and Environment. The research data is in the form of annual targets and realizations for each KPI for the 2023-2025 period, which are obtained from the company's internal documents in the form of Annual KPI Reports, Production Reports, Financial Reports, and Occupational Safety Reports (HSE Report). The free variable in this study is the achievement of the company's operational KPIs, namely target data and KPI realization in six operational dimensions, which are positioned as the main inputs in the evaluation process. The variable that is the center of the assessment is the Variance Score (SV), which is a score that represents the level of achievement of the target based on the achievement rate of all KPIs at the dimensional and aggregate level of the company. Data collection techniques are carried out through documentary studies on KPI reports and company operational reports, as well as data verification (cross check validation) to ensure the validity and reliability of the analysis results (Sugiyono, 2015).

Data Analysis Techniques

Data processing is carried out using Microsoft Excel software and cross-verified to guarantee accuracy. Variance analysis was carried out by calculating the achievement rate for each KPI using Equation (1) for the higher-is-better KPI and Equation (2) for the lower-is-better KPI, then averaged at the dimensional level and then at the overall level (six dimensions) to obtain the aggregate Variance Score (SV) using Equation (3). This graded aggregation ensures that each dimension has an equal contribution to the overall score, so that the evaluation not only focuses on the performance of each KPI individually, but also reflects the performance of the KPI system in the aggregate (Neely et al., 1995; OECD & JRC, 2008). The results of the calculation are presented in the form of a table and a graph of comparison of interdimensional variance scores.

RESULTS AND DISCUSSION

Data Overview and KPI Structure

This study evaluates the operational performance achievements of PT XXX based on KPI indicators in nickel mining operations during the 2023-2025 period. The data analyzed consisted of 35 actual KPIs, namely 6 lagging KPIs and 29 leading KPIs which were grouped into six dimensions, including Production, Exploration, Sales, Finance, Occupational Safety and Health (K3), and Environment. The structure of the analyzed indicators is presented in Table 3.

Table 3. Analyzed KPI Structure

No.	Dimensions	Lagging KPIs	Number of Leading KPIs	Total KPIs
1	Production	Realization of Nickel Ore Production	6	7
2	Exploration	Adding Reserves through Exploration	4	5
3	Sales	Realization of Nickel Ore Shipping Volume	5	6
4	Finance	Cash Margin Achievement	6	7
5	K3	Total Injury Frequency Rate (TIFR)	5	6
6	Environment	Realization of Land Revegetation	3	4
	Total	6 Lagging KPIs	29	35

Source: Author's compilation based on PT XXX internal KPI documents (2023–2025)

The raw data of 35 KPIs is not displayed entirely in this section so that the discussion remains focused on the results of the target achievement analysis. Target-actual annual data is used as the basis for variance analysis. The KPI measurement direction is differentiated into higher-is-better (H) and lower-is-better (L), and in the target achievement analysis, the achievement rate is limited to a maximum of 100% so that overachievement in one KPI does not cover the nonachievement of other KPIs.

Results of Target Achievement Rate Analysis

The analysis of the achievement of the target resulted in an aggregate Variance Score (SV) of 92.85%. The value is calculated from the actual achievement rate against the annual target for each KPI, then averaged at the dimensional level and then averaged back to six dimensions. This graded aggregation ensures each dimension has an equal contribution to the global score. In general, the achievement of targets is at a high level, but the variation between dimensions indicates that evaluation still needs to be carried out up to the indicator level, as presented in Table 4 and Figure 1.

Table 4. Target Achievement Score (Variance Score) per Dimension

No.	Dimensions	Variance Score (%)	Interpretation
1	Production	94,99	Good
2	Exploration	88,39	Good
3	Sales	94,52	Good
4	Finance	99,86	Excellent
5	K3	97,53	Excellent
6	Environment	81,81	Good

Source: Author's calculation based on PT XXX KPI realization data (2023–2025)

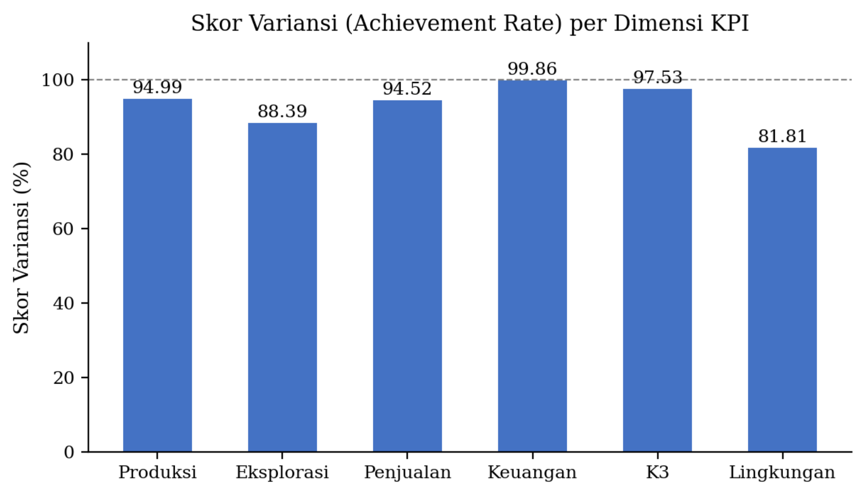

Figure 1. Achievement Score per KPI Dimension
Source: Author's visualization based on variance analysis results from PT XXX KPI data (2023–2025)

Achievement of Production Targets

Production Dimension obtained SV of 94.99%. The lagging, the KPI of nickel ore production realization reached an average achievement rate of 98.97%. In the leading KPI, the mining recovery rate reached 100.00%, LGO production 96.32%, mine sequence coverage suitability 95.96%, stripping efficiency ratio 96.59%, and HGO production 93.59%. The lowest achievement was in the transfer of overburden of 83.48%.

These findings show that final production yields are relatively good, but there are still gaps in activities that shape production readiness. In mining operations, overburden removal is related to the formation of exposed ore, while mine sequence is related to the suitability of the location and mining sequence to the plan. Therefore, production achievements need to be read along with the conditions of front preparation activities and the quality of the implementation of the mine plan.

Achievement of exploration targets

The Exploration Dimension obtained SV of 88.39%. The addition of reserves through exploration as KPI lagging reached an average achievement rate of 80.00%. In the leading KPI, the achievement of coverage area was 83.16%, drilling 80.00%, Sampling & Assay 99.82%, and Geological Model Update 98.95%. These results show that the output of the reserves and main field activities still has a relatively larger gap than the completion of the geological evaluation process.

Technically, the results need to be read as a chain of exploration processes. Coverage and drilling form a geological database, while sampling, assay, and geological model updates are stages that convert field data into geological information for resource and reserve estimation. Therefore, high achievement at the evaluation stage does not automatically guarantee additional reserves if coverage or drilling has not fully reached the target.

Achievement of Sales Targets

The Sales Dimension obtained an SV of 94.52%. The realization of nickel ore shipping volume as a lagging KPI has an average achievement rate of 97.56%. In the leading KPI, HGO shipments, cargo loading rates, and suitability when loading reached full scores, demurrage efficiency reached 93.32%, while LGO shipments obtained 76.27%.

These results show that most of the targets in the sales and shipment process can be achieved. However, the success of the shipment remains the result of a series of downstream activities that depend on material availability, stockpile readiness, ore quality suitability, loading point readiness, and shipping schedule.

Achievement of Financial Targets

The Finance dimension obtained an SV of 99.86%, the highest among all dimensions. Cash margin, nickel ore selling price, revenue, gross profit, cost of goods sold efficiency, and overhead cost efficiency achieved full achievement scores, while capex cost efficiency reached 99.03%.

In the context of mining operations, financial performance is the combined result of sales volume, selling price, ore quality, mining and hauling costs, resource use efficiency, and capital expenditure decisions. Thus, a high financial value describes a good finish, but does not automatically mean that the entire technical process has been optimalized.

Achievement of Occupational Safety and Health (K3) Targets

The K3 dimension obtained SV of 97.53%. The Total Injury Frequency Rate (TIFR) as the lagging KPI reached an average achievement rate of 97.06% with a lower-is-better direction. In the leading KPI, the SMKP Audit score reached 99.48%, Safety Accountability 96.82%, Fatigue

Management 93.33%, HSE training program effectiveness 100.00%, and periodic health checks 98.47%.

TIFR is positioned as an indicator of safety outcomes, while SMKP Audit, Safety Accountability, Fatigue Management, HSE training, and periodic health checks describe the activities or control conditions that precede safety outcomes. The combination allows the evaluation not only to stop at the incidence rate, but also to assess the consistency of the implementation of preventive controls.

Achievement of Environmental Targets

The Environmental Dimension obtained an SV of 81.81%. Revegetation as a lagging KPI reached an average achievement rate of 82.73%. In the leading KPI, recontouring reached 74.52%, topsoil distribution 73.13%, and availability of ready-to-plant seedlings 96.87%.

The findings show that the availability of reclamation inputs is relatively good, but there is still a gap in the physical completion of land management and topsoil distribution. Recontouring, topsoil spreading, and revegetation are sequential processes, so that inachievements in the early stages have the potential to form a backlog that affects the realization of revegetation in the next period.

General discussion

Overall, the results of the variance analysis show that PT XXX's operational performance achievements based on KPI indicators are at a high level, with an aggregate Variance Score of 92.85%. The Finance and K3 dimensions achieved the highest score because most of the indicators were the final result (lagging) of a series of operational processes that have been running relatively consistently, while the Environment and Exploration dimension showed a lower score because there were still gaps in leading indicators that formed process readiness, such as overburden removal, coverage area and exploration drilling, as well as recontouring and topsoil distribution in reclamation activities. These findings confirm that the high achievement of the final result indicator does not necessarily reflect that all outcome-forming activities have run optimally, so the evaluation of the achievement of KPI targets needs to be carried out up to the leading indicator level, not only at the level of lagging indicators or aggregate scores.

CONCLUSION

Based on the variance analysis of PT XXX’s 35 operational KPIs during the 2023–2025 period, the company achieved an aggregate Variance Score (SV) of 92.85%. The dimensional scores were 99.86% for Finance, 97.53% for Occupational Safety and Health (K3), 94.99% for Production, 94.52% for Sales, 88.39% for Exploration, and 81.81% for Environment. Overall, target achievement was categorized as high, although notable gaps remained in several indicators, particularly overburden removal (83.48%), exploration coverage area and drilling achievement (83.16% and 80.00%, respectively), low-grade ore (LGO) shipping (76.27%), and recontouring and topsoil placement in reclamation activities (74.52% and 73.13%, respectively). These results indicated that overall operational outcomes were relatively strong; however, several leading indicators related to operational readiness still required tighter control.

Based on these findings, PT XXX should strengthen control within the production dimension by linking production output indicators with mine readiness indicators, particularly compliance with the mine sequence, grade control, and mining recovery. Exploration performance should be improved by maintaining adequate area coverage and drilling achievement, while sales performance should be supported by strengthening shipment readiness indicators, particularly for LGO shipments. In the environmental dimension, physical reclamation indicators should be complemented by quality-based indicators, such as revegetation survival rate and topsoil balance, so that performance evaluation measures not only the extent of physically completed reclamation areas but also the effectiveness of ecological restoration. Accordingly, KPI performance evaluation should extend to the level of leading indicators within each dimension rather than relying solely on aggregate scores, thereby enabling more precise identification of operational control priorities.

Future research should extend the analysis period to capture longer-term performance trends, incorporate correlation or regression analysis to examine relationships between leading and lagging KPIs, and compare KPI effectiveness across multiple mining companies to provide broader industry-level insights. In addition, future studies may integrate qualitative approaches, such as interviews with operational managers, to investigate the contextual factors underlying KPI achievement gaps and identify barriers to effective KPI implementation in nickel mining operations.

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