

Decision Analysis to Obtain Accelerate Solutions on Coal Exploration Programme in Block Pasopati Selatan at PT. Borneo Indobara

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ABSTRACT

The coal industry in Indonesia is currently facing pressure to improve operational efficiency amid declining global demand and increased emphasis on sustainable energy practices. PT Borneo Indobara (PT BIB), in an effort to meet its future production targets, is planning to open a new coal mining site at Pasopati Selatan Block. However, this initiative is hampered by various issues such as licensing delays, limited drilling equipment, manpower shortages, and complex geological conditions. This study aims to identify the root causes of exploration delays, evaluate alternative solutions, and determine the most effective strategy to accelerate the exploration programme. Using a qualitative research approach, data were collected through interviews, focus group discussions (FGDs), field observations, and document analysis. The Kepner-Tregoe and SMART methods were employed for decision-making analysis. The results indicate that using contractor drilling services (OPTION 2) is the most optimal solution, offering a high benefit-to-cost ratio and robustness in sensitivity tests. This research provides practical contributions for strategic planning in PT BIB and offers theoretical value by demonstrating how integrative decision analysis models can support effective project management in complex mining environments. Future studies can extend this framework to other sectors facing similar operational and regulatory challenges.

Keywords: Coal, Exploration, Kepner Tregoe, Mining, SMART.

INTRODUCTION

The global coal industry is undergoing significant transformation in response to shifting energy demands, environmental concerns, and international commitments to reduce carbon emissions (Aguirre-Villegas & Benson, 2022). Countries around the world are gradually reducing their dependence on fossil fuels and transitioning to cleaner, renewable energy sources (Holechek et al., 2022). This trend has substantial implications for coal-producing nations like Indonesia, where coal remains a critical component of the national energy mix and export revenue (Kurniawan et al., 2020). Amid these changes, coal producers are required to adapt by enhancing operational efficiency, ensuring sustainable mining practices, and strengthening the economic viability of their production plans through accurate exploration and forecasting (Firoozi et al., 2024).

In 2024, the total production from approved RKABs is projected to reach 922.14 million tons, which is 19.6% higher than the coal production realized in 2023, which was 770.97 million tons. However, starting next year, the coal production target will decrease. In 2025, total coal tonnage is expected to decrease to 917.16 million tons, and it will further decrease to 902.97 million tons in 2026. This aligns with the International Energy Agency's announcement in 2023 of a 2.3% decline in global coal demand by 2026 (Sugiyono, 2016). Coal at PT BIB is formed within two formations: the Tanjung Formation and the Warukin Formation.

PT BIB began mining production in 2005. Initially, production was trialed at a small capacity (168 thousand tons/year). The production figures steadily increased, reaching 1 million tons/year by 2007. During the period from 2008 to 2010, PT BIB's production remained in the range of 1.1 million to 1.3 million tons/year. China is the largest buyer of BIB coal, accounting for 43.60% of sales. Domestic buyers make up 36.31%, which includes fulfillment of the domestic market obligation (DMO). This is followed by India at 15.52%, South Korea at 2.54%, and the Philippines at 2.03%.

Coal production at PT BIB reached 42 million tons in 2023, with a target of 46.8 million tons for 2024. The production target will increase to 50 million tons in 2025 and 54 million tons in 2026. To support the production increase, a new mining pit in the Sub Block Pasopati Selatan, part of the Western Block, is planned to open in 2026.

Sub Block Pasopati consists of the Pasopati Utara and Pasopati Selatan areas. According to the feasibility research, this sub-block has a coal reserve of 2.028 million tons with a strip ratio of 13.34. The coal from Pasopati has the highest quality at PT BIB, with a calorific value of 6,200 kcal/kg-ar and a price significantly higher compared to coal in other sub-blocks.

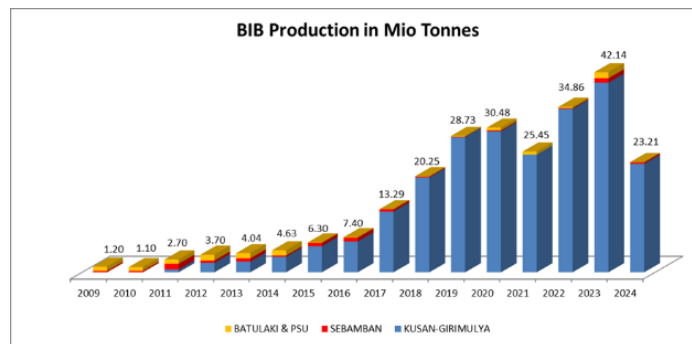


Figure 1. Coal Production of PT BIB

With the plan to open the Pasopati Selatan Pit, detailed exploration activities are required to enhance the validation of the geological model and the economic feasibility of mining and supporting infrastructure. This exploration drilling is crucial before mining begins, as the current exploration data for geological modeling in this area is still very limited. The results from detailed exploration will determine whether mining the Pasopati Selatan Pit is feasible and economical.

The exploration program for Pasopati Selatan faces several challenges that have led to delays. The identified issues include permitting problems, limitations in manpower and supporting equipment, local geological conditions, and social issues. The delay in the exploration programme will impact the accuracy of the geological model and the value of coal resources and reserves in the South Pasopati sub-block, making the mining process low confidence and impacting the company's production costs and revenue.

Coal Exploration

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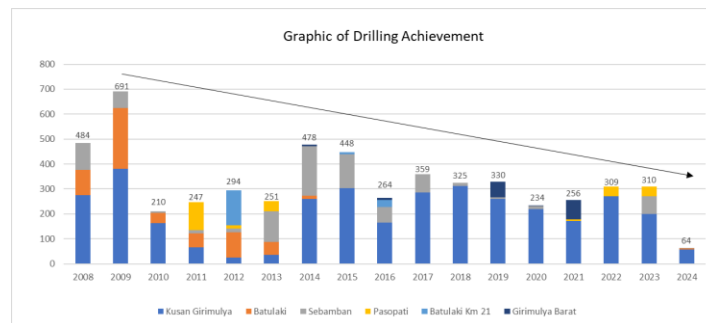


Figure 2. Drilling Achievement PT BIB

Several previous studies have explored the importance of detailed exploration in supporting production sustainability in coal mining. A research by (Armstrong et al., 2021) emphasizes that insufficient geological data significantly increases operational risk and uncertainty in mine planning, especially in areas with complex stratigraphy and limited access.. Research conducted by (Yuniar, 2024) examined the relationship between regulatory delays and the underperformance of coal exploration projects. They found that licensing bottlenecks and bureaucratic constraints are primary contributors to delays, affecting both project costs and scheduling. Meanwhile, a research by (Rahmi & Budiani, 2020) investigated the effect of social and environmental factors on the success of mining exploration in South Sumatra. The research concluded that community engagement and clear communication between mining companies

and local stakeholders play a crucial role in reducing resistance and promoting smoother project implementation.

Based on the above background, the objectives of this research are to identify the factors causing delays in the exploration program in the South Pasopati Sub-Block, explore alternative acceleration solutions that can be applied, and determine the best strategy that can support the achievement of the company's production targets optimally. The benefits of this research are expected to make a practical contribution to the management of PT BIB in formulating measures to accelerate exploration that are targeted, efficient, and sustainable. In addition, this research also provides a theoretical contribution to the development of studies in the field of mining project management and geological exploration, especially in the context of strategic decision making in the midst of operational challenges and the dynamics of national energy policy.

RESEARCH METHOD

The research design used in this research is Qualitative Methods. Qualitative methods can be used to dig deeper into the factors that cause delays in exploration programmes, such as social issues, permits, and limited resources.

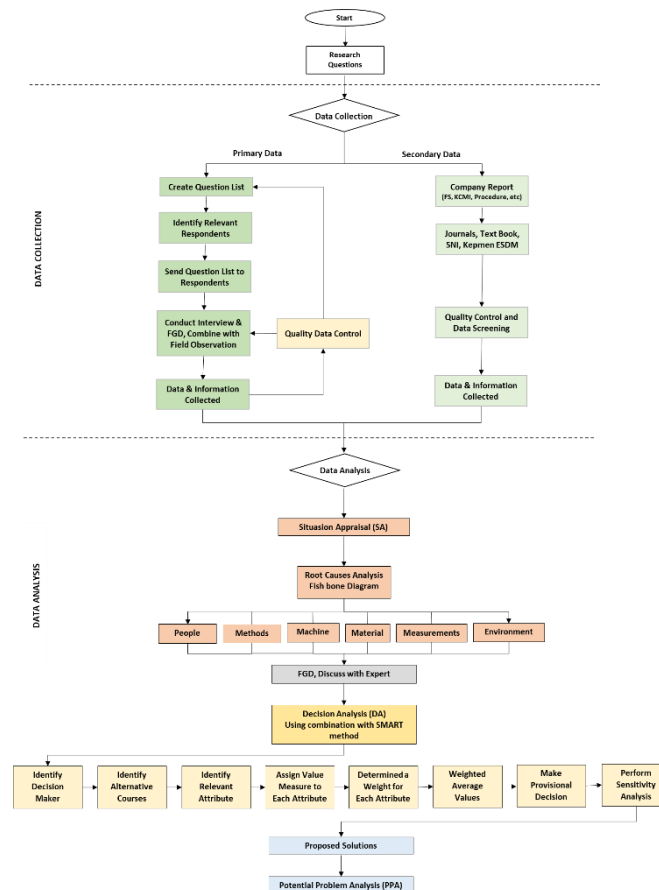


Figure 3. Research Design Diagram

Primary data in this research were obtained through interviews, Focus Group Discussions (FGDs), and field observations in the Pasopati area. Semi-structured interviews were conducted to explore stakeholder perspectives, while field observations aimed to understand the actual conditions of exploration drilling. Secondary data were collected from company reports, journals, books, and relevant government regulations. The data analysis used qualitative methods, focusing on identifying patterns and themes from descriptive data. Additionally, the Kepner-Tregoe method was applied, consisting of situational appraisal, problem analysis (using fishbone diagrams), decision analysis (with the SMART method), and potential problem analysis to anticipate and manage risks from the chosen solution.

RESULT AND DISCUSSION

Interview and Focus Group Discussions (FGDs)

Interviews and FGDs were conducted to obtain an overview of the direct and indirect causes of delays in the exploration programme and to obtain criteria for solutions that could be implemented to accelerate the programme.

Table 1. Interviewer's Description

Interviewer	Person	Method	Topics
Division Head of MDC Division	1	Direct interview	<ul style="list-style-type: none"> a. Company target and strategy to increase production b. Mining sequens of PT BIB c. Impact to company if the exploration programme delayed or failed
Manager of SGE Department	1	Direct interview	<ul style="list-style-type: none"> a. Mining sequens of PT BIB b. Exploration programme in current conditions and next plan c. Cost of exploration programme d. Stakeholders or other department that contribute to continueing exploration programme e. Whats impact to company if the exploration programme delayed or failed
Superintendent of Geological Operation & Wellsite Team Leader	6	FGDs meeting	<ul style="list-style-type: none"> a. Exploration planning at Pasopati Selatan b. Exploration current progress c. Cost of exploration drilling project d. Factors that causes delayed programme e. Solutions idea were conducted to accelerated and the result f. What criterias about solutions g. How does implementation about solutions was choosen h. Potential problems in the future

Field Observation

From observations in the field, researchers obtained an overview of the conditions of the exploration plan location in Pasopati Selatan. The field conditions include:

1. The distance travelled to the location and the obstacles encountered during the trip.
2. The geological conditions that include the nature of rock layers and structures that develop in Pasopati Selatan.
3. The condition of the forest area to be explored.
4. Social conditions of the community found around the exploration site.

Company and Publics Documents Review

A review of company documents was conducted to obtain an overview of PT Borneo Indobara's future mining planning. Documents used include:

1. Feasibility Research (FS) of PT Borneo Indobara to increase production to 46 million tonnes per year.
2. RKAB document for the period 2024 - 2026

General publication documents used as regulatory references in the implementation of coal exploration include:

1. Permen ESDM No. 26 tahun 2018 Pelaksanaan kaidah pertambangan yang baik dan pengawasan pertambangan mineral dan batubara
2. Kepmen ESDM 1827 tahun 2018 Pedoman pelaksanaan kaidah teknis pertambangan yang baik
3. SNI 5015 – 2019 Pedoman pelaporan eksplorasi sumber daya dan cadangan batubara

Analysis

The process of formulating decision making was carried out. Using the Kepner-Tregoe and SMART methods, measurable and effective alternatives are obtained in accelerating the exploration programme in Pasopati Selatan.

1. Situation Appraisal (SA)

Situation Appraisal is technique to assess and clarify situation, sort the things out, outlines complex situation so decision maker can manage the related components and maintain the control (Bartram et al., 1999).

Table 2. Situation appraisal of exploration activity

No	Concern	Sub Concern	Action Statement	Timing	Trend	Impact	Process Needed	Priority
1	Regulatory & Legal Security	IPPKH Licensing from the Ministry of Environment and Forestry (KLHK)	Acceleration of IPPKH submission process at KLHK	H	H	H	DA	1
		Licensing from PT HRB	Acceleration of license	H	H	H	DA	3

No	Concern	Sub Concern	Action Statement	Timing	Trend	Impact	Process Needed	Priority
			application at PT HRB					
		Licensing from Mangkalapi Village Government	Acceleration of license application at Village Government	H	H	H	DA	2
2	Exploration Budget	No budget for exploration activities at Pasopati Selatan Block	Relocate budgets from divisional project budgets that are potentially unused this year	H	H	H	DA	4
3	Feasibility and Economics of the Pasopati Selatan Block	Needs of Exploration Data In Pasopati Selatan area	Acceleration of detailed exploration activities in the Pasopati Selatan Block area	H	H	H	PA	5
4	Coal Mining Production	Pasopati Selatan Block is not viable and economical to mine	Redesign of Pit Pasopati Selatan and explor another potential area.	M	H	H	PPA	6
5	Socio conflict	Rejection and interference from unscrupulous residents of Belanai Hamlet	Involving local residents in projects for non-skilled work	M	M	H	PPA	7
			CSR program to improve community empowerment	M	M	H	PPA	8

Root Causes Analysis

Based on the identification of problems in the Situation Aparsial above, it is known that the problem that requires root causes analysis process is related to delays in exploration activities in Pasopati Selatan. To identify the basic cause of the delay, an analysis was carried out using the Fishbone Diagram.

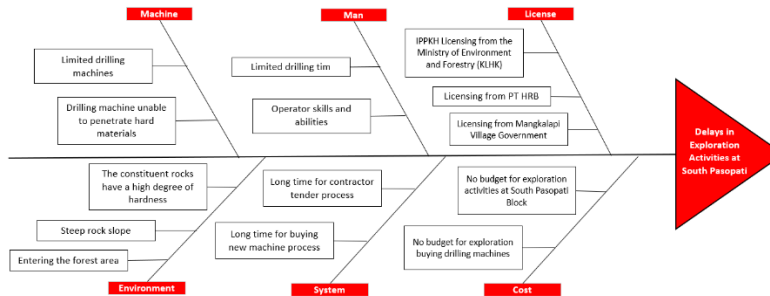


Figure 4. Fish bone diagram of root causes delayed exploration programme

a. Machine Factor

a) Limited Drilling Machine

The limitation of drilling machines because PT BIB currently only has two units of drilling machines that are operated in two work shifts.

b) Drilling Machine Ability

The geological conditions in Pasopati Selatan have a moderate structure and higher rock hardness than other mining areas in PT Borneo Indobara.

c) Limited Excavator for Support Clearing Area

To create access and drillpad for exploration drilling, excavator support is required. Currently there is only one excavator unit that is used to support the exploration programme mentioned above, so there is no unit that can be used in Pasopati Selatan.

b. Man Factor

a) Limited Drilling Team

PT Borneo Indobara has 4 exploration drilling teams consisting of 20 people, including 4 drilling masters and 16 crew members. Therefore, there is no man power that can be diverted to work on exploration drilling in Pasopati Selatan.

b) Operator Skill and Abilities

The drill master and crew do not have sufficient skills and abilities to conduct incline drilling and overcome the geological constraints that exist in Pasopati Selatan.

c. License Factor

a) IPPKH Licensing from Kementrian Lingkungan dan Kehutanan (KLHK)

Almost 50% of the exploration plan area does not have an Ijin Pinjam Pakai Kawasan Hutan (IPPKH) for both exploration and exploitation activities.

b) Licensing from PT Hutan Rindang Banua (HRB)

In addition to permits from the KLHK, exploration in the Pasopati Selatan area has not yet received permission from the owner of the Industrial Plantation Forest (HTI) power of attorney, PT Hutan Rindang Banua (HRB), which is still waiting for certainty of the IPPKH exploration permit above.

c) Licensing from Mangkalapi Village Government

The Pasopati Selatan area is included in the administrative area of Magakalapi Village, permission from the Head of Mangkalapi Village has also not been obtained, because the village government expects returns for local residents from exploration activities carried out in their area.

d. Cost Factor

a) No Budget for Exploration

The exploration programme in Pasopati Selatan was not included in PT Borneo Indobara's Work Plan and Budget which was set at the beginning of 2024.

b) No Budget for Buying Drilling Machine

The same is true for the procurement of new drilling machine units. In the 2024 RKAB, no capital expenditure (Capex) budget is planned for the procurement of new machine units.

e. Procurement System

a) Long time Process for Contractor Tender or Buying Drilling Machine

For the procurement process of mining services, namely exploration drilling using contractor services, it requires a long stage and relatively long time.

f. Environment Factor

a) Geological Conditions

The geological conditions in the Pasopati Selatan Block area belong to the Tanjung Formation which has moderate complexity. As explained earlier, the rock hardness in this area is higher than other areas, so not all drilling machines can be used for drilling in this area.

b) Steep Rock Slope

The condition of the rock layer in Pasopati Selatan also has a steep slope > 70 degrees. For effectiveness and adequacy of geological data, drilling is carried out using the incline method.

c) Forest Area

The entire area of the Pasopati Selatan exploration plan is within the original forest area, so there will still be limited areas that can be explored once the IPPKH has been obtained.

Decision Anlysis (DA)

After identifying the factors that cause delays in the exploration programme, further analysis is carried out to obtain and determine alternative options to overcome this delay problem using SMART method (Aziz et al., 2019). The limitation of the problems raised by researchers in the Pasopati Selatan exploration programme is decision making and problem solving related to machine, man power, cost, and geological conditions that can become obstacles faced by the SGE Department as the main implementer of this exploration activity.

SMART helps in identifying and directing objectives that are specific, measurable, achievable, relevant, and limited by time (Robins, 2014). The series of analysis processes in the SMART method consists of identifying the decision maker, identifying the alternatives courses of

action, identifying the attributes with are relevant, assigning values to measure the performance of each alternative on each attribute, determining a weight for each attribute, making a provisional decision, performing sensitivity and proposed solutions.

1. Identify the Decision Maker

In this case, the decision maker is the SGE Department Manager who is the main implementer of the exploration programme at PT BIB.

2. Identify the Alternatives Courses of Action

In determining alternative options that will be taken as steps to resolve the problem. From the results of interviews following 3 options were obtained.

a. Purchase of Additional Jacro 500 Rig Unit (OPTION 1)

Option 1 is for SGE Department to purchase a new Jacro 500 drill rig and accessories or equivalent to enable exploration drilling in areas with medium to high rock hardness, and incline drilling in areas with steep to upright slopes.

b. Exploration Drilling Contracting Services (OPTION 2)

Option 2 is the implementation of a coal exploration programme in Pasopati Selatan using the services of a drilling contractor. The contractor is a third party or partner of PT BIB who has obtained a cooperation agreement in the implementation of exploration drilling within the period and value of work agreed in the work agreement contract.

c. Ground Penetration Radar (GPR) and Geoelectric Programme (OPTION 3)

Option 3 is the implementation of an exploration programme using one of the geophysical survey methods, namely GPR and geoelectricity.

The investment and operational costs previously described can be used to determine cost attributes including CAPEX and OPEX. Summary costs for the three options are shown in table 3 below.

Table 3. Investment and Operational Cost

No.	Alternative	CAPEX	OPEX	Total
1	OPSI 1	6,000,000,000	54,104,000,000	60,104,000,000
2	OPSI 2	0	76,800,000,000	76,800,000,000
3	OPSI 3	0	27,090,000,000	27,090,000,000

Identify The Attributes With Are Relevant

The next step is to weight each alternative option that has been determined previously. Weighting begins with determining the relevant attributes for all alternative options, then determining the weight scale for each attribute. The method used is a direct assessment of each attribute of each option conducted during the FGD. An overview of the flow chart for weighting is shown in Figure 5 below.

After determining several alternative decision-making solutions, next step with FGD process conduct identify relevant attributes that can be used to assess the superiority of each alternative. These attributes consist of values that are considered when determining alternatives,

in this case we divide them into 2 criteria, namely cost criteria and benefit criteria. Cost criteria are divided into CAPEX and OPEX sub criteria, while benefits are divided into sub criteria, namely Faster starting, Flexibility, Risk, Compatible and Duration (Figure 5).

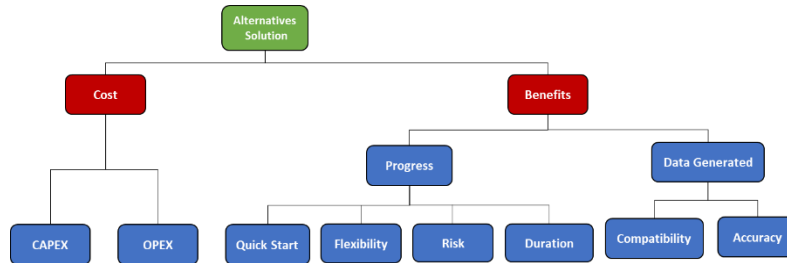


Figure 5. Value Tree of Decision Making

Assign Value to Measure Performance of Each Alternative on Each Attribute

After determining the criteria for each alternative option, the next step is to measure and calculate the performance of each option directly through the FGD process involving all representatives of the exploration implementation.

Tabel 4. Criteria Value Weighting Provisions

No.	Criteria	Requirement	Class	Score
1	Quick Start	Faster the programme can be implemented has good value (faster > slower)	Slow	0
			Medium Slow	50
			Medium Fast	80
			Fast	100
2	Flexibility	Operations that are flexible have a higher value (flexible > low flexible)	Less Flexible	0
			Medium Low	50
			Medium High	80
			More Flexible	100
3	Risk	Operations that have a low safety risk have a higher value. (low risk > high risk)	High Risk	0
			Medium High	50
			Medium Low	80
			Low Risk	100
4	Compatibility	The resulting product can be compatible with the current geological model, has a higher value (more compatible > less compatible)	Less Compatible	0
			Medium Low	50
			Medium High	80
			More Compatible	100
5	Duration	Faster programme completion has a higher score (faster > slower)	Slow	0
			Medium Slow	50
			Medium Fast	80
			Fast	100
6	Accuracy	The resulting data product has high accuracy, has a higher weight value (more accurate > less accurate)	Less Accurate	0
			Medium Low	50
			Medium High	80

No.	Criteria	Requirement	Class	Score
			More Accurate	100

From interviews and FGDs with the exploration team, the SGE Department conducted a direct assessment of each sub-criterion.

Table 5. Identifikasi Status Sub Kriteria Pada Setiap Opsi

No.	Criteria	OPTION 1	OPTION 2	OPTION 3
1	Quick Start	Slower	Faster	Faster
2	Flexibility	Flexible	Not Flexible	Not Flexible
3	Risk	High	High	Medium High
3	Compatibility	Compatible	Compatible	Not Compatible
4	Duration	Slower	Medium	Faster
5	Data Accuracy	More Accurate	More Accurate	Less Accurate

The assessment for the CAPEX and OPEX cost sub criteria, it was found that only Option 1 had CAPEX cost expenditure and OPEX cost expenditure was found in all Options, but it was found that Option 3 had the lowest OPEX value. Table 6 shows the costs incurred for each alternative option.

Table 6. Cost of Three Project Investment

No.	Alternative	CAPEX	OPEX	Total
1	OPTION 1	6,000,000,000	54,104,000,000	60,104,000,000
2	OPTION 2	0	76,800,000,000	76,800,000,000
3	OPTION 3	0	27,090,000,000	27,090,000,000

Next, a direct assessment is made on the benefits sub-criteria and given a score value from 0 to 100 for each option according to its status. A score of 0 is the lowest score and 100 is the highest score. The process of assessing the sub-criteria for each option was conducted through FGDs with the exploration team and interviews with experts.

The assessment for the sub-criterion of speed of commencement of the exploration programme in Pasopati Selatan. From the assessment results, it was found that Option 2 and Option 3 have the opportunity to start work earlier so that they have a score of 100 and Option 1 requires a longer time to start work.

Table 7. Direct Rating Quick Start Status

No.	Alternative	Quick Start	Criteria Status	Criteria Value
1	OPTION 1	Slower	Low	0
2	OPTION 2	Faster	High	100
3	OPTION 3	Faster	High	100

Assessment of the exploration programme flexibility sub-criterion. From the assessment results, it was found that Option 1 has more flexibility than Option 2 and Option 3, so Option 1 received a score of 100.

Table 8. Direct Rating Flexibility Status

No.	Alternative	Flexibility	Criteria Status	Criteria Value
1	OPTION 1	Flexible	High	100
2	OPTION 2	Not Flexible	Low	0
3	OPTION 3	Not Flexible	Low	0

Assessment for safety risk sub criteria for each option. From the assessment results it was found that of the three options there is a risk to safety, but Option 3 has a smaller safety risk than Option 1 and Option 2.

Table 9. Direct Rating Flexibility Status

No.	Alternative	Risk	Criteria Status	Criteria Value
1	OPTION 1	High Risk	Low	0
2	OPTION 2	High Risk	Low	0
3	OPTION 3	Medium Risk	Medium	50

Assessment of the sub-criterion of the compatibility of the data generated with existing geological models. This sub-criterion takes precedence because the results of the exploration will be used immediately to update the geological model. The assessment found that Option 1 and Option 2 are compatible and Option 3 is not compatible.

Table 10. Direct Rating Flexibility Status

No.	Alternative	Compatibility	Criteria Status	Criteria Value
1	OPTION 1	Compatible	Hgh	100
2	OPTION 2	Compatible	High	100
3	OPTION 3	Not Compatible	Low	0

Assessment for the duration sub-criterion of the completion period of the exploration programme. From the assessment results, it is found that Option 3 has a faster completion period than Option 1 and Option 2.

Table 11. Direct Rating Time Duration Status

No.	Alternative	Duration	Criteria Status	Criteria Value
1	OPTION 1	Long	Low	0
2	OPTION 2	Medium	Medium	80
3	OPTION 3	Short	High	100

Assessment for the accuracy sub criteria of exploration data generated from each option. From the assessment results, it is found that Option 1 and Option 2 have higher data accuracy than Option 3.

Table 12 Direct Rating Data Accuracy Status

No.	Alternative	Accuracy	Criteria Status	Criteria Value
1	OPTION 1	More Accurate	High	100
2	OPTION 2	More Accurate	High	100
3	OPTION 3	Less Accurate	Low	0

The results of the direct assessment of all alternative options.

Table 13. Direct Rating Benefits of Three Project Alternative

No.	Alternative	Quick Start	Flexibility	Risk	Compatibility	Duration	Accuracy
1	OPTION 1	0	100	0	100	0	100
2	OPTION 2	100	0	0	100	80	100
3	OPTION 3	100	0	50	0	100	0

Determine a Weight for Each Attribute

Base on of the 6 benefit attributes, each attribute is given a weight value to show how important it is compared to other attributes in realising the acceleration of the exploration programme in Pasopati Selatan. The attributes Quick Start, Compatible and Accuracy are the top priority in decision making, followed by the attributes of the duration of the implementation period, flexibility and finally the risk factor (Bonissone et al., 2019). The weight assessment was conducted using the direct rating method through the FGD and interview process.

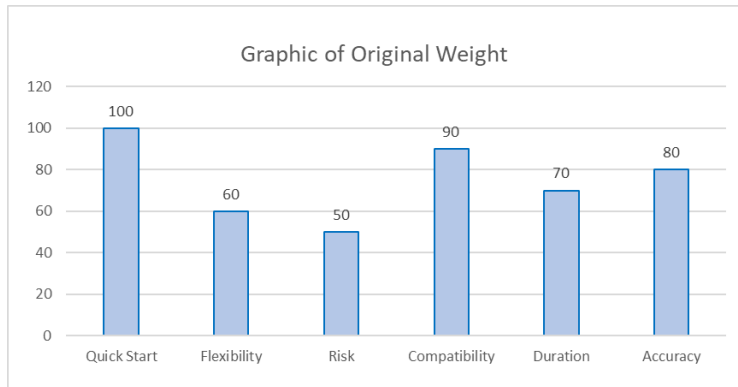


Figure 7. Graphic of Original Weight Each Attribute

Furthermore, the normalized weight in this stage with following formula :

$$Normalized\ Weight = \frac{Original\ Weight}{Total\ Original\ Weight} \times 100\%$$

The result of calculated normalized weight each attribute.

Table 14. Calculated Normalized Weight

No.	Attribute	Original Weight	Normalized Weight
1.	Quick Start	100	0.22
2.	Flexibility	60	0.13
3.	Risk	50	0.11
4.	Compatibility	90	0.20
5.	Duration	70	0.16
6.	Data Accuracy	80	0.18

For Each Alternative, Take a Weighted Average of Values Assigned to That Alternatives

This method is done by multiplying the original value by the normalised weight of each attribute, then summing the results of all attribute multiplications.

Table 15. Total Weight Value for OPTION 1

No.	Attributes	Normalized Weights	Value	Normalized Weights x Value
1	Quick Start	0.22	0	0.00
2	Flexibility	0.13	100	13.33
3	Risk	0.11	0	0.00
4	Compatibility	0.20	100	20.00
5	Duration	0.16	0	0.00
6	Accuracy	0.18	100	17.78
Total				51.11

Table 16. Total Weight Value for OPTION 2

No.	Attributes	Normalized Weights	Value	Normalized Weights x Value
1	Quick Start	0.22	100	22.22
2	Flexibility	0.13	0	0.00
3	Risk	0.11	0	0.00
4	Compatibility	0.20	100	20.00
5	Duration	0.16	80	12.44
6	Accuracy	0.18	100	17.78
Total				72.44

Table 17. Total Weight Value for OPTION 3

No.	Attributes	Normalized Weights	Value	Normalized Weights x Value
1	Quick Start	0.22	100	22.22
2	Flexibility	0.13	0	0.00
3	Risk	0.11	50	5.56
4	Compatibility	0.20	0	0.00
5	Duration	0.16	100	15.56
6	Accuracy	0.18	0	0.00
Total				43.33

The calculation of total values for all alternatives solutions

Table 18. Aggregate Value for Each Alternative Solutions

Alternatives	Quick Start	Flexibility	Risk	Compatibility	Duration	Accuracy	Aggregated of Weighted Value
OPTION 1	0	100	0	100	0	100	51.11
OPTION 2	100	0	0	100	80	100	72.44
OPTION 3	100	0	50	0	100	0	43.33

Make A Provisional Decision

The next step was to make a provisional decision by considering the comparison between the costs and benefits of each option. This was done because researchers found it difficult to assess costs and benefits equally.

Table 19 Trading Cost vs Benefits

Alternatives	Total Cost	Benefits
OPTION 1	60,104	51.11
OPTION 2	76,800	72.44
OPTION 3	27,090	43.33

To illustrate the comparative position of each option, the cost and aggregate benefit plots are shown in Figure 8. An option will be more attractive if the benefit value is higher or moves upwards and the cost value is lower or moves far to the right. There are two alternatives, OPTION 2 and OPTION 3, on the efficient frontier. The decision maker's relative weighting of costs and benefits will determine the best alternative.



Figure 8. Graphic Plot of Trading Cost vs Benefits

To compare the alternatives OPTION 2 and OPTION 3 is made in table 20, from the table it can be seen the benefit value increases from OPTION 3 to OPTION 2 by 29.11 points at an additional cost of 49,710,000,000. Consequently this will cost 1,707,595,420 for each additional point of benefit.

Table 20. Comparison of Alternative OPTION 2 and OPTION 3

Alternative	Ops 2		
		76,800,000,000	72.44
Ops 3	27,090,000,000	49,710,000,000	29.11
	43.33	1,707,595,420	

Perform Sensitivity Analysis

Sensitivity analysis is a method to observe the stability of a selected solution when the importance level for a particular attribute is changed (Christopher Frey & Patil, 2002). It serves as a tool to assess how resilient or robust the solution is when faced with uncertainty or variations in benefit parameters. In this case, sensitivity analysis was carried out by changing the weight on the benefit progress criterion to 0 because these three values have an influence on the completion of work on alternative options. This change shows that OPTION 2 is still the main choice with a benefits value of 100. Furthermore, the weight value for benefit data is changed to

0, which is a criterion related to the data generated in the alternative option work. This change shows that there is a shift, namely OPTION 3 is the top choice with a benefits value of 69.44.

Table 21. Aggregate of Weighted Value after Sensitivity Analysis

Alternatives	Aggregate of Weighted Value (Progress = 0)	Aggregate of Weighted Value (Original)	Aggregate of Weighted Value (Data Generated = 0)
OPTION 1	100.00	51.11	21.43
OPTION 2	100.00	72.44	55.71
OPTION 3	0.00	43.33	69.64

The new value in table 21 above is then plotted in a graph as in Figure 9 below which shows that OPTION 2 is an alternative solution that is not affected by changes in the weight of progress benefits. However, if there is a change in the weight of the benefit data criteria, OPTION 3 will become an alternative solution.

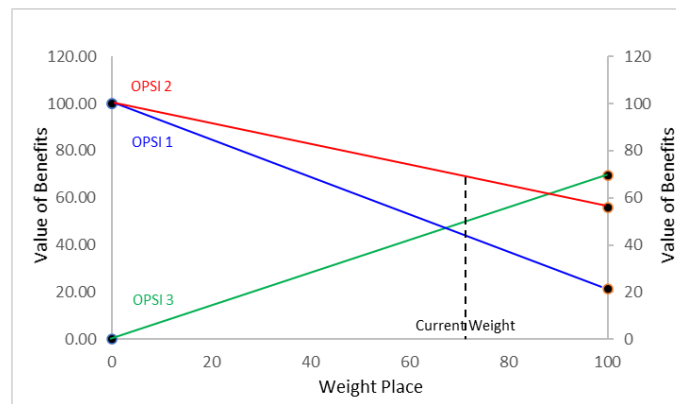


Figure 9. Sensitivity Analysis Result

Potential Problem Analysis

After the decision-making analysis as described above, Potential Problem Analysis (PPA) is carried out, which is an analysis to identify potential events and problems that may arise in the future in the implementation of the selected alternative programme.

Table 22. Potential Problem Analysis Result

No.	Potential Problem	Consequence	Possible Cause	Preventive Action	Contingent Action
1	Rejection and interference from unscrupulous residents of Belanai Hamlet	Exploration work cannot start immediately or the project does not run smoothly and safely	Residents feel they are not getting any contribution from the project	CSR program to improve community empowerment	Involving local residents in projects for non-skilled work

No.	Potential Problem	Consequence	Possible Cause	Preventive Action	Contingent Action
2	Drilling machine operation is not optimal	Exploration drilling progress hampered	Complex geology and hard rock of the Pasopati Selatan Block	Preliminary research of geological conditions in Pasopati Selatan and determine appropriate drilling equipment and methods.	Changing drilling machine
3	Pasopati Selatan Pit mining cannot be carried out	Shortage of coal reserves for increased production of 54 million tons	Exploration work results show Pasopati Selatan Block is not feasible and not economical	Redesign of Pasopati Selatan Pit utilizing economical area	Mining option planning in other blocks
			IPPKH Exploitation licensing cannot be fulfilled entirely	Redesign of Pasopati Selatan pit utilizing an area that already has IPPKH Exploitation	Mining option planning in other blocks

Proposed Business Solutions

In an effort to accelerate the exploration programme in the Pasopati Selatan area, three alternative options for acceleration steps have been determined as described in the Identify the Alternatives Courses, namely:

1. Purchase of Additional Jacro 500 Rig Unit (OPTION 1)
2. Exploration Drilling Contractor Services (OPTION 2)
3. Ground Penetration Radar (GPR) and Geoelectric Programme (OPTION)

Based on the results of the analysis of the three alternative solutions using the SMART method as described above, it is known that there are benefit criteria attached to each alternative, namely criteria in terms of progress including quick start, flexibility, risk, and duration, criteria in terms of data generated include compatibility and accuracy (Taherdoost & Mohebi, 2024).

Each criterion is then given a value and weighted successively. The weighting results show that OPTION 2 and OPTION 3 are on the efficient line. OPTION 2 has an investment value of 76,800,000,000 with the highest benefit of 72.44, compared to OPTION 1 and OPTION 3 will provide an attractive alternative option for decision makers.

Based on the sensitivity analysis with the SMART method, it shows that OPTION 2 is an alternative solution that is not affected by changes in the weight of progress benefits. However, if there is a change in the weight of the benefit data criteria, OPTION 3 will become an alternative solution. For the current condition, OPTION 2 is still the first choice alternative option, because

to get the objective of this final project is a solution to accelerate the exploration programme in Pasopati Selatan which can be carried out immediately and the exploration data can be used directly for updating the geological model.

CONCLUSION

The conclusion of this research shows that the delay in the exploration program at Pasopati Selatan is caused by a combination of licensing factors, limited equipment and manpower, complex geological conditions, and social aspects of the surrounding community. Through the SMART analysis approach and the Kepner-Tregoe method, it was found that the option of using drilling contractor services (OPTION 2) is the best alternative solution that can accelerate the exploration process while producing accurate geological data to support the updating of geological models. This option is considered the most balanced in terms of benefits and costs and is resistant to parameter changes in the sensitivity analysis. This research not only makes a practical contribution to strategic decision-making at PT BIB, but also a theoretical contribution to the development of data-driven exploration evaluation models and decision-making in the mining sector. In the future, this integrative approach can be adapted for other exploration projects in similar industries, especially in the face of evolving technical and regulatory complexity challenges.

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