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Vendor Selection for The Procurement of Gold Crusher at PT. ILBB Using Analytic Hierarchy Process

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Abstract

This research aims to address the issue of vendor selection for the procurement of a gold crusher, a primary need for PT. Indotan Lombok Barat Bangkit (ILBB) in its transition from exploration to gold production. Choosing the right vendor is crucial as it directly impacts the sustainability of the company's business operations. The study employs the Analytical Hierarchy Process (AHP) to evaluate three vendor alternatives: Liming, Jinpeng, and Yifan, based on five main criteria: Financial, Delivery, After-sales, Machine, and Vendor Credibility, which were developed through a combination of literature reviews and interviews with ILBB decision-makers. The analysis results indicate that the Machine criterion is the top priority with a weight of 49.1%, particularly focusing on the sub-criterion of Machine Reliability. This reflects ILBB's emphasis on operational efficiency and production stability. Vendor Credibility ranks second with a weight of 23.65%, highlighting the importance of trust in the vendor's ability to meet the company's needs. The After Sales criterion ranks third, with the availability of spare parts sub-criterion being a major consideration to ensure operational continuity. The timeliness of the delivery sub-criterion within the Delivery criterion also plays a significant role, whereas the financial criterion is less prioritized. Liming emerges as the best choice with a priority weight of 52.15%, excelling in sub-criteria such as Machine Reliability, Machine Technology, and Manufacturing Standards, aligning with ILBB's strategic and operational needs. This study demonstrates that AHP effectively supports multi-criteria decision-making processes, offering a replicable methodology applicable to other companies with similar challenges.

Keywords: analytic hierarchy process, vendor selection, procurement, criteria, decision-making

INTRODUCTION

Gold is one of the commodities that can be considered a safe haven asset. A safe haven asset is an asset that is expected to have a stable or increased price in the midst of an economic downturn or market turbulence (source: investopedia.com). Gold can be used as an asset to diversify the risk of investment. Over the last ten years, gold has had an increasing trend of price and reached its all-time high in September 2024 (tradingeconomics.com).

Indonesia is one of the biggest gold producers in the world (source: tradingeconomics.com). Indonesia currently accounts for around four percent of global gold production, half of that coming from the giant Grasberg mine, the world's largest gold mine, on the western half of Papua. That mine, which has what is thought to be the world's largest gold reserves (67.4 million ounces), is among the majority owned by the American company Freeport-McMoRan Copper & Gold Inc. and makes it the single largest taxpayer to the Indonesian government (source: indonesia-investments.com).

As the business of gold production seems promising in Indonesia, PT. Ancora

Indonesia Resources tried to take advantage by acquiring PT. Indotan Lombok Barat Bangkit (ILBB). Unlike big gold-producing companies such as Freeport, AMMAN, Agrincourts Resources, and others, PT. ILBB does not have the infrastructure and machines for producing gold. ILBB has only done exploration but not gold production. To be able to compete with other gold producers in Indonesia, ILBB requires infrastructure and machines that support the gold production activity to achieve the determined quantity and quality of gold that is going to be produced. In providing infrastructure and machines for gold production, PT. ILBB needs the help of vendors or suppliers because gold production machinery is not part of the company's expertise.

The novelty of this research is not just about procuring infrastructure and machinery, but building a strategic partnership model with vendors/suppliers that includes technology and knowledge transfer. Focus on developing local capabilities through training and mentoring, so that ILBB can be independent in maintaining and operating machinery in the long term.

According to research conducted by Atlam, H. F., & Wills, G. B. (2019). Intersections between IoT and distributed ledger. In Advances in Computers. the results are that IoT has been proven to provide several benefits in various domains. IoT has evolved to include the perception of realizing a global infrastructure of interconnected physical and virtual object networks. These objects are interconnected using wired or wireless networks to share information between various IoT devices to create new applications and services. However, the current centralized IoT architecture faces many problems related to security and scalability.

The purpose of this research is to develop an effective strategic partnership framework, which includes technology and knowledge transfer mechanisms, as well as local capacity development models. These benefits build a reputation as a sustainable and responsible mining company.

RESEARCH METHODS

Research methodology serves as the backbone of any study, providing a structured approach to collecting, analysing, and interpreting data to address the research objectives. A well-defined methodology ensures that the study is systematic, reliable, and replicable. Research design, as a critical component of methodology, outlines the overall plan or framework that guides the research process. It determines how data will be collected, analysed, and interpreted while aligning with the research objectives. Broadly, research designs can be categorized into qualitative, quantitative, or mixed methods, depending on the nature of the research problem and the type of data involved.

In this study, the research design and methodology are tailored to address the decision-making process of vendor selection for the gold crusher procurement using the Analytical Hierarchical Process (AHP). The methodology integrates both qualitative and quantitative approaches to capture expert insights and numerical evaluations required for

AHP analysis. This chapter outlines the research design, data collection methods, and analysis approach employed to achieve the study's objectives. The first stage in this research is identifying the problems experienced by the company. The problem raised in this research is the process of selecting a vendor to provide a gold crusher for PT. ILBB. Currently PT. ILBB is in the stage of preparing infrastructure so that it can immediately start gold mining operations and one of the things needed is a gold crusher.

After determining the problem, the next stage is determining the objectives of this research. In order to produce gold with adequate quality and quantity, PT. ILBB requires adequate infrastructure and equipment, including a gold crusher. In connection with this research, PT. ILBB must be able to choose the gold crusher that best suits the company's needs from several available vendor options. Therefore, the aim of this research is to help PT. ILBB in choosing the best vendor for procuring gold crushers. In choosing the best gold crusher vendor, there are several criteria that PT must consider. ILBB in selecting vendors. The specified criteria must be appropriate so that PT. ILBB was not wrong in choosing a gold crusher vendor. Therefore, after knowing that this research aims to help select a gold crusher vendor, the next stage is to determine the criteria needed in selecting a gold crusher vendor. Criteria for selecting vendors will be obtained through literature reviews and interviews with decision-makers involved in selecting gold crusher vendors at PT. ILBB. First, the author will look for criteria through a literature review to then submit to the decision maker during the interview. Decision makers will provide suggestions related to the criteria needed for vendor selection based on their opinions and provide suggestions related to the criteria proposed by the author. After customization, the criteria required for vendor selection will be obtained.

It is known that PT. ILBB must choose the best gold crusher vendor from several existing options based on predetermined criteria. Therefore, the next stage is to choose a method that can be used to select the best alternative based on several criteria. The method that will be used in this research is the Analytical Hierarchical Process. After determining AHP as the method used in research for selecting gold crusher vendors, the next stage is data processing using AHP. Before carrying out further processing using AHP, what must be done first is to create a hierarchical tree from the criteria that have been obtained through interviews and literature reviews. There are 4 levels in the hierarchical tree; level 1 is objective, level 2 is criteria, level 3 is sub-criteria, and level 4 is alternatives. After that, the hierarchical tree will be processed by carrying out pairwise comparisons using the AHP method. Pairwise comparison is carried out between criteria, between sub-criteria within a criterion, and between alternatives. The final result of the pairwise comparison is the best vendor with the largest weighting value.

After getting the best vendor using the AHP method, an implementation plan will be created to determine the gold crusher procurement planning for PT. ILBB.

Analysis method

Data obtained through filling out the AHP questionnaire by respondents will be analyzed further using the AHP analysis flow. The following are the steps in analyzing

using the AHP method.

1. **Determine the hierarchy of criteria**

The first stage taken is to determine the criteria and sub-criteria for selecting a crusher vendor. The criteria and sub-criteria in this research were obtained through interviews with decision-makers in the company.

2. **Create a pairwise comparison matrix and calculate the Consistency Ratio**

The results of respondents filling out the AHP questionnaire will be input for creating a pairwise comparison matrix for criteria, sub-criteria, and alternatives. Each matrix will have its CR value calculated to ensure that the CR value of each matrix is below 0.1. A matrix with a CR value above 0.1 is considered inconsistent.

3. **Create an aggregate pairwise comparison matrix of all respondents**

After ensuring that each matrix has a value below 0.1, an aggregate matrix is created for each respondent. The aggregate matrix also takes into account the level of importance of each respondent. The aggregate matrix will be used for weight calculations.

4. **Calculate local weight and global weight for each criterion, sub-criteria, and alternative**

After creating, local and global weight calculations are carried out for each criterion, sub-criteria, and alternative using the geometric mean.

5. **Analyze the results of weighting calculations**

The weight calculation results obtained will be analyzed to evaluate the best vendor that the company will choose.

RESULTS AND DISCUSSION

1. Final Criteria and Sub-Criteria

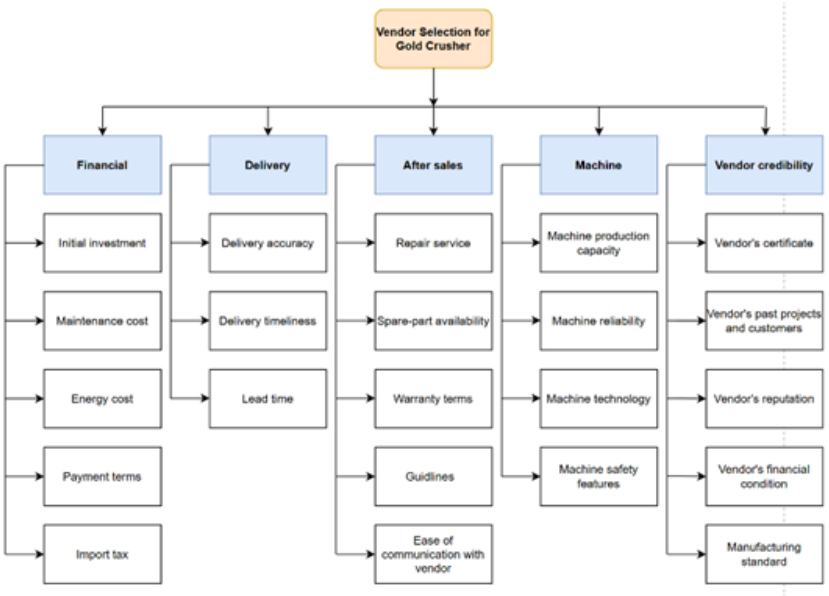

Figure 1. Final Criteria and Sub-Criteria

After conducting interviews with decision-makers at PT. ILBB, the final criteria and sub-criteria that will be used in the AHP process are obtained. The following is a definition of the criteria and sub-criteria for selecting a gold crusher vendor.

Table 1. Criteria definition

Criteria	Definition
Financial	Aspects related to costs that must be incurred by PT. ILBB for purchasing and operating a gold crusher. The financial aspect needs to be considered because there are limited budget allocations from PT. ILBB.
Delivery	Vendor's capability in delivering gold crusher to the company on the required time and as specified. Delivery is important to be considered to ensure there is no disruption that can hinder PT. ILBB to start the production process.
After sales	Aspects that ensure the continuity of gold crusher operations without any obstacles after the machine is installed by the vendor.
Machine	Aspects that focus on the technical capabilities of the machine and the quality of the machine. It is important to pay attention to the machine aspects so that the gold crusher purchased can operate according to expectations and meet production demands efficiently and effectively.
Vendor credibility	Aspect that shows the vendor is capable of meeting the specific requirements of PT. ILBB for the gold crusher that is going to be purchased.

Table 2. Sub-criteria definition

Sub-criteria	Definition
Initial investment	The initial costs that must be incurred by PT. ILBB to be able to get a gold crusher, such as costs for purchasing and installing equipment.
Maintenance cost	Costs that must be incurred by PT. ILBB after the crusher is installed to ensure the crusher can still function properly without any operational problems.
Energy cost	Costs that must be incurred by PT. ILBB for power consumption from the crusher.
Payment terms	Rules regarding payments given by vendors to PT. ILBB. These rules regulate how much must be paid in advance, how long time is given to PT. ILBB to make payments, penalties related to payments, and/or other rules related to payments that are binding on PT. ILBB.
Import tax	Costs that must be incurred by PT. ILBB is to pay taxes on imported goods because the goods purchased come from abroad.

Sub-criteria	Definition
Delivery accuracy	The vendor's ability to deliver goods in accordance with the specifications and quality mutually agreed upon by the vendor and PT. ILBB without any defects or other nonconformities.
Delivery timeliness	Vendor's ability to meet delivery deadlines mutually agreed upon by the vendor and PT. ILBB.
Lead time	Compliance with the lead time promised by the vendor to PT. ILBB with a timeline set by PT. ILBB.
Repair service	Vendor capability to provide gold crusher repair services if damage occurs. The repair services provided can take the form of providing repair consultations or sending workers directly to the site to carry out repairs.
Spare-part availability	Ease of finding replacement spare parts for components that are damaged during use. Vendors must also guarantee that the required spare parts are available within the specified time so that production activities are not hampered.
Warranty terms	Guarantee that is given by the vendor to replace or repair broken products without additional fee within a certain period of time.
Guidelines	Guidelines provided by the vendor to PT. ILBB relates to stock guidelines for critical parts, manuals for operating equipment, and providing training to PT workers. ILBB to operate the gold crusher.
Ease of communication with vendor	Ease of maintaining long-term relationships and communications with vendors once the product is installed. The aim of facilitating communication with vendors is to exchange information with vendors regarding important matters related to the operational continuity of the equipment.
Machine production capacity	Machine capacity to produce gold ore.
Machine reliability	The ability of the machine to be able to operate for a long period of time without damage.
Machine technology	Advancement of technology used in the crusher machine of vendor.
Machine safety features	Availability of safety features on the gold crusher to avoid work accidents or minimize the impact of work accidents.

Sub-criteria	Definition
Vendor's certificate	Official technical certificate held by the vendor to validate the vendor's conformity to applicable standards and regulations.
Vendor's past projects and customers	List of clients and projects that the vendor has worked on in the past. If the vendor's previous client is a company with a good reputation or has similar characteristics to PT. ILBB, this can be an attractiveness for PT. ILBB to select vendors.
Vendor reputation	Industry perceptions, both positive and negative, towards vendors are based on feedback from industry players who have used the vendor's services or heard news about the vendor.
Vendor's financial condition	Conditions that show that the vendor is in good health and financially stable. This needs to be considered to ensure that there are no obstacles from vendors in delivering products to PT. ILBB caused by the financial condition of the vendor.
Manufacturing standard	The production operation standards implemented by vendors in product manufacturing are in accordance with applicable standards. This is to ensure that the products produced by the vendor meet the specifications and quality expected by PT. ILBB.

2. AHP Results for Criteria and Sub-Criteria

Weight Calculation for Criteria

Table 3. Weight calculation for criteria

	Financial	Delivery	After Sales	Machine	Vendor Credibility	**Weight**
Financial	1.000	0.970	0.794	0.177	0.371	8.46%
Delivery	1.030	1.000	0.742	0.201	0.301	8.30%
After Sales	1.260	1.348	1.000	0.246	0.351	10.46%
Machine	5.635	4.969	4.063	1.000	2.952	49.14%
Vendor Credibility	2.697	3.326	2.853	0.339	1.000	23.65%

Source: Data processed

Based on the results of weight calculations for the criteria, the engine criterion is the most prioritized criterion among the other 5 criteria with a value of 49.14%. The delivery criterion is the least prioritized criterion with a value of 8.3%.

a. Weight calculation for sub-criteria

Sub-criteria: Financial

Table 4. Weight calculation for sub-criteria of financial

	Initial Investment	**Maintenance cost**	**Energy cost**	**Payment terms**	**Import tax**	**Weight**
Initial Investment	1.000	1.369	1.309	2.644	5.814	32.77%
Maintenance cost	0.731	1.000	1.096	1.992	3.688	24.07%
Energy cost	0.764	0.913	1.000	1.172	5.277	22.62%
Payment terms	0.378	0.502	0.853	1.000	4.174	15.61%
Import tax	0.172	0.271	0.189	0.240	1.000	4.93%

Source: Data processed

Based on the calculation results for the sub-criteria of the financial criteria, the initial investment sub-criteria is the most prioritized with a weight of 32.77%. The sub-criteria of the financial criteria that is least prioritized is import tax with a weight of 4.93%.

Sub-criteria: Delivery

Table 5. Weight calculation for sub-criteria of delivery

	Delivery accuracy	Delivery timeliness	Lead time	**Weight**
Delivery accuracy	1.000	7.096	3.577	70.86%
Delivery timeliness	0.141	1.000	0.630	10.76%
Lead time	0.280	1.587	1.000	18.39%

Source: Data processed

Based on the calculation results for the sub-criteria of the delivery criteria, the delivery accuracy sub-criteria is the most prioritized with a weight of 70.86%. The sub-criteria of the financial criteria that is least prioritized is delivery timeliness with a weight of 10.76%.

Sub-Criteria: After Sales

Table 6. Weight calculation for sub-criteria of after-sales

	Repair service	**Spare-part availability**	**Warranty terms**	**Guidelines**	**Ease of communication with vendor**	**Weight**
Repair service	1.000	0.196	0.279	1.414	1.435	0.092
Spare-part	5.089	1.000	2.913	7.047	4.851	0.498

	Repair service	Spare-part availability	Warranty terms	Guidelines	Ease of communication with vendor	Weight
availability						
Warranty terms	3.583	0.343	1.000	5.632	3.047	0.264
Guidelines	0.707	0.142	0.178	1.000	0.502	0.056
Ease of communication with vendor	0.697	0.206	0.328	1.991	1.000	0.089

Source: Data processed

Based on the calculation results for the sub-criteria of the after-sales criteria, the spare-part availability sub-criteria is the most prioritized with a weight of 49.8%. The sub-criteria of the financial criteria that is least prioritized is the guideline with a weight of 5.6%.

Sub-criteria: Machine

Table 7. Weight calculation for sub-criteria of machine

	Machine production capacity	Machine reliability	Machine technology	Machine safety features	Weight
Machine production capacity	1.000	0.218	1.489	1.930	15.70%
Machine reliability	4.579	1.000	4.732	7.592	63.18%
Machine technology	0.672	0.211	1.000	3.013	14.27%
Machine safety features	0.518	0.132	0.332	1.000	6.84%

Source: Data processed

Based on the calculation results for machine sub-criteria, machine reliability sub-criteria is the most prioritized with a weight of 63.18%. The sub-criterion of the reliability criteria that is least prioritized is machine safety features with a weight of 6.84%.

Sub-Criteria: Vendor Credibility

Table 8. Weight Calculation for Sub-Criteria of Vendor Credibility

	Vendor certificate	Past projects and customers	Vendor reputation	Vendor financial condition	Manufacturing standard	Weight
Vendor certificate	1.000	0.205	0.187	0.177	0.154	4.29%
Past projects and customers	4.874	1.000	0.860	1.107	0.967	22.82%
Vendor reputation	5.335	1.163	1.000	1.335	0.699	24.01%
Vendor financial condition	5.635	0.904	0.749	1.000	0.833	21.30%
Manufacturing standard	6.509	1.034	1.432	1.201	1.000	27.58%

Source: Data processed

Based on the calculation results for the sub-criteria of the vendor credibility criteria, the manufacturing standard sub-criteria is the most prioritized with a weight of 27.58%. The sub-criteria of the vendor credibility criteria that is least prioritized is the vendor certificate with a weight of 4.29%.

AHP Results for Alternatives

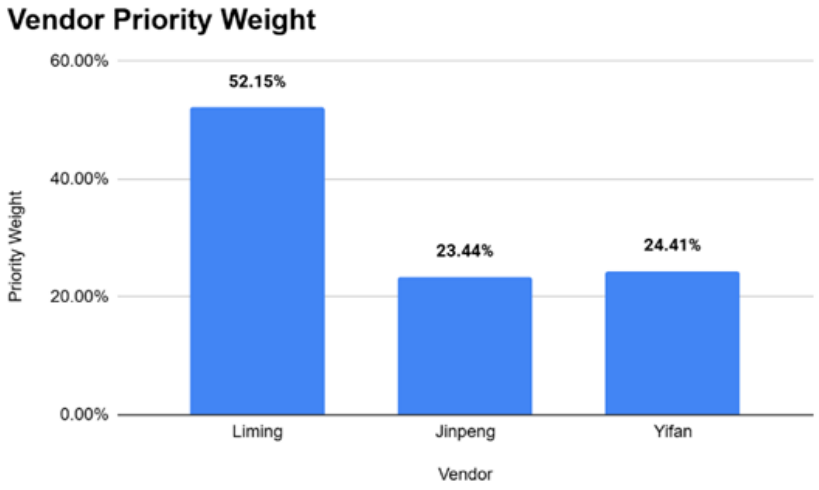

Figure 2. Vendor's Weight Result

Based on the weight calculation results for vendors, Liming received the highest

weight with a value of 52.15%, followed by Yifan with a value of 24.41%, and Jinpeng with a value of 23.44%.

Discussion

Table 9. Final results

Criteria	Local Weight	Sub-criteria	Local weight	Global Weight	Liming	Jinpeng	Yifan
Financial	0.085	Initial investment	0.328	0.028	0.085	0.650	0.265
		Maintenance cost	0.241	0.020	0.568	0.154	0.279
		Energy cost	0.226	0.019	0.332	0.224	0.444
		Payment terms	0.156	0.013	0.263	0.317	0.420
		Import tax	0.049	0.004	0.333	0.333	0.333
Delivery	0.083	Delivery accuracy	0.709	0.059	0.486	0.184	0.330
		Delivery timeliness	0.108	0.009	0.541	0.236	0.223
		Lead time	0.184	0.015	0.406	0.349	0.245
After sales	0.105	Repair service	0.092	0.010	0.362	0.425	0.213
		Spare part availability	0.498	0.052	0.449	0.252	0.299
		Warranty terms	0.264	0.028	0.378	0.183	0.439
		Guidelines	0.056	0.006	0.245	0.286	0.469
		Ease of communication with vendor	0.089	0.009	0.290	0.482	0.228
Machine	0.491	Machine production capacity	0.157	0.077	0.333	0.333	0.333
		Machine reliability	0.632	0.310	0.703	0.093	0.204
		Machine technology	0.143	0.070	0.721	0.095	0.184
		Machine safety features	0.068	0.034	0.333	0.333	0.333
Vendor credibility	0.236	Vendor certificate	0.043	0.010	0.390	0.373	0.237
		Past projects and customers	0.228	0.054	0.499	0.363	0.138
		Vendor reputation	0.240	0.057	0.519	0.321	0.160
		Vendor financial condition	0.213	0.050	0.295	0.479	0.227
		Manufacturing standard	0.276	0.065	0.524	0.284	0.192
					52.15%	**23.44%**	**24.41%**

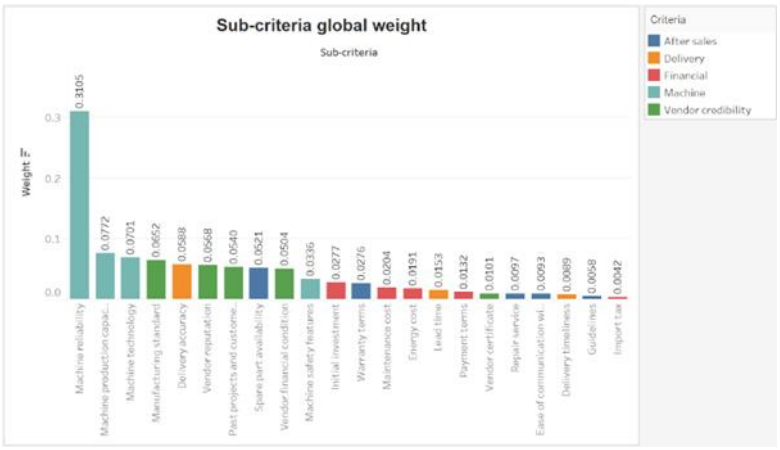

Figure 3. Sub-Criteria Global Weight

The most prioritized criteria in the gold crusher vendor selection is the machine criteria with a weight of 49,1%. The sub-criterion of machine which are machine reliability, machine production capacity, and machine technology, with local weight of 31,05%, 7,72%, and 7,01% respectively, become one of the most prioritized criteria in the gold crusher vendor selection. In this research, machine reliability is the most important sub-criteria, indicating that the company does not want the operations to be disrupted. It emphasized the company's commitment to achieving operational efficiencies and reducing production downtime due to machine breakdown. The weight of machine production capacity and technology shows the company's need for scalability and quality in meeting long-term production targets.

After sales is the third most prioritized criterion after vendor credibility with a weight of 10,5%. The most prioritized sub-criteria for after-sales is the availability of spare parts and it is one of the most prioritized sub-criteria in choosing a gold crusher vendor with a global weight of 5,2%. The availability of spare parts is important for PT. ILBB because if the machine experienced spare part damage and cannot be repaired, PT. ILBB will need a replacement so that production activities continue and are not hampered. Spare parts availability could also help to minimize production downtime and ensure operational stability. Even though the delivery criterion is the least prioritized of the five other criteria, one of the sub-criteria of delivery, namely delivery accuracy, is one of the most prioritized sub-criteria, with a global weight of 5,9%. Delivery accuracy is related to the vendor's ability to deliver goods according to the conditions desired by PT. ILBB. This is also related to the company's most prioritized criteria in selecting vendors, which is machine criteria. The goods sent must have met the quality desired by PT. ILBB. While lead time and delivery timeliness were less weighted, they still have roles in avoiding delays in project implementation.

While financial criteria are less prioritized than other criteria like machine, vendor credibility, and after-sales, these criteria still play a role in the decision-making process.

Financial criteria still become a consideration due to the company's limited budget allocation

Liming is the most superior vendor with a weight of 52,15%. When compared with the other two alternatives, Liming has advantages in 11 sub-criteria out of 23 sub-criteria. The results show that Liming has advantages in sub-criteria most of which are the company's top priorities in choosing a gold crusher vendor. It indicates that Liming is the most capable vendor in providing a gold crusher that meets all the requirements of PT. ILBB.

Business Solution

PT. ILBB should choose Liming as the gold crusher vendor that is going to provide the crusher for the company. Liming got the priority weight of 52,15%, which is the highest among all alternatives. Liming excels in criterion and sub-criterion that align with the company's most prioritized criterion. Liming is the vendor that most likely will be able to deliver crusher in accordance with the company's desired requirements. Liming excels in the sub-criterion of machine reliability and machine technology indicating that Liming's product is aligned with the company's goal to achieve operational efficiency, minimize production downtime, and produce gold with the desired quality.

Liming got the lowest weight for the investment and payment terms sub-criterion. It indicates that PT. ILBB will have to pay a lot to get Liming's product and the payment terms that Liming requires might not be favourable for PT. ILBB. Although payment terms don't seem to be the concern of PT. ILBB in choosing gold crusher vendor, PT. ILBB still could do further negotiation with Liming regarding the payment terms or make several adjustments so that the company could meet the demands of Liming. Liming also got the lowest weight for the guidelines sub-criterion. It indicates that Liming may lack detailed documented operational guidelines for using the machine and maintaining the part stocks. In the future, there may be a risk that PT. ILBB faces problems that require guidelines from Liming to resolve them. To mitigate this risk, PT. ILBB can consider the guidelines from Liming as one of the clauses of the agreement with Liming.

CONCLUSION

This research was conducted to solve the main business issue faced by PT. Indotan Lombok Barat Bangkit (ILBB), which is the selection of a vendor for the procurement of gold crusher. Gold crusher is required for the company as PT. ILBB transition from the gold exploration phase to the production phase. Selecting the best vendor for the procurement of a gold crusher is considered as determining factor for operational efficiency, production quality, and long-term sustainability of the business. To address this problem, the Multi-Criteria Decision-Making (MCDM) method was applied, specifically the Analytical Hierarchy Process (AHP). AHP provided a systematic evaluation of three vendor alternatives which are Liming, Jinpeng, and Yifan on five main

criteria, which are Financial, Delivery, After-sales, Machine, and Vendor Credibility with the corresponding sub-criteria gathered from literature review and expert interviews. From the AHP analysis results, it was identified that the "Machine" criteria with its "Machine Reliability" sub-criteria got the highest global priority weight, indicating that it is the most crucial for PT. ILBB as consideration for PT. ILBB in selecting the best vendor. It also reflects the company's need to minimize operational downtime and ensure production efficiency. Liming was identified as the best vendor alternative, having a weight of 52.15% and having the highest scores outperforming the other vendors in key criteria like Machine Reliability, Machine Technology, and Manufacturing Standard. The results show that AHP is applicable to effectively address complex decision-making problems. AHP is capable of providing PT. ILBB is a robust framework to ensure strategic alignment in vendor selection. This research focuses on one aspect of the gold mining industry, namely the gold crusher procurement process. This research can be used as a reference for research that aims to solve similar problems but from different aspects within the same industry or different industries. For future research, adjustments need to be made to the criteria used to select alternatives. The criteria used can be adjusted to the needs of the problem owner. Future research can also use other multi-criteria decision-making methods that are more appropriate to the problems faced and the objectives of the research being conducted.

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