Applying Value-Focused Thinking (VFT) and Analytical Hierarchy Process (AHP) to Determine the Authority for Rig-Owned Transportation Management at PT Pertamina Hulu Rokan Zone 4

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ABSTRACT

This study aims to identify the appropriate authority responsible for managing rig-owned transportation within Pertamina Hulu Rokan Zone 4 by employing mixed-method approach, integrating both qualitative and quantitative methodologies. Value-Focused Thinking (VFT) generates values, alternatives, and objectives. Analytical Hierarchy Process (AHP) quantifies and prioritizes criteria and alternatives. VFT, through expert interviews, enhances the initial set of criteria and alternatives by introducing additional sub-criteria and alternatives. AHP is then employed to prioritize the outputs from VFT through a structured computational process. Ultimately, the selected authority established a new operation support function, which is preferred over the existing SCM-RAM system and the Well Intervention (self-managed) alternative.

INTRODUCTION

Pertamina Hulu Rokan (PHR) Zone 4 is one of the busiest locations under Pertamina Subholding Upstream, overseeing operations that involve hundreds of oil rigs and thousands of work plans annually. As the costs associated with both discovering new oil reserves and maintaining existing production continue to rise, the company has prioritized operational efficiency. This focus extends beyond core activities to include supporting operations such as transportation management. In response, Pertamina, through Upstream Subholding Drilling and Well Intervention (DWI), has been tasked with assessing the existing centralized system in which Supply Chain Management (SCM) oversees heavy transport, and Reliability, Availability, and Maintainability (RAM) manages heavy equipment. These two divisions handle all transportation requirements across and beyond their respective departments. However, with increasing operational demands, Pertamina seeks alternative approaches to optimize resource utilization for daily operations more effectively.

The Well Intervention division was established to support both reservoir management and production optimization through well intervention activities. These interventions aim either to enhance production gains or to maintain current output from existing wells. Well intervention activities are categorized into light and heavy interventions: light interventions can be performed on active wells, whereas heavy interventions require a temporary halt in production.

To meet its work plan targets, PHR Zone 4 relies on oil rigs for both well intervention (WI) and well service (WS) operations. Some of these rigs are leased from vendors, while others—specifically 12 rigs—are owned by PHR Zone 4. The maintenance, personnel, certifications, and overall management of these owned rigs fall under Pertamina's responsibility. In combination with 25 leased rigs, these assets are utilized to execute the work plan, which is revised annually. While the number of rigs may vary each year, their role in operations remains indispensable.

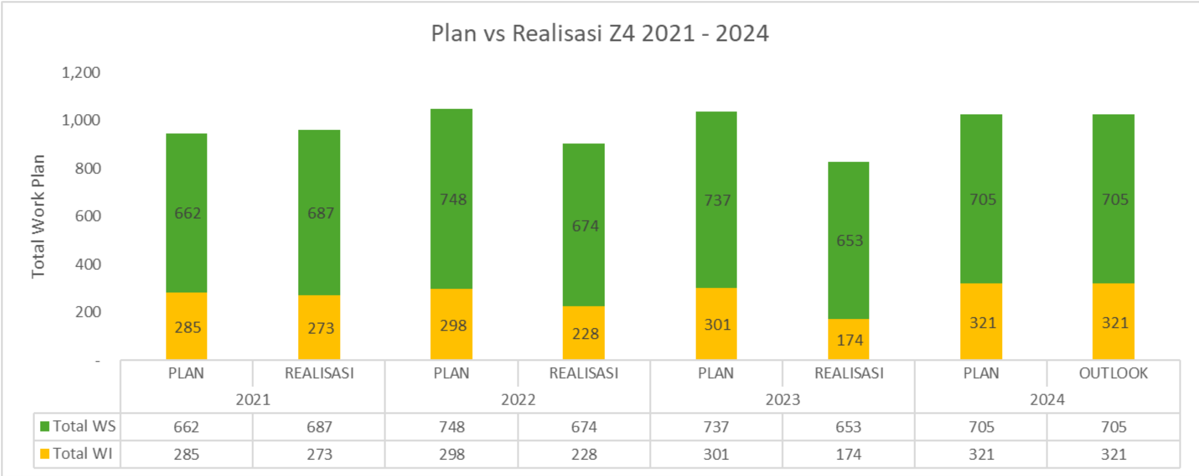

Figure I. PHR Zone 4 work plan vs realisation from 2021 - 2024

Despite their critical function, availability, reliability, and utility rates of company-owned rigs remain significantly lower than those of leased rigs due to various challenges—one of the most pressing being transportation inefficiencies. The need to share equipment across departments often results in long wait times, leading to deviations from planned schedules. These delays not only cause operational setbacks but also contribute to increased costs required to complete the assigned tasks.

In 2023, 35 rigs (both owned and leased) were in operation. This number increased to 37 rigs in 2024 to compensate for lower-than-expected realization rates. However, in 2025, the total rig count is expected to return to 35, despite maintaining a similar work plan as in 2024. Given this projection, improving rig performance is essential to ensure that actual execution aligns with planned objectives. Since transportation delays directly impact rig availability and utility—factors incorporated into performance calculations—addressing transportation inefficiencies is expected to enhance rig-owned performance, enabling smoother, faster, and safer operations.

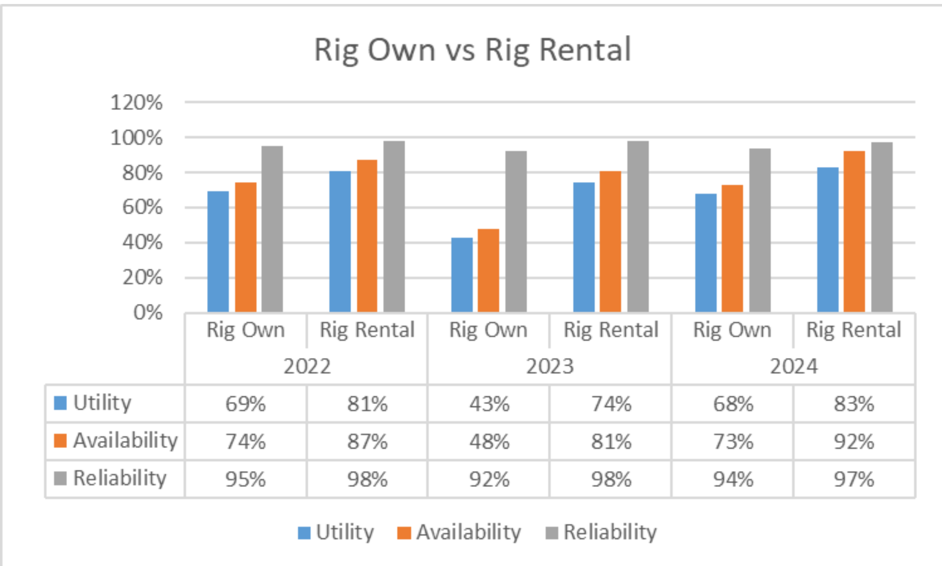

Figure 2. Rig owned vs rig rental performance

The field of transportation science encompasses both theoretical frameworks and empirical research on transportation processes (Yannis et al., 2020). Selecting a reliable transportation management system requires balancing multiple challenges, including timeliness, cost-effectiveness, and operational complexity (Ulutas et al., 2021). Beyond addressing current inefficiencies, modern decision-makers are increasingly adopting advanced decision-making frameworks to improve the accuracy and reliability of evaluations, particularly in sustainability-focused initiatives (Kumar et al., 2020). Prior research has highlighted the effectiveness of Multi-Criteria Decision Making (MCDM) in resolving transportation-related challenges. For example, Jain (2014) employed AHP-based survey analysis to assess transportation efficiency in Delhi, India, while Duleba (2012) examined strategies to improve public bus services while balancing costs and stakeholder interests.

Although Value-Focused Thinking (VFT) and Analytical Hierarchy Process (AHP) are well-established methods in MCDM literature, their combined application in transportation management—particularly within the complex operational environment of the oil and gas sector—remains underexplored. Existing studies, such as Logullo et al. (2022), have relied on limited stakeholder engagement (involving only two stakeholders), thereby reducing decision-making coherence. Similarly, Affandi et al. (2023) identified the same issue, as their study only considered stakeholders from the same organizational hierarchy.

This research addresses this gap by integrating a broader and more diverse range of stakeholders—including individuals from different organizational levels and functional expertise—into a hybrid VFT-AHP framework. By incorporating multi-stakeholder inputs from ten experts, this study seeks to enhance the robustness and generalizability of its findings. Focusing specifically on the challenges of transportation management in the oil and gas sector, this research aims to provide a structured, value-driven decision-making approach that can serve as a foundation for similar applications in other industries. Additionally, the study is expected to serve as a reference for future research in comparable operational contexts where decision-making frameworks must balance efficiency, cost, and risk.

RESEARCH METHOD

Given the complexity of the research, a mixed-method approach combining both qualitative and quantitative research methods will be employed. The qualitative component utilizes Value-Focused Thinking (VFT) to identify and structure the core objectives and criteria relevant to the study. This approach enables a thorough exploration of the values and priorities of stakeholders. The quantitative component, on the other hand, applies the Analytical Hierarchy Process (AHP) to prioritize and rank alternatives based on the criteria developed through VFT. The mixed-methods approach is chosen for the following reasons:

1. Qualitative research provides valuable insights into stakeholders' values and objectives, ensuring that the decision-making framework is rooted in real-world needs and is applicable to the context.
2. Quantitative research offers a systematic and objective means of analyzing and prioritizing alternatives, adding precision to the decision-making process.

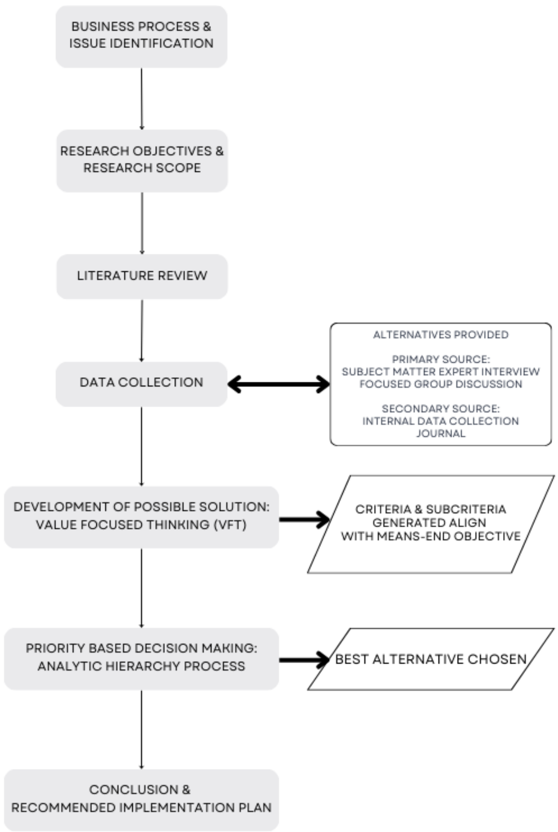

Figure. 3. Research design

Data for this research will be collected through both primary and secondary methods. Primary data will be gathered through focus group discussions, including internal meetings in which rig-owned transportation issues are addressed. Additionally, data will be obtained through interviews with internal subject matter experts who possess knowledge of rig operations and associated transportation challenges.

The most effective way to refine judgments in this context is through pairwise comparisons, where two elements are assessed based on a single attribute without considering other factors (Kuo, 2023). Pairwise comparison (PC) is widely used in various management disciplines to accurately reflect human judgment (Waldemar et al., 2016). Therefore, pairwise comparisons will be conducted as part of a survey distributed to subject matter experts and decision-makers selected from PHR Zone 4, PHR Regional 1, and Pertamina Subholding Upstream. The selected experts are those with comprehensive experience, capable of viewing both the problem and the potential solutions holistically. They are also part of the decision-making team and come from functions that will be directly impacted by the alternative solution chosen.

Table 1. Expert for pairwise comparison respondent

Structure origin	Position	Experience (Oil & Gas)
HC Subholding	Analyst Organization Development	15 years
DWI Subholding	Sr. Manager Evaluation & Planning	28 years
DWI Subholding	Sr. Engineer Evaluation	12 years
DWI Regional 1	Manager Operational	25 years
DWI Regional 1	Sr. Engineer WI Operation	13 years
SCM Regional 1	Sr. Manager	21 years

WI Zone 4	Manager Well Intervention	24 years
WI Zone 4	Company Man WI Operation	13 years
SCM Zone 4	Manager	16 years
RAM Zone 4	Asst. Manager Prabumulih Field	25 years

Value-Focused Thinking (VFT)

The value search process involved two key respondents: the Company Man of Well Intervention (WI) Operations from Zone 4 and a Senior Engineer in Evaluation from Subholding Upstream (SHU). From the Zone 4 perspective, the value identified through information collection centered on three primary criteria: cost, benefit, and risk. The user's viewpoint was limited to values directly affecting operations, specifically sub-criteria such as project cost, operational cost, rig-owned performance, time to implement, and both operational and social risks. The focus was primarily on enhancing rig-owned performance, as this was of significant concern to the user. As a result, the alternatives discussed in this interview were limited to two options: SCM-RAM and Well Intervention.

SHU, however, sought a more comprehensive set of criteria to ensure the chosen decision would facilitate the involvement of multiple stakeholders. This is where the sub-criteria of expertise and synergy became important. These values were incorporated not only to address the problem but also to align the solution with the company's core values, encapsulated in the AKHLAK framework. The expertise sub-criterion, aligned with the core value of competence, was emphasized to ensure that the selected alternative could independently manage both transportation and operational issues, making decisions on a daily basis without reliance on other functions. The synergy sub-criterion, aligned with the core value of collaboration, aimed to ensure that cross-functional collaboration would be maintained throughout the process. This interview also introduced an additional alternative—operation support—as a potential solution to address transportation management challenges more holistically.

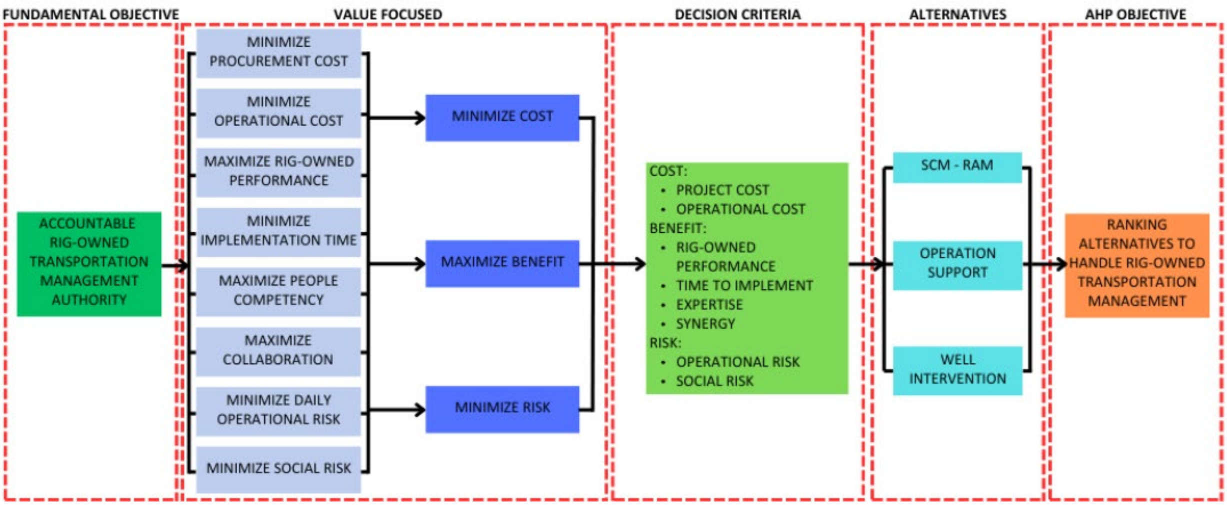

Figure. 4. Mean Objective (VFT) process to criteria for AHP

To ensure a shared understanding before proceeding with pairwise comparisons, it was essential that the experts were thoroughly informed about the variables to be evaluated.

Table 2. Description of alternative, criteria and sub-criteria

AHP Structure	Description
SCM-RAM	Current rig-owned transport management authority
Operation support	A new function is proposed to solely support operation

Well intervention	User will handle its rig-owned transport management
Cost	Total cost to implement alternative
Project Cost	Cost of all aspect related to rig-owned transportation procurement
Operational Cost	Cost associated with operation on field (driver, solar, etc.) and office (staff, dispatcher, etc.) in daily basis
Benefit	Any benefit expected from applied alternative
Rig-Owned Performance	A primary benefit to seek from chosen alternative where rig-owned utility and availability improved from cutting waiting time and reduce operational trouble bonded with user by Key Performance Indicator
Time to Implement	Duration needed for the alternative to be effectively implemented
Expertise	Competent people and organization to manage in accordance with AKHLAK core value
Synergy	Collaborative work is part of the benefit to be kept and expanded in accordance with AKHLAK core value
Risk	Any risk expected from transport issue once applied
Operational Risk	Daily risk associated with operational both technical and non-technical
Social Risk	Social risk associated with operation daily due to high social issue specifically in Zone 4
Time to Implement	Duration needed for the alternative to be effectively implemented

Analytical Hierarchy Process (AHP)

The data collected from the survey are then entered into a comparison matrix. The diagonal elements of this matrix are always assigned a value of "1," and only the upper triangular portion of the matrix is populated. To streamline the process, two rules are applied when filling the upper triangular matrix:

1. If a respondent's judgment value (C) is less than 1, the actual judgment value is used.
2. If a respondent's judgment value (C) is greater than 1, the reciprocal of the value is used.

Table 3. Pairwise comparison matrix

Criteria/ sub-criteria/alternative	C1	C2	C3	C4
C1	1	R_{1-2}	R_{1-3}	R_{1-k}
C2	$1/R_{1-2}$	1		
C3	$1/R_{1-3}$		1	
C4	$1/R_{1-k}$			1

A major challenge in group decision-making lies in determining how to combine individual judgments into a single collective judgment and how to form a group decision based on individual choices. This is where the geometric mean becomes essential. The geometric mean formula is as follows:

$$GM = \sqrt[n]{x_1 \times x_2 \times \ldots x_n}$$

where x represents individual values (values from different experts or respondents), and n is the total number of values being averaged. Once the geometric mean is computed, we proceed with filling the matrix based on the respective geometric means calculated.

The next step involves calculating the matrix for each criterion, sub-criterion, and alternative to perform an analysis that identifies the most and least important factors. This process is repeated for each group to determine, for example, which criterion is most significant among cost, benefits, and risks, and which alternative is most important in terms of operational costs. The following steps are then undertaken to complete this analysis:

1. Sum the values of each column in the matrix.

Table 4. Sum of matrix column

Criteria/ sub-criteria/alternative	C1	C2	C3
C1	1	x	y
C2	a	1	z
C3	b	c	1
Total	(1+a+b)	…	…

2. Normalize each value by dividing it by the sum of its respective column, ensuring that the total of each column equals one.

Table 5. Normalization of matrix column

Criteria/ sub-criteria/alternative	C1	C2	C3
C1	1/(1+a+b)	…	…
C2	a/(1+a+b)	…	…
C3	b/(1+a+b)	…	…
Total	1	1	1

3. Compute the priority vector by averaging the values in each row of the normalized matrix (also referred to as the eigenvector).

Table 6. Priority vector of matrix

Criteria/ sub-criteria/alternative	C1	C2	C3	Eigenvector
C1	1	x	y	(1+x+y)/3
C2	a	1	z	(a+1+z)/3
C3	b	c	1	(b+c+1)/3
Total				1

The results obtained from these calculations will reveal the ranking of criteria, sub-criteria, and alternatives.

The final step in the AHP process is the consistency check, which ensures that the judgments made throughout the process are consistent. This step helps to minimize bias, improve the quality of the decision, and increase confidence in the outcomes. A high consistency ratio (CR) indicates that the judgments may be inconsistent and should be reviewed. If the CR exceeds 0.01 (10%), the decision-maker should revisit their pairwise comparisons. For the judgments to be considered acceptable, the consistency ratio must be equal to or less than 0.01. The consistency ratio is calculated using the following formula:

$$CR = \frac{CI}{RI} \quad (2)$$

$$CI = \frac{\lambda max - n}{n} \quad (3)$$

where CR is the consistency ratio, CI is the consistency index and RI is the random consistency index (shown in the table below). λmax is the maximum eigenvalue and n is the size of the comparison matrix. The value of RI depends on the dimension of the matrix (n), as shown in the corresponding table.

Table 7. Random consistency index

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

RESULTS AND DISCUSSION

The results of the study will be presented in the form of tables, showing the prioritization of each criterion, sub-criterion, and alternative, with corresponding rankings derived from the judgments of the experts. The initial output will provide a prioritization of all variables considered in the decision-making process.

The final stage involves determining the optimal alternative through the AHP process by synthesizing the results obtained at various levels of the hierarchy, including criteria, sub-criteria, and alternatives. This synthesis is achieved by combining the priority vectors from each level to generate the outcome. The result can be interpreted as a ranking of the alternatives, identifying the best alternative to achieve the stated objective.

Criteria Prioritization

The criteria evaluated in this study consist of three primary factors: cost, benefit, and risk. Based on the judgment of the experts, the priority ranking of these criteria has been established. The analysis indicates that benefit is regarded as the most important criterion, followed by cost and risk.

Table 8. Priority vector of criteria

	Eigenvector	Priority
Cost	0.355	2
Benefit	0.387	1
Risk	0.258	3
Total	1	

Sub-criteria and Alternative Prioritization

Each of the three criteria is further divided into sub-criteria, which were identified through a process of brainstorming and discussions with relevant survey respondents. These sub-criteria provide a more detailed framework for evaluating the alternatives under each main criterion. The prioritization of both sub-criteria and alternatives will be based on the insights derived from these discussions and the expert judgments.

Table 9. Priority vector of cost sub-criteria and alternative

Sub-criteria	Eigenvector	Priority
Project Cost	0.322	2
Operational Cost	0.678	1
Alternative		
Project Cost		

SCM-RAM	0.355	2
Operation Support	0.477	1
Well Intervention	0.168	3
Operational Cost		
SCM-RAM	0.235	2
Operation Support	0.570	1
Well Intervention	0.194	3

The operational cost is deemed more critical than the project cost, as it reflects daily expenses, which are more influential than periodic project costs tied to contracts. In the alternatives evaluated under both cost-related sub-criteria, operation support ranked highest, indicating that this alternative is seen as the most important in cost management.

Table 10. Priority vector of benefit sub-criteria and alternative

Sub-criteria	Eigenvector	Priority
Rig-Owned Performance	0.436	1
Time to Implement	0.115	4
Expertise	0.280	2
Synergy	0.168	3
Alternative		
Rig-Owned Performance		
SCM-RAM	0.110	2
Operation Support	0.689	1
Well Intervention	0.202	3
Time to Implement		
SCM-RAM	0.484	1
Operation Support	0.267	2
Well Intervention	0.249	3
Expertise		
SCM-RAM	0.201	2
Operation Support	0.660	1
Well Intervention	0.139	3
Synergy		
SCM-RAM	0.209	2
Operation Support	0.637	1
Well Intervention	0.154	3

Among the benefit-related sub-criteria, rig-owned performance is prioritized, aligning with the research's goal to enhance rig performance, as discussed in the introduction. Operation support emerged as the dominant alternative here as well, though it ranked lower in the time to implement sub-criterion, where SCM-RAM (the existing transportation system) outperformed it.

Table 11. Priority vector of risk sub-criteria and alternative

Sub-criteria	Eigenvector	Priority
Operational Risk	0.828	1
Social Risk	0.172	2
Alternative		
Operational Risk		
SCM-RAM	0.286	2
Operation Support	0.549	1
Well Intervention	0.165	3
Social Risk		
SCM-RAM	0.321	2
Operation Support	0.447	1
Well Intervention	0.232	3

Despite the significant social challenges in Zone 4, South Sumatra, where frequent clashes with neighboring residents occur, operational risk was still regarded as a more important factor by a significant margin.

Before synthesizing the results, a consistency ratio was calculated to ensure the reliability of the judgments. The overall consistency ratio, as computed using the formula mentioned earlier, is displayed below.

Table 12. Consistency ratio between sub-criteria and alternative

Sub-criteria	CR	CR < 0.1?
Cost	0.000	TRUE
Benefit	0.010	TRUE
Risk	0.000	TRUE
Alternative		
Project Cost	0.001	TRUE
Operational Cost	0.000	TRUE
Rig-Owned Performance	0.010	TRUE
Time to Implement	0.002	TRUE
Expertise	0.003	TRUE
Synergy	0.006	TRUE
Operational Risk	0.001	TRUE
Social Risk	0.000	TRUE

The final decision is derived from synthesizing the AHP results. This involves combining the priority vector at each hierarchical level (criteria, sub-criteria, and alternatives) to derive the final ranking. The combination process entails multiplying the criteria weights by the alternative scores.

Table 13. Final score and ranking of all alternatives

Criteria	Weight	Sub-criteria	Weight	Alternatives		
				SCM-RAM	Operation Support	Well Intervention
Cost	0.355	Project Cost	0.322	0.355	0.477	0.168
		Operational Cost	0.678	0.235	0.570	0.194
Benefit	0.387	Rig-Owned Performance	0.436	0.110	0.689	0.202
		Time to Implement	0.115	0.484	0.267	0.249
		Expertise	0.280	0.201	0.660	0.139
		Synergy	0.168	0.209	0.637	0.154
Risk	0.258	Operational Risk	0.828	0.286	0.549	0.165
		Social Risk	0.172	0.321	0.447	0.232
Total weigh				**0.248**	**0.570**	**0.182**
Ranking				**2**	**1**	**3**

The final AHP structure, with the attached scores, is shown below. It reveals that the optimal solution, with a score of 57%, is the creation of a new function called operation support. This is followed by SCM-RAM with 24.8% and Well Intervention with 18.2%.

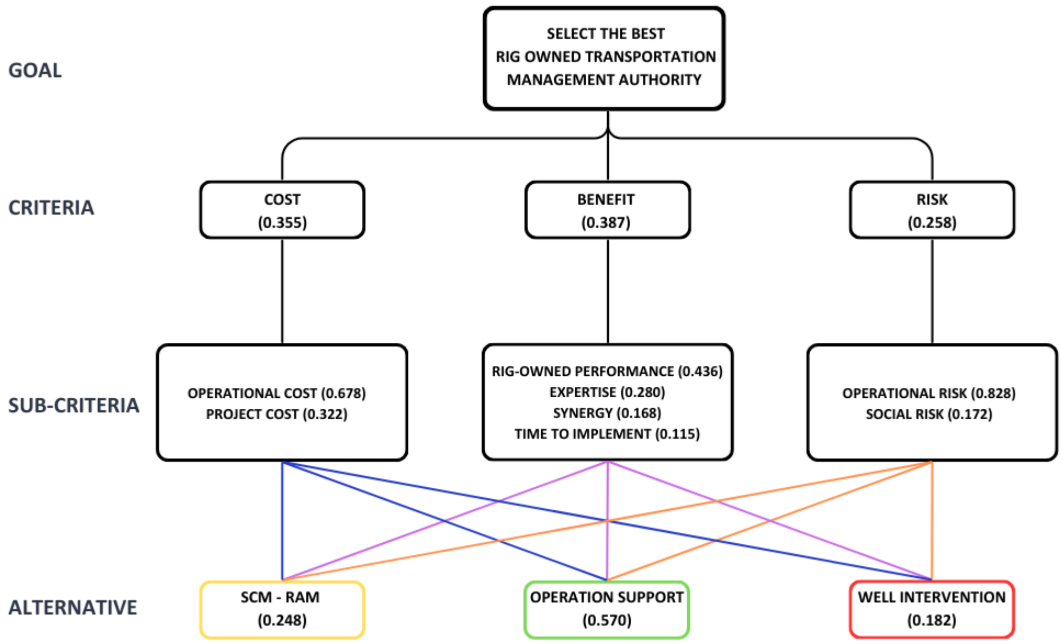

Figure 5. Final hierarchy structure of AHP with score

The decision to establish an independent operation support function is primarily driven by its superior ranking in benefit-related criteria, particularly rig-owned performance and synergy. This alternative ensures that operational needs are met independently, which is a major limitation of SCM-

RAM and Well Intervention. Although SCM-RAM scores higher in the time to implement sub-criterion, its operational constraints and resource allocation inefficiencies undermine its long-term effectiveness. Similarly, Well Intervention, while beneficial for immediate needs, lacks the infrastructure to manage rig-owned transportation effectively on its own.

Thus, operation support emerges as the optimal solution by offering a balanced approach to cost, benefit, and risk. By centralizing transportation management, operation support reduces operational costs through streamlined processes and improved resource allocation. It also mitigates operational risks by ensuring dedicated oversight and a quick response to transportation issues, ultimately enhancing rig availability and reliability. Furthermore, the establishment of a specialized function for transportation management fosters continuous improvement, innovation, and sustained operational efficiency. In contrast, the existing SCM-RAM system, although familiar, lacks the flexibility and focus required to address increasing transportation demands. The Well Intervention alternative, while addressing immediate operational needs, does not provide the comprehensive oversight necessary for long-term strategic planning.

CONCLUSION

This study contributes to the MCDM literature by demonstrating how stakeholder-driven VFT can enhance the applicability of the AHP in complex, multi-departmental industrial settings. VFT serves as an initial step to define and refine the criteria and sub-criteria before selecting among alternative solutions. The criteria for determining the authority responsible for rig-owned transportation management in PHR Zone 4 include minimizing costs (both project and operational), maximizing benefits (rig-owned performance, implementation time, expertise, and synergy), and minimizing risks (operational and social). These criteria serve as the key decision factors in selecting the appropriate transportation management authority.

A panel of ten Subject Matter Experts (SMEs) from various functional departments directly involved in the project and operations participated in the evaluation process. They assessed the criteria, sub-criteria, and alternatives using a pairwise comparison approach. Based on the survey results and subsequent analysis, the optimal alternative for managing rig-owned transportation is the establishment of a new operation support function, with a 57% preference. This alternative is followed by maintaining the existing SCM-RAM system (24.8%) and the Well Intervention (self-managed) approach (18.2%).

The primary challenge of establishing the operation support function is the extended implementation timeline. To ensure timely execution, a well-structured schedule is necessary. Internal company guidelines on the formation of new organizational functions will be adhered to throughout the process. A transition strategy will also be implemented to facilitate a seamless handover of responsibilities from the existing functions to the new unit, mitigating potential disruptions. Regular evaluations during the transition phase will help refine the structure and define job descriptions within the new function. The implementation plan and its justification have been developed to ensure execution by early 2026.

While this study specifically examines rig-owned transportation management at PT Pertamina Hulu Rokan, its findings have broader implications for industries reliant on resource-intensive transportation logistics, such as mining, construction, and manufacturing—particularly those grappling with centralized versus decentralized operational decisions. The proposed methodology and identified decision criteria (cost, benefit, and risk) can be adapted to similar transportation management challenges. By integrating VFT and AHP, organizations can systematically evaluate alternative solutions, prioritizing operational efficiency, cost-effectiveness, and risk mitigation. Future research can explore the application of this approach in different industrial contexts to further validate its effectiveness.

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