
RESEARCH ARTICLE

Risk Analysis of Material Procurement in Oil and Gas EPC Projects in Sudan

Ahmed Atta Elhussein Ali¹✉, Zhang Xinli², Mohammad Mesba Ul Hoque³

¹Master Student, School of Business, Sichuan University, China

²Professor, School of Business, Sichuan University, China

³Ph.D Student, School of Business, Sichuan University, China

Corresponding Author: Author's Name, Ahmed Atta Elhussein Ali, **E-mail:** mesbahoque@stu.scu.edu.cn

ABSTRACT

The rapid expansion of the Sudanese oil and gas industry, driven by rising demand, relies heavily on the Engineering, Procurement, and Construction (EPC) project model. Given that material procurement accounts for over 60% of EPC contract value and faces diverse risks, effective risk management is crucial for Sudanese enterprises engaged in international projects. This paper investigates and assesses the material procurement risks in oil and gas EPC projects, specifically focusing on improving risk management and procurement capabilities for Sudanese firms. The methodology involved first defining EPC concepts and risk analysis methods (identification, assessment, response). A comprehensive risk list for material procurement was constructed and subsequently assessed using the Risk Matrix Method, classifying risks into four levels (A to D). Finally, these steps were applied to a case study project to identify, assess, and propose specific risk-response measures. The results categorize procurement risks into two major groups: external risks (natural, political, social, market, owner, supplier) and internal risks (decision-making, plan, orders, transportation, inspection, inventory). The study concludes that Sudanese oil enterprises face significantly higher external risks than internal risks during material procurement in international oil and gas EPC projects.

KEYWORDS

Oil and gas EPC project; EPC (Engineering, Procurement, and Construction); Material Procurement; Risk Management; Risk Assessments

ARTICLE INFORMATION

ACCEPTED: 01 November 2025

PUBLISHED: 12 November 2025

DOI: 10.32996/jbms.2025.7.9.1

1. Introduction

The evolution of fossil fuel utilization reflects humanity's adaptive response to increasing energy demands. Initially reliant on wood, societies transitioned to coal during the Industrial Revolution, spurring mechanization and urban growth. The discovery of oil and natural gas drove advancements in transportation and manufacturing. In Sudan, hydrocarbon exploration began in 1959, leading to significant discoveries like the Unity Field in 1980, which paved the way for an export pipeline in 1999, boosting the economy. However, the secession of South Sudan in 2011, which took 75% of the oil reserves, disrupted this growth. Sudan's shift to partial self-sufficiency began with 80% oil imports, which strained resources (Gambrell 2025). The Al-Jayli refinery, capable of processing 100,000 bpd, helped reduce reliance on imports, yet the country remains a net importer of refined products. Crude oil exports earned \$317 million in 2020, supplemented by transit fees from South Sudan's oil. Collaboration between state entities and multinational companies like GNPOC, involving major stakeholders such as CNPC and PETRONAS, is crucial for sustaining the oil and gas sector amidst challenges. Sudan's oil and gas industry, crucial to its development, faces significant challenges such as the 2011 separation from South Sudan, which reduced reserves and triggered border disputes, impacting revenue. Infrastructural issues, exemplified by the 2025 Al-Jayli refinery fire, and economic sanctions have increased costs while limiting domestic manufacturing capabilities (Berawi et al., 2020). Security threats in extraction zones and market volatility further complicate operations, prompting the need for effective risk mitigation strategies. In response, Sudanese enterprises are increasingly participating in international Engineering, Procurement, and Construction (EPC) projects to overcome domestic limitations. Procurement becomes a vital component of these projects, constituting over 50% of contract value and introducing uncertainties

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from logistical to financial aspects. Consequently, robust procurement risk management is essential to ensure project success and enhance competitiveness. The evolution of Sudan's oil sector—from initial exploration in 1959 to current global engagement—highlights both resilience and vulnerability, reinforcing the necessity for advancements in procurement strategies to improve project outcomes and strengthen Sudan's position in the global energy market (Nurdiana & Susanti, 2020). The study examines the uncertainties surrounding material procurement in oil and gas engineering, specifically through the lens of engineering procurement and construction (EPC) projects in Sudan. It highlights the lack of focused research in this area, particularly considering the unique challenges faced by Sudanese firms in global markets, such as political volatility, economic instability, and cultural differences. By analyzing the Jake FPF Project executed by Petro Energy, the research aims to create a framework for identifying and evaluating procurement risks. This investigation combines theoretical insights with practical applications, offering strategies for mitigating disruptions and enhancing project execution. The findings are intended to support future inquiries and empower Sudanese companies to navigate complex procurement landscapes, ultimately contributing to Sudan's economic resilience and competitiveness in the international arena. The study serves as both a scholarly contribution and a practical guide, enhancing understanding and management of procurement uncertainties in oil and gas engineering projects (Tao, 2022). EPC material procurement management in Sudan faces challenges such as currency fluctuations, import restrictions, and limited local suppliers. Success hinges on understanding local regulations and customs, with extensive research conducted on enhancing procurement processes. Scholars Adnan et al. (2020) emphasize procurement's role in project outcomes and have proposed various management models, including hierarchical procurement management under the EPC model. In contrast, international studies focus on supplier selection and risk management (Avilaq et al. (2017). The identification and prioritization of risks in procurement processes are vital, requiring continuous monitoring and adaptable strategies. Tsiglianu et al. (2023) applied the Risk assessment methods like risk matrices, fuzzy AHP, and integrated systems are crucial for managing procurement risks across various sectors, showcasing the need for ongoing exploration in material procurement research Varavenko et al. (2022). Overall, existing literature indicates a gap in comprehensive studies regarding material procurement risks in EPC projects within the oil and gas sector.

2. Overview of Material Procurement Theory for Oil and Gas Engineering EPC Project

Material procurement is a crucial aspect of Engineering, Procurement, and Construction (EPC) projects in the oil and gas industry, where project success heavily relies on the strategic acquisition of specialized materials and equipment. (Czachorowski et al., 2023) The EPC model integrates design, procurement, construction, and commissioning, requiring comprehensive planning and coordination to deliver functional projects while maintaining quality, safety, and cost efficiency. In oil and gas engineering, procurement could represent over 60% of total project costs, and this percentage could be even higher for specific large projects such as the FULA Central Processing Facilities (Nur Sholeh & Fauziyah, 2018). The procurement process in these projects involves several complexities and challenges that require careful management. (Alhammadi et al., 2024) The substantial volume of materials needed, particularly for large-scale endeavors like long-distance pipelines, creates a heavy workload as contractors must often import high-quality, specialized materials from developed countries due to domestic suppliers not meeting industry standards. (Berawi et al., 2020) The lengthy procurement cycle requires precise planning aligned with construction activities since delays can lead to significant project disruptions and cost overruns. Additionally, strict quality requirements are intrinsic to the procurement of materials in oil and gas projects. The safety and performance of pipelines depend greatly on the materials used, which must comply with stringent specifications due to the hazardous nature of the substances involved (Azambuja et al., 2009). Noncompliance can lead to severe risks affecting both human lives and national resources, necessitating robust quality management practices. Moreover, procurement processes are laden with uncertainties related to product pricing, transportation logistics, and market conditions, which can impact not only the cost but also the timely availability of materials. Currency fluctuations and political conditions in supplier countries further introduce risks, necessitating effective supplier management and enhanced communication to mitigate issues during procurement (Berawi et al., 2020). Strategies to address these challenges include implementing lean principles, such as just-in-time delivery, and using Critical Chain Project Management (CCPM) to anticipate uncertainties within the procurement process (Nur Sholeh & Fauziyah, 2018). Advanced technologies like artificial intelligence and data analytics are also being leveraged to optimize procurement strategies, improving decision-making and risk management. Thus, managing procurement effectively in oil and gas EPC projects is fundamental for achieving project objectives while navigating complexities and uncertainties inherent in the material acquisition process (Wang & Wang, 2022). The material procurement process in oil and gas engineering EPC projects varies depending on the type of material and procurement method employed. However, for contractors, the fundamental process typically consists of three main stages: planning, procurement, acceptance, and settlement. They base their procurement plans on the project's material procurement list and demand plan, considering market supply-demand, inventory levels, and consumption patterns to create a comprehensive strategy. This plan, crucial for procurement activities, requires review and approval by relevant departments before implementation. The procurement process involves personnel handling inquiries, placing orders, and managing the transportation of materials. Based on the approved plan, suppliers are selected using various methods, including public or invitational bidding, typical in oil and gas engineering EPC projects. Procurement staff negotiate contracts and monitor supplier performance to ensure timely delivery and proper transportation methods. For bulk materials, 3 to 5 suppliers may be chosen for competitive bidding or direct negotiations. During the acceptance stage, personnel inspect the materials' quality and quantity before acceptance and financial settlement. If

materials do not meet requirements, they are rejected, and alternatives are discussed with suppliers. The financial department manages payments and documentation for accepted items, ensuring all comply with contractual quality standards. This study focuses on the material procurement risk analysis within oil and gas Engineering, Procurement, and Construction (EPC) projects. It begins by defining risk in the context of procurement, describing it as the probability of unfavorable variations from anticipated outcomes due to unforeseen circumstances. Within EPC projects, material procurement risk refers specifically to situations where the acquired materials and equipment are delayed, incomplete, unsatisfactory in quality, or fail to meet contractual obligations, thus impacting project timelines and overall costs, including transportation logistics. The material procurement risk identification process stands as a fundamental step in managing these risks, emphasizing the importance of a systematic classification and evaluation of potential procurement-related risks. It encourages a comprehensive understanding of all possible risk factors to implement effective control measures. Various risk identification methods are highlighted, including brainstorming, the Delphi method, scenario analysis, checklist method, flowchart method, and financial statement analysis, each offering unique advantages in recognizing and categorizing risks. Following the identification phase, a thorough assessment of the identified risks is crucial. This assessment combines qualitative and quantitative methodologies to evaluate the likelihood of occurrence and the potential severity of each risk. Common assessment methods discussed include expert scoring, fault tree analysis, analytic hierarchy processes, fuzzy comprehensive evaluations, gray systems, risk matrices, and Monte Carlo simulations. Each method offers distinct approaches for evaluating risk significance and developing risk response strategies. Material procurement risk response involves several strategies designed to mitigate losses from these risks. Key responses include risk avoidance, where decisions are altered to prevent risks, and risk transfer, where risks are shifted to other parties or insurance. Risk mitigation focuses on reducing the probability or impact of potential losses through strategic planning, while risk retention acknowledges and accepts risks with a plan for financial management. The chapter concludes by summarizing the critical role of material procurement in enhancing project success and cost management, highlighting the challenges faced, including fluctuating costs and compliance demands, and advocating for technological advancements such as AI and data analytics to further optimize procurement processes in EPC projects.

3. Identification of Risks in Material Procurement for Oil and Gas Engineering EPC Projects

The risk decomposition structure method is utilized to thoroughly identify and categorize material procurement risks within oil and gas engineering EPC projects. This method deconstructs risks to generate a detailed risk list and is built on prior research, enterprise case studies, and expert interviews. The identified material procurement risks are classified into three levels, predominantly captured as external and internal risks. External risks, which cannot be avoided, arise from outside factors during procurement, while internal risks are related to management issues within the purchasing entity. External risks encompass market fluctuations, geopolitical events, and natural disasters, which may disrupt supply chains and affect material costs and availability (Sulistianto et al., 2020). Conversely, internal risks include poor inventory control, ineffective supplier selection, and procurement process inefficiencies. It is critical to differentiate these categories to craft effective risk mitigation strategies. External risks can be segmented into six subcategories: natural, political, social, market, owner, and supplier risks, whereas internal risks pertain to various stages of the procurement process such as decision-making, planning, ordering, transportation, acceptance, and inventory management. The third-level decomposition of risks allows for further refinement and specificity of risks initially identified at the second level (Dita et al., 2020). Despite the unique characteristics of each project, common risks such as supplier reliability, raw material price volatility, and customs clearance delays often surface. Geopolitical factors and regulatory changes also significantly influence material procurement practices, necessitating a deep understanding of the geographical context of projects. Detailed analysis at this level enables project teams to develop targeted risk mitigation strategies. Natural risks comprise unpredictable disruptions from environmental events, which can lead to significant procurement delays and increased costs (Berawi et al., 2020). These risks fall into five main categories, including meteorological and geological disasters. Project managers must devise comprehensive risk management plans to include contingency measures and alternative sourcing strategies to counteract natural risks effectively. Political risks vary, though they generally stem from instability, policy fluctuations, and regulatory changes within the host country, creating challenges that can hinder project progress and escalate costs. (Santos et al., 2010) Social risks, encompassing conflicts arising from societal factors, can also lead to serious project disruptions if local customs are not respected. Market risks tend to manifest as discrepancies between procurement costs and material quality, exacerbated by inflation and currency fluctuations, particularly in international transactions. Owner risks relate to strict material standards, rejections, and payment delays from project owners, potentially causing disruptions and increased costs. (Bhat & Mukherjee, 2019) Supplier risks arise when a supplier fails to meet contractual terms, posing multiple challenges related to bankruptcy, pricing, quality, delivery, and contractual disputes. Effective mitigation of these diverse and complex risks relies on robust supplier evaluation systems, contingency planning, and ongoing communication among project stakeholders. Overall, the detailed framework provided by this risk decomposition not only supports targeted risk management but also fosters improved collaboration among all parties involved in oil and gas engineering projects. (Khumpaisal 2018) Decision-making risk refers to the chance that the outcomes of decisions will fail to meet expected objectives, influenced by factors like the decision-maker and the context. In procurement, these risks can significantly affect decisions made by procurement managers and may result from disrupted procurement activities. Two main risk

contributors are identified: flaws in the decision-making system and the decision-maker's challenges due to insufficient information and capabilities (Gusti Andaru & Wahyu Adi, 2024). Effective material procurement is critical in oil and gas engineering projects and necessitates established decision-making frameworks. Deviations from these processes can lead to errors, such as poor supplier choices, miscalculations in material quantities, or misjudging market conditions, resulting in project delays, cost overruns, and quality compromises. Planning risk in material procurement arises when the procurement process strays from its objectives, often due to an inadequate procurement plan. The root causes often involve miscalculations in material volumes and management failures at different stages. Additionally, planning risks can stem from a lack of skilled personnel in the planning stages, highlighting the need for improved information access and capabilities. As projects often require adjustments, organizations must develop skilled planning personnel and employ strong information systems and flexible strategies to manage these risks effectively (Said & El-Rayes, 2010). During procurement, risks arise when material procurement staff make poor decisions which can lead to irregular processes, skill deficiencies, and legal liabilities due to non-compliance with project laws (Peclat & Ramos, 2016). A rigorous training regime and a sound contract review process involving experts are vital to mitigate risks. Contractual issues can introduce disputes and complications if contracts are poorly defined, emphasize power imbalances, or are signed without comprehensive understanding. To prevent further issues, organizations should ensure that contracts are clear and that procurement staff are well-versed in all contractual obligations. Transportation risks account for the potential failures in delivering materials as scheduled and in required conditions, with significant economic implications stemming from losses during transit or delayed deliveries. The choice of transportation method plays a crucial role in addressing these risks (Dita et al., 2020). Companies in expansive projects, like oil and gas EPC ones, face particular challenges due to the varied geographical areas covered and should thus invest in efficient transportation strategies that consider external factors impacting delivery timelines and costs (Malla et al., 2022). Upon arrival, the acceptance inspection ensures material quality, with risks originating from lax acceptance processes that may allow substandard materials to pass unnoticed. (Nurdiana & Susanti, 2020) To reduce acceptance risks, firms should reinforce quality control, set clear acceptance standards, and foster accountability to cultivate integrity in the acceptance personnel. Inventory management also poses risks due to inaccuracies in forecasting and storage practices. Optimum management strategies can help balance material availability against project needs, minimizing the risks of shortages or excessive stock. Developing robust inventory-tracking systems and storage practices can mitigate these issues. Overall, procurement in oil and gas engineering projects is fraught with challenges, including risks tied to supplier reliability, quality control, logistics, and price fluctuations. Comprehensive risk mitigation strategies must incorporate thorough vendor evaluations, stringent quality controls, and contingency planning to navigate the complexity of procurement risks effectively. Subsequently, an oil and gas engineering EPC project material procurement risk list was constructed. The identification of individual risk factors and the compilation of this risk list serve as the foundation for risk assessment and response in the material procurement process, which will be explored in the next chapter.

4. Risk Assessment and Response for Material Procurement in Oil and Gas Engineering EPC Project

In this paper, the distinct features of material procurement risks associated with oil and gas engineering EPC (Engineering, Procurement, and Construction) projects are analyzed through the application of the risk matrix method. The study utilizes a risk list developed during the identification phase to delve into various procurement risks, evaluating their potential impacts while assessing the likelihood and scale of their occurrence. This rigorous examination helps to determine the overall risk levels and devise suitable response strategies. To achieve precise quantification of the impacts and probabilities associated with each identified procurement risk, the research suggests the inclusion of insights from a panel of industry leaders and experts in oil and gas engineering, typically numbering between 7 and 13 individuals. Given that contractors prioritize cost, schedule, and quality in their procurement strategies, the paper also assesses how each risk affects these critical dimensions. The influence of risks on these objectives is categorized into five levels of severity: extremely low, low, medium, high, and extremely high. Detailed definitions and associated tasks for each severity level are elaborated in Tables 4-1, 4-2, and 4-3, ensuring clarity in the assessment process.

Table 4.1: Definition of the Impact of Risks on Procurement Cost Targets			
Impact Degree	Quantitative Value	Impact Degree on Procurement Cost	Impact Amount (10,000 US dollars)
Extremely High	5	More than 5%	More than 100
High	4	(2.5%, 5%]	(50, 100]
Middle	3	(1%, 2.5%]	(20, 50]
Low	2	(0.5%, 1%]	(10, 20]
Extremely Low	1	Less than 0.5%	Less than 10

Table 4.2: Definition of the Impact of Risks on Procurement Progress Targets

Degree of Impact	Quantitative Value	Impact on procurement progress	Impact Time
Very High	5	More than 8%	More than 1.5 months
High	4	(5%, 8%]	1 to 1.5 months
Middle	3	(3%, 5%]	2 to 4 weeks
Low	2	(1%, 3%]	1 to 2 weeks
Very Low	1	Less than 1%	Less than 1 week

Table 4.3: Definition of the Impact of Risks on Procurement Quality Targets

Impact Degree	Quantitative Value	Impact Degree on Procurement Quality	Impact on Non - conformity Rate
Very High	5	Most of the quality is not up to standard	More than 5%
High	4	Some quality is not up to standard	(2.5%, 5%]
Middle	3	A small part of the quality is unqualified	(1%, 2.5%]
Low	2	A small number of products are of unqualified quality	(0.5%, 1%)
Very Low	1	Almost no quality failures	Less than 0.5%

Suppose n experts evaluate the impact of risk r_i on procurement cost, schedule, and quality objectives as c_{ij} , s_{ij} and q_{ij} ($j=1,2,\dots,n$). If the difference between the highest and lowest scores of the experts is less than 3, the following conditions are met:

$$\max\{c_{ij}\} - \min\{c_{ij}\} < \delta \quad \text{..... (Formula 4 - 1)}$$

$$\max\{s_{ij}\} - \min\{s_{ij}\} < \delta \quad \text{..... (Formula 4 - 2)}$$

$$\max\{q_{ij}\} - \min\{q_{ij}\} < \delta \quad \text{..... (Formula 4 - 3)}$$

If these conditions are not met, it indicates that experts have diverse views on the impact of risk r_i on procurement objectives. In such a case, the evaluation status of the non - compliant indicators will be fed back to the experts, who will be invited to re - evaluate and provide explanations for their scores. This process is repeated until all risk assessments meet the above conditions. When the conditions are met, it implies that experts have relatively consistent opinions on the impact of risk r_i on procurement objectives, and further analysis can proceed. This study takes the average of each expert's score as the comprehensive evaluation value, representing the impact of this risk on the project procurement cost, schedule, and quality targets. The calculation formulas are as follows:

$$C_i = \frac{\sum_{j=1}^n c_{ij}}{n} \quad \text{..... (Formula 4 - 4)}$$

$$S_i = \frac{\sum_{j=1}^n s_{ij}}{n} \quad \text{..... (Formula 4 - 5)}$$

$$Q_i = \frac{\sum_{j=1}^n q_{ij}}{n} \quad \text{..... (Formula 4 - 6)}$$

Where:

C_i , S_i , and Q_i represent the impact degrees of risk r_i on the procurement cost, quality, and schedule objectives respectively; c_{ij} , s_{ij} and q_{ij} represent the evaluation values of the j^{th} expert on the impact degrees of risk r_i on the procurement cost, quality, and schedule objectives respectively.

According to the comprehensive evaluation principle of the impact of risk occurrence on project objectives, the maximum value among the impact degrees of risk r_i on the project procurement cost, schedule, and quality objectives is taken as the final impact evaluation value of this risk on project procurement, that is:

$$I_i = \max \{C_i, S_i, Q_i\} \quad \text{..... (Formula 4 - 7)}$$

where I_i represents the final evaluation value of the impact of risk r_i on project procurement objectives.

This paper classifies the probability of risk occurrence into five levels based on the likelihood of risk occurrence: very low, low, medium, high, and very high. The corresponding values and probabilities for each level are shown in Table 4 - 4

Table 4.4: Definition of Risk Probability			
Probability of Occurrence	Quantitative Value	Possibility Description	Probability of Occurrence
Very High	5	Very likely to happen	(70%, 100%]
High	4	The probability of occurrence is very high	(50%, 70%]
Medium	3	The probability of occurrence is relatively high	(30%, 50%]
Low	2	The probability of occurrence is small	(10%, 30%]
Very Low	1	Extremely unlikely to occur	(0, 10%]

Suppose experts estimate the Probability of risk r_i occurring, and the evaluation value is p_{ij} . Similar to the risk impact assessment, for further analysis, the difference between the highest and lowest scores of each expert evaluation should be less than 3, that is:

$$\max\{p_{ij}\} - \min\{p_{ij}\} < \delta \quad \text{..... (Formula 4 - 8)}$$

If this condition is not met, the same processing method as above is adopted. After the condition is satisfied, the average value of each expert's score is taken as the comprehensive evaluation value of the possibility of risk occurrence, that is:

$$P_i = \frac{\sum_{j=1}^n p_{ij}}{n} \quad \text{..... (Formula 4 - 9)}$$

Where:

P_i represents the likelihood of the occurrence of risk r_i

p_{ij} represents the likelihood evaluation value of the occurrence of risk r_i estimated by the j^{th} expert.

The Probability-Impact Matrix (PIM) is a crucial tool in risk management, specifically used to assess and categorize risks based on their likelihood of occurrence and potential impact on a project (A. Kassem et al., 2019). The probability of occurrence is classified into five levels: Very High (5), High (4), Medium (3), Low (2), and Very Low (1), each corresponding to a range of percentages that represent the likelihood of the risk happening. Very High risks are nearly certain to occur (70%-100%), while Very Low risks are extremely unlikely (0%-10%). These probability ratings are then aligned with Impact Ratings, which also range from Very Low (1) to Very High (5), to create a 5x5 matrix. This matrix allows for the classification of risks into four categories: Class A (Critical Risk), Class B (Moderate-High Risk), Class C (Moderate-Low Risk), and Class D (Low Risk), based on the product of the impact and probability values.

Risk Matrix						
Probability Rating	5- Very High	Class C (VL, VH)	Class B (L, VH)	Class A (M, VH)	Class A (H, VH)	Class A (VH, VH)
	4- High	Class D (VL, H)	Class B (L, H)	Class A (M, H)	Class A (H, H)	Class A (VH, H)
	3- Medium	Class D (VL, M)	Class C (L, M)	Class B (M, M)	Class A (H, M)	Class A (VH, M)
	2- Low	Class D (VL, L)	Class D (L, L)	Class C (M, L)	Class B (H, L)	Class B (VH, L)
	1- Very Low	Class D (VL, VL)	Class D (L, VL)	Class D (M, VL)	Class D (H, VL)	Class C (VH, VL)
		1	2	3	4	5
		Very Low	Low	Medium	High	Very High
Impact Rating						

Figure 4.1: Probability- impact Matrix

Based on expert evaluations, a risk assessment matrix is developed to categorize risks related to project procurement, utilizing both impact (consequences of the risk) and probability (likelihood of occurrence). The classification divides risks into four categories: Class A (critical risk, $I_i * P_i \geq 12$), Class B (moderate-high risk, $8 \leq I_i * P_i < 12$), Class C (moderate-low risk, $4 \leq I_i * P_i < 8$), and Class D (low risk, $I_i * P_i \leq 4$) (Dumbravă & Iacob, 2013). This prioritization allows for the effective management of risks, ensuring that critical risks (Class A) are avoided or transferred, while lower-priority risks (Class D) require minimal action. The matrix also delineates zones: the Red Zone (Critical) and Yellow Zone (Moderate), emphasizing the need for mitigation measures for specific risks. The Probability-Impact Matrix offers a structured approach for project managers, facilitating resource allocation to avert potential setbacks on project success. This study outlines strategies for managing material procurement risks in oil and gas engineering projects, focusing on the Jake FPF project in Sudan. Identified risks include natural events like extreme weather, economic instability affecting market conditions, supplier challenges, and logistical issues. Resilience planning and adaptive strategies are recommended for natural risks, while economic risks warrant enhanced risk management and diversified supply frameworks. Supplier risks involve procurement challenges due to the scale of sourcing unique items, compounded by transportation hurdles like customs delays and poor infrastructure. Proposed solutions include a Material Tracking System (MTS) and lean management practices to improve procurement efficiency and mitigate logistical delays.

5. Project Material Procurement Risk Assessment

This study, conducted from November 2024 to January 2025, investigates Material Procurement Theory for Oil and Gas Engineering EPC Projects in Sudan, focusing on the Jake FPF project. It assesses procurement risks and decision-making processes, incorporating insights from 13 professionals, including 5 middle-level managers, 3 senior managers, and 5 technical professionals engaged in procurement operations. The respondents were categorized by department: 6 from the Purchasing Department (46.15%), 4 from the Project Department (30.77%), and 3 from the Contract Department (23.08%). This distribution emphasizes the crucial role of procurement functions in EPC projects. The participants showed diversity in organizational roles, with a significant representation of middle management (38.46%) and senior engineers (38.46%), alongside a smaller percentage of senior managers (23.08%). Their work experience varied, with 38.46% having 15 to 20 years, 38.46% holding 5 to 10 years, and 23.08% having over 20 years, highlighting a mixture of established professionals and those in earlier career stages. Educationally, a majority (61.54%) held Master's degrees, pointing to a well-educated sample capable of complex decision-making and strategic procurement negotiations. The evaluation method featured four rounds of assessment, where experts provided feedback on identified risks, achieving consistent scoring results with a minimal variance across responses. This convergence underscores the methodological rigor of the study. The demographic profile presents a well-qualified sample with substantial experience and academic credentials, making the findings reliable and relevant to the challenges faced in material procurement for EPC projects in Sudan. The risk evaluation findings are detailed in accompanying tables, culminating in an overall risk assessment presented in Table 5.7.

Risk Name	A	B	C	D	E	F	G	H	I	J	K	L	M	all value
Earthquake Disaster A11	4	2	2	4	4	3	4	2	2	4	3	4	3	3.73
Flood Disaster A12	4	3	4	4	2	4	4	4	2	4	2	4	3	4
Meteorological Disaster A13	4	2	2	4	2	2	4	2	2	3	2	4	3	3.27
Political Instability A21	5	3	3	4	4	3	5	3	3	5	3	4	3	4.36
Changes in Institutional Policies A22	4	3	3	4	5	3	4	3	3	4	3	4	3	4.18
Changes in Laws and Regulations A23	2	3	3	2	3	4	3	2	3	4	3	4	3	3.55
Social Conflict A31	4	3	2	4	4	2	4	2	3	4	2	4	2	3.64
Social Chaos A32	3	2	2	4	3	2	4	2	2	3	2	4	2	3.18
Social Disorder A33	3	3	3	4	3	3	2	3	2	4	2	4	2	3.45
Differences in Religious Customs A34	4	2	2	2	3	4	2	3	3	4	3	4	3	3.55
Information Asymmetry A41	4	3	3	3	3	4	3	3	2	4	2	3	3	3.64
Inflation A42	4	3	3	2	3	3	2	3	2	4	2	2	3	3.27
Exchange Rate Fluctuations A43	3	4	5	3	5	5	3	5	3	4	3	3	4	4.55
High or Unrealistic Owner Requirements A51	4	2	2	4	3	2	2	2	2	4	3	2	2	3.09
Rejection or Delay of Acceptance of Materials A52	3	2	2	3	2	2	2	2	2	3	2	2	1	2.55
delay in payment A53	3	2	2	3	2	2	1	2	2	3	1	2	2	2.45
Risk of Bankruptcy A61	3	2	2	2	2	2	3	2	2	3	2	3	2	2.73
Price Risk A62	4	3	4	4	3	4	4	4	4	5	3	4	3	4.45
Quality Risk A63	5	3	3	4	3	3	4	3	3	5	3	3	3	4.09
Delivery time Delays Risk A64	3	4	2	4	3	2	3	2	3	3	3	2	4	3.45
Contract-Related Risk A65	4	3	3	4	3	3	4	3	2	4	2	2	2	3.55

Inadequate decision - making system B11	2	2	2	2	2	2	2	2	2	2	2	2	2	2.36
Unreasonable Decision - Making Process B12	3	1	2	1	2	3	2	1	2	3	2	1	1	2.18
Insufficient Information for Decision - Making B13	3	2	3	3	1	3	3	3	2	3	2	2	2	2.91
Insufficient capability of Decision - Makers B14	3	1	1	3	2	1	2	1	2	3	2	1	1	2.09
Inadequate Information Control B21	3	3	3	3	1	3	2	3	1	3	2	2	2	2.82
Insufficient planning staff capability B22	3	2	2	2	2	2	3	2	2	3	2	2	2	2.64
Improper Planning Management B23	3	2	3	2	3	3	3	3	2	2	1	3	1	2.82
Procurement Process Is Not Standardized B31	3	1	1	3	2	1	2	1	2	2	3	1	2	2.18
Lack of Skills Among Procurement Staff B32	3	1	1	3	1	1	2	1	1	3	2	1	1	1.91
Mistakes in the Conclusion of Procurement Contracts B33	2	1	1	2	2	1	3	1	2	3	1	1	2	2
Improper Transportation Method B41	2	2	3	2	2	3	3	3	1	3	2	3	2	2.82
Transportation Costs Are Too High B42	3	2	2	2	2	3	2	3	2	2	2	2	2	2.64
Shipping Time Is Too Long B43	3	3	2	3	2	2	2	2	2	3	3	2	2	2.82
The Acceptance Process Is Not Strict B51	3	2	2	3	2	2	3	2	4	3	2	2	2	2.91
Insufficient Professional of Acceptance Personnel B52	3	2	2	2	2	2	3	2	3	4	2	2	2	2.82
Insufficient Quality of Acceptance Personnel B53	2	2	2	2	2	2	2	2	3	3	2	3	1	2.55
Excessive Inventory B61	2	2	2	1	1	2	1	3	2	1	2	1	2	2
Insufficient Inventory B62	2	2	2	2	2	2	3	2	2	3	2	2	1	2.45
Improper Inventory Storage B63	2	2	1	2	1	2	3	1	2	2	1	2	2	2.09

The above Table 5.3, titled "The Impact of Each Risk on The Procurement Cost," presents the risk evaluation results based on the assessments of 13 experts (A to M) directly involved in the procurement of materials for the Jake FPF project. The table lists various risks, with their impact scores assigned by each expert, and the "all value" column reflects the average impact score for each risk across all experts.

Table 5.4: The Impact of Each Risk on The Procurement Progress														
Risk name	A	B	C	D	E	F	G	H	I	J	K	L	M	all value
Earthquake Disaster A11	3	3	3	4	3	3	4	3	3	4	3	3	3	3.82
Flood Disaster A12	4	4	4	5	4	3	3	4	4	5	3	4	5	4.73
Meteorological Disaster A13	3	3	3	5	3	3	3	3	3	4	3	3	4	3.91
Political Instability A21	4	4	2	4	3	3	4	2	2	4	3	2	4	3.73
Changes in Institutional Policies A22	3	4	3	4	2	2	4	3	2	4	2	3	4	3.64
Changes in Laws and Regulations A23	2	3	3	2	2	2	3	3	2	3	2	3	4	3.09
Social Conflict A31	4	4	3	3	2	2	4	3	2	4	2	3	4	3.64
Social Chaos A32	2	3	2	4	3	2	4	2	2	3	2	4	2	3
Social Disorder A33	4	4	2	2	2	2	4	2	2	4	4	2	4	3.45
Differences in Religious Customs A34	4	4	2	3	3	2	4	2	2	4	3	2	4	3.55
Information Asymmetry A41	2	3	2	3	3	3	2	2	2	3	1	2	2	2.73
Inflation A42	2	3	2	3	2	2	2	2	3	3	1	2	3	2.73
Exchange Rate Fluctuations A43	1	3	1	2	3	3	2	1	3	3	1	1	3	2.45
High or Unrealistic Owner Requirements A51	1	3	1	3	2	2	3	1	1	3	2	1	2	2.27
Rejection or Delay of Acceptance of Materials A52	3	4	2	3	2	2	4	2	2	4	2	2	2	3.09
delay in payment A53	2	4	3	3	2	2	3	3	3	3	3	3	3	3.36
Risk of Bankruptcy A61	3	2	2	3	2	2	2	2	2	3	3	2	3	2.82
Price Risk A62	2	4	2	4	2	2	4	2	2	3	4	2	2	3.18
Quality Risk A63	3	4	3	4	2	2	4	3	2	2	3	3	3	3.45
Delivery time Delays Risk A64	5	3	4	3	4	4	3	4	3	4	3	4	4	4.36
Contract-Related Risk A65	1	3	2	2	2	1	3	2	1	3	3	2	2	2.45
Inadequate decision - making system B11	1	3	2	3	2	2	2	2	1	3	1	2	2	2.36
Unreasonable Decision - Making Process B12	2	3	2	1	2	1	2	3	1	2	1	2	2	2.18
Insufficient Information for Decision - Making B13	1	3	3	2	1	1	2	3	2	2	2	3	1	2.36
Insufficient capability of Decision - Makers B14	3	3	2	2	1	1	3	2	2	2	1	2	1	2.27
Inadequate Information Control B21	1	3	3	3	3	2	3	3	3	3	1	3	2	3.00
Insufficient planning staff capability B22	3	3	3	3	2	1	3	3	3	3	2	3	2	3.09

Improper Planning Management B23	3	3	3	3	2	1	3	3	3	3	2	3	2	3.09
Procurement Process Is Not Standardized B31	1	1	2	2	1	1	3	2	1	2	3	2	2	2.09
Lack of Skills Among Procurement Staff B32	2	3	2	2	1	1	2	2	2	3	2	2	1	2.27
Mistakes in the Conclusion of Procurement Contracts B33	1	3	1	3	1	2	3	1	1	2	2	1	1	2.00
Improper Transportation Method B41	3	2	2	4	2	2	2	3	2	4	3	4	3	3.27
Transportation Costs Are Too High B42	2	2	3	3	2	1	2	1	2	3	2	3	2	2.55
Shipping Time Is Too Long B43	4	4	5	4	3	3	3	5	4	4	4	5	3	4.64
The Acceptance Process Is Not Strict B51	1	3	1	3	2	1	3	1	3	2	2	1	1	2.18
Insufficient Professional of Acceptance Personnel B52	2	3	1	2	1	1	3	1	3	2	1	1	1	2.00
Insufficient Quality of Acceptance Personnel B53	2	2	1	2	1	1	2	1	3	3	1	1	1	1.91
Excessive Inventory B61	1	2	1	1	2	2	1	1	2	2	1	1	2	1.73
Insufficient Inventory B62	3	3	2	2	3	3	3	2	3	4	2	2	3	3.18
Improper Inventory Storage B63	1	2	1	1	3	2	2	1	1	2	1	2	3	2.00

The above Table 5.4, titled "The Impact of Each Risk on The Procurement Progress," presents the risk evaluation results based on the assessments of 13 experts (A to M) directly involved in the procurement of materials for the Jake FPF project. The table lists various risks, with their impact scores assigned by each expert, and the "all value" column reflects the average impact score for each risk across all experts.

Table 5.5: The Impact of Each Risk on The Procurement Quality														
Risk name	A	B	C	D	E	F	G	H	I	J	K	L	M	all value
Earthquake Disaster A11	1	2	1	2	2	1	2	1	2	1	1	2	3	1.91
Flood Disaster A12	1	2	3	2	1	1	2	1	2	3	1	2	1	2.00
Meteorological Disaster A13	1	3	2	1	3	1	1	1	2	2	1	1	3	2.00
Political Instability A21	1	3	2	1	3	1	3	1	3	2	2	1	3	2.36
Changes in Institutional Policies A22	1	1	2	1	2	1	2	1	2	2	3	1	3	2.00
Changes in Laws and Regulations A23	1	3	1	1	2	1	2	1	2	1	1	1	3	1.82
Social Conflict A31	1	2	1	1	2	1	2	1	2	1	1	1	3	1.73
Social Chaos A32	1	3	1	1	2	1	2	1	2	1	1	1	3	1.82
Social Disorder A33	1	2	1	2	1	2	2	1	2	1	1	2	2	1.82
Differences in Religious Customs A34	1	1	2	2	1	2	3	1	3	2	3	2	3	2.36
Information Asymmetry A41	2	3	2	2	3	3	3	2	3	2	2	2	3	2.91
Inflation A42	2	3	1	1	3	2	3	2	3	1	2	1	3	2.45
Exchange Rate Fluctuations A43	2	3	2	2	3	1	2	2	3	2	3	2	3	2.73
High or Unrealistic Owner Requirements A51	2	2	3	2	2	3	2	1	3	3	1	2	3	2.64
Rejection or Delay of Acceptance of Materials A52	3	1	1	1	1	1	2	1	2	1	1	1	3	1.73
delay in payment A53	3	1	1	1	1	1	2	1	2	1	1	1	3	1.73
Risk of Bankruptcy A61	2	1	2	2	1	2	3	2	3	2	2	2	3	2.45
Price Risk A62	3	2	2	3	2	1	2	2	2	2	3	3	2	2.64
Quality Risk A63	3	3	4	4	3	5	4	3	4	4	5	4	3	4.45
Delivery time Delays Risk A64	3	4	3	2	4	2	3	4	3	3	4	2	2	3.55
Contract-Related Risk A65	3	2	3	2	2	3	3	1	2	3	2	2	2	2.73
Inadequate decision - making system B11	2	2	3	1	2	1	3	1	3	2	2	2	2	2.36
Unreasonable Decision - Making Process B12	2	1	3	1	1	1	3	1	3	3	3	1	2	2.27
Insufficient Information for Decision - Making B13	2	2	3	1	2	3	3	2	3	3	2	1	3	2.73
Insufficient capability of Decision - Makers B14	2	2	2	2	2	2	3	2	2	2	2	2	3	2.55
Inadequate Information Control B21	2	3	4	2	2	3	2	2	3	2	3	2	4	3.09
Insufficient planning staff capability B22	2	1	3	1	1	1	2	2	2	3	2	1	2	2.09
Improper Planning Management B23	2	1	2	1	1	1	2	2	2	2	3	1	2	2.00
Procurement Process Is Not Standardized B31	2	1	1	2	1	1	3	1	3	1	1	2	3	2.00
Lack of Skills Among Procurement Staff B32	2	2	3	2	2	2	3	2	4	2	3	2	2	2.82
Mistakes in the Conclusion of Procurement Contracts B33	2	2	3	1	2	2	3	1	3	2	1	1	2	2.27
Improper Transportation Method B41	3	2	3	3	2	1	2	1	2	3	3	3	3	2.82
Transportation Costs Are Too High B42	3	2	1	1	1	1	2	2	2	1	3	1	2	2.00

Shipping Time Is Too Long B43	3	3	1	2	1	1	2	2	2	1	3	2	3	2.36
The Acceptance Process Is Not Strict B51	2	2	3	2	2	4	3	3	2	4	2	3	2	3.09
Insufficient Professional of Acceptance Personnel B52	2	2	3	2	2	3	2	4	3	2	2	3	2	2.91
Insufficient Quality of Acceptance Personnel B53	3	3	4	2	2	4	3	4	4	3	3	4	2	3.73
Excessive Inventory B61	2	3	2	1	2	1	2	2	2	1	2	2	1	2.09
Insufficient Inventory B62	1	2	1	1	2	1	2	2	2	1	1	1	1	1.64
Improper Inventory Storage B63	1	3	2	1	2	1	2	1	2	1	2	2	3	2.09

The above Table 5.5, titled "The Impact of Each Risk on The Procurement Quality," presents the risk evaluation results based on the assessments of 13 experts (A to M) directly involved in the procurement of materials for the Jake FPF project. The table lists various risks, with their impact scores assigned by each expert, and the "all value" column reflects the average impact score for each risk across all experts.

Table 5.6: Probability Score of Each Risk														
Risk Name	A	B	C	D	E	F	G	H	I	J	K	L	M	all value
Earthquake Disaster A11	1	2	2	2	2	1	2	2	2	2	1	2	2	2.09
Flood Disaster A12	4	3	3	3	3	4	2	4	3	3	4	3	4	3.91
Meteorological Disaster A13	2	2	1	3	2	1	1	2	1	1	2	2	2	2.00
Political Instability A21	1	3	3	3	2	3	2	2	2	3	2	2	2	2.73
Changes in Institutional Policies A22	3	2	1	1	3	3	2	2	3	2	2	3	3	2.73
Changes in Laws and Regulations A23	3	3	2	4	2	4	3	3	2	2	3	4	2	3.36
Social Conflict A31	1	2	1	2	2	3	2	1	2	2	2	2	2	2.18
Social Chaos A32	3	4	3	3	3	3	3	2	4	3	3	4	3	3.73
Social Disorder A33	2	2	2	3	2	3	2	1	2	1	2	2	1	2.27
Differences in Religious Customs A34	3	1	2	2	2	2	1	2	1	2	2	2	2	2.18
Information Asymmetry A41	2	3	3	4	2	4	3	3	2	3	2	3	2	3.27
Inflation A42	2	3	3	3	4	3	2	3	4	3	2	4	4	3.64
Exchange Rate Fluctuations A43	4	3	4	4	5	4	3	3	4	4	3	4	4	4.45
High or Unrealistic Owner Requirements A51	4	3	4	4	3	3	2	3	3	2	3	3	4	3.73
Rejection or Delay of Acceptance of Materials A52	3	2	3	3	2	1	2	1	2	2	2	2	3	2.55
delay in payment A53	3	3	3	4	3	2	3	2	3	3	3	3	4	3.55
Risk of Bankruptcy A61	1	1	1	1	1	2	1	1	1	1	1	1	2	1.36
Price Risk A62	4	2	4	4	3	3	3	3	3	4	3	3	4	3.91
Quality Risk A63	4	3	4	4	3	5	3	3	3	3	3	3	3	4.00
Delivery time Delays Risk A64	3	4	3	3	4	4	3	3	4	4	3	4	3	4.09
Contract-Related Risk A65	2	4	3	3	3	4	2	3	3	3	2	3	2	3.36
Inadequate decision - making system B11	1	2	1	1	2	1	1	2	1	2	1	2	1	1.64
Unreasonable Decision - Making Process B12	2	1	2	1	2	1	2	1	2	1	1	2	1	1.73
Insufficient Information for Decision - Making B13	2	1	3	3	2	2	3	2	2	1	2	2	2	2.45
Insufficient capability of Decision - Makers B14	1	1	2	2	1	1	1	2	1	1	1	2	1	1.55
Inadequate Information Control B21	3	1	3	1	1	3	2	2	2	2	2	2	3	2.45
Insufficient planning staff capability B22	2	1	3	3	1	2	2	2	2	1	2	2	2	2.27
Improper Planning Management B23	2	1	3	3	2	2	2	2	2	1	1	2	2	2.27
Procurement Process Is Not Standardized B31	2	1	3	2	1	2	1	1	1	1	1	1	3	1.82
Lack of Skills Among Procurement Staff B32	1	1	1	2	1	1	1	1	1	2	1	1	1	1.36
Mistakes in the Conclusion of Procurement Contracts B33	1	1	1	2	2	3	1	1	1	2	1	1	2	1.73
Improper Transportation Method B41	3	1	2	2	1	3	2	2	2	2	2	2	2	2.36
Transportation Costs Are Too High B42	3	2	2	2	3	4	3	2	2	2	3	3	2	3.00
Shipping Time Is Too Long B43	3	3	3	3	4	5	3	3	4	3	3	4	3	4.00
The Acceptance Process Is Not Strict B51	2	2	2	3	2	2	2	3	2	2	2	2	2	2.55
Insufficient Professional of Acceptance Personnel B52	2	2	2	3	2	2	2	3	2	2	2	3	2	2.64
Insufficient Quality of Acceptance Personnel B53	2	1	2	3	1	1	2	2	1	2	1	1	3	2.00
Excessive Inventory B61	1	2	1	3	2	1	2	1	1	2	1	2	2	1.91
Insufficient Inventory B62	1	2	3	3	2	2	2	2	2	2	1	2	3	2.45

Improper Inventory Storage B63	2	2	1	2	2	1	2	1	2	1	2	1	2	1.91
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The above Table 5.6, titled "The Impact of Each Risk on The Procurement Probability," presents the risk evaluation results based on the assessments of 13 experts (A to M) directly involved in the procurement of materials for the Jake FPF project. The table lists various risks, with their impact scores assigned by each expert, and the "all value" column reflects the average impact score for each risk across all experts.

Table 5.7: Project Material Procurement Risk Assessment Results					
Risk Name	Risk Category	Risk Impact Value	Risk Prob. Value	Risk Size	Risk Level
Earthquake Disaster A11	Natural Risks A1	3.82	2.09	7.98	C
Flood Disaster A12		4.73	3.91	18.49	A
Meteorological Disaster A13		3.91	2.00	7.82	C
Political Instability A21	Political Risk A2	4.36	2.73	11.9	B
Changes in Institutional Policies A22		4.18	2.73	11.41	B
Changes in Laws and Regulations A23		3.55	3.36	11.93	B
Social Conflict A31	Social Risk A3	3.64	2.18	7.94	C
Social Chaos A32		3.18	3.73	11.86	B
Social Disorder A33		3.45	2.27	7.83	C
Differences in Religious Customs A34		3.55	2.18	7.74	C
Information Asymmetry A41	Market Risk A4	3.64	3.27	11.9	B
Inflation A42		3.27	3.64	11.9	B
Exchange Rate Fluctuations A43		4.55	4.45	20.25	A
High or Unrealistic Owner Requirements A51	Owner Risk A5	3.09	3.73	11.53	B
Rejection or Delay of Acceptance of Materials A52		3.09	2.55	7.88	C
delay in payment A53		3.36	3.55	11.93	B
Risk of Bankruptcy A61	Supplier Style Risk A6	2.82	1.36	3.84	D
Price Risk A62		4.45	3.91	17.4	A
Quality Risk A63		4.45	4.00	17.8	A
Delivery time Delays Risk A64		4.36	4.09	17.83	A
Contract-Related Risk A65		3.55	3.36	11.93	B
Inadequate decision - making system B11	Decision Risk B1	2.36	1.64	3.87	D
Unreasonable Decision - Making Process B12		2.27	1.73	3.93	D
Insufficient Information for Decision - Making B13		2.91	2.45	7.13	C
Insufficient capability of Decision - Makers B14		2.55	1.55	3.95	D
Inadequate Information Control B21	Procurement Plan Risk B2	3.09	2.45	7.57	C
Insufficient planning staff capability B22		3.09	2.27	7.01	C
Improper Planning Management B23		3.09	2.27	7.01	C
Procurement Process Is Not Standardized B31	Procurement and Ordering Risk B3	2.18	1.82	3.97	D
Lack of Skills Among Procurement Staff B32		2.82	1.36	3.84	D
Mistakes in the Conclusion of Procurement Contracts B33		2.27	1.73	3.93	D
Improper Transportation Method B41	Transportation Risks B4	3.27	2.36	7.72	C
Transportation Costs Are Too High B42		2.64	3.00	7.92	C
Shipping Time Is Too Long B43		4.64	4.00	18.56	A
The Acceptance Process Is Not Strict B51		3.09	2.55	7.88	C

Insufficient Professional of Acceptance Personnel B52	Inspection Risk B5	Acceptance	2.91	2.64	7.68	C
Insufficient Quality of Acceptance Personnel B53			3.73	2.00	7.46	C
Excessive Inventory B61	Inventory Risk B6		2.09	1.91	3.99	D
Insufficient Inventory B62			3.18	2.45	7.79	C
Improper Inventory Storage B63			2.09	1.91	3.99	D

From the table 5.7, in the material - procurement risk assessment of this project, 6 risks are classified as Class A, 9 as Category B, 16 as Category C, and the remaining 9 as Category D. The most significant (with the highest risk level) Class A risk indicators are Flood Disaster, exchange-rate fluctuations, supplier price risk, supplier quality risk, supplier delivery-time risk, and long-transportation-time risk. Moreover, the table shows that the external risks in the project's material procurement are more severe than the internal risks. Exogenous risks are mainly A, B, and C risks, with only a few D risks, while endogenous risks are mostly C and D risks. This phenomenon is consistent with the overall situation of Sudanese enterprises' material procurement for international oil and gas engineering projects. Based on the expert opinions from the survey and combined with my own and my project team's experience, I have determined the project's main challenges and formulated corresponding risk-response measures, including strategies and specific response plans.

5.4.1 Response Measures for Category A Risks

Table 5.8: Countermeasures for Category A Risks in Project Material Procurement			
Risk coding	Risk name	Response strategies	Countermeasures
A12	Flood disaster	Risk Aversion Risk Transfer	Avoid flood - prone areas; use insurance to transfer risk
A43	Exchange rate fluctuation	Risk Transfer	When the purchase price of materials is determined through contract terms, specify the time and exchange rate at that time
A62	Price Risk	Risk Mitigation Risk Transfer	Fully understand possible supplier information on the market; cooperate with and maintain good cooperative relations with suppliers; The contract terms clearly state the scope of price fluctuations of materials provided by suppliers
A63	Quality risk	Risk Mitigation Risk Transfer	Strictly check the quality of purchased materials; specify through contract terms how to deal with unqualified materials and the supplier's breach - of - contract compensation
A64	Delivery time risk	Risk Transfer	Specify supplier delivery dates and breach - of - contract compensation through contract terms
B43	Transportation time too long	Risk Mitigation Risk Transfer	Relax transportation time requirements when developing material procurement plans; Entrust the material transportation to a professional and reliable third - party; Clearly define liability for breach of contract through contract terms

The above Table 5.8 outlines the countermeasures developed to address Category A risks associated with material procurement in oil and gas EPC projects, focusing on high-priority challenges that could significantly impact project timelines and budgets. The table identifies six key risks, each assigned a specific code: flood disaster (A12), exchange rate fluctuation (A43), price risk (A62), quality risk (A63), delivery time risk (A64), and transportation time too long (B43).

5.4.2 Response Measures for Category B Risks

Table 5.9: Countermeasures for Category B Risks in Project Material Procurement			
Risk coding	Risk name	Response strategies	Solution
A21	Political Instability	Risk avoidance Risk transfer	Avoid passing through places where political changes may occur; purchase insurance

A22	Changes in Institutional Policies	Risk mitigation	Gain a detailed understanding of the institutional policies of the places involved in procurement
A23	Changes in Laws and Regulations	Risk mitigation	Learn more about the relevant laws and regulations of the place where the procurement is involved and their changes
A32	Social chaos	Risk mitigation Risk retention	Cooperate with local security and police departments; strengthen physical safety supervision and guarantee work of capital procurement
A41	Information asymmetry	Risk mitigation Risk transfer	Establish a complete supplier information system; Clarify the conditions and qualifications that suppliers should meet
A42	Inflation risk	Risk mitigation Risk transfer	When the calculation of material purchase price is clarified through contract terms
A51	High or Unrealistic Owner Requirements	Risk mitigation Risk transfer	Understand the owner's material - procurement requirements in detail; Maintain good communication; subcontract to a third - party for some material procurement
A53	Delay in Payment	Risk mitigation Risk transfer	Clarify the time and terms of material payment through contract terms; If it is clarified through the contract terms that the payment is not timely, define the liability for breach of contract
A65	Contract-Related Risk	Risk mitigation	Establish a professional international material - procurement contract team

The above Table 5.9 presents a detailed set of countermeasures designed to address Category B risks in material procurement for oil and gas EPC projects, focusing on challenges that, while not the most severe, still pose significant threats to project success. The table lists nine risks which are: political instability (A21), changes in institutional policies (A22), changes in laws and regulations (A23), social chaos (A32), information asymmetry (A41), inflation risk (A42), high or unrealistic owner requirements (A51), delay in payment (A53), and contract-related risk (A65). Each risk is paired with a response strategy, primarily centered on risk mitigation and transfer, with some elements of avoidance.

5.4.3 Response Measures for Category C Risks

Table 5.10: Countermeasures For Category C Risks in Project Material Procurement			
Risk coding	Risk name	Response strategies	Countermeasures
A11	Earthquake disaster	Risk avoidance Risk transfer	Avoid passing through earthquake - prone areas; use insurance to transfer risk
A13	Meteorological disasters	Risk aversion Risk transfer	Avoid passing through areas where Meteorological disasters may occur; Suppliers or third - parties deliver purchased materials
A31	Social Conflict	Risk mitigation Risk retention	Cooperate with local security and police departments; strengthen physical safety supervision and guarantee work of capital procurement
A34	Differences in Religious Customs	Risk mitigation Risk retention	Learn in detail and respect the religious customs of the places where materials are purchased
A33	Social disorder	Risk mitigation Risk retention	Cooperate with local security and police departments; strengthen physical safety supervision and guarantee work of capital procurement
A52	Rejection or Delay of Acceptance of Materials	Risk transfer Risk retention	Clarify the owner's refusal or delay through contract terms; define supplier's responsibilities
B13	Insufficient Information for Decision - Making	Risk mitigation	Establish a complete material procurement decision - making information system
B21	Insufficient information risk	Risk mitigation	Establish a comprehensive material demand planning information system
B22	Insufficient planning staff capability	Risk mitigation	Provide regular training to improve planning capabilities of planners; recruit excellent planning management talents

B23	Improper Planning Management risk	Risk mitigation	Learn from the experience and lessons learned from improper behavior and improve planning management level
B41	Improper transportation method risk	Risk transfer	Subcontract to third - parties for material transportation
B42	Transportation costs are too high risk	Risk retention	Subcontract to third - parties for material transportation
B51	The Acceptance Process Is Not Strict B51	Risk mitigation	Establish a complete material acceptance process
B52	Insufficient Professional of Acceptance Personnel B52	Risk mitigation	Provide regular training to improve the acceptance level of the acceptance personnel
B53	Insufficient Quality of Acceptance Personnel B53	Risk mitigation Risk transfer	Establish a code of conduct for acceptance personnel; adopt a contract to clearly define the responsibilities of acceptance personnel in terms of clauses
B62	Insufficient Inventory	Risk mitigation Risk retention	Establish a complete inventory information system to ensure timely understanding of material inventory information and update procurement plans

The above Table 5.10 outlines countermeasures for Category C risks in material procurement specifically for oil and gas EPC projects, as detailed in Table 5.10. It identifies 16 risks that arise in natural, social, and operational domains, including risks such as earthquake disasters, meteorological disasters, and social conflicts. The response strategies for these risks focus on mitigation, transfer, retention, and aversion. For instance, strategies for natural disasters involve avoiding prone areas and transferring risk through insurance, while social risks are managed by collaborating with local security. Operational risks are addressed by developing robust information systems, training staff, and ensuring skilled personnel recruitment. Challenges related to transportation and acceptance are managed through subcontracting and clarifying contract terms, while inventory shortages are mitigated through effective inventory management. This structured approach provides Sudanese oil companies with actionable strategies for minimizing disruptions to enhance project efficiency within the complex global energy sector. The chapter also references previous chapters detailing the Jake Field Processing Facility (FPF) project and summarizes evaluations from thirteen experts, with classifications of risks across different classes informing the response measures for more critical risks.

6. CONCLUSION

Oil and gas engineering projects structured under the Engineering, Procurement, and Construction (EPC) framework navigate a labyrinth of intricate and dynamic uncertainties, particularly within the realm of material procurement. This investigation embarked on a thorough exploration, meticulously combing through existing scholarly contributions to unearth and assess the factors that introduce vulnerability into this critical phase. A spotlight was cast on the Jake FPF Project, overseen by Petro Energy Operation Company, where a detailed risk analysis illuminated the procurement challenges specific to this initiative, paired with tailored strategies to address them. The findings weave together a compelling tapestry of insights grounded in evidence and shaped by practical intent. What follows is a distillation of the key takeaways that emerged from this endeavor, offering a clear window into the complexities at play. The first revelation centers on the classification of procurement uncertainties. These risks naturally divide into two overarching domains : those originating externally and those arising internally. External uncertainties span six distinct subcategories—natural events such as floods or seismic disruptions ; political shifts like regulatory changes or instability; social pressures including community resistance or labor disputes; market fluctuations such as commodity price volatility; owner-induced issues like ambiguous specifications, and supplier-related hurdles encompassing delivery delays or substandard goods. Internal uncertainties, meanwhile, branch into six areas : flawed decision-making processes, inadequate planning efforts, errors in order issuance, logistical bottlenecks during transit, quality assurance failures at receipt, and mismanagement of stockpiles. These 12 subcategories unravel into 40 finely detailed sub-risks, crafting a comprehensive map of the potential stumbling blocks Sudanese firms may face. Next, the methodology employed to evaluate these uncertainties stands as a beacon of scientific integrity and practical utility. The risk matrix approach utilized here merges theoretical soundness with operational ease, plotting risks by their probability and consequence to yield a clear hierarchy. This technique proves accessible—it demands neither excessive time nor vast pools of personnel or funding—making it a feasible tool for real-world deployment. Its elegance lies in its balance: robust enough to withstand scrutiny yet straightforward enough for project teams to wield effectively. For Sudanese companies navigating tight schedules and lean budgets, this method offers a lifeline, enabling them to confront the unpredictable with a steady hand. The third insight revolves around the stratification of risk severity and the strategic responses it inspires. Procurement uncertainties are organized into four tiers—A, B, C, and D—ranked from most critical to least impact. For A and B levels, where the stakes are highest, proactive tactics dominate: avoidance sidesteps the hazard entirely, transfer shifts the burden elsewhere (think insurance or subcontracting), and mitigation softens the blow through preemptive action. C-level threats typically blend transfer and mitigation, balancing cost with caution, while D-level issues, being milder, often fall under retention—absorbing them as an acceptable trade-off. This tiered structure isn't rigid; it's a flexible guide, empowering firms to calibrate their approach based on

each risk's weight and context. Finally, the Jake FPF Project emerges as a vivid case study, spotlighting a spectrum of procurement challenges tailored to its reality. Six A-level threats tower above the rest: flood disasters that could sever supply lines, exchange rate volatility unsettling financial plans, supplier-driven price surges, quality lapses from vendors, delayed deliveries, and prolonged transit abjurations. Beyond these, the project faces nine B-level, 16 C-level, and nine D-level uncertainties. A striking pattern emerges—external risks overshadow internal ones for Sudanese enterprises engaged in global EPC ventures. This tilt reflects Sudan's vulnerability to forces beyond its borders—geopolitical currents, economic tides, and environmental whims—highlighting a pressing need for vigilance in these arenas over which local control is often limited.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

ORCID iD: Ahmed Atta Elhoussein Ali : 0009-0009-7177-6547, Zhang Xinli : 0000-0002-0954-793X, Mohammad Mesba Ul Hoque: 0009-0006-0113-8644

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