Strategic Decision-Making Analysis for Digital Innovation Development in Supporting Oil and Gas Business Sustainability in Offshore Brownfield Projects in Indonesia

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Abstract. Indonesia's oil and gas industry faces significant challenges due to the dominance of aging offshore facilities amid increasingly ambitious national energy production targets, making brownfield project management crucial for maintaining cost efficiency while ensuring technological reliability to support energy sustainability. Based on this condition, this study first aims to identify causal relationships among strategic factors of digital innovation through questionnaires analyzed using the DEMATEL method and second to formulate digital innovation development strategies through in-depth interviews analyzed using the SWOT–TOWS framework based on the perspectives of oil and gas industry experts in Indonesia. The DEMATEL results indicate that Facilities Factors represent the most important factor with a Di+Rj value of 24.01, while Site-Specific Risk acts as the primary driving factor with a Di−Rj value of 1.59 influencing the interrelationships among other factors and shaping a strategic structure that integrates environmental aspects, stakeholder concerns, and health and safety within the digital innovation system. Furthermore, the SWOT–TOWS analysis generates strategies that emphasize the adoption of digital twins, AI-based predictive maintenance and real-time monitoring systems to enhance operational efficiency, asset reliability, and industry competitiveness so that the integration of strategic factors and digital innovation can establish more adaptive decision-making and strengthen the sustainability of oil and gas businesses in offshore brownfield projects.

Keywords: brownfield offshore, decision-making, DEMATEL, SWOT–TOWS

1 Introduction

As one of the leading oil and gas producers in Southeast Asia and home to one of the world's five largest natural gas reserves, Indonesia positions the oil and gas sector as a

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strategic pillar for national energy security and economic development, as reflected in state revenues exceeding Rp110 trillion in 2024 and its contribution to investment growth, job creation, and value added across related industries [1], [2]. However, the decline in oil and gas lifting, reflected in crude oil production of 579 thousand barrels per day against a target of 635 thousand barrels per day, along with gas production that remains below expectations, indicates significant pressure on the sector's performance, thereby requiring companies to strengthen operational efficiency, optimize assets, and leverage digital innovation to maintain competitiveness [3], [4]. Efforts to increase production are further constrained by the fact that most hydrocarbon reserves are located offshore on complex and aging platforms, necessitating an integrated approach among stakeholders to ensure long-term operational and business sustainability [5], [6]. These conditions underscore the importance of facility development strategies through both greenfield and brownfield projects, with brownfield development being more relevant for Indonesia as it utilizes existing facilities with lower initial investment requirements, although it still demands strengthened asset integrity management and technical modifications to sustain operations [7], [8]. Therefore, the advancement of digital innovation becomes a strategic element to optimize facility performance, reduce operational risks, and support systematic and integrated decision-making so that each alternative can rationally and measurably balance technical risks, market uncertainties, and investment burdens [9].

Previous research shows that digital innovation has been applied in the upstream oil and gas sector through technologies such as Digital Twin, IoT, robotics, drones, cloud computing, and 3D printing, which improve operational efficiency, accuracy, and data-driven decision-making [10], [11] These performance improvements also strengthen operational safety and reliability and encourage smarter energy system integration, making digital transformation an important foundation for industrial competitiveness in the era of energy transition. Based on these developments and the challenges of offshore brownfield projects, this study is expected to contribute academically by strengthening the literature on adaptive management strategies and contribute practically as a guide for stakeholders in making innovation-based investment decisions. This study then focuses on analyzing the causal relationships between strategic factors in digital innovation development and formulating structured strategies as a basis for decision-making to maintain the sustainability of the oil and gas business amid technical, financial, and market uncertainty risks. Therefore, the management of offshore brownfield projects in the future needs to be directed towards a systematic digital innovation strategy as the main foundation for the sustainability of the oil and gas business in Indonesia.

2 Literature Review

2.1 Offshore Technology

The oil and gas industry is divided into upstream and downstream sectors where offshore platforms are the main upstream infrastructure, both fixed platforms with tubular steel jackets and floating platforms, with topsides that house production facilities, accommodation, and flares in accordance with API and ISO standards [12], [13]. In brownfield projects, understanding platform technology is important for retrofit, revamp, replacement, or decommissioning decisions because the topside affects technical evaluation, capacity, and safety.

2.2 Hevner's Framework

The Hevner framework emphasizes two main approaches: behavioral science to examine human and organizational behavior, and design science to create and evaluate artifacts or solutions [14]. This framework encompasses three core elements: environment (people, organizations, and technology), knowledge base (theory, methods, experience), and Information Systems research covering artifact development and evaluation, with two important dimensions, relevance and rigor, to maintain a balance between practical needs and academic foundations.

3 Methodelogy

This study uses a mixed-method approach involving three experts from Indonesian oil and gas companies with experience in brownfield projects, namely a Consultant for Project Management / Project Service and Contract Professional, Engineering Manager, and an Management of Changes (MOC) Engineer. The questionnaire data was analyzed quantitatively using the DEMATEL method to identify the cause-and-effect relationships between strategic factors, while in-depth interviews were analyzed using the SWOT–TOWS framework to formulate digital innovation-based strategic recommendations in facing the challenges of aging oil and gas facilities [15], [16].

3.1 Data Collection Techniques

This study uses questionnaires as a quantitative data collection method because they can produce large amounts of data efficiently and in a standardized manner to measure research variables systematically [17], [18]. This study uses a mixed-method data collection technique through questionnaires and in-depth interviews to obtain complementary quantitative and qualitative information. Questionnaires were used to collect standardized data in order to measure research variables systematically and minimize researcher bias through structured instruments [17], [18]. Furthermore, in-depth interviews with three employees of an Indonesian oil and gas company were conducted to explore their experiences, perceptions, and practical views regarding offshore brownfield project management [19], [20].

3.2 Data Analysis Techniques

This study uses DEMATEL as an initial stage to map the cause-and-effect relationships between digital innovation strategic factors through the calculation of direct and total relationship matrices, thereby obtaining the level of importance of each factor and identifying groups of causes and effects [21]. Furthermore, SWOT analysis was used to identify the internal and external conditions of the company that influence the success of offshore brownfield project development [15]. The results of this identification are then processed using TOWS analysis to integrate strengths, weaknesses, opportunities, and threats into more applicable and targeted strategic alternatives [16], [22]. Through a combination of these methods, the study produces a systematic basis for decision-making in supporting the sustainability of brownfield projects in the oil and gas industry.

4 Results & Discussion

This section presents the findings from the DEMATEL analysis and the SWOT–TOWS strategic formulation. DEMATEL identifies the prominence and causal relationships among digital innovation factors, while SWOT–TOWS translates these results into actionable strategies. Together, they provide a structured basis for decision-making in offshore brownfield projects.

4.1 Analysis of Causal Relationships among Strategic Factors

The DEMATEL analysis process begins with the preparation of an average matrix based on respondent assessments, where the diagonal elements have a value of zero because the criteria do not influence themselves. The results of the total relationship matrix are then used to calculate the values of Di + Rj and Di − Rj as the basis for determining the level of importance and causal role of each factor so that the factors that have a dominant influence and the factors that are more influenced by other factors can be identified.

Table 1. The Most Important Factors In Digital Innovation Development

Kriteria	***Di+Rj***	***Ranking***
Facilities Factors	24.01	1
Environmental Factors	24.00	2
Additional Concerns from Stakeholders	23.63	3
Health and Safety	23.61	4
Site-Specific Risk	23.30	5
Social Factors	20.22	6

Based on Table 1, the DEMATEL analysis shows that Facilities Factors have the highest score (24.01), making them the most important factor in digital innovation development. The next position is occupied by Environmental Factors (24.00), followed by Additional Concerns from Stakeholders (23.63) and Health and Safety (23.61), reflecting the strong interconnection between environmental aspects, stakeholders, and safety. Site-Specific Risk (23.30) continues to contribute significantly, while Social Factors (20.22) ranks last but remains an important part of the influence structure.

Table 2. Priority Factors In Digital Innovation Development

Kriteria	***Di-Rj***	***Ranking***
Site-Specific Risk	1.59	1
Additional Concerns from Stakeholders	0.15	2
Environmental Factors	-0.02	3
Facilities Factors	-0.40	4
Health and Safety	-0.41	5
Social Factors	-0.92	6

Based on Table 2, the Di-Rj value indicates Site-Specific Risk as the main driver of digital innovation with the highest score of 1.59, followed by Additional Concerns from Stakeholders (0.15), which also has a positive influence on the direction of innovation. Meanwhile, Environmental Factors (-0.02), Facilities Factors (-0.40), and Health and Safety (-0.41) tend to play a more influential role, although they remain important in maintaining integrated innovation implementation. Social Factors received the lowest score (-0.92) but remain part of the system's influence structure. Overall, these findings confirm that all of these factors are interrelated strategic elements in driving digital innovation to support the sustainability of the oil and gas business in offshore brownfield projects.

Based on the values of Di + Rj and Di – Rj, the Impact Relation Map can be illustrated as follows.

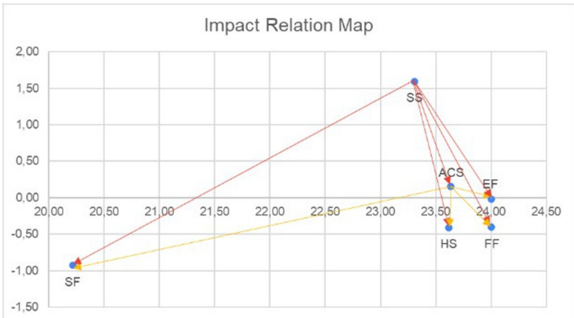

Fig. 1. Impact Relation Map

Based on the Impact Relation Map in Figure 1, Site-Specific Risk (Di−Rj = 1.59) and Additional Concerns from Stakeholders (0.15) are in the positive area as causal factors that influence other factors, while Facilities Factors (-0.40), Health and Safety (-0.41), Environmental Factors (-0.02), and Social Factors (-0.92) are more influenced, although they remain strategic. In terms of importance, Facilities Factors are the highest (Di+Rj = 24.01), followed by Environmental Factors (24.00), Additional Concerns from Stakeholders (23.63), and Health and Safety (23.61), while Social Factors (20.22) are relatively the lowest. The arrows on the map illustrate the flow of influence from the causative factors to the affected factors, confirming Site-Specific Risk as the main driver of digital innovation in offshore brownfield projects.

4.2 The Right Strategy to Apply to the Brownfield Offshore Project in the Oil and Gas Industry

Offshore brownfield projects in the oil and gas industry have several internal strengths and weaknesses, as well as external opportunities and threats, which greatly affect the effectiveness of business sustainability strategies. A summary of the SWOT factors that most influence the strategic position of offshore brownfield projects based on the results of interviews with informants is presented in Tabel 3 for internal strategic factors using the IFAS (Internal Factor Analysis Summary) and in Tabel IV for the external strategic factors using the EFAS (External Factor Analysis Summary).

Table 3. IFAS Matrix

Num	Answer	Sig-nifi-cant	Weight	Rating	Weighted Score
Strength					
1.	The organization demonstrates extensive experience in overseeing offshore brownfield projects, supported by established capabilities in engineering, safety management, and regulatory compliance.	2.5	0.107	10	1.071
2.	The presence of completed offshore infrastructure, such as operational platforms, pipeline systems, processing facilities, and integrated utilities, supports the implementation of brownfield projects by eliminating the need to initiate development from the ground up.	2.5	0.089	9	0.804
3.	The project team possesses multidisciplinary expertise encompassing mechanical, process, electrical, integrity, and project management domains.	2	0.089	9	0.804
4.	The team has established familiarity in coordinating and collaborating with both vendors and regulatory authorities.	2	0.071	8	0.571
5.	Financial backing from corporate entities and joint venture partners provides the company with the capacity to advance brownfield projects even amid volatility in oil and gas prices.	2	0.089	9	0.804
6.	The health, safety, and environment management framework is aligned with internationally recognized standards, including API, OSHA, and ISO.	2.5	0.089	9	0.804
7.	Safety case requirements and Management of Change (MOC) procedures are implemented with rigorous enforcement.	2.5	0.089	9	0.804
8.	Incident reporting is conducted through the Synergilife system, enabling the effective dissemination of lessons learned.	2	0.071	8	0.571
Weakness					
1.	The persistence of several manual processes that remain unintegrated with digital systems slows information flow and interfunctional coordination, thereby prolonging decision-making in offshore brownfield projects.	1	0.036	1	0.036
2.	Delays frequently occur in procurement and logistics activities, primarily driven by extended lead times associated with specialized equipment.	1.5	0.054	2	0.107
3.	A portion of the current equipment is approaching the end of its service life, leading to reduced operational reliability.	1.5	0.054	2	0.107

Num	**Answer**	**Sig-nifi-cant**	**Weight**	**Rating**	**Weighted Score**
4.	Challenges persist in achieving alignment between internal teams and EPC contractors or overseas vendors, particularly in relation to design standards and documentation.	1.5	0.054	2	0.107
5.	The constrained availability of human resources represents a significant impediment to offshore brownfield project implementation.	1.5	0.054	2	0.107
6.	Project priorities may periodically shift in response to evolving corporate directives.	1.5	0.054	2	0.107
		28	1		**6.804**

Table 4. EFAS Matrix

Num	Answer	Significant	Weight	Rating	Weighted Score
Opportunity					
1.	Brownfield projects provide a cost-efficient approach for enhancing production capacity.	3	0.143	10	1.429
2.	Regulatory support from SKK Migas and KESDM encourages production optimization initiatives while maintaining a strong emphasis on safety priorities.	2.5	0.119	9	1.071
3.	There is a significant opportunity to establish partnerships with technology firms and international vendors to support project development.	2.5	0.119	9	1.071
4.	Residual potential remains in marginal or stranded gas reserves located near existing facilities, which can be developed through the utilization of current infrastructure.	2	0.095	8	0.762
5.	The implementation of advanced compressor control systems and AI-driven predictive maintenance, along with the application of digital twin technology for real-time monitoring, operational scenario simulation, and decision optimization, supports more effective project execution.	3	0.143	10	1.429
Threats					
1.	Adverse and severe weather conditions.	1.5	0.071	2	0.143
2.	Disruptions affecting global supply chain networks.	1.5	0.071	2	0.143
3.	Fluctuations in oil and gas prices have a substantial influence on the economic feasibility of brownfield projects.	1	0.048	1	0.048
4.	A highly competitive market environment.	1.5	0.071	2	0.143
5.	Rival firms demonstrate faster adoption of digitalization initiatives and low-carbon solutions.	1.5	0.071	2	0.143
6.	Modifications to PSC frameworks, taxation policies, or licensing requirements may lead to higher costs or prolonged project schedules.	1	0.048	1	0.048
		21	1		**6.429**

Based on the IFAS and EFAS matrices presented in Tables 3 and 4, the offshore brownfield project has significant internal strengths (6.804) such as project management track record, established infrastructure, and a multidisciplinary team, as well as significant external opportunities (6.429) in the form of marginal reserve potential, technological collaboration, and low-carbon efficiency innovation. However, the project also faces internal weaknesses such as procurement delays, silos between functions, and human resource limitations, as well as external threats in the form of extreme weather, supply chain disruptions, oil and gas price fluctuations, and regulatory changes. Therefore, a SWOT quadrant diagram is used to map these factors and assess the project's strategic position in order to determine the appropriate strategy. Each quadrant reflects a different strategic condition: aggressive, diversification, overcoming internal weaknesses, and defensive or turnaround [23].

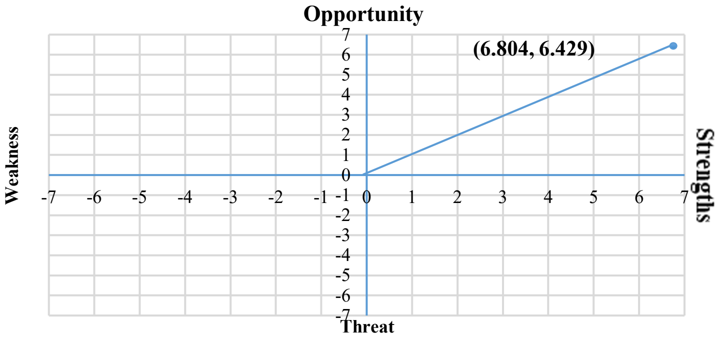

Fig. 2. SWOT Analysis Matrix Quadrant Diagram

As shown in Figure 2, the project coordinates (6.804; 6.429) place it in Quadrant I, indicating strong internal strengths and favorable external opportunities, resulting in a relatively good strategic position for the project. Based on this, the TOWS analysis as the final stage of SWOT formulates practical strategies by integrating internal and external factors to support decision-making in offshore brownfield projects in the oil and gas industry, as shown in Table 5.

Table 5. SWOT–TOWS Matrix

SWOT MATRIX	S-STRENGTH	W-WEAKNESS
INTERNAL **EXTERNAL**	1. The organization demonstrates extensive experience in overseeing offshore brownfield projects, supported by established capabilities in engineering, safety management, and regulatory compliance. 2. The presence of completed offshore infrastructure, such as operational platforms, pipeline systems, processing facilities, and integrated utilities, supports the implementation of brownfield projects by eliminating the need to initiate development from the ground up. 3. The project team possesses multidisciplinary expertise encompassing mechanical, process, electrical, integrity, and project management domains. 4. The team has established familiarity in coordinating and collaborating with both vendors and regulatory authorities. 5. Financial backing from corporate entities and joint venture partners provides the company with the capacity to advance brownfield projects even amid volatility in oil and gas prices.	1. The persistence of several manual processes that remain unintegrated with digital systems slows information flow and interfunctional coordination, thereby prolonging decision-making in offshore brownfield projects. 2. Delays frequently occur in procurement and logistics activities, primarily driven by extended lead times associated with specialized equipment. 3. A portion of the current equipment is approaching the end of its service life, leading to reduced operational reliability. 4. Challenges persist in achieving alignment between internal teams and EPC contractors or overseas vendors, particularly in relation to design standards and documentation. 5. The constrained availability of human resources represents a significant impediment to offshore brownfield project implementation.

	6. The health, safety, and environment management framework is aligned with internationally recognized standards, including API, OSHA, and ISO. 7. Safety case requirements and Management of Change (MOC) procedures are implemented with rigorous enforcement. 8. Incident reporting is conducted through the Synergilife system, enabling the effective dissemination of lessons learned.	6. Project priorities may periodically shift in response to evolving corporate directives.
O-OPPORTUNITY	STRATEGY-SO	STRATEGY-WO
1. Brownfield projects provide a cost-efficient approach for enhancing production capacity. 2. Regulatory support from SKK Migas and KESDM encourages production optimization initiatives while maintaining a strong emphasis on safety priorities. 3. There is a significant opportunity to establish partnerships with technology firms and international vendors to support project development. 4. Residual potential remains in marginal or stranded gas reserves located near existing facilities, which can be developed through the utilization of current infrastructure. 5. The implementation of advanced compressor control systems and AI-driven predictive maintenance, along with the application of digital twin technology for real-time monitoring, operational scenario simulation, and decision optimization, supports more effective project execution.	1. Leveraging extensive experience in brownfield project management and offshore infrastructure to develop and implement digital twin technology and AI-based predictive maintenance to improve production efficiency as a more cost-effective brownfield solution and optimize marginal or stranded gas development around existing facilities. (S1, S2, O1, O4, O5) 2. Utilizing cross-disciplinary team competencies and experience working with vendors and regulators to build strategic collaborations with technology companies and international vendors in the development of real-time monitoring systems, digital compressor optimization, and data-driven offshore operating system integration. (S3, S4, O3, O5) 3. Utilize financial support from the company and joint ventures to invest in digital technologies that improve operational efficiency and production optimization, thereby ensuring the sustainability of brownfield projects. (S5, O1, O5) 4. Using an international standard HSE system, strict implementation of safety cases and MOCs, and the Synergilife incident reporting system to support government policies in optimizing production while prioritizing safety through the strengthening of digital-based monitoring and reporting systems. (S6, S7, S8, O2)	1. Leveraging advances in digital technology and AI to build an integrated project management system to reduce silos between teams and accelerate the approval and execution of work, ensuring that brownfield projects remain efficient and cost-effective. (W1, O1, O5) 2. Utilizing opportunities for cooperation with technology companies and international vendors to develop digital procurement and logistics systems in order to reduce delays in procurement and long lead times for specialized equipment. (W2,O3) 3. Utilizing digital technologies such as predictive maintenance and digital twins to monitor the condition of aging equipment and improve operational reliability in support of production optimization. (W3, O2, O5) 4. Using collaboration with international technology vendors and global standard-based digital systems to improve design and documentation alignment between internal teams and EPC/overseas vendors. (W4,O3,O5) 5. Utilizing automation technology, real-time monitoring, and digital simulation to overcome limitations in human resources and maintain project flexibility when corporate priorities change, so that business operations run efficiently and sustainably. (W5, W6, O1, O5)
T-THREATS	STRATEGY-ST	STRATEGY-WT
1. Adverse and severe weather conditions. 2. Disruptions affecting global supply chain networks. 3. Fluctuations in oil and gas prices have a substantial influence on the economic feasibility of brownfield projects. 4. A highly competitive market environment. 5. Rival firms demonstrate faster adoption of digitalization initiatives and low-carbon solutions. 6. Modifications to PSC frameworks, taxation policies, or licensing requirements may lead to higher costs or prolonged project schedules.	1. Utilizing extensive experience in brownfield project management and joint venture financial support to implement a digital-based economic evaluation system to maintain project feasibility amid oil and gas price fluctuations. (S1, S5, T3) 2. Leveraging the competencies of a multidisciplinary team and experience working with vendors and regulators to accelerate the implementation of digital innovation and increase competitiveness against competitors who are transforming more quickly. (S3, S4, T4, T5) 3. Utilizing the Synergilife-based incident reporting system, as well as experience working with vendors, to build a digital-based risk assessment and supply chain management system to reduce the impact of global supply chain disruptions. (S4, S8, T2)	1. Implementing a digital asset integrity and predictive maintenance system to improve the reliability of aging equipment so that projects remain economically viable amid fluctuations in oil and gas prices. (W3, T3) 2. Developing a digital-based collaboration and document control platform to reduce internal silos and coordination issues with EPC/vendors so that the company can be more competitive. (W1, W4, T4) 3. Implementing a data-driven project planning and control system to mitigate the impact of corporate priority changes and anticipate changes in PSC regulations and licensing. (W6, T6)

Based on the results of the TOWS, the offshore brownfield project development strategy emphasizes the utilization of the company's internal strengths, such as project management experience, existing infrastructure, multidisciplinary team competencies, and funding support to encourage the implementation of digital twins, AI-based predictive maintenance, real-time monitoring systems, and data-based economic evaluations to improve efficiency, operational reliability, and production optimization, including the development of marginal gas around existing facilities. At the same time, weaknesses such as inter-team silos, procurement delays, aging equipment, and human resource constraints are addressed through a digital-based integrated project management system, collaboration platforms, and enhanced predictive maintenance, while various threats such as extreme weather, global supply chain disruptions, price fluctuations, industry competition, and regulatory changes are minimized through risk assessment and data-driven project planning.

5 Conclusion

The DEMATEL research results show Facilities Factors as the most important, followed by Environmental Factors, Additional Concerns from Stakeholders, and Health and Safety, confirming the interrelationship between environmental aspects, stakeholders, and health and safety in digital innovation. Causally, Site-Specific Risk is the main driving factor with support from Additional Concerns from Stakeholders, while other factors are more influenced but remain crucial for innovation integration. SWOT–TOWS analysis show that leveraging internal strengths, optimizing external opportunities, and mitigating weaknesses through digital twins, AI-based predictive maintenance, and real-time monitoring systems improve project efficiency, reliability, and competitiveness. Thus, the integration of strategic factors and digital innovation is key to the sustainability of the oil and gas business in offshore brownfield projects and opens up opportunities for further research.

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