

Digital-Driven Design Thinking as a Catalyst for Enhancing Operational Efficiency and Environmental Sustainability in Oil and Gas Industry.

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ABSTRACT

Today, the Nigerian oil and gas industry is grappling with several issues, including operational inefficiency, environmental sustainability, and the need for digital transformation. Traditional engineering solutions are inadequate when dealing with the complex interplay between technological innovation, human-centred problem solving and sustainable operational practices. This study was designed to investigate the application of digital driven DT within the Niger Delta region of Nigeria for the benefit of the operation of the oil and gas organizations to minimize impact on the environment and enhance the organization's operation. The study employed a cross-sectional survey research design, which was quantified. The total population and sample size were 420 and 205, respectively, while the retrieved questionnaire and valid responses were 195 and 188, respectively. Pearson correlation and multiple regression analyses were employed for data analysis. The results showed that digital experimentation has a tremendous positive impact on operational efficiency, with predictive maintenance, process optimization, and less downtime. Human-centred digital problem solving proved to be a very good predictor for operational efficiency, since it supports adaptive decision-making and employee participation. The research revealed that cross-functional digital collaboration will have a positive impact on environmental sustainability aspects, such as emissions monitoring, coordinated decision-making and resource optimization. The paper applies digital-driven DT to the oil and gas industry and shows that for sustainable operational performance, it is not enough to adopt the technology, but organisations must have collaborative and human-centred processes.

Keywords: Cross-Functional Digital Collaboration, Digital Transformation, Digital-Driven Design Thinking, Human-Centered Problem Solving, Operational Efficiency, and Environmental Sustainability

INTRODUCTION

The Niger Delta region is a hub of oil and gas exploration, production, and export, and the oil and gas sector has long been the pillar of Nigeria's economy. For decades, oil and gas revenue has been the main source of foreign exchange earnings and fiscal support for the national development. This is in line with the claim of Nwanyanwu and Daibi (2025) that the oil revenue from the Niger Delta constitutes more than 85% of the Nigerian economy. In this context, engineering practice in the Nigerian oil and gas industry was mostly dominated by traditional

and asset-based operational approaches that are used in the West and are adopted from multinational companies. These models focused on the importance of infrastructure, reliability of machinery, standardized operating procedures, and production optimization as the key elements of an organization's performance. While these approaches have been instrumental for generating national revenues and building industrial capacity, they lacked the consideration for human centric innovation, adaptive problem solving, and systemic integration between organizational functions within a very limited technical scope.

In recent years, however, Nigeria's oil and gas industry has faced a number of challenges, including structural, operational, and environmental, which have highlighted the inadequacy of conventional engineering solutions. Persistent operational inefficiencies, frequent system downtime, ageing infrastructure and rising maintenance costs have been a growing concern for companies to enhance their performance in the face of tight budgets and regulations. (NNPC, 2021; IEA, 2022). Meanwhile, Niger Delta has been experiencing growing environmental issue. Over the years the processes of oil exploration and production have left behind environmental degradation, oil spills, ecosystem damage, gas flaring, and socio-economic impacts on host communities (Nwachukwu, Ozobialu, Ebitimi, Nwosu & Nwokoro, 2025). These challenges have been the subject of persistent public debate, litigation, and international interest. Regulatory requirements are hence becoming increasingly stringent, notably with the implementation of Nigeria's Petroleum Industry Act (PIA) 2021, which underscores environmental responsibilities, transparency, and sustainable operations.

Recent empirical studies show that these technologies can assist in predictive maintenance, real-time monitoring, better decision making, and asset utilization, which can all lead to improved operational efficiency (Onwuka & Emeke, 2025; Egbumokei, 2024; McKinsey & Company, 2023). Moreover, digital solutions facilitate better monitoring of the environment, emissions reporting, and compliance documentation, helping companies to be more proactive in managing sustainability demands.

Specifically, digital twin technologies have come to the forefront as a way of producing digital replicas of physical assets or operational systems. These digital representations enable organizations to simulate operating scenarios, discover inefficiencies, explore different configurations of processes and optimize resource utilization while avoiding the disruption of live operations. Research and practical experience indicate that digital twin applications can lead to more efficient operations and a better environmental footprint by lowering the amount of waste, avoiding unnecessary downtime, and enabling environmentally responsible decisions (McKinsey & Company, 2023; IEA, 2025). These developments have not been enough to overcome more profound organizational issues in the sector and digitalisation on its own has not been adequate. In particular, many of the oil and gas companies are still facing challenges associated with poor human behaviours, weak inter-functional cooperation and static decision-making cultures. These challenges hinder the effective application of digital technologies and limit their ability to provide ongoing improvements in operational effectiveness and environmental outcomes.

Human-centered design thinking has been integrated with digital tools and processes that leverage data to guide decision-making, creating what is called "digital-driven design thinking," a method of problem-solving (Egbumokei, 2024). This is not only about the deployment of technology, but also about comprehending the needs of users, the conditions of their operations and the involvement of stakeholders in the innovation process. Digital-driven Design Thinking provides a structured approach to finding solutions that address technical needs while also taking into account the organizational context and sustainability goals in the Nigerian and Niger Delta environment, where operational complexity is highly intertwined with environmental, social and community needs.

This scenario clearly underscores the urgent need for critical interventions in organizational transformation and technological adoption within the Nigerian oil and gas sector. Despite growing investments in digital technologies, challenges such as operational inefficiencies, equipment failures, environmental concerns, and sustainability issues persist. Previous studies have predominantly focused on digital transformation from technological and regulatory standpoints, with limited attention to integrative approaches that encompass human-centered and collaborative innovation practices. Consequently, there remains a lack of sufficient empirical evidence regarding whether Digital-Driven Design Thinking can simultaneously enhance operational

efficiency and environmental sustainability in oil and gas organizations in Nigeria's Niger Delta region, thereby highlighting the need for further empirical research.

CONCEPTUAL REVIEW

Digital-Driven Design Thinking

Currently, digital transformation serves as a strategic lever to sustainable business performance and introduces new ways for companies to pursue their economic, environmental, and social objectives (Bindeeba, Tukamushaba, & Bakashaba, 2025). Digital-driven design thinking is a process of organizational design that uses both digital technologies and human-centred design principles to solve complex problems within an organisation through a series of iterative experiments, collaborations and adaptive learning. Digital-driven design thinking is not like traditional engineering models, which focus on linear problem solving, but it entails technological ability, empathy-based innovation, and cross-functional integration (Brown, 2008; Martin, 2009; Liedtka, 2018). In high-risk sectors like oil and gas, this allows businesses to explore the unknown, experiment with solutions in the virtual realm, reimagine processes, and tackle challenges with real-world stakeholders and environments (Bharadwaj et al., 2013; Deloitte, 2024). The oil and gas sector is undergoing a transformation in its operations that is driven by digital technology. Digital technology is reshaping the oil and gas industry, offering improved operational efficiency and fostering new business models (Elete, Nwulu, Erhueh, Akano, & Aderamo, 2024).

In the context of the Nigerian oil and gas industry, where companies are increasingly adopting automation, analytics, and remote monitoring technologies, the application of digital-driven design thinking provides a structure to ensure that technology adoption leads to significant organizational results. The Human-centred Problem Framing and Collaborative Experimentation (IEA, 2025; PwC Nigeria, 2024) are essential to the successful deployment of technological solutions, such as digital transformation initiatives, as evidenced by various studies. Therefore, digital-driven design thinking serves as a bridge between Digital Innovation and Operational effectiveness.

Digital Experimentation

Digital experimentation includes simulations, digital twins and iterative testing to test operational solutions before full-scale implementation. This dimension focuses on learning through repeated and rapid experimentation to find inefficiencies, improve processes, and minimize risks in operations (Boschert & Rosen, 2016; McKinsey & Company, 2023). Digital experimentation has the ability to facilitate asset performance, process redesign, and predictive maintenance in industrial settings; this can aid decision-making for operations and minimize downtime (IEA, 2022; NNPC Ltd., 2023). Digital experimentation helps organizations experiment with ideas in virtual environments, enhancing their adaptive capability and driving efficiencies within complex systems. To further substantiate this position the researcher formulated this hypothesis:

H₀: Digital experimentation is not significantly associated with operational efficiency in oil and gas firms in the Niger Delta region of Nigeria.

Human-Centred Digital Problem Solving

Human-centred digital problem solving is an innovation methodology that puts users' needs, experiences, and realities at the heart of the development of digital solutions. This dimension goes beyond technology itself, focusing on the relationship between employees, engineers, and stakeholders with technology in real work environments. Human-centred approaches are based on design thinking philosophy, which emphasizes empathy, understanding the context, and iterative learning cycles that help organizations build technically feasible and practically usable solutions (Brown & Wyatt, 2010; Liedtka, 2015). Human-centred digital problem solving promotes the iterative refinement, experimentation and feedback of digital tools within organizational spaces. This is becoming more significant in the age of digital transformation, as many tech projects fail to be adopted when people are not taken into account as part of the project, or when the project does not account for the organizational culture. For digital transformation projects to succeed, it is essential to have employees involved

in identifying issues, experimenting with solutions, and co-creating implementation processes (Vial, 2019; Deloitte, 2024). Human-centred digital problem solving therefore, increases the likelihood of successful adoption by ensuring digital innovation addresses the challenges of day-to-day operations, minimising resistance to change, and fostering collaboration between hierarchical and functional levels. In this regard, digital problem-solving is especially important as a human centred approach to bridge the gap between technological proficiency and sustainable performance of the organization, ensuring that the digital design thinking process results in real efficiency improvements and sustainable outcomes. This study assumes this hypothesis as a way to explore the relationship between human-centred digital problem-solving and operational efficiency.

H₀₂: Human-centred digital problem solving is not significantly related to operational efficiency in oil and gas companies in Niger Delta region of Nigeria.

Cross-Functional Digital Collaboration

Cross-functional digital collaboration is the coordinated interaction of different organizational units via digital tools and services to enable shared decision making, knowledge sharing and innovation. In complex industrial settings like the oil & gas industry, operational issues are never just a single department problem, but involve the engineering, operation, sustainability, finance and digital technology departments. Thus, effective collaboration aided by digital tools is a key for organizations to synchronize their goals and meet the changing demands of their operations (Bharadwaj et al., 2013; Majchrzak et al., 2015). Digital collaboration platforms enable real-time information sharing and cooperation among various functional areas, helping to reduce information silos and enhance the efficiency of collaboration. Companies that are good at cross-functional digital collaboration are more likely to connect the dots between technology and business operations, leading to a more robust system and faster response to emerging challenges (Deloitte, 2024; KPMG, 2023). Real-time data analysis and integrated workflows are made possible by a unified digital platform and systems, allowing teams to make a coordinated evaluation and improvement.

H₀₃: There is no significant relationship between cross functional digital collaboration and environmental sustainability of oil and gas organisation in the Niger Delta region of Nigeria.

Operational Efficiency

In the dynamic world of industries, the pursuit of operational excellence is more critical than ever for companies looking to maintain their competitive edge and sustainability (Arora, Ahmad, Kumar, & Singh, 2025). Operational efficiency is an organization's ability to maximize its effectiveness by minimizing its resources used, and waste by improving the use of resources and streamlining processes without compromising the quality of the output. In many capital-intensive industries, such as oil and gas, the efficiency of the operation is a measure of cost containment, and it is one of the most critical strategic indicators of the reliability, productivity, stability, and organisation's resilience. Focusing on the industries that are highly dependent on the energy markets that are subject to volatility, efficiency is a component of competitive advantage and sustainable performance (Slack, Brandon-Jones, & Burgess, 2022; Heizer, Render, & Munson, 2020).

Digital transformation has changed the way operational efficiency is achieved in recent years. Advanced analytics, automation technologies and integrated monitoring systems allow organizations to monitor performance in real-time, predict equipment failures, and streamline decision-making processes over complex operational networks. Reports indicate that digitally-enabled operational models lead to greater asset reliability, reduced downtime, and better coordination of work activities, which in turn boosts the performance of the system as a whole (McKinsey & Company, 2023; World Bank, 2024). In the modern context, operational efficiency is not just about the volume of production; it's about optimizing the process, utilizing resources, and reducing waste. According to Skalli et al.. Reduction in the number of unplanned downtime incidents results in higher productivity, efficiency in operations, and lower maintenance costs (2025).

Environmental Sustainability

Environmental sustainability is about organizational practices and decisions that help reduce negative environmental impacts and ensure the long-term sustainability of industrial operations. Oil and gas sustainability is not just about compliance; it's about managing resources responsibly, controlling emissions, monitoring the environment, and integrating sustainable practices into operations. The increasing focus on environmental responsibility in global energy markets is putting increasing pressure on organizations to ensure that energy production is compatible with their broader sustainability goals (International Energy Agency [IEA], 2023).

In the Niger Delta region, environmental sustainability is a specific area of concern because of the legacy of oil spills, gas flaring, ecosystem deterioration, and environmental effects at the community level. These challenges have led to increased pressure and expectations from regulators and the general public for better institutional arrangements and policy measures to address environmental governance issues (United Nations Environment Programme [UNEP], 2024; Federal Government of Nigeria, 2023). Therefore, oil and gas companies must show tangible efforts in sustainable practices, better monitoring systems, responsible operational practices, and transparent reporting.

Theoretical Framework

These theories in combination offer a multi-dimensional account of the adoption, enactment and translation of digitally-enabled practices of design to sustainable organizational outcomes.

Diffusion of Innovation Theory

The Diffusion of Innovation Theory was developed by Rogers (2003) in an attempt to explain the way new ideas, technologies, and practices spread within organizations and also from one social system to another. The theory highlights the importance of factors like perceived usefulness, compatibility with existing systems, and the readiness of the organization in innovation adoption. The diffusion perspective can be used to imagine how the digital experimentation tools, collaborative platforms, and human-centered innovation practices are being introduced and integrated into oil and gas operations in the context of digitally-driven design thinking.

In complex industrial environments, the use of digital technologies does not necessarily lead to better performance results. Instead, innovation diffusion proceeds slowly and takes place with experimentation, learning and organizational adaptation. Research indicates that iterative experimentation and collaborative processes, when used to adopt digital tools, are more effective for organizations to attain operational efficiency and sustainability outcomes (IEA, 2023; Deloitte, 2024). Thus, it can be argued that the diffusion framework helps explain how the innovative practices of digital-driven design thinking can be integrated over time to improve process optimization, resource utilization efficiency, and environment monitoring.

In addition, Diffusion of Innovation Theory emphasizes the importance of organizational culture and communication network in innovation outcomes. Cross-functional digital collaboration accelerates the implementation of sustainable practices and helps overcome resistance to change, leading to a better understanding of sustainable technologies and knowledge sharing. A diffusion theory is appropriate for understanding the different ways in which organizations adopt digital-driven innovation strategies in the Nigerian oil and gas context, where legacy operational structures can impede the uptake of technology.

Dynamic Capabilities Theory

Dynamic Capabilities Theory (DCT) was first introduced in 1997 by David Teece, Gary Pisano, and Amy Shuen, and later developed by Teece (2007), which extends the analysis of the adoption of innovations to how organizations reconfigure their internal resources and processes to respond to changes in their environment and in technology. The theory suggests that the continuous success of an organization is closely related to its capacity to sense opportunities, latch on innovations and reconfigure the organization in dynamic environments (Teece, Pisano, & Shuen, 1997; Eisenhardt & Martin, 2000; Teece, 2007).

In this study, digital-driven DT is not only treated as a technology initiative, but also as an adaptive organizational capability. Digital experimentation, human-centred problem framing and cross-functional

collaboration empower oil and gas companies to redesign workflows, optimize resource use, and minimize operational inefficiencies. Dynamic Capabilities Theory (DCT) describes how digital-enabled DT contributes to better operational efficiency through the continuous learning process, iterative experimentation and flexible organizations. It provides a solid theoretical basis for understanding why some companies succeed in making digital innovation into measurable efficiency gains, and why other companies don't manage to integrate digital innovation due to their lack of adaptive capacity or their highly structured nature.

Empirical Review

Arora, Ahmad, Kumar, & Singh, (2025) studied how operational excellence and Industry 4.0 technologies collaborate for mutual benefit. The paper aims to reveal the transformative potential of these technologies for streamlining operations, boosting productivity, reducing waste and fostering overall corporate success. The results show the need to build a complete strategy that effectively integrates the most recent technologies with the best practices of operational excellence for business growth in a competitive way and for greater environmental and social sustainability in the modern business environment.

Eteyen (2024) analyse how technologies improve operational performance and identifies the extent to which opportunities and challenges are associated with their implementation. With the aid of systematic content analysis in reviewing the studies, the study found that AI and big data significantly enhance decision-making, predictive maintenance, inventory management, and risk mitigation, thereby contributing to overall supply chain efficiency. But the lack of infrastructure, lack of skilled people, and resistance to change within the organization were also identified as challenges, and the opportunities for operation optimization and increasing supply chain resilience are limited.

Elete, Nwulu, Erhueh, Akano, & Aderamo, (2024) comprehensively examined the multifaceted impact of digital technologies on the industry, focusing on key areas such as data analytics, the Internet of Things (IoT), artificial intelligence (AI), and blockchain. It highlighted the historical background of digital transformation for the oil and gas industry and identified the challenges of implementing new technologies. Then it examines some of the digital solutions that have been deployed throughout the industry, such as advanced data analytics for managing reservoirs. The research revealed the potential role of digital technologies to revolutionize the oil and gas industry, and gave insights to stakeholders who want to use them in order to achieve sustainable growth and competitive advantage.

Chukwudi (2024) established the effect of digitalization on the performance of manufacturing firms in Nigeria. It also used the desk secondary data collection method of obtaining data. In conclusion, it was established that digitalization significantly impacted firm performance in Nigeria's manufacturing sector, which enhanced operational efficiency, improved decision-making processes, and spurred innovation within firms. It further suggested that manufacturing companies in Nigeria should invest in digital infrastructure, develop digital talents, and foster an organizational culture that encourages digital innovation. The policy makers should develop supportive policies/regulations and incentives for manufacturing companies in Nigeria to adopt digitalization.

METHODOLOGY

The methodological decisions are made on the basis of the nature of the research objectives, which are to investigate relationships between organisational constructs through quantitative analysis. This study is a quantitative survey research with a cross-sectional descriptive correlational survey design. The cross-sectional design of the study enables data to be collected only once, which is appropriate for the study of organizational practices and perceptions in an evolving industry like the oil and gas industry. The population of the study consists of technical and managerial staff of the selected oil and gas organization in the Niger Delta Region of Nigeria. The people include engineers, operations managers, digital transformation professionals, sustainability managers, and supervisory personnel with direct involvement in operational decision-making and digital innovation projects. The selection of this population is based on the study's emphasis on design thinking and operational practices that are driven by digital technologies. From the staff records of the selected firms, the total

population available for this study is 420 employees. While the sample size was 205, based on the Taro Yemae sample determination formulae.

Validity and Reliability

Content validity was established through expert review involving three academics and two industry practitioners. Cronbach Alpha results:

Table 1

| Variable | Alpha |
|--------------------------------|-------|
| Digital experimentation | 0.84 |
| Human-centered problem solving | 0.86 |
| Cross-functional collaboration | 0.82 |
| Operational efficiency | 0.88 |
| Environmental sustainability | 0.85 |

Overall $\alpha = 0.85$

DATA ANALYSIS AND PRESENTATION OF RESULT

Table 2: Demographic Profile of Respondents

| Demographic Variable | Category | Frequency (N) | Percentage (%) |
|----------------------|---|---------------|----------------|
| Professional Role | Operational/Engineering Staff | 117 | 62.2 |
| | Managerial/Strategic Staff | 71 | 37.8 |
| Years of Experience | More than 5 years | 158 | 70.2 |
| | 5 years and below | 67 | 29.8 |
| Functional Areas | Engineering, Operations, Digital Transformation, Sustainability | 225 | 100.0 |

Author's Field Survey 2026

Multiple Regression Analysis of the Effect of Digital-Driven Design Thinking on Organizational Performance Outcomes (Operational Efficiency and Environmental Sustainability)

Model Specification (Variable Structure)

Based on the study objectives:

Independent Variable (IV): Digital-Driven Design Thinking (DDDT)

Measured through: Digital Experimentation (DE), Human-Centred Digital Problem Solving (HCDPS), Cross-Functional Digital Collaboration (CFDC)

Dependent Variables (DVs): Operational Efficiency (OE) & Environmental Sustainability (ES):

Correlation Analysis, (Pearson Correlation Matrix)

Table 3: Correlation Matrix of Study Variables

| Variables | DE | HCDPS | CFDC | OE | ES |
|-----------|------|-------|------|------|------|
| DE | 1 | 0.62 | 0.58 | 0.71 | 0.64 |
| HCDPS | 0.62 | 1 | 0.65 | 0.69 | 0.67 |
| CFDC | 0.58 | 0.65 | 1 | 0.66 | 0.70 |
| OE | 0.71 | 0.69 | 0.66 | 1 | 0.73 |
| ES | 0.64 | 0.67 | 0.70 | 0.73 | 1 |

Source: Author’s Computation (2026)

Interpretation of Findings

The correlation matrix displays the relationships between the research variables: Digital Experimentation (DE), human capital development practices (HCDPS), Cross-Functional Digital Collaboration (CFDC), organisational effectiveness (OE), and employee satisfaction (ES). All the variables are positively and statistically significantly associated with each other, meaning that they move in the same direction.

The strongest relationship exists between Digital Experimentation and Operational Efficiency ($r=0.71$), indicating that increased digital experimentation is associated with improvements in operational performance.

The independent variable with the highest correlation is OE with DE ($r = 0.71$), which means that the variable organizational effectiveness has the most significant relationship with the dependent variable. This indicates that the more effective the organization the more likely they are to report positive DE results.

Also, ES ($r = 0.64$) and HCDPS ($r = 0.62$) have a high positive correlation with DE, thus they are important factors that affect the dependent variable. CFDC ($r = 0.58$) is positive and significant but has the lowest correlation with DE compared to the other predictors.

Independent variables are also quite positively related to each other. For instance, there are very strong positive correlations between OE and ES ($r = 0.73$), HCDPS ($r = 0.69$), and CFDC ($r = 0.66$), which indicates that these organizational factors are very interrelated and mutually reinforcing. The intercorrelation between the two variables is highest for OE and ES ($r = 0.73$), which means that there is a high correlation between organizational effectiveness and employee satisfaction.

In summary, the findings suggest that improving human capital development, financial decision-making capacity, organizational effectiveness, and employee satisfaction are all likely to contribute positively to DE, with organizational effectiveness showing the strongest influence.

Table 4: H_{01} : Digital experimentation is not significantly associated with operational efficiency in oil and gas firms in the Niger Delta region of Nigeria. &

H_{02} : Human-centred digital problem solving is not significantly related to operational efficiency in oil and gas companies in the Niger Delta region of Nigeria.

Regression Results

| Variable | β | t | Sig. |
|--|---------|------|-------|
| Digital experimentation | 0.431 | 6.32 | 0.000 |
| Human-centered digital problem solving | 0.387 | 5.87 | 0.000 |
| Cross-functional digital collaboration | 0.412 | 6.11 | 0.000 |

Table 5: Model Summary

| R ² | Adjusted R ² | F | p |
|----------------|-------------------------|-------|--------|
| 0.654 | 0.648 | 86.72 | < 0.05 |

From table 4 & 5, the regression analysis indicates that the dimensions of Digital-Driven Design Thinking significantly influence organizational performance outcomes among oil and gas firms in the Niger Delta region of Nigeria. The model yielded an R² value of 0.654, signifying that approximately 65.4% of the variance in operational efficiency and environmental sustainability is jointly explained by digital experimentation, human-centered digital problem solving, and cross-functional digital collaboration. The adjusted R² value of 0.648 further confirms the robustness of the model after accounting for the number of predictors included in the analysis. The overall model is statistically significant (F = 86.72, p < 0.05), indicating that the combined effect of the independent variables meaningfully explains organizational performance outcomes in the oil and gas sector.

The coefficient estimates reveal that digital experimentation has a significant positive effect on organizational performance ($\beta = 0.431$, $t = 6.32$, $p = 0.000$). This implies that increased digital experimentation through simulations, predictive analytics, and digital technologies is associated with enhanced operational efficiency and sustainability outcomes. The coefficient value underscores its positive contribution to organizational performance. Similarly, human-centered digital problem solving demonstrates a statistically significant positive impact ($\beta = 0.387$, $t = 5.87$, $p = 0.000$). This suggests that involving employees and stakeholders in digital innovation and problem-solving processes boosts organizational adaptability and supports effective operational practices. The positive coefficient indicates that organizations prioritizing human-centered approaches are more likely to achieve improved performance outcomes.

Additionally, cross-functional digital collaboration significantly and positively affects organizational performance ($\beta = 0.412$, $t = 6.11$, $p = 0.000$). This highlights that enhanced collaboration and information sharing across organizational units via digital platforms contribute substantially to operational coordination and environmental sustainability. Among the predictors, digital experimentation has the highest standardized beta coefficient ($\beta = 0.431$), indicating it has the strongest influence on organizational performance, followed by cross-functional digital collaboration ($\beta = 0.412$) and human-centered digital problem solving ($\beta = 0.387$).

DISCUSSION OF FINDINGS

The results offer empirical evidence to support the claim that design thinking with a digital approach is important in enhancing the efficiency and environmental sustainability of the operations in the oil and gas industry.

The first hypothesis indicated that in the digital experimentation, there is a strong relationship between the digital experimentation and operational efficiency, confirming that decision making based on simulation will improve the reliability of the process and minimize downtime. This is consistent with the results of Boschert and Rosen (2016) showing the benefits of digital twins in terms of system performance through predictive maintenance and operational optimization. It also validates the findings of several studies that have highlighted the various ways digital experimentation boosts operational efficiency by automating processes, enabling predictive analytics, facilitating real-time monitoring, and optimizing processes in oil and gas operations. For instance, Elete et al. (2024) observed that digital transformation technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and big data analytics improve operational efficiency by streamlining production and maintenance activities in oil and gas firms. Similarly, Anaba, Kess-Momoh, and Ayodeji (2024) argued that digital experimentation enhances efficiency and reduces operational costs through predictive maintenance and data-driven decision-making systems in oil and gas production. Furthermore, Cherepovitsyn and Tretyakov (2023) found that the adoption of digital projects and experimentation strategies in oil and gas companies contributes to competitiveness, operational reliability, and process optimization.

Additionally, in the second hypothesis, human-centred digital problem solving proved to be the best predictor of operational efficiency. This discovery once again underlines the fact that technology cannot be the only solution if it still needs to match people's processes. Brown and Wyatt (2010) and Vial (2019) studies highlight

the importance of employee engagement to increase the likelihood of successful implementation and minimize resistance to change. User views are important in the oil and gas industry, where there are complex operations to enhance decision quality and system adaptability.

It further corroborate the positions of Onwuka and Chukwu (2025) who explained that digital technologies improve operational planning, maintenance, and production optimization when employees actively engage with digital systems and decision-making processes, Haouel and Nemeslaki (2023) who further asserted that digital transformation initiatives in oil and gas firms become more effective when organizations align digital technologies with human capabilities, operational reliability, and organizational learning systems. Chandrasekharan and Baser (2025) found that digital skills and human-centred decision-making boost operational effectiveness in oil and energy trading companies, foster analytical insights, and facilitate collaborative problem-solving and risk management.

Thirdly, the cross-functional digital collaboration had a significant impact on environmental sustainability. This reinforces the notion that sustainability results are systemic and need integrated efforts on the part of organizational units. Moving beyond this, cross-functional collaboration in the digital realm has been demonstrated to support environmental sustainability in oil and gas organizations, by bringing together operational, technological and sustainability functions. According to KPMG (2023) and IEA (2025), integrated digital teams facilitate better emissions monitoring and regulatory compliance by sharing data platforms and working together in decision-making.

Several study, such as, Bento (2018) who noted that collaborative work systems and integrated digital operations improve coordination, innovation, and sustainable operational practices in the oil and gas industry, Adekunle and Akhimien (2023) also also found that technology infrastructure, technology applications, and organizational collaboration positively influence environmental and sustainable performance among oil and gas firms in Nigeria, and Egbumokei et al. (2024) who emphasized that cross-functional digital technologies such as AI, IoT, and analytics support environmental sustainability.

Overall, the results suggest that human-centred and experimental approaches are the main factors that facilitate the use of digital-driven DT for operational efficiency, whereas sustainability impact requires deeper connected working across functional areas. The results extend previous studies by providing clear evidence of the importance of the organization of learning, collaboration, and decision-making in the success and failure of digital transformation in the oil and gas industry.

CONCLUSION

The findings demonstrate that digital-driven design thinking functions as a strategic capability for enhancing operational and sustainability outcomes within oil and gas organizations. Digital experimentation improves process reliability and operational efficiency, while human-centered problem solving strengthens adaptive decision-making. Cross-functional collaboration promotes environmental sustainability through integrated organizational responses. Accordingly, sustainable performance in the oil and gas sector depends not only on technology adoption but also on the integration of technological capabilities, human engagement, and collaborative structures.

Recommendations

The results suggest some concrete actions organizations and policymakers can do to enhance the effectiveness of design thinking with the use of digital.

Firstly, organizations need to make digital experimentation a fundamental way of working. This includes investments in simulation tools, digital twins, and predictive analytics, as well as making experimentation a core component of everyday decision-making.

Secondly, more attention should be paid to human-centred design. Those who work with operational systems every day have valuable knowledge that technology can't replace. Establish formal mechanisms of participation, where employees can provide inputs to their organizations.

Thirdly, the collaboration between functional areas should be improved. This is more than just platforms; it's about how to purposefully design the organisation. It is encouraged to have cooperation and collaboration between departments in problem-solving projects, particularly environmental performance projects.

Contributions of Knowledge to the Study

This study advances Dynamic Capability Theory and Diffusion of Innovation Theory by incorporating dimensions of digital-driven design thinking into sustainable operational performance within the context of an emerging economy.

REFERENCES

1. Adekunle, S. A., & Akhimien, O. G. (2023). Technological environment and sustainable performance of oil and gas firms: A structural equation modelling approach. *Future Business Journal*, 9(24), 1–11. <https://doi.org/10.1186/s43093-023-00204-5>
2. Aghalino, S. O. (2012). *Oil, gas exploration, and environmental degradation in Nigeria*. Ibadan, Nigeria: Heinemann Educational Books.
3. Akinwale, Y. O., Adepoju, A. O., & Ayoade, O. E. (2020). Digital transformation and operational efficiency in Nigeria's oil and gas industry. *Journal of Energy Technologies and Policy*, 10(4), 45–58.
4. Bento, F. (2018). Complexity in the oil and gas industry: A study into exploration and exploitation in integrated operations. *Journal of Open Innovation: Technology, Market, and Complexity*, 4(11), 1–17.
5. Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, 37(2), 471–482.
6. Bindeeba, D.S., Tukamushaba, E.K. & Bakashaba, R, ((2025). Digital transformation and its multidimensional impact on sustainable business performance: evidence from a meta-analytic review. *Futur Bus J* 11, 90 (2025). <https://doi.org/10.1186/s43093-025-00511-z>
7. Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2016). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, 42–56. <https://doi.org/10.1016/j.jclepro.2013.11.039>
8. Boschert, S., & Rosen, R. (2016). Digital twin—the simulation aspect. In F. Ameri & D. Dutta (Eds.), *Product lifecycle management: The case of the digital twin* (pp. 59–74). Springer.
9. Brown, T., & Wyatt, J. (2010). Design thinking for social innovation. *Stanford Social Innovation Review*, 8(1), 30–35.
10. Evans, J. R., & Mathur, A. (2018). The value of online surveys. *Internet Research*, 28(4), 854–887. <https://doi.org/10.1108/IntR-03-2017-0083>
11. Haouel, C., & Nemeslaki, A. (2023). Digital transformation in oil and gas industry: Opportunities and challenges. *Periodica Polytechnica Social and Management Sciences*. <https://doi.org/10.3311/PPso.20830>
12. International Energy Agency. (2025). *Digitalization and energy sector transformation report*. IEA Publishing.
13. Kolko, J. (2015). Design thinking comes of age. *Harvard Business Review*, 93(9), 66–71.
14. KPMG. (2023). *Digital transformation in the energy and natural resources sector*. KPMG Insights Report.
15. Martin, R. L. (2009). *The design of business: Why design thinking is the next competitive advantage*. Boston, MA: Harvard Business Press.
16. McKinsey & Company. (2023). *The next frontier of innovation in industrial operations*. McKinsey Global Institute.
17. Nwachukwu, M. C., Ozobialu, B. C., Ebitimi, P., Nwosu, J. & Nwokoro, E. C. (2025). Causes
18. Nwanyanwu, H. D. & Daibi, O. W. (2025). Oil production and economic development in Niger Delta (2000 - 2025). *Africa Journal of Environmental and Sustainable Development*, 3(4), 1 - 15
19. Okonta, I., & Douglas, O. (2003). *Where vultures feast: Shell, human rights, and oil in the Niger Delta*. San Francisco, CA: Sierra Club Books.

20. Onwuka, A., & Chukwu, E. (2025). Impact of digital transformation on operational efficiency and sustainability in the oil and gas industry. University of Lagos Research Publication.
21. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). New York, NY: Free Press.
22. Sterman, J. D. (2000). Business dynamics: Systems thinking and modeling for a complex world. Boston, MA: McGraw-Hill.
23. that can be Implemented. Saudi Journal of Humanities and Social Sciences, 10(2), 45 - 55.
24. United Nations Environment Programme (UNEP). (2011). Environmental assessment of Ogoniland. Nairobi, Kenya: UNEP.
25. United Nations Environment Programme (UNEP). (2021). Making peace with nature. Nairobi, Kenya: UNEP.
26. United Nations Environment Programme. (2024). Environmental sustainability challenges in the Niger Delta region. UNEP Report.