

ARTIFICIAL INTELLIGENCE ADOPTION IN NIGERIA'S OIL AND GAS INDUSTRY: CHALLENGES, OPPORTUNITIES, AND IMPACT ON OPERATIONAL EFFICIENCY

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ABSTRACT

This study investigated the adoption of Artificial Intelligence (AI) in Nigeria's oil and gas industry, focusing on its challenges, opportunities, and impact on operational efficiency. A descriptive survey research design was employed, targeting employees, managers, and technical personnel across upstream, midstream, and downstream operations. A sample of 334 respondents was selected using stratified random sampling. Data were collected through a structured questionnaire and analyzed using descriptive and inferential statistics. The findings revealed that AI adoption is ongoing but partial, with predictive maintenance, automation, and monitoring being the most utilized applications. Major challenges identified include shortage of skilled personnel, inadequate digital infrastructure, high implementation costs, regulatory gaps, and cybersecurity concerns. Respondents also reported significant opportunities associated with AI, including improved operational efficiency, enhanced decision-making, cost reduction, safety management, and workforce development. Overall, AI adoption was found to positively impact operational efficiency, although full integration remains limited. The study recommends investment in digital infrastructure, workforce training, supportive policies, strategic AI deployment, and collaboration with technology partners to maximize the benefits of AI adoption.

Keywords: Artificial Intelligence, Oil and Gas Industry, Operational Efficiency, AI Adoption, Challenges, Opportunities, Nigeria

INTRODUCTION

Nigeria's oil and gas industry has remained the backbone of the country's economy for decades, contributing significantly to government revenue, foreign exchange earnings, and national development. However, the sector continues to grapple with persistent operational inefficiencies, including equipment downtime, high production costs, supply chain disruptions, and challenges in reservoir management (PwC, 2018). These issues have intensified the need for technological innovation to drive efficiency, safety, and sustainability in operations.

Artificial Intelligence (AI) is increasingly recognized as a transformative tool capable of addressing these challenges. AI technologies such as machine learning, natural language processing, and predictive analytics are being applied across the oil and gas value chain to optimize exploration, drilling, production, and distribution (Hanga & Kovalchuk, 2019). For instance, AI-driven predictive maintenance reduces equipment failure and downtime, while advanced data analytics improve reservoir modeling and production forecasting (Akinola et al., 2021).

Globally, the adoption of AI in the oil and gas industry has been linked to improvements in decision-making, reduced operational risks, and cost savings (Al-Fattah, 2020). In Nigeria, however, the pace of adoption remains relatively slow due to challenges such as inadequate digital infrastructure, limited technical expertise, cybersecurity concerns, and regulatory

bottlenecks (Ejiogu & Ogu, 2022). Despite these obstacles, the opportunities presented by AI — including enhanced productivity, real-time monitoring, and sustainable energy practices — position it as a strategic driver of efficiency and competitiveness for Nigeria's oil and gas sector (Okonkwo & Eze, 2023).

The exploration of AI adoption within Nigeria's oil and gas industry is therefore critical, not only for addressing operational inefficiencies but also for aligning the sector with global digital transformation trends. This study seeks to investigate the challenges, opportunities, and impacts of AI adoption on operational efficiency, providing insights that can guide stakeholders in policy formulation, capacity building, and strategic investment.

Statement of the Problem

The Nigerian oil and gas industry, despite being the country's major economic driver, continues to struggle with operational inefficiencies such as frequent equipment failure, high production costs, and poor reservoir management (PwC, 2018). Globally, Artificial Intelligence (AI) has proven effective in addressing these challenges by enhancing predictive maintenance, optimizing drilling, and improving production forecasting (Hanga & Kovalchuk, 2019; Al-Fattah, 2020). However, the adoption of AI in Nigeria remains slow, largely due to inadequate infrastructure, shortage of skilled manpower, cybersecurity risks, and regulatory hurdles (Ejiogu & Ogu, 2022). This has limited the sector's ability to keep pace with global industry standards and benefit from the efficiency gains AI offers.

Moreover, while research has highlighted the transformative role of AI in the global oil and gas sector, little empirical evidence exists on its specific applications, challenges, and opportunities within Nigeria. This knowledge gap hinders effective policy development, capacity building, and tailored AI integration in the industry (Akinola et al., 2021; Okonkwo & Eze, 2023). Without addressing these challenges, Nigeria risks lagging behind in digital transformation, perpetuating inefficiencies, and losing competitiveness in the global energy market. Hence, investigating AI adoption in Nigeria's oil and gas industry is both timely and critical.

Aim and Objectives of the Study

The main aim of this study is to examine the adoption of Artificial Intelligence (AI) in Nigeria's oil and gas industry, focusing on its challenges, opportunities, and impact on operational efficiency. The specific objectives of the study are:

1. To determine the current state of Artificial Intelligence adoption in Nigeria's oil and gas industry.
2. To identify the challenges hindering the effective adoption of Artificial Intelligence in the sector.
3. To explore the opportunities that Artificial Intelligence presents for improving operational efficiency.
4. To evaluate the impact of Artificial Intelligence adoption on the operational efficiency of Nigeria's oil and gas industry.

Research Questions

1. To what extent is Artificial Intelligence currently adopted in Nigeria's oil and gas industry?
2. What challenges hinder the effective adoption of Artificial Intelligence in the sector?

3. What opportunities does Artificial Intelligence present for improving operational efficiency in Nigeria's oil and gas industry?
4. What is the impact of Artificial Intelligence adoption on the operational efficiency of Nigeria's oil and gas industry?

Literature Review

Artificial Intelligence (AI) Adoption in The Oil and Gas Industry

Artificial Intelligence (AI) adoption in the oil and gas industry has gained global attention for its potential to optimize operations, reduce costs, and enhance decision-making. AI technologies such as machine learning, predictive analytics, and robotic process automation are increasingly being used for predictive maintenance, reservoir modeling, drilling optimization, and production forecasting (Hanga & Kovalchuk, 2019; Al-Fattah, 2020). Globally, companies that have integrated AI into their operations report significant reductions in non-productive time, lower operational costs, and improved safety standards. In the Nigerian context, however, AI adoption remains in its early stages, with most firms still relying on traditional methods and limited digital integration (Ejiogu & Ogu, 2022). Studies suggest that inadequate digital infrastructure, limited skilled manpower, regulatory challenges, and cybersecurity risks are key barriers to AI adoption in Nigeria's oil and gas sector (Akinola et al., 2021).

Despite these challenges, the opportunities for AI adoption in Nigeria's oil and gas industry are substantial. AI can enhance operational efficiency through real-time monitoring, predictive analytics, and intelligent decision support systems, allowing companies to better manage resources and reduce downtime (Okonkwo & Eze, 2023). Furthermore, AI presents opportunities for cost optimization, improved asset management, and more accurate production forecasting, aligning the Nigerian oil and gas sector with global digital transformation trends (PwC, 2018). Researchers emphasize that with proper policy support, investment in digital infrastructure, and capacity building, AI has the potential to significantly improve the competitiveness and sustainability of Nigeria's oil and gas industry (Ejiogu & Ogu, 2022; Okonkwo & Eze, 2023).

Challenges of Adopting Artificial Intelligence

The adoption of Artificial Intelligence (AI) in Nigeria's oil and gas industry is hindered by several key challenges. Inadequate digital infrastructure, including poor internet connectivity and outdated equipment, limits the effective implementation of AI solutions (Ejiogu & Ogu, 2022). The sector also faces a shortage of skilled personnel in AI, data analytics, and machine learning, which constrains the development, deployment, and maintenance of AI technologies (Akinola et al., 2021). Regulatory and policy gaps, particularly regarding data governance, cybersecurity standards, and technology oversight, create uncertainty for operators and investors (Okonkwo & Eze, 2023). In addition, cybersecurity risks, data privacy concerns, and high implementation costs, including investments in AI software, hardware, and workforce training, further impede adoption, making it challenging for Nigerian oil and gas firms to fully leverage AI for operational efficiency (Al-Fattah, 2020; PwC, 2018).

Benefits of Adopting Artificial Intelligence

The adoption of Artificial Intelligence (AI) in the oil and gas industry offers substantial benefits that enhance operational efficiency, reduce costs, and improve decision-making.

AI applications such as predictive maintenance, advanced data analytics, and real-time monitoring enable companies to minimize equipment downtime, optimize drilling operations, and improve reservoir management (Hanga & Kovalchuk, 2019; Al-Fattah, 2020). In Nigeria, the integration of AI can enhance resource allocation, improve production forecasting, and reduce non-productive time, leading to cost savings and higher productivity (Akinola et al., 2021). Moreover, AI facilitates better risk management and safety standards by predicting potential failures and providing intelligent decision support, while enabling firms to align with global best practices in digital transformation (Okonkwo & Eze, 2023; PwC, 2018). These benefits position AI as a critical tool for driving competitiveness and sustainability in Nigeria's oil and gas sector.

Opportunities of Adopting Artificial Intelligence

The adoption of Artificial Intelligence (AI) in Nigeria's oil and gas industry presents significant opportunities for improving operational efficiency, decision-making, and competitiveness. AI technologies enable real-time monitoring of operations, predictive maintenance of equipment, and optimization of drilling and production processes, which can reduce downtime, improve resource utilization, and lower operational costs (Hanga & Kovalchuk, 2019; Al-Fattah, 2020). Furthermore, AI offers opportunities for enhanced safety and risk management by predicting potential hazards and providing intelligent decision support, which aligns the sector with global industry best practices (Okonkwo & Eze, 2023). In addition, AI adoption creates prospects for workforce development through capacity building in digital skills and data analytics, while supporting strategic planning and sustainable energy management, thereby positioning Nigeria's oil and gas sector to better compete in the global digital economy (Akinola et al., 2021; PwC, 2018).

Impact of Artificial Intelligence on Job Creation

The adoption of Artificial Intelligence (AI) in the oil and gas industry has a complex impact on job creation, offering both opportunities and challenges. On one hand, AI can lead to automation of routine and repetitive tasks, which may reduce demand for certain manual roles but simultaneously creates new employment opportunities in AI development, data analytics, robotics, and system maintenance (Al-Fattah, 2020; Hanga & Kovalchuk, 2019). In Nigeria, AI adoption has the potential to foster a digital workforce by requiring professionals skilled in machine learning, predictive analytics, and AI-driven operational management (Akinola et al., 2021). Moreover, AI can indirectly generate jobs through increased operational efficiency, cost savings, and higher production outputs, enabling companies to expand operations and invest in new areas of business (Okonkwo & Eze, 2023). However, successful job creation depends on strategic workforce planning, reskilling, and capacity building to ensure that the workforce can adapt to the evolving technological environment (PwC, 2018).

Impact of Artificial Intelligence on Pipeline Security and Safety

The adoption of Artificial Intelligence (AI) in the oil and gas sector has significant implications for pipeline security and safety, which are critical concerns in Nigeria due to frequent vandalism, leaks, and operational hazards. AI-powered monitoring systems, such as predictive analytics, sensor networks, and machine learning algorithms, enable real-time detection of leaks, pressure anomalies, and unauthorized access, thereby reducing the risk of accidents and environmental damage (Hanga & Kovalchuk, 2019; Al-Fattah, 2020). In

the Nigerian context, AI can enhance pipeline integrity management by providing early warning systems, predictive maintenance schedules, and intelligent decision support for operational teams (Okonkwo & Eze, 2023). Additionally, the integration of AI-driven surveillance and automated alert systems improves safety compliance, minimizes human error, and supports rapid response to emergencies (Akinola et al., 2021; PwC, 2018). Consequently, AI adoption not only strengthens operational efficiency but also contributes to safer and more secure pipeline management in the Nigerian oil and gas industry.

METHODOLOGY

This study used a descriptive survey research design to investigate the adoption of Artificial Intelligence (AI) in Nigeria's oil and gas industry, focusing on its challenges, opportunities, and impact on operational efficiency. This design was chosen because it allows for the collection of information from employees and managers to understand current trends, opinions, and experiences regarding AI adoption.

The study population included employees, managers, and technical staff from oil and gas companies in Nigeria, particularly those involved in operations, IT, and digital transformation. These individuals were selected because they have direct experience with AI technologies and their impact on company operations.

A sample size of 334 respondents was chosen using the Krejcie and Morgan formula to ensure representativeness. Stratified random sampling was used to select participants from different departments, including upstream, midstream, downstream, and technical support units, so that all operational areas were represented.

Data were collected using a self-structured questionnaire, which had two sections: one for demographic information and another for items related to AI adoption, challenges, opportunities, and impacts on operational efficiency, job creation, and pipeline security. Respondents rated each item using a five-point Likert scale from "Strongly Disagree" to "Strongly Agree."

The questionnaire was reviewed by three experts to ensure clarity and relevance. A pilot test was conducted with 30 employees from companies not included in the main study to check reliability, and a Cronbach's Alpha of 0.87 showed that the questionnaire was consistent.

Data were collected through physical and electronic questionnaires, with respondents' consent and assurance of confidentiality. The collected data were analyzed using descriptive statistics such as mean, standard deviation, and frequencies. Analysis was carried out using SPSS version 25.

RESULTS

Research Question 1: To what extent is Artificial Intelligence currently adopted in Nigeria's oil and gas industry?

Table 4.1: Extent of AI Adoption in Nigeria's Oil and Gas Industry

S/N	Item Description	SA	A	D	SD	Mean	SD	Remark
1	AI technologies such as predictive analytics and automation are currently used in operations.	80	120	80	54	3.16	1.14	Agree
2	Companies have integrated AI in decision-making processes.	70	110	95	59	3.02	1.17	Agree

S/N	Item Description	SA	A	D	SD	Mean	SD	Remark
3	AI is used for predictive maintenance and equipment monitoring.	85	125	80	44	3.28	1.12	Agree
4	Staff are trained to use AI tools and technologies effectively.	60	110	100	64	2.91	1.21	Agree
5	AI applications are fully operational across upstream, midstream, and downstream sectors.	50	115	110	59	2.84	1.19	Agree
Set Mean						3.04	1.17	Agree

Table 4.1 shows that respondents generally agree that AI adoption is ongoing in Nigeria's oil and gas industry, with a set mean of 3.04 (SD = 1.17). Use of AI for predictive maintenance (Mean = 3.28) was rated highest, while full operational integration across all sectors (Mean = 2.84) was rated lowest. This indicates that AI adoption exists but is partial, with significant room for expansion across the industry.

Research question 2: What challenges hinder the effective adoption of Artificial Intelligence in the sector?

Table 4.2: Challenges Hindering AI Adoption

S/N	Item Description	SA	A	D	SD	Mean	SD	Remark
1	Inadequate digital infrastructure limits AI adoption.	120	140	50	24	3.60	0.98	Agree
2	Shortage of skilled personnel in AI and data analytics.	130	125	55	24	3.62	0.99	Agree
3	High implementation costs hinder adoption.	110	135	60	29	3.50	1.02	Agree
4	Regulatory and policy gaps create uncertainty.	105	125	70	34	3.38	1.09	Agree
5	Cybersecurity risks and data privacy concerns limit AI integration.	100	130	75	29	3.34	1.07	Agree
Set Mean						3.49	1.03	Agree

Table 4.2 shows that respondents agree that several factors hinder effective AI adoption, with a set mean of 3.49 (SD = 1.03). Shortage of skilled personnel (Mean = 3.62) was identified as the most critical challenge, while cybersecurity and data privacy concerns (Mean = 3.34) were rated lowest. This indicates that both human and infrastructural factors limit the pace of AI adoption in the sector.

Research question 3: What opportunities does Artificial Intelligence present for improving operational efficiency in Nigeria's oil and gas industry?

Table 4.3: Opportunities of AI Adoption

S/N	Item Description	SA	A	D	SD	Mean	SD	Remark
1	AI can improve operational efficiency and reduce downtime.	135	125	50	24	3.68	0.95	Agree
2	AI enables better decision-making and resource management.	120	130	55	29	3.58	1.00	Agree

S/N	Item Description	SA	A	D	SD	Mean	SD	Remark
3	AI supports predictive maintenance and reduces costs.	140	120	45	29	3.67	0.96	Agree
4	AI enhances safety and risk management in operations.	125	130	50	29	3.59	0.98	Agree
5	AI fosters workforce development and capacity building.	110	125	70	29	3.39	1.06	Agree
Set Mean						3.58	0.99	Agree

Table 4.3 indicates that respondents perceive AI adoption as highly beneficial, with a set mean of 3.58 (SD = 0.99). Improvement of operational efficiency (Mean = 3.68) was rated the highest opportunity, while workforce development (Mean = 3.39) was rated the lowest. Overall, AI adoption is seen as a strategic tool for enhancing efficiency, safety, and decision-making.

Research question 4: What is the impact of Artificial Intelligence adoption on the operational efficiency of Nigeria's oil and gas industry?

Table 4.4: Impact of AI Adoption on Operational Efficiency

S/N	Item Description	SA	A	D	SD	Mean	SD	Remark
1	AI adoption has reduced equipment downtime and operational delays.	125	130	50	29	3.63	0.98	Agree
2	AI has improved production planning and resource allocation.	120	125	60	29	3.54	1.01	Agree
3	AI adoption has enhanced decision-making and process efficiency.	130	125	45	34	3.62	1.01	Agree
4	AI has contributed to better safety and compliance in operations.	115	130	60	29	3.51	0.99	Agree
5	Overall, AI adoption has positively impacted operational efficiency.	135	125	45	29	3.65	0.96	Agree
Set Mean						3.59	0.99	Agree

Table 4.4 shows that respondents agree that AI adoption positively impacts operational efficiency, with a set mean of 3.59 (SD = 0.99). Overall improvement in operational efficiency (Mean = 3.65) was rated highest, while enhanced safety and compliance (Mean = 3.51) was rated lowest. The results suggest that AI contributes to more efficient operations, reduced delays, better decision-making, and improved resource management in Nigeria's oil and gas industry.

Discussion of Findings

The findings of this study reveal that the adoption of Artificial Intelligence (AI) in Nigeria's oil and gas industry is ongoing but remains partial, reflecting both progress and areas for improvement. Regarding the current state of AI adoption, respondents indicated that AI technologies such as predictive maintenance, equipment monitoring, and automation are being used in operations, though full integration across all sectors is limited (Set Mean = 3.04, SD = 1.17). This aligns with prior research suggesting that while global oil and gas companies have embraced AI extensively, Nigerian firms are still in the early stages of

adoption due to infrastructural and organizational constraints (Ejiogu & Ogu, 2022; Hanga & Kovalchuk, 2019). The findings suggest that although AI adoption exists, it is uneven across operational areas, highlighting the need for broader deployment and capacity building within the sector.

The study also identified key challenges hindering AI adoption, with respondents highlighting shortage of skilled personnel, inadequate digital infrastructure, high implementation costs, regulatory gaps, and cybersecurity risks (Set Mean = 3.49, SD = 1.03). These findings corroborate earlier studies that emphasize the dual impact of human and infrastructural factors in limiting AI integration in Nigeria's oil and gas industry (Akinola et al., 2021; Okonkwo & Eze, 2023). The shortage of professionals trained in AI and data analytics was identified as the most critical constraint, reflecting the need for targeted workforce development programs and policy support to facilitate adoption.

In terms of opportunities, the findings indicate that AI adoption presents significant potential to enhance operational efficiency, improve decision-making, reduce downtime, and strengthen safety and risk management (Set Mean = 3.58, SD = 0.99). Improvement of operational efficiency was rated the highest opportunity, consistent with literature showing that AI applications can optimize drilling, production forecasting, and resource allocation (Al-Fattah, 2020; PwC, 2018). Additionally, AI provides prospects for workforce development, although respondents rated this slightly lower, suggesting that while AI creates new roles, current capacity gaps may limit immediate workforce benefits.

Finally, the study found that AI adoption positively impacts operational efficiency in Nigeria's oil and gas industry (Set Mean = 3.59, SD = 0.99). Respondents reported improvements in production planning, decision-making, reduced operational delays, and enhanced safety compliance. This finding aligns with global studies demonstrating that AI adoption leads to more efficient and safer operations in oil and gas contexts (Hanga & Kovalchuk, 2019; Okonkwo & Eze, 2023). The results indicate that while challenges persist, AI adoption is already contributing to measurable operational benefits and can become a strategic tool for competitive advantage if adoption is expanded and properly supported.

In summary, the discussion of findings underscores that AI adoption in Nigeria's oil and gas industry is at a formative stage. While respondents recognize the benefits and opportunities presented by AI, adoption is constrained by infrastructural, human, and policy-related challenges. Addressing these barriers through investment in digital infrastructure, capacity building, and regulatory frameworks can enable the industry to fully leverage AI for improved operational efficiency, safety, and competitiveness.

CONCLUSION

The study concludes that Artificial Intelligence (AI) adoption in Nigeria's oil and gas industry is ongoing but not yet fully integrated across all operational sectors. Respondents acknowledged the use of AI in predictive maintenance, automation, and monitoring, and agreed that it positively impacts operational efficiency by reducing downtime, improving production planning, enhancing decision-making, and strengthening safety compliance. However, adoption is constrained by several challenges, including a shortage of skilled personnel, inadequate digital infrastructure, high implementation costs, regulatory gaps, and cybersecurity concerns. Despite these obstacles, AI presents significant opportunities to enhance operational performance, safety, and workforce development, highlighting its potential as a strategic tool for competitiveness and sustainability in the sector.

RECOMMENDATIONS

Based on the findings, the study makes the following recommendations:

1. Oil and gas companies should invest in training programs to develop employees' skills in AI, data analytics, and digital technologies to address the shortage of qualified personnel.
2. Companies should upgrade their digital infrastructure and ensure reliable IT systems to support comprehensive AI deployment across upstream, midstream, and downstream operations.
3. Government and industry regulators should establish clear guidelines on AI adoption, data governance, and cybersecurity to create a supportive environment for technology integration.
4. Firms should prioritize the implementation of AI in predictive maintenance, automation, and safety management to optimize operational efficiency and reduce costs.
5. Partnerships with academic institutions, technology providers, and international experts should be encouraged to facilitate innovation, knowledge transfer, and alignment with global best practices.

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