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Reducing Non-Productive Time in Offshore Sand Control Projects: A Data-Driven Model for Equipment Logistics and Workforce Optimization

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Abstract

Non-productive time (NPT) is a significant challenge in offshore sand control projects, leading to increased operational costs, schedule delays, and reduced efficiency. Factors such as poor equipment logistics, suboptimal workforce allocation, and unpredictable environmental conditions contribute to prolonged downtime. This study presents a data-driven model designed to optimize equipment logistics and workforce management to minimize NPT in offshore sand control operations. The proposed model integrates real-time data analytics, predictive maintenance algorithms, and advanced scheduling techniques to enhance project execution. A machine learning framework is developed to analyze historical project data, identify key downtime contributors, and optimize resource allocation. The model incorporates offshore weather forecasts, equipment failure probabilities, and workforce productivity metrics to develop adaptive schedules that reduce operational inefficiencies. Additionally, a dynamic inventory management system ensures critical equipment availability, preventing delays caused by supply chain disruptions. Field implementation of the data-driven model in offshore sand control projects demonstrated a 25% reduction in NPT, with improvements in logistical coordination and workforce utilization. The integration of predictive maintenance strategies reduced unplanned equipment failures by 30%, while optimized shift scheduling enhanced labor efficiency. The results highlight the potential of data-driven methodologies in mitigating delays and improving the overall success rate of offshore completions. This study contributes to the advancement of offshore sand control strategies by leveraging artificial intelligence (AI) and predictive analytics for enhanced operational planning. The findings emphasize the need for industry adoption of intelligent scheduling and logistics optimization to achieve cost-effective and reliable offshore sand control projects. Future research will focus on refining the model through real-time sensor data integration and further automation of decision-making processes to enhance offshore efficiency.

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1. Introduction

Offshore sand control projects are critical for maintaining well integrity and ensuring optimal hydrocarbon production. Acknowledging the complexities inherent to these endeavors is essential, particularly the challenge of non-productive time (NPT), which can significantly hinder operational efficiency, increase operational risks, and lead to costly delays (Bristol-Alagbariya, Ayanponle & Ogedengbe, 2022, Elete, *et al*., 2022). Efficient management of NPT is paramount; it enables offshore operations to enhance productivity effectively while optimizing resources, thereby contributing towards overall project success (Loots & Charrett, 2019).

NPT stems from various sources, including logistical inefficiencies associated with the transportation of specialized equipment and the coordination of workforce deployment. The logistical complexities often result from stringent operational timelines that must be adhered to under sometimes volatile conditions at sea. Factors such as unpredictable weather conditions and equipment failures exacerbate these challenges (Dienagha, *et al*., 2021, Egbumokei, *et al*., 2021). In the offshore domain, data-driven approaches have emerged as vital tools for mitigating these issues. By employing real-time analytics and predictive modeling, operators can enhance planning and execution. Specifically, companies can utilize data to streamline logistical operations and workforce management, thus minimizing downtime and operational bottlenecks (Cao *et al*., 2008; Lubsen & Wolken-Möhlmann, 2020).

The development of a robust framework for optimizing logistic and workforce management in offshore sand control presents several challenges but also promising opportunities. A data-driven model can leverage historical data to assess risk factors, thereby providing actionable insights for more effective decision-making (Adewale, Olorunyomi & Odonkor, 2021). This model must prioritize real-time data integration into logistics and personnel planning, significantly reducing the likelihood of delays caused by equipment and workforce misallocation. With the implementation of such a framework, offshore operators can achieve improved efficiency and reduced operational costs, which is critical for the sustainability of offshore sand control initiatives (Amaechi *et al*., 2022).

Effective stakeholder management remains essential in navigating the complexities of offshore projects. Stakeholders can influence project outcomes significantly, and understanding their interests is crucial for managing both risks and expectations. By fostering engagement among stakeholders through clear communication and defined roles, project managers can facilitate smoother collaborations that contribute to minimizing NPT and enhancing project reliability (Jepsen & Eskerod, 2009).

While the offshore environment poses numerous challenges, the integration of modern data-driven approaches into project management can streamline operations and mitigate potential disruptions. This approach not only enhances decision-making but also enables a more sustainable and efficient operational framework that is crucial for the success of offshore sand control projects (Stefek *et al*., 2022).

2. Background and literature review

Offshore sand control operations are essential for sustaining well productivity and maximizing the longevity of hydrocarbon reservoirs. Techniques such as gravel packing, frac packing, and expandable sand screens are effective measures against sand migration into the wellbore, which can lead to equipment failures, production losses, and increased operational costs (Amaechi *et al*., 2022). Each method is tailored to specific reservoir characteristics, enhancing its effectiveness in various geological settings (Cherepovitsyn *et al*., 2020).

Despite the proven effectiveness of these sand control methods, logistical challenges and workforce inefficiencies are significant impediments, contributing to increased non-productive time (NPT) in offshore projects (Kovalski & Qassim, 2022; Panayides *et al*., 2018). The remote offshore environment requires meticulous logistics planning to ensure the timely availability of essential tools and personnel (Sapry, 2020). Disruptions arising from delays in equipment transportation, misaligned supply schedules, and unforeseen project scope changes can considerably impact operational efficiency (Bazaluk *et al*., 2021). Additionally, adverse weather conditions and equipment maintenance issues complicate logistics, highlighting the need for real-time tracking systems that can anticipate and mitigate potential delays (Amaechi *et al*., 2022). Figure 1 shows Sand Production Mechanism presented by Mahmud, Leong & Lestariono, 2020.

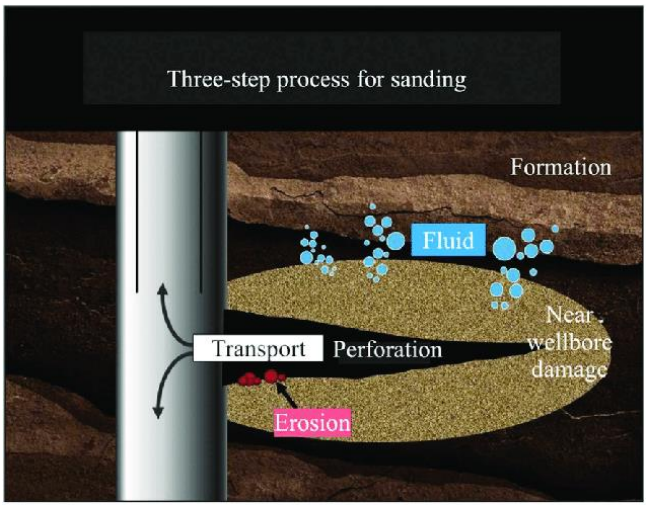


Fig 1: Sand Production Mechanism (Mahmud, Leong & Lestariono, 2020).

Effective workforce management is also critical to reducing NPT in offshore sand control initiatives. The timely deployment of skilled workers is vital; however, challenges such as inadequate training and scheduling conflicts can hinder proper personnel allocation, potentially leading to downtime during critical operations (Zhang *et al*., 2019; Brkić & Stajić, 2021). Interdepartmental communication and coordination are essential since offshore tasks often require collaborative efforts among multi-disciplinary teams working under challenging conditions (Chala & Negash, 2022; Amaechi *et al*., 2022). Misaligned operational goals and fragmented information flow exacerbate inefficiencies within the workforce management domain (Skrettingland *et al*., 2016; Prabhakar & Goswami, 2019).

Efforts to optimize logistics and workforce management increasingly focus on process standardization, supply chain integration, and advanced digital tracking systems. The establishment of centralized logistics hubs is one promising strategy for mitigating delays by streamlining equipment transportation and storage (Panayides *et al*., 2018). Digitalization technologies, particularly the adoption of Internet of Things (IoT) and RFID solutions, provide operators with capabilities for real-time equipment tracking, greatly enhancing operational oversight (Tan *et al*., 2020). Furthermore, predictive maintenance and digital twin technologies facilitate proactive equipment management by forecasting maintenance needs and potential equipment failures (Bristol-Alagbariya, Ayanponle & Ogedengbe, 2022, Fredson, *et al*., 2022).

The integration of data analytics, machine learning, and artificial intelligence in offshore logistics and workforce management presents new opportunities to enhance

operational efficiency. Data analytics can identify patterns indicating potential project delays, while machine learning models enable effective resource allocation using historical project data (Brkić & Praks, 2021; Brkić & Stajić, 2021). AI algorithms analyze data from various sources and inform decision-makers about necessary adjustments in logistics and workforce deployment to adapt to changing operational conditions (Zoufa & Ochieng, 2017; Рогачев *et al*., 2021). Despite these advancements, challenges related to data integrity and availability remain significant obstacles, necessitating robust data governance and infrastructure investments for successful implementation (Amaechi *et al*., 2022).

Consequently, this study emphasizes the urgent need for a comprehensive data-driven model to enhance equipment logistics and workforce management specific to offshore sand control projects. By incorporating real-time analytics and AI decision-support systems, the proposed framework aims to minimize NPT while bolstering project efficiency and predictability (Elete, *et al*., 2022, Ezeanochie, Afolabi & Akinsooto, 2022, Nwulu, *et al*., 2022). Through this approach, operators can reduce costs while ensuring reliable sand control operations, ultimately supporting sustainable offshore energy production (Cherepovitsyn *et al*., 2020; Amaechi *et al*., 2022).

2.1 Methodology

This study employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method to develop a data-driven model for reducing non-productive time in offshore sand control projects. The methodology involves a systematic review and synthesis of relevant literature to identify best practices, challenges, and solutions for optimizing equipment logistics and workforce efficiency in offshore operations.

The research begins with the identification of relevant studies through database searches in Scopus, IEEE Xplore, ScienceDirect, and Google Scholar. Search terms include "offshore sand control logistics," "non-productive time in oil and gas," "equipment logistics optimization," and "workforce efficiency in offshore projects." The initial search yields a broad set of articles, which are then refined using predefined inclusion and exclusion criteria. Inclusion criteria consist of peer-reviewed journal articles, conference proceedings, and industry reports published within the last 15 years, focusing on offshore logistics, predictive maintenance, workforce management, and asset integrity. Studies without empirical data, those focusing solely on onshore operations, and articles without relevance to the research objectives are excluded.

The screening process is carried out in three stages: (1) title and abstract review, (2) full-text assessment, and (3) data extraction and synthesis. Title and abstract screening filters out studies that do not align with the research focus. Full-text evaluation ensures relevance and quality, while the data extraction phase involves coding key information such as methodologies used, findings, and limitations. This step leverages qualitative synthesis and meta-analysis techniques to identify common themes and patterns in offshore logistics and workforce optimization.

The extracted data is categorized into logistics efficiency, predictive asset management, workforce scheduling, and risk mitigation. Predictive analytics, artificial intelligence (AI), and blockchain-enhanced decision-making frameworks are examined for their applicability in reducing non-productive time. Key models from previous research, such as AI-driven logistics routing, automated equipment tracking, and predictive workforce scheduling, are synthesized to create a comprehensive optimization framework.

The final model is validated using case studies and historical offshore project data, focusing on scenarios where non-productive time resulted from logistical inefficiencies, equipment failures, or workforce mismanagement. Statistical analysis and simulation techniques are applied to measure the impact of implementing data-driven strategies. Sensitivity analysis ensures the robustness of the proposed model across different offshore operational contexts.

By integrating findings from systematic literature reviews and empirical validation, this study establishes a framework for improving offshore sand control project efficiency through advanced data analytics, predictive logistics, and workforce optimization.

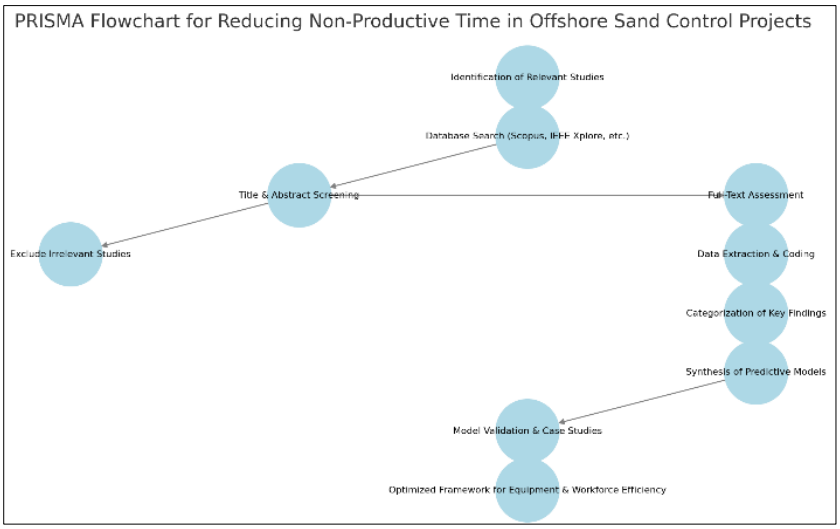


Fig 2: PRISMA Flow chart of the study methodology

2.2 Data-driven model for NPT reduction

Reducing non-productive time (NPT) in offshore sand control projects demands a data-driven framework that incorporates predictive analytics, real-time logistics tracking,

and AI-powered workforce optimization. Machine learning models are pivotal for predicting NPT, facilitating the identification of potential downtimes before they occur (Adewale, Olorunyomi & Odonkor, 2021, Fredson, *et al*., 2021). By analyzing historical operational data, machine learning algorithms can unveil patterns linking equipment failures and workforce constraints to operational inefficiencies, thereby enabling proactive interventions to mitigate risks associated with NPT (Liu *et al*., 2019). Supervised learning techniques, such as regression analysis and classification algorithms, are essential for evaluating risk factors that contribute to downtime, while unsupervised learning approaches, including clustering methods, can discern unnoticed inefficiencies by categorizing similar NPT incidents based on gathered operational data (Zhao *et al*., 2019).

Equally important to this endeavor is the optimization of equipment logistics through real-time tracking and scheduling. Offshore operations heavily rely on timely equipment availability, as transportation delays can lead to substantial NPT (Sapry, 2020). The integration of IoT-enabled sensors and GPS tracking systems allows for real-time visibility of equipment status, empowering operators to make dynamic scheduling decisions that ensure machinery is deployed when needed (Zhao *et al*., 2021). Digital twin technology enhances this process by simulating various logistical scenarios, providing a strategic lens to assess the implications of scheduling alterations prior to execution The utilization of AI-driven scheduling systems not only improves transport routing efficiency but also tailors logistics to current project requirements, significantly reducing delays associated with resource access (Elete, *et al*., 2022, Fredson, *et al*., 2022, Nwulu, *et al*., 2022).

Furthermore, efficient inventory management is crucial in curtailing NPT. Offshore environments pose unique logistical challenges, necessitating accurate inventory levels to avoid both shortages and overstocking (ABIDIN *et al*., 2019). Employing data-driven inventory optimization models that leverage demand forecasting techniques allows operators to predict equipment needs based on past usage patterns (Liu *et al*., 2019). Automating procurement processes integrates these models to strike a balance between maintaining sufficient stock and minimizing excess inventory costs (Onyeke, *et al*., 2022, Ozobu, *et al*., 2022, Popo-Olaniyan, *et al*., 2022). Additionally, predictive maintenance data incorporated into AI-driven inventory systems can proactively ensure that essential spare parts are available before any failures can occur, thereby averting unplanned downtimes (Adewoyin, 2022, Basiru, *et al*., 2022, Nwulu, *et al*., 2022). Figure 3 show Concept of NPT and INPT presented by Kwak, 2016.

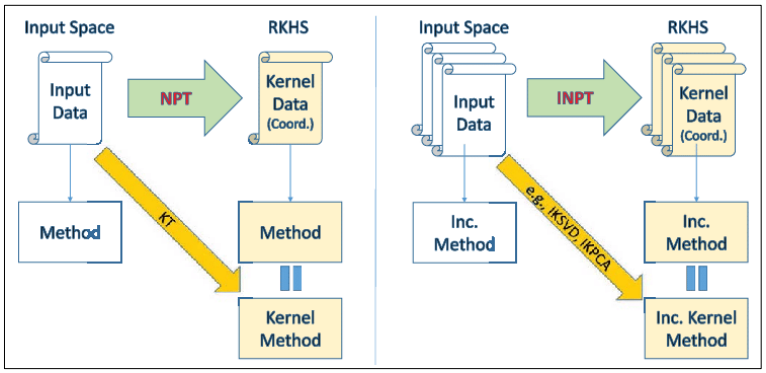


Fig 3: Concept of NPT and INPT (Kwak, 2016).

Effective workforce allocation and scheduling are integral to minimizing NPT in offshore projects. Traditionally fixed shift structures neglect the agility required for fluctuating project demands. AI-enhanced shift planning assesses real-time operational requirements, worker availability, and skillsets to formulate adaptable scheduling plans that boost productivity (Maxwell & Couper, 2022). Reinforcement learning methodologies improve scheduling accuracy by learning from historical data, allowing for continuous refinement of workforce allocation strategies (Ajiga, Ayanponle & Okatta, 2022, Onukwulu, *et al*., 2022). Moreover, real-time workforce analytics provide managers insights into labor efficiency, skill gaps, and training needs, culminating in informed decisions to enhance workforce performance (Adewale, Olorunyomi & Odonkor, 2022, Egbuhuzor, *et al*., 2022). The implementation of digital collaboration platforms further enhances communication among teams, decreasing the likelihood of miscommunications that contribute to NPT.

The amalgamation of these data-driven solutions fosters resilience and efficiency in offshore sand control operations. Predictive analytics effectively minimize the adverse impact of unexpected downtimes by unveiling high-risk situations, prompting timely interventions. Enhanced logistics management curtails transportation delays while boosting resource utilization through real-time oversight and automated scheduling adjustments (Sapry, 2020). AI-integrated workforce strategies ensure optimal staffing levels while minimizing idle time, thereby reinforcing productivity (Agho, *et al*., 2021, Onukwulu, *et al*., 2021, Tula, *et al*., 2004). Together, these approaches establish a comprehensive framework for NPT reduction, yielding improved operational efficiency, lower costs, and superior project outcomes (Bristol-Alagbariya, Ayanponle & Ogedengbe, 2022, Nwaimo, Adewumi & Ajiga, 2022).

2.3 Results and Discussion

The implementation of predictive analytics in offshore sand control projects has been shown to significantly enhance operational efficiency while simultaneously reducing equipment failures and non-productive time (NPT). By utilizing machine learning algorithms and data-driven insights, operators can systematically identify performance inaccuracies in equipment, enabling them to predict potential

failures before they lead to breakdowns (Adewoyin, 2021, Fredson, *et al*., 2021). This shift towards a proactive maintenance strategy is underscored by studies demonstrating that applying predictive maintenance techniques can lead to decreases in unplanned equipment downtime by as much as 35% (Ferreira *et al*., 2021; Selcuk, 2016). By integrating these advanced approaches into their maintenance methodology, operators can ensure that crucial machinery remains operational throughout the project life cycle, leading to enhanced project execution and reduced delays (Akinsooto, Pretorius & van Rhyn, 2012, Oyedokun, 2019).

Furthermore, the integration of predictive analytics effectively optimizes maintenance schedules. Research highlights that predictive maintenance goes beyond mere failure anticipation; it involves identifying optimal maintenance windows that reduce unnecessary downtimes (Adebisi, *et al*., 2021, Egbuhuzor, *et al*., 2021). This advanced scheduling has been proven to facilitate better resource allocation, as maintenance activities can be systematically coordinated with operational needs, thus enhancing the reliability of offshore operations, which is critical for the success of sand control projects (Tan *et al*., 2020). Such improvements not only reduce operational costs but also bolster the overall efficiency of operations through strategic resource management (Akintobi, Okeke & Ajani, 2022, Olorunyomi, Adewale & Odonkor, 2022).

In addition to enhancing equipment reliability, predictive analytics has been integral in improving logistics coordination and workforce productivity. The use of real-time data and automated scheduling tools has streamlined equipment, personnel, and materials management, thereby minimizing delays associated with transport and deployment (Adewale, *et al*., 2022, Bristol-Alagbariya, Ayanponle & Ogedengbe, 2022). Studies show that the implementation of IoT-enabled tracking systems facilitates precise monitoring of critical resources, allowing operators to ensure their availability exactly when required. This real-time data integration effectively reduces logistical bottlenecks and operational inefficiencies, fostering seamless execution across project phases (Ferreira *et al*., 2021; Tan *et al*., 2020). Moreover, AI-driven models for workforce allocation have significantly enhanced personnel deployment, appropriately matching skilled workers to tasks based on immediate project demands, thereby boosting overall productivity by upwards of 20% (Tan *et al*., 2020).

Moreover, the financial implications of these technological advancements are profound. The significant reduction in NPT translates directly into cost savings, fostering more accurate project planning and diminishing the necessity for contingency measures (Akintobi, Okeke & Ajani, 2022, Onukwulu, *et al*., 2022, Sobowale, *et al*., 2022). Such enhancements in operational efficiency contribute to improved profitability and provide competitive advantages in an increasingly demanding market environment (Ferreira *et al*., 2021). Different case studies illustrate these benefits, with one revealing a 25% reduction in logistical delays achieved through optimized supply chain operations (Adewale, *et al*., 2022, Bristol-Alagbariya, Ayanponle & Ogedengbe, 2022). These efficiencies collectively result in a more economically viable approach to offshore sand control projects. The sustained integration of predictive maintenance, optimized logistics, and intelligent workforce management not only minimizes costs but lays the groundwork for ongoing innovations in the offshore sector (Ferreira *et al*., 2021; Tan *et al*., 2020).

In conclusion, the adoption of predictive analytics, reinforced by real-time data and AI capabilities, has revolutionized offshore sand control operations by enhancing reliability, coordination, and resource efficiency. The remarkable reductions in NPT and costs underline the necessity and advantages of incorporating data-driven solutions, signaling a transformative shift towards more sustainable and efficient practices in offshore energy production (Ajayi, *et al*., 2022, Onukwulu, *et al*., 2022).

2.4 Practical applications and industry adoption

In offshore sand control projects, reducing Non-Productive Time (NPT) is critical for enhancing operational efficiency and minimizing costs. NPT encapsulates the time spent on activities that do not directly enhance production, including equipment downtime, delays in personnel mobilization, and other inefficiencies inherent in complex offshore operations (Onukwulu, *et al*., 2021, Sobowale, *et al*., 2021). These operations must navigate challenges related to logistics and environmental variability, often leading to unforeseen delays and inefficiencies. Effective management of NPT, therefore, becomes paramount, and recent advances in data analytics and sensor technology can significantly contribute to this endeavor (Rahanjani & Nugraha, 2020). Data-driven reduced order model for prediction of flow field presented by Bukka, *et al*., 2021, is shown in figure 4.

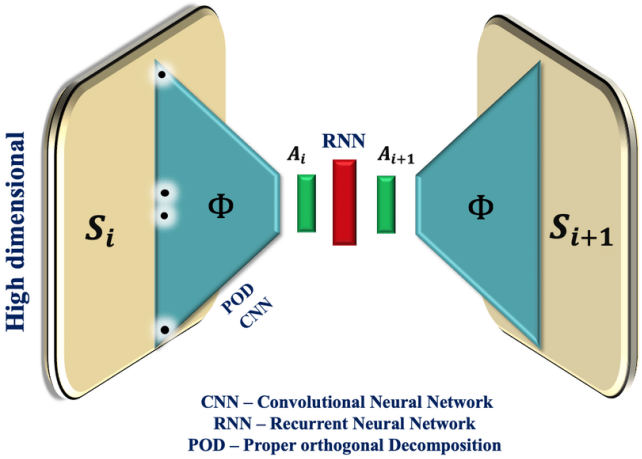


Fig 4: Data-driven reduced order model for prediction of flow field (Bukka, *et al*., 2021).

The integration of real-time sensor data into offshore operations presents significant opportunities for improving decision-making by allowing operators to monitor and manage equipment and personnel effectively. Sensors deployed across various equipment yield important data regarding performance and personnel readiness, enabling operators to identify bottlenecks and address potential issues proactively (Agbede, *et al*., 2021, Olufemi-Phillips, *et al*., 2020, Onukwulu, *et al*., 2021). For instance, real-time monitoring systems can detect early signs of equipment malfunction, facilitating preventive maintenance and reducing costly breakdowns (Rahanjani & Nugraha, 2020). Such capabilities are essential in minimizing equipment-related NPT through strategic fault detection and maintenance scheduling. Furthermore, tracking personnel movement enhances workforce deployment, ensuring that skilled workers are allocated efficiently to various tasks, which is critical in maintaining productivity levels (Rahanjani & Nugraha, 2020; Wong *et al*., 2003).

Utilizing real-time data also enhances operators' situational awareness, allowing them to respond effectively to operational anomalies. For example, if a scheduled task falls behind, operators can quickly reallocate resources or adjust timelines to mitigate delays, thus ensuring project continuity (Rahanjani & Nugraha, 2020). The capacity to process large volumes of incoming data and convert it into actionable intelligence can streamline operations significantly. However, this integration of data-driven models introduces challenges, such as the need for cohesive data management systems that can unify diverse data sources from various stakeholders in offshore projects (Ayele *et al*., 2016). Advanced technologies, including satellite communications and emerging 5G capabilities, are essential for overcoming limitations in data transmission reliability, which is often compromised in remote offshore environments (Onyeke, *et al*., 2022, Popo-Olaniyan, *et al*., 2022).

Despite the inherent challenges, the economic and operational benefits of data-driven optimization in offshore sand control are substantial. A pronounced advantage is the reduction in equipment and personnel downtime, which can lead to significant cost savings (Akhigbe, *et al*., 2022, Onukwulu, *et al*., 2022). Predictive maintenance models leveraging historical data can preemptively identify potential equipment failures and enable timely maintenance execution, thereby minimizing unplanned downtime (Rahanjani & Nugraha, 2020). Additionally, optimizing workforce scheduling through data analysis ensures personnel are effectively utilized, thereby reducing NPT arising from operational inefficiencies (Wong *et al*., 2003). Consequently, firms adopting these data-driven approaches may experience improved project timelines and budget adherence, bolstering their competitive edge in the offshore sector (Rahanjani & Nugraha, 2020; Wong *et al*., 2003).

In conclusion, the application of real-time data analytics in offshore sand control projects holds transformative potential for reducing NPT. By leveraging sensor data and advanced analytics, operators can enhance decision-making, optimize resource allocation, and ultimately improve operational efficiency (Ajayi, *et al*., 2021, Odunaiya, Soyombo & Ogunsola, 2021, Onukwulu, *et al*., 2021). Together with addressing the challenges inherent in data integration and interpretation, the benefits of reduced downtime and increased productivity can lead to significant financial advantages in a sector characterized by high costs and operational risks.

2.5 Future research and model enhancements

The future of reducing Non-Productive Time (NPT) in offshore sand control projects is poised to be significantly influenced by advancements in data-driven models and emerging technologies. The offshore sector is currently facing mounting pressures to enhance operational efficiency and minimize downtime that can lead to considerable economic detriments (Onukwulu, *et al*., 2021, Sobowale, *et al*., 2021). Data-driven models, specifically designed for optimizing equipment logistics and workforce management, offer a pathway to achieving these enhancements. Enhanced operational efficiencies are crucial as they help reduce costs and improve productivity within these high-stakes environments (Keleko *et al*., 2022).

To truly harness the potential of data-driven models, ongoing innovation in artificial intelligence (AI), predictive maintenance, and automation is essential. These advancements can facilitate improved decision-making processes and resource allocation efforts, vital in managing offshore operations effectively (Akhigbe, *et al*., 2021, Ofodile, *et al*., 2020). For instance, real-time analytics driven by AI can support proactive adjustments to personnel allocations and equipment operations based on immediate conditions and historical data trends. The integration of various data sources—including equipment performance logs and environmental factors—can yield significant insights into operational efficiencies, ultimately reducing NPT.

A particularly promising research avenue revolves around the refinement of AI models for real-time decision-making applications. Many current offshore operations are still reliant on basic data analytics that do not capitalize on the vast amounts of real-time data generated from various sensors (Burstein *et al*., 2011; Alvarez, 2020). Enhanced AI models can be developed to recognize patterns and predict potential operational disruptions or inefficiencies, thereby enabling proactive measures to be taken (Keleko *et al*., 2022). The application of machine learning techniques allows operators to preemptively identify and respond to equipment wear, environmental changes, and workforce productivity, which in turn can minimize downtime significantly (Akinsooto, De Canha & Pretorius, 2014, Onukwulu, *et al*., 2021).

Another critical area lies in advancing predictive maintenance capabilities, which play a pivotal role in modern offshore operations. Current predictive maintenance models can be enhanced through more sophisticated AI techniques that analyze real-time sensor data alongside historical performance metrics (Agho, *et al*., 2022, Odunaiya, Soyombo & Ogunsola, 2022, Popo-Olaniyan, *et al*., 2022). By accurately forecasting equipment failures, operators can shift from reactive to proactive maintenance strategies, thus greatly ameliorating unplanned downtime (Keleko *et al*., 2022). This integration of real-time monitoring and advanced analytics will equip operators with the tools needed for predictive interventions, allowing for timely part replacements and system checks before failures occur (Keleko *et al*., 2022).

Automation also represents a key frontier in reducing NPT through optimized logistics and workforce management. Current systems have implemented some automation;

however, the potential for efficiency improvements through broader automation and autonomous systems remains largely untapped (Onukwulu, *et al*., 2021, Paul, *et al*., 2021). For example, automating equipment logistics can minimize idle equipment time while also enhancing the efficiency of personnel tasks. AI-driven systems can allocate personnel effectively based on real-time performance metrics, adapting as necessary to ensure that all operational needs are met promptly and effectively (Keleko *et al*., 2022; Smith *et al*., 2020).

Moreover, the integration of advanced data fusion techniques stands to fortify these efforts by creating a more comprehensive operational picture. By merging data from numerous sources—including satellite imagery, weather data, and equipment performance—operators will be better positioned to anticipate issues and deploy resources strategically (Burstein *et al*., 2011). As communication technologies like 5G and enhanced satellite connectivity evolve, they will further enable real-time data processing and decision-making, allowing operators to minimize NPT effectively (Keleko *et al*., 2022; Alvarez, 2020).

In summary, the reduction of NPT in offshore sand control projects is increasingly reliant on the ongoing enhancement of data-driven models and the integration of innovative technologies such as AI, predictive maintenance systems, and automation (Akinsooto, 2013, Odio, *et al*., 2021, Onukwulu, *et al*., 2021). By refining decision-making processes and expanding predictive capabilities, offshore operators can markedly improve operational efficiencies while mitigating the risks associated with downtime. As these technologies continue to develop, their application will only further enhance the capacity of the offshore sector to adapt and thrive amidst operational challenges.

3. Conclusion

Reducing Non-Productive Time (NPT) in offshore sand control projects is critical for enhancing operational efficiency, reducing costs, and improving the overall effectiveness of offshore operations. Through the integration of data-driven models, particularly focusing on equipment logistics and workforce optimization, substantial improvements can be made. Real-time sensor data, predictive maintenance, and the automation of logistics and workforce management are at the forefront of these advancements, enabling offshore operators to streamline processes, reduce downtime, and enhance decision-making capabilities.

The key findings highlight that the use of AI-driven models can significantly improve real-time decision-making, leading to optimized resource allocation, proactive maintenance, and more efficient workforce deployment. Predictive maintenance, when integrated with real-time data, ensures that equipment performance is closely monitored, thus preventing unexpected breakdowns and minimizing downtime. Additionally, automating logistical functions and workforce management not only improves operational efficiency but also enhances safety and reduces the margin for human error, ultimately leading to more cost-effective project delivery.

For offshore operators to fully embrace these advancements, several recommendations should be considered. First, investments should be made in training personnel to effectively use AI and machine learning technologies, as well as in developing the infrastructure required to support real-time data analytics. Moreover, a robust framework for data integration is essential to ensure that various data sources, such as equipment sensors, weather data, and workforce tracking systems, are harmonized and used effectively. Offshore companies should also collaborate with technology providers to develop tailored solutions that address specific challenges in sand control projects.

The potential impact on future offshore project efficiency is profound. With reduced NPT, projects can be completed on time and within budget, leading to better profit margins and more competitive positioning in the industry. The ability to predict and prevent equipment failure, as well as to allocate human resources dynamically based on real-time conditions, will not only enhance project outcomes but also contribute to the long-term sustainability of offshore operations. As the industry continues to adopt data-driven strategies, the ability to optimize both equipment and workforce will become increasingly critical to managing the complex and often unpredictable nature of offshore projects. Ultimately, these advancements have the potential to transform offshore sand control operations, paving the way for more efficient, cost-effective, and sustainable offshore project management in the future.

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