An Evaluation of the Extent of Adoption of Lean in Offshore Facility Maintenance Projects in the Oil and Gas Industry [1]

Chimezie Henry Achaka, Benedict Amade, PhD, Prof Kevin Aku Okorocha, PhD, and Prof Emmanuel Chinenye Ubani, PhD

Department of Project Management Technology
Federal University of Technology, Owerri, Nigeria

Abstract

Lean production can be used to overcome serious organisational performance issues in the oil and gas industry, affecting both production and service delivery. This study will look into the extent and understanding of lean concept adoption in offshore facility maintenance projects in Nigeria's oil and gas industry. The study employed descriptive and survey research design methods of investigation, as well as a purposive and convenience sampling methodology, to pick a sample size from a population of 122 practitioners working in eleven (11) oil servicing enterprises in the Niger Delta region of South-South Nigeria. The data collection and survey instrument included a well-structured questionnaire, semi-structured/focused group discussions, personal observations, and site visits to gather information from respondents, oil and gas servicing firms, and projects. The collected data was displayed using frequency distribution in the form of tables and Cronbach's Alpha test using IBM SPSS Statistics version 26.0. A survey of 113 respondents found that 34.51% are involved in major offshore facility maintenance projects, with the majority (24%) working on pipe and structural maintenance. The study also found that 19.48% of respondents were unaware of lean in offshore facility maintenance projects, with the remainder (45.82%, 18.58%) being slightly knowledgeable. The study also found that 22.12% of respondents were unaware of lean tools for waste reduction in offshore facility maintenance projects, while the remaining respondents (45.13%) were only marginally knowledgeable.

Keywords: Facility, Gas, Maintenance, Nigeria, Oil, Projects.

Introduction

Despite using planning and scheduling techniques, they do not meet the projected delivery time, resulting in higher costs and lower profit margins. This problem highlights the need for modern tools and superior management skills or philosophy to address the shortcomings associated with traditional project management planning and scheduling, as stated by Wenchi, Wang, Wang, and Chong (2015). The oil and gas industry has been focusing on the lean thinking philosophy to enhance the efficiency of the maintenance project process, starting from the planning stage.

[1] How to cite this paper: Achaka, C. H., Amade, B., Okorochac, K. A., Ubani, E. C. (2024). An Evaluation of the Extent of Adoption of Lean in Offshore Facility Maintenance Projects in the Oil and Gas Industry; *PM World Journal*, Vol. XIII, Issue IX, September.

According to Jongeling and Olofsson (2007), there is a lot of room to improve workflow, which is the movement of resources through different areas of a site. This is because current activity-based scheduling methods don't support workflow planning well enough for practical and methodological reasons. According to field surveys and investigations, the OSC has problems with delivering oil and gas facility maintenance projects. These include problems with finished products, not having enough Just In Time (JIT) flow, having too many raw materials and consumables on hand—some of which go bad before they can be used—having too much work-in-progress (WIP), making too many finished products and keeping them on hand when they're not needed, long lines at the fabrication section, and hard work processes. This leads to frequent machine breakdowns, high overhead costs and wage bills, low worker morale, and low productivity in the absence of income generation for sustenance, affecting the company's ability to be sustainable, deliver projects, pay wages, and pay operating bills. Such a negative impact, combined with a prolonged period of inactivity when the firm is unable to obtain a contract, forces many OSC management to downsize and lay off employees in order to keep the company operating.

According to Tourki (2010), businesses are under pressure to cut costs, customer lead time, and cycle time while increasing efficiency and quality. The decline in oil and gas prices, combined with the worldwide crisis, presented additional problems and challenges for both OGPC and OSC. While the OGPC is reducing their business costs and developing various techniques to reduce project and operational costs, the OSC must innovate to stay in business, given the increased competition among OSCs. We need to address other tactics, rendering the direct cost-cutting technique obsolete. The need to establish modern ways for improving project delivery is critical to survival, whereas a strategy aimed at reducing project delivery time, increasing profitability, and reducing waste connected with project-relevant resources and procedures is appropriate. Duran et al. (2017) stated that the lean maintenance concept is one of numerous strategies utilised to increase maintenance efficiency.

Lean goes beyond project planning and focusses on the removal of waste, non-value-adding activities, and processes that consume resources and take up space in order to smooth out the flow and reallocate those resources acquired from waste elimination. Uzochukwu and Ossai (2016) assert that the Toyota Production System (TPS) primarily inspired the lean system, a management philosophy that emerged in the 1990s. The Toyota Production System (TPS) is widely recognized for its emphasis on minimizing the original Toyota seven wastes, namely transport, inventory, movement, waiting, overprocessing, overproduction, and defects. Womack and Jones (2003), as well as Womack, Jones, and Roos (1991), characterised Lean theory as a real-world method for removing waste at the lowest possible cost and highest value.

Authors like Onwughalu, Okeke and Henry-Chibor (2017) and Taj and Morosan (2011) have outlined philosophies that could yield strategic gains, influence, or positively impact the performance of firms in their projects and operations. These philosophies include business process reengineering (BPR), queueing theory, total quality management (TQM), benchmarking (BM), just in time (JIT), and continuous improvement.

The majority of experts in offshore facility maintenance projects hold the belief that the project documentation process undergoes a multi-stage review cycle, requiring reviewers to dedicate days to the process before moving on to the next reviewer. However, they suggest simplifying such burdensome reviews to enhance efficiency and speed. Falk, Kamara, Brathen, Helle, Moe, and Kokkula (2020) argue that documentation is an important part of the managerial effort in delivering facility maintenance projects and equipment to the oil and gas industry, as it helps to articulate and guide the project as well as affect the flow and transfer of information and knowledge between stakeholders. Falk et al. (2020) and Achaka (2024) proposed that documentation helps to define anticipated deliverables and influences quality on deliverables and throughout operations, whereas timely access to complete and correct documentation is critical for project, product, and safety.

Other facility maintenance specialists confirmed that equipment downtime, a lack of maintenance experience, and the multitasking ability of mobilised equipment operators deployed for maintenance projects all contribute to project delays and increased costs. According to Franciosi, Lambiase, and Miranda (2017), the cost of an equipment failure (downtime losses, repairs, and output losses) exceeds the cost of preventative maintenance, highlighting the importance of developing an effective maintenance strategy.

Purchasing an excessive number of spare parts and components and storing them in a warehouse not only increases logistics and handling costs, but also diverts funds away from other productive uses. Ramiya and Suresh (2021) assert that these actions result in waste and implementing a lean maintenance strategy can boost employee and environmental safety, minimize the organization's environmental impact, and plan ahead for components or spare parts that significantly contribute to sustainable maintenance, eliminating resource waste and enhancing reliability. Experts in offshore facility maintenance projects assert that when OSCs fail to consult frontline workers for specific job tasks during planning, they often overlook crucial components that simplify project tasks, leading to a loss of productive hours or days.

From discussions and interactions with experts in offshore facility maintenance projects, it was found that the most common issues include waste from over procurement of project materials, losses due to defects and reworks, downtime and loss of workdays and hours due to equipment breakdown, improper tooling, laborious work procedures that involve non-value-added activities and processes that do not directly impact the deliverables, and poorly motivated workers. This study aims to investigate the scope and awareness level of lean concept adoption in offshore facility maintenance projects in the Nigerian oil and gas industry.

Literature review

According to Salem et al. (2015), the lean system of production originated at Toyota Motor Company, where a new business strategy was introduced with a focus on identifying waste sources as a first step and then applying methods, tools, and techniques to eliminate wastes. Since then, lean has expanded and spread to other types of industries, and many principles, concepts, and tools for lean implementations have been developed. The lean system of production originated in Japan in the 1980s as an evolution of manufacturing practices that evolved in the automobile industry,

as the automobile industry prior to this time from the early 1908 relied on craftsmanship and thus faced many challenges and capacity crises in the automobile production arena (Madanayake, 2015; Mostafa et al., 2013; Womack and Jones, 2003). The automobile business has progressed significantly through numerous production processes, ranging from artisan to mass manufacture. According to Womack and Jones (2003) and Womack et al. (1991), craft producers employ highly skilled workers who use simple but flexible tools to create what the consumer specifically requested one item at a time, but the goods produced by the craft method are expensive for people to afford because they are unique and one-of-a-kind. In response to these manufacturing constraints, mass production emerged as an alternative to artisan production at the turn of the twentieth century.

Womack and Jones (2003) and Womack et al. (1991) confirmed that mass-producers use narrowly skilled professionals to design and redesign products made by unskilled or semiskilled workers using expensive single-purpose machines to churn out standardised products in very high volume, despite the machinery being expensive and intolerant of disruption. The mass-producer added many buffers, additional supplies, extra workers, and extra space to assure seamless production, while consumers received cheaper products at the sacrifice of variety, and most employees found their jobs uninteresting and discouraging (Achaka, 2024; Womack & Jones, 2003; Womack et al., 1991).

According to Adom et al. (2018) and Camp (2001), a conceptual framework is a structure that the researcher believes best describes the natural course of the phenomenon under investigation. The study aims to create a system of interconnected activities with the goal of solving an issue linked with waste, disruption, and delivery time during the production cycle, hence achieving the study objective. The study applies lean concepts to an empirical and exploratory assessment of activities among a focused group of OSC professionals who employ traditional management systems to handle OGFMP operations under their organization's purview. The results of the literature review content analysis, questionnaires, and associated data subjected to statistical analysis to support the conclusions will confirm the research findings. The conclusion will develop a lean framework for offshore facility maintenance projects relevant to Nigeria's oil and gas industry.

Project Delivery Management Approach

Over the years, industry and academic practitioners have been concerned about the ability of various industries to meet key performance indicators of time, quality, and cost in project and service delivery when compared in terms of productivity, flow, quality control, waste elimination, and value generation. According to Igwe et al. (2018), many project management tools, techniques, and processes have been proposed as means of managing projects to ensure that they better meet stakeholders' expectations, but these have not been entirely successful in improving and delivering value due to waste, which is prevalent in the various processes, necessitating the need for a modern management approach. Project management, Value Management (VM), and Supply Chain Management (SCM) are some of the most common management methodologies for tackling issues related to project delivery and organisational processes across industries.

Lean System

According to Pettersen (2009), a lack of a clear definition of lean can hinder communication, complicate education, and lead to varying interpretations of the concept. This makes it difficult to make claims about its effects and requires researchers to specify their research. According to Pettersen (2009) and Achaka (2024), a lack of a precise definition can make it difficult to determine whether changes made in an organisation align with the lean philosophy and evaluate the concept's effectiveness.

Tiwari et al. (2011) further opined that, what we call lean system today should not be viewed in the narrow sense as merely a set of tools, techniques, and practices, but rather as a holistic approach that transcends the boundaries of the shop floor, thus affecting apart from the production itself almost all the operational aspects, e.g. design, development, quality, maintenance, etc., as well as the entire organisation and management of the company, and now a step ahead, According to Tiwari et al. (2011), researchers and practitioners of lean have made it the point of attraction for so many years, as many have tried to define the lean concept, but a review of literature indicates lean as a philosophy and a long-term journey for organisations seeking to gain and perfect the ideology.

Amade et al. (2019) described lean as a method of providing more value for customers with fewer resources, with the key premise being to maximise customer value while minimising waste. A lean organisation acknowledges the value of its customers and focusses its core operations on constantly increasing it, with the ultimate goal of providing perfect value to the client via a zero-waste value generation process.

Lean principles

Lean thinking begins with a deliberate effort to accurately define value in terms of specific products with specific capabilities offered at specific pricing through discussion with specific consumers (Rahman et al., 2012). Ignoring existing assets and technologies and reinventing product-line basis with strong, dedicated product teams is the foundation of lean, because lean is all about improving value and removing waste that impedes flow while precisely identifying value (Womack & Jones, 2003).

According to Achaka (2024), if an organisation does not follow the essential principles of lean but continues to adapt one or a few of the lean management features, it is likely that the organisation would fail in the future. Furthermore, if an organisation lacks prerequisites such as good leadership, a participative culture, and high commitment from managers and employees, in addition to a positive attitude, high motivation, and a sense of ownership from its team, the organisation will fail in the long run, but they did not provide a yardstick for implementing and assessing such prerequisites. Rahman et al. (2012) believed that in order to effectively increase organisational performance, lean concepts needed to be integrated with other lean tools, but they did not specify how or in what order.

According to Al-Kitab, Al-Nuaimi, and Ansari (2021), maintenance processes include all technical, managerial, and administrative actions taken during the life cycle of a product facility

in order to keep or restore the product facility in a state that allows it to perform the desired function of an oil and gas production facility.

During periods of inactivity, organisations schedule facility maintenance to maximise production efficiency and uptime (Achaka, 2024; Falk et al., 2020). They went on to say that these intervals are conservative and predicated on worst-case scenarios, rather than reflecting real facility and equipment usage. According to Falk et al. (2020), maintenance activities may include mobilisation, demobilisation, inspection and testing, periodic maintenance, and in-storage maintenance, which are carried out both offshore and onshore. Offshore facility maintenance necessitates specialised equipment, staff, and processes, as well as adherence to applicable standards and laws. It is also connected with a difficult and expensive task that necessitates meticulous preparation, organisation, and execution, necessitating a strategic approach (Rahim et al., 2021). Offshore facility maintenance can be performed by the facility's owner or operator, as well as by external contractors or service providers.

To extract oil and gas products, it must be connected to an existing producing offshore facility platform or an onshore facility. A subsea production system, which consists of wells located on the sea floor in shallow or deep water, provides a safe and controlled method of extracting and transporting raw oil and natural gas from subsea oil and gas wells to subsea flowlines and then to a process onshore or offshore oil and gas facility (Falk et al., 2020).

According to Omolekan, Ajayi, Kazeem-Bayo, and Babalola (2022), the Nigerian oil and gas industry is crucial to the country's economy. The recent drop in international oil prices is a major concern for all oil producing and exporting countries, including Nigeria. According to Lawal et al. (2023), the management of Nigeria's upstream oil and gas industry should initiate an effective planning process with periodic assessments to ensure that projects are completed on time and in estimating project costs while incorporating inflation and exchange rate factors into their plans.

According to Korovina (2023), oil and gas producing enterprises have no experience in using lean systems, but it appears to be cost-effective, while some of the factors that affect the success of projects in the Nigerian oil and gas sector can be traced to lack of use of a defined project management method, mismanagement, disconnection of policy formulation and policy implementation, improper regulation, political diversity, design risk factors such as cost overrun, project timing.

According to Jameel (2021) and Achaka (2024), implementing Lean in the oil and gas business reduces wasted time and resources, boosting the efficiency of the people, equipment, and processes involved. According to Jameel (2021), this results in less waste, more delighted customers, and higher-quality output at a cheaper cost, which leads to better profitability, while the benefits of Lean application in oil and gas are considerable and extend far beyond financial rewards.

According to Hasan and Al-Zu'bi (2014), applying lean maintenance in oil and gas fields increased crude oil production productivity by 6.72% per day, in addition to overcoming natural decline of oil wells, increasing profit, improving service quality, reducing wastes, reducing cycle time, inventory and raw materials, lowering costs, and reducing the number of operations.

The lean business improvement tool is the focal theme of concern for evaluation and adoption in this regard, as it has been corroborated by various literatures Salem, Musharavati, Hamouda, and Al-khalifa (2015); Lizak (2016); Atanas, Rodrigues, and Simmons (2016); Uzochukwu and Ossai (2016); that lean management concept and principles have been used in various industrial sectors of the global economy as one way of positioning operating efficiencies towards leading value indicators. According to Onwughalu et al. (2017) and Rachna and Peter (2007), lean is an integrated sociotechnical system tool that consists of a management practices package that can be used to eliminate waste and reduce variability in suppliers, customers, internal resources, and processes associated with all activities related to the provision of products and services.

Lean is a philosophy and technique that focusses on eliminating waste (non-value-added activities) and streamlining processes through close coordination of all activities. The lean system has three key components: it is demand driven, focused on waste reduction, and has a culture dedicated to excellence and continuous improvement (Womack & Jones, 2003). These are the advantages of the lean ideology.

According to Adegbembo, Bamisaye, and Aghimien (2016), the benefits of the lean approach include increased productivity, increased reliability, improved quality, increased client satisfaction, increased predictability, shortened schedules, less waste, lower costs, enhanced build-ability, design improvements, and increased safety.

Lean Tools & Techniques

According to Bokrantz et al. (2014), the core of lean principles is a commitment to continuous improvement and customer satisfaction, while striving for perfection and waste elimination is best achieved through tools such as 5S, Standardised work, Kaizen, Poka-Yoke, and Value Stream Mapping (VSM), which are mostly used in production environments and geared towards reducing lead-time or cost. According to Achaka (2024), these tools can also be used in maintenance operations, alongside standardised work for maintenance operators, Andon signals to trigger corrective maintenance, and the use of VSM to identify and remove waste in maintenance operations. Bokrantz et al. (2014) further said that the lean fundamental aspects, specifically TPM, must be in place before using specific lean tool techniques, as lean maintenance is a proactive maintenance strategy that employs planned and scheduled maintenance tasks in a TPM way.

The successful application of Lean tools will lead the organisation towards a competitive advantage, continuous flow of operations process enhancement, error removal in production, and enhanced elimination of non-value-added activities (Uzochukwu & Ossai, 2016). The rules and tools to apply are a major issue in lean concept implementation, as it has been noted that incorrect or mismatched application has a catastrophic effect on the organization's performance, while some critics of lean tools concept have argued that its implementation has a negative impact on the workforce, as they tend to lose jobs due to redundancy (Tiwari et al., 2011; Mostafa et al., 2013; Kariuki & Mburu, 2013; Onwughalu et al., 2017; Agyemang et al., 2019). Academic research and studies have not developed a central and uniform mechanism to measure lean implementation in any given organisation, while Lizak (2016) contends that a distorted view of lean concepts and tools is frequently the result of an inadequate management attitude, and it is frequently the cause of the inappropriate use of financial measures to assess the effectiveness of lean tools.

According to Rahman et al. (2012), utilising a single lean tool alone is insufficient to reduce waste and enhance performance; other lean principles and tools must be coupled to achieve the desired level of performance improvement. Overall, numerous literatures have been unable to clearly standardise the applicable tool or exact tools that would be known and baselined as the lean tool. The list of lean tools is enormous, and more researchers are constantly adding and subtracting from it, producing even more uncertainty for those attempting to implement the lean concept to their organisational endeavour. The table shows some of the lean tools that are relevant and suitable to oil and gas facility maintenance projects.

Table 1: Summary of Lean Tools and Requirements

Summary of Lean Tools and Requirements		
S/N	**Lean Tools**	**Requirements**
1	Workplace Organisation (5S)	Provides a methodology for organizing, cleaning, developing and sustaining a productive work environment to reduce waste, time and motion as it ensures that everything needed to deliver is in place and in order
2	Kanban	Schedule production planning for materials and tools to minimizing work-in-process
3	Kaizen	Relates to activities that improve every function of a business to change for better every day
4	Single Minute Exchange of Die (SMED)	To minimize setup time and cost thereby freeing capacity and enabling the production of very small lots
5	Cellular Manufacturing	The process allows producing similar products in one cell as it optimizes process for better performance
6	Team Development/Training	A motivated and trained team has better knowledge of work
7	Total Productive Maintenance (TPM)	Prevent machine downtime within the production process and ensure uptime, Improve process capability and consistency
8	Total Quality Management (TQM)	Improve quality by preventing defects from occurring and increasing quality of every single step in an organizational workflow
9	Value Stream Mapping (VSM)	Use flow diagram to depict every step of a process and their conformance to lean principles
10	Visual Management	Using visual aids to convey messages quicker and more efficiently, as visual information enables people to make correct decisions and manage their work and activities faster
11	Work Standardization	Ensure that all workers execute their tasks in the same manner and thus reduce variation from differences in work method
12	Production leveling (Heijunka)	It reduces unevenness and waste, levels the type and quantity of production while reducing batching
13	Inventory Management	Puts all inventory products in a proper sequence to supply these items in proper network
14	Lean Thinking	Provides new ideas to organize activities to deliver more benefits and value to industry production and services while eliminating waste
15	Just-In-Time (JIT)	Production of what a customer wants, when they want it, in the quantity they want it, and where they want it
16	Last Planner System (LPS)	A realistic planning approach that takes account of system's ability to meet their obligations in a consistent approach, it includes master schedule, stage/phase planning, look-ahead planning and weekly work plan
17	Multifunctional Team	Where employees are flexible and thus able to perform more than one task in the team
18	Concurrent Engineering	A design process where all life cycle phases of a product are considered simultaneously from the conceptual stage through the detailed design stage

19	PDCA	PDCA means Plan-Do-Check-Act and is a four-step method for creating and carrying out change. The PDCA method is a cycle and is repeated over and over again in order to drive continuous improvement.
20	Productive Meetings	A meeting style that uses a collaborative method of generating the topics and structure in order to facilitate more engaged and directed conversation. It keeps team members informed, help hold people accountable and allow for sharing of collective intelligence
21	First-In First-Out (FIFO)	A queue system in which the first item coming into the queue is handled first, the next one coming in is handled second, and the last one to arrive in the queue is handled last

Source: Author's compilation

Last Planner System (LPS)

The Last Planner System (LPS) is a technique developed by Glen Ballard in 1992 to reduce waste sources in the construction system, and it is classified as a reliable lean tool that involves continuous monitoring of the flow process in order to maintain a correlation between worker skills and scheduled tasks (Bajjou et al., 2017). The LPS planning concept is based on four types of plans: the Master Schedule, Stage/Phase Planning, Look-Ahead Planning, and Weekly Work Plan (Achaka, 2024; Bajjou et al., 2017; Amade et al., 2019). The entire project package tasks, the work sequences and steps that is proposed to be carried out at the execution phase of the project is planned on the Master Schedule, the Stage/Phase planning puts together all activities for which the team can engage with for a period of three to four months, while two to eight-weeks planning constitutes a Look-Ahead planning that allows for identifying what is to be done, aligning resources and constraints to be taken into account.

Visual Management

Visual management is the enhancement of capacity in production processes and sub-processes to ensure that materials, resources, and information circulate in such a way that communication between different stakeholders becomes more flexible; additionally, visual management makes processes transparent, simple to understand, and safe for people on site (Bajjou et al., 2017). The strategy includes visual gadgets that facilitate simple stakeholder communication, increase flexibility, and reduce interdependence, as well as a system transparency process that has a good impact on employee engagement (Bajjou et al., 2017).

The 5S approach is a lean tool based on Japanese terminology, including Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardise), and Shitsuke (sustain). This tool adds value to the system by verifying that everything needed for delivery is in place and in order. Several studies have found that a well-organised workplace facilitates the production of quality products and services, and 5S should be considered as the first tool of choice during lean system implementation (Achaka, 2024; Bajjou et al., 2017; Womack & Jones, 2003; Womack et al., 1991). The 5S definition is as follows:

Seiri (Sort) is to tidy the organization's Tools, Materials, and Equipment in the work area, retaining only necessary items, while equipment and materials frequently used should be separated from lesser used elements, thus making it possible for better accessibility as the need of the materials or equipment arises and it becomes easier to find, this reduces time losses that may affect work duration (Achaka, 2024; Deshmukh & Patil, 2018; Bajjou et al., 2017; Womack & Jones, Seiton

(Set in order) refers to arranging each material or equipment in its proper location, which helps to reduce waste associated with worker movement to look for materials or equipment, freeing up more time for productivity and ensuring the organization's orderliness (Achaka, 2024; Deshmukh & Patil, 2018; Womack & Jones, 2003; Womack et al., 1991). Seiso (Shine) refers to keeping a workplace, working tools, and equipment as clean as possible and storing them in order to reduce waste associated with dirtiness, which leads to increased employee job satisfaction and productivity (Deshmukh and Patil, 2018; Bajjou et al., 2017; Womack & Jones, 2003; Womack et al., 1991). Seiketsu (Standardise) aims to standardise practice and publicise the three initial S as a norm by disseminating simple and clear methods for action (Deshmukh & Patil, 2018; Bajjou et al., 2017; Womack & Jones, 2003; Womack et al., 1991). Shitsuke (Sustain) refers to attempting to infuse the 5S strategy as the norm into the organization's culture and way of life via training, monitoring, controls, and promotions.

Error proofing (Poka-Yoke)

Error correction (Poka-Yoke). Poka-Yoke is a Japanese term for a mechatronics device used to automatically prevent flaws from flowing through a process or mistake-proofing device or technique to prevent order-taking or manufacturing defects (Bajjou et al., 2017; Womack and Jones, 2003; Womack et al., 1991). They may be visual communication tools that ensure workforces working on-site work in a self-regulating, self-ordering, self-improving, and self-explanatory manner; however, the devices are not only visual tools; they also have the capability to launch sound alarms in the event of defects, as this approach is an innovative way to avoid unintentional errors in a simple and cost-effective manner (Bajjou et al., 2017; Womack & Jones, 2003; Womack et al., 1991).

Kanban

According to Deshmukh and Patil (2018), "Kanban" is a Japanese word that means "Visible" or "Card" and was developed by Onho at the Toyota manufacturing plant to control production between processes and implement JIT manufacturing. According to Womack and Jones (2003), Kanban cards were introduced in 1953 to reinforce the process flow system and make information flow backwards at the same rate as products flowed forward. Kanban is a signal card raised with information about amounts of product to be produced, product origin, and product destination, while Kanban system is designed to simplify handling material and inventory management; instead of stacking materials issued for production near the production line in larger quantities, smaller material quantities are held physically at usage points on line and replenished when only Kanban or signal is generated (Deshmukh & Patil, 2018; Woma Deshmukh and Patil (2018) discovered that by only manufacturing products based on customer signals sent via the Kanban system, Toyota manufacturing was able to reduce waste and inventory holding costs, while other benefits included reduced inventory, improved flow, reduced or eliminated overproduction, improved responsiveness to demand changes, and increased supply chain management ability. According to Deshmukh and Patil (2018) and Womack and Jones (2003), the primary purpose of Kanban is to eliminate waste, because ordering items only when necessary, saves time, money, and space.

According to Kenton (2019), just-in-time inventory management aligns raw material orders with production schedules, leading to increased efficiency and reduced waste. This strategy also reduces inventory handling costs by accurately forecasting demand. JIT can be used in lean maintenance to synchronize supplier orders for spare parts/parts with the maintenance schedule. According to Tiwari et al. (2011), the JIT is a distinguishing aspect of TPS, particularly in an assembly industry such as automotive manufacturing. This system's distinguishing feature is that just the necessary products are made at the necessary time and in the appropriate quantities, with the minimum amount of additional stock maintained. The Japanese industry developed the JIT system framework in order to thrive in the post-World War II market, whereas most corporations across the world began applying the system in their own production systems as soon as it became popular (Tiwari et al., 2011). The JIT is the basic and fundamental element of TPS, and its evolution as a concept has resulted in the development of other parallel complementary elements such as the shift from batch to small lot size production, set-up time reduction through SMED, the Kanban system, Andon cards, and so on (Tiwari et al., 2011). Furthermore, Tiwari et al. (2011) argue that the newly developed parts quickly were integrated into the JIT system, leading to the idea that the JIT system "in its entirety" is considered as a complete manufacturing philosophy.

Standardised work.

Standardised work is a baseline tool used to document current best practices applicable, thus it serves as a guide to improve the current standard and ensure that the new standard becomes the baseline for subsequent improvement. According to Womack and Jones (2003), standardised work helps to eliminate the "to do list" and enhance quality.

Methodology

The study used both descriptive survey and case study research designs, with the descriptive survey collecting quantitative and qualitative data to describe the nature of oil and gas offshore facility maintenance project delivery activities and applicable project operation structures in the decomposed tasks and constituents. The understanding of the practice and process led to the creation of a questionnaire that incorporates the content into perspective for the assessment of the extent and level of awareness of lean concept adoption in facility maintenance projects. Where suitable to the study objective, questionnaires would be distributed to oil and gas facility maintenance experts. This is due to the technicality and knowledge base required for data collection from respondents in this study area, whereas the Likert scale would be used in the administered questionnaire to measure reports presented by respondents, as recommended by researchers (Kothari, 2004). The researcher self-administered the questionnaires using methods that were appropriate for the responder, such as emailing and handing out physical copies in person. The questionnaire was divided into sections, with one section designed to collect demographic characteristics of the target population, such as work experience, level of education, industry status, discipline, and so on, and the other sections containing pertinent questions raised in the research question poised to meet the research objectives. Each item was assessed on a five-point scale ranging from 1 (low) to 5 (high) grade.

The study was limited to oil services companies (OSC) operating for four major oil and gas producing companies (OGPC) in Nigeria, with the study population recruited from workers in the selected OSC working on the OGPC's facility maintenance project. The study's population target

consisted of oil and gas professionals with extensive expertise in oil and gas facility maintenance projects (OGFMP) in Nigeria's Niger Delta region. As a result, the survey's stakeholders include project managers, project engineers, project supervisors, quality engineers, and client representatives with hands-on expertise who can relate their experiences to real-life situations. The study used a purposeful sampling strategy to pick respondents, which is favoured since it allows for sampling respondents or participants who have the necessary information, skill, and competence concerning the research being conducted.

As it is hard to reach every member of a population being investigated, a representative sample size was established. According to Walonick (1997), sample size and characteristics must be acceptable, as this contributes to the credibility of a study. The sample method used was convenience sampling. Convenience sampling is a way of selecting study participants depending on the convenience of the investigator. To avoid random errors in the convenience sampling strategy, the researcher's judgement and experience in the study region were used during sampling.

This is consistent with Marshall's (1996) assertion that sampling can be done using the researcher's judgement if he or she has adequate experience in the issue under investigation. The researcher used a census since the study seeks to reach out to all experts in OGPC firms and projects in Nigeria's Niger Delta region. The census approach is justified because, according to Njeru (2015), data acquired through census contributes to the collection of unbiased data representing all persons' viewpoints in the study population on a research subject. The census approach is also justified because census results are more likely to be reflective of accurate and reliable data derived from a population sample, allowing for the generalization of study findings. Censuses provide a more accurate count of the population since there is no sampling error and more thorough information about the studied problem is likely to be acquired.

According to Kothari (2004), primary data are those that are acquired for the first time and are thus unique in character, whereas secondary data are those that have already been collected by someone else and have been subjected to statistical processing. The survey consists of personal observations, documentation, and semi-structured interviews with specialists in oil and gas facility maintenance project management. The experts gave information on practice and method, as well as task decomposition of constituent elements in relation to the research objectives. The research technique includes a survey of oil and gas facility professionals as well as a case study of four (4) OGPC facility sites in the Niger Delta region of Nigeria's oil and gas industry. A survey questionnaire was created to gather a series of questions on oil and gas facility maintenance projects and research objectives. The study focused on Nigeria's Niger Delta region, with a concentration of oil and gas facilities in Rivers, Delta, and Akwa Ibom states due to logistical constraints, company strategy, and facility location.

The study data were analysed using a variety of descriptive statistical methods such as median, mean, mode, frequency distribution, and percentile ranks, and the statistical package for social science (SPSS) software was used to ease analysis, interpretation, and data presentation. To investigate the extent and awareness level of lean concept adoption in offshore facility maintenance projects in the Nigerian oil and gas industry, collected data were analysed using a number of descriptive statistical tools such as median, mean, mode, frequency distribution, and

percentile ranks, and statistical package for social science (SPSS) software was deployed to facilitate analysis, interpretation, and data presentation.

Results

The study sample included eleven (11) oil servicing companies/firms (OSC) that work for four (4) major oil and gas producing companies (OGPC) in Nigeria, with a study population derived from personnel in the selected OSC who work on the OGPC's facility maintenance projects. Project managers, project engineers, project supervisors, quality engineers, and client representatives all work in the four primary OGPCs. Professionals from the 11 OSC working in the four major OGPC businesses and projects filled out self-administered surveys. 118 of the 122 professionals completed and submitted the questionnaires, while 113 were found to be appropriate for the study, resulting in a 94.17% response rate. The high response rate of 94.17% permitted the collection of adequate data that could be extrapolated to determine the achievement of the research objectives established at the outset. According to Njeru (2015), a response rate of more than 50% is required to collect enough data to accurately represent the perspectives of respondents in the target demographic. The response rates are presented in tables 2 and 3, respectively.

Table 2: Details of Oil and gas Servicing and Major OGPC Firms

SN	Code	Major OGPC Firms				Professionals
		CN	TN	SN	MN	
1	AMGV	X	X	X	X	12
2	AFN	X	X	X		10
3	CAN	X	X	X	X	10
4	ADB	X	X	X	X	14
5	AAS		X	X	X	9
6	APN	X	X	X	X	12
7	APMN	X	X	X	X	13
8	AGH	X	X	X	X	14
9	ADV		X	X	X	9
10	ATG	X	X	X	X	12
11	APN	X	X	X	X	19
	Total					**122**

Source: Analysis of Field Survey data, 2022.

Table 3: Response Rate of the respondents

	OSC Firms	Population	Sample Sent	Sample Returned	Sample Used
1	AMGV	12	12	11	11
2	AFN	10	10	10	10
3	CAN	10	10	9	9
4	ADB	14	14	14	14
5	AAS	9	9	9	9
6	APN	12	12	11	11
7	APMN	13	13	13	13
8	AGH	14	14	14	13
9	ADV	9	9	9	8
10	ATG	12	12	12	12
11	APN	19	19	18	15
	Total	**122**	**122**	**118**	**113**

Source: Analysis of Field Survey data, 2022.

Extent of awareness of Lean concept

In investigating the extent and awareness level of lean concept adoption in offshore facility maintenance projects in the Nigerian oil and gas industry, the collected data was analyzed using frequency distribution and charts as depicted in table 4, figure 1 and table 5.

Table 4: Major Offshore Facility Maintenance Project Type

Project Type	Frequency	Percentage
Piping and structural maintenance project	39	34.51
Coating maintenance project	15	13.28
Valve and pumps maintenance project	20	17.70
Pressure vessels and tank maintenance project	26	23.01
Inspections/NDT and lifting equipment maintenance project	13	11.50
Total	**113**	**100**

Source: Analysis of Field Survey data, 2022.

Based on the types of major offshore facility maintenance projects involved in by the respective firms, the table above revealed that (39) 34.51% of the respondents are involved in piping and structural maintenance projects, (15) 13.28% are involved in coating maintenance projects, (20) 17.70% are involved in valve and pumps maintenance projects, while (26) 23.01% are involved in pressure vessels and tank maintenance projects, while (13) 11.50% are involved in inspections/NDT and lifting equipment maintenance projects.

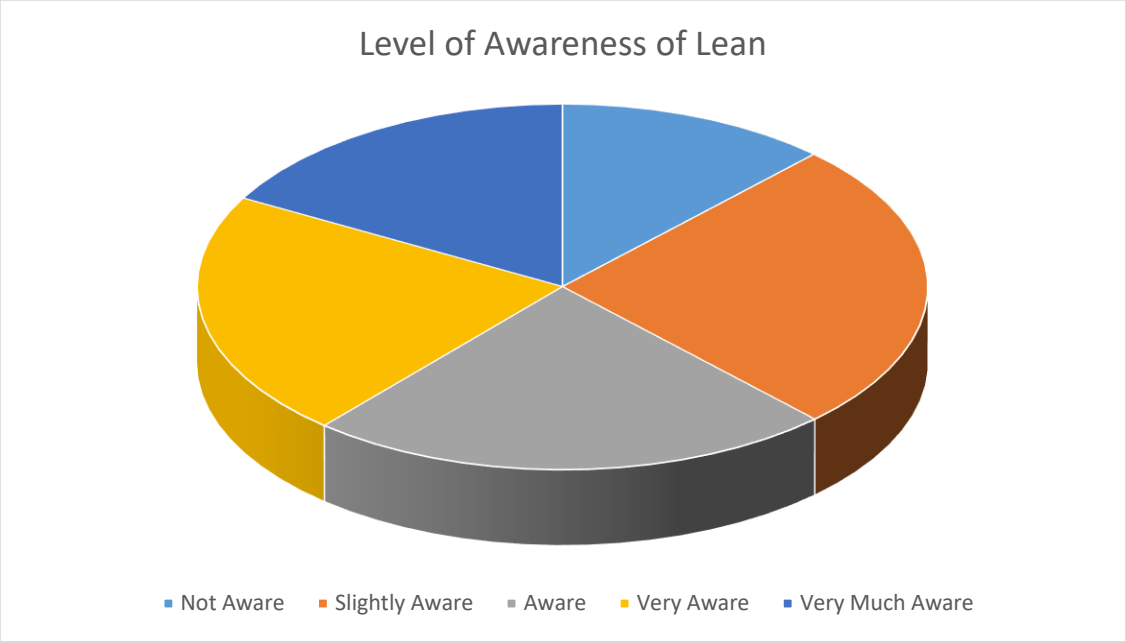

Figure 1: Level of lean awareness in offshore facility maintenance project

Source: Analysis of Field Survey data, 2022.

Based on the level of lean awareness in offshore facility maintenance projects of the respondents in their respective firms, the figure above revealed that (22) 19.48% of the respondents are not aware of lean in offshore facility maintenance projects in the oil and gas industry, (45) 39.82% are slightly aware of lean, (21) 18.58% are aware, (17) 15.04% are very aware, while (8) 7.08% are very much aware of lean in offshore facility maintenance projects in the oil and gas industry.

Table 5: Awareness level on identifying lean tools for waste reduction

Awareness level	Frequency	Percentage
Not aware	25	22.12
Slightly aware	51	45.13
Aware	20	17.70
Very aware	12	10.62
Very much aware	5	4.43
Total	**113**	**100**

Source: Analysis of Field Survey data, 2022.

Based on the level of lean awareness on identifying lean tools for waste reduction in the offshore facility maintenance projects of the respondents in their respective firms, the table above revealed that (25) 22.12% of the respondents are not aware of lean on identifying lean tools for waste reduction in the offshore facility maintenance projects in the oil and gas industry, (51) 45.13% are slightly aware, (20) 17.70% are aware, (12) 10.62% are very aware, while (5) 4.43% are very much aware of lean tools in identifying waste reduction in the offshore facility maintenance projects of the respondents in their respective firms and the in the oil and gas industry in general.

Discussion of Results

In investigating the extent and awareness level of lean concept adoption in offshore facility maintenance projects in the Nigerian oil and gas industry, the collected data was analyzed using frequency distribution and charts as depicted in table 4, figure 1 and table 5. Based on the types of major offshore facility maintenance projects involved in by the respective firms, the table above revealed that (39) 34.51% of the respondents are involved in piping and structural maintenance projects, (15) 13.28% are involved in coating maintenance projects, (20) 17.70% are involved in valve and pumps maintenance projects, while (26) 23.01% are involved in pressure vessels and tank maintenance projects, while (13) 11.50% are involved in inspections/NDT and lifting equipment maintenance projects. The outcomes of this study agree with that of Anand and Kodali (2009) and Achaka (2024) who aver that, the reasons for improper understanding of lean management by managers and employee is due to the lack of education and body of knowledge, while these issues need to be thoroughly addressed given the circumstances surrounding its advantage in offshore facility maintenance projects. Ferguson et al. (2022) opined that, the processes associated with facility maintenance activities are costly, time-consuming, labor-intensive, and must be conducted on-site, while stating that, moreover, inspection findings are subjective and provide incomplete asset coverage, leading to increased risk of unplanned shutdowns. Based on the level of lean awareness in offshore facility maintenance projects of the respondents in their respective firms, the figure above revealed that (22) 19.48% of the respondents are not aware of lean in offshore facility maintenance projects in the oil and gas industry, (45) 39.82% are slightly aware of lean, (21) 18.58% are aware, (17) 15.04% are very aware, while (8) 7.08% are very much aware of lean in offshore facility maintenance projects in the oil and gas industry. Based on the level of lean awareness on identifying lean tools for waste reduction in the offshore facility maintenance projects of the respondents in their respective firms, it was revealed that (25) 22.12% of the respondents are not aware of lean on identifying lean tools for waste reduction in the offshore facility maintenance projects in the oil and gas industry, (51) 45.13% are slightly aware, (20) 17.70% are aware, (12) 10.62% are very aware, while (5) 4.43% are very much aware of lean tools in identifying waste reduction in the offshore facility maintenance projects of the respondents in their respective firms and the in the oil and gas industry in general.

Conclusions

From the outcomes of the results, the study now concludes that; there is a moderate level of awareness and adoption of lean system and its concept as applicable in the offshore facility maintenance project in the oil and gas industry in Nigeria, given that (45) 39.82% of the

respondents are slightly aware of lean in offshore facility maintenance projects in the oil and gas industry, (51) 45.13% are slightly aware of lean in identifying lean tools for waste reduction in the offshore facility maintenance projects in the oil and gas industry. On the extent of involvement in types of major offshore facility maintenance projects by the respective firms, majority of the OSC firms were involved in the major types of offshore facility maintenance projects. The study recommends that given the moderate level of awareness and adoption of lean system and its concept as applicable in the offshore facility maintenance project in the oil and gas industry, there's need for industry players and government at all levels to brace up to the paradigm change and embrace the "lean thinking" philosophy in their offshore facility maintenance activities in the oil and gas sector in particular. Lean thinking and philosophy have proven to be a cost cutting and saving mechanism that would help curb waste in the entire offshore facility maintenance project. Some of the notable problems bedeviling the OSC in the delivery of oil and gas facility maintenance projects such as defects in completed products, overstocking of raw materials and consumables – where consumables with short product lifespan expire before usage, dearth Just In Time (JIT) flow, unnecessary queues at fabrication sections, high work-in-progress (WIP), over production and stocking of finished products without matching usage, laborious work process, etc can be nipped in the bud by the application of a lean philosophy.

References

Achaka, C.H. (2024). Development of a lean framework for successful offshore facility maintenance projects in the Nigerian oil and gas industry. PhD Thesis Department of Project Management Technology, Federal University of Technology, Owerri, Nigeria.

Adegbembo, T. F., Bamisaye, O. P. & Aghimien, D. O. (2016). Assessment of lean construction practice in the Nigerian construction industry. *The Joint International Conference (JIC)* on 21st Century Human Habitat: Issues, Sustainability and Development, 21-24 March 2016, Akure, Nigeria, pg. No. 756-764

Adom, D., Hussein, E. & Agyem, J. (2018). Theoretical and conceptual framework: Mandatory ingredients of a quality research. *International Journal of Scientific Research*, Volume-7, Issue-1, ISSN No 2277 – 8179, IF: 4.176, IC Value: 93.98.

Agyemang, D., Fong, P. & Kissi, E. (2019). The influence of organizational infrastructure on organizational effectiveness in the construction industry. *CIB World Building Congress 2019 Hong Kong SAR, Conference Paper, China*. Retrieved from https://www.researchgate.net/publication/334029696

Al-Kitab, M. H., Al-Nuaimi, F. I., Ansari, M. N., & Ibrahim, T. K. (2021), Robust lean management model for maintenance in Iraqi oil and gas industry: A review study, *Journal of Mechanical Engineering Research and Developments* ISSN: 1024-1752 CODEN: JERDFO Vol. 44, No. 5, pp. 249-257

Amade, B., Ononuju, C., Obodoh, D., & Okorie, C. (2019). Barriers to lean adoption for construction projects. *The Pacific Journal of Science and Technology*, Vol. 20, No. 1, 153 – 166. Retrieved from http://www.akamaiuniversity.us/PJST20_1_153.pdf

Atanas, J., Rodrigues, C., & Simmons, R. (2016). Lean six sigma applications in oil and gas industry: Case Studies. *International Journal of Scientific and Research Publications*, Volume 6, Issue 5, 540 ISSN 2250-3153.

Bajjou, M. S.,Chafi, A., Ennadi, A, & El-Hammoumi, M. (2017). The practical relationships between lean construction tools and sustainable development: A literature review. *Journal of Engineering Science and Technology Review* 10 (4)170- 177. www.jestr.org, doi:10.25103/jestr.104.20

Bokrantz, J., Ylipää, T., & Skoogh, A (2014). Lean principles and engineering tools in maintenance organizations – A survey study. Retrieved from http://publications.lib.chalmers.se/records/fulltext/210354/local_210354.pdf

Camp, W. G. (2001). Formulating and evaluating theoretical frameworks for career and technical education research. *Journal of Vocational Educational Research*, 26 (1), 27-39.

Deshmukh, G. & Patil, C. (2018). Lean assessment using fuzzy interference decisive system in manufacturing industries. *International Journal of Engineering Research and Applications (IJERA).* ISSN: 2248-9622, Vol. 8, Issue4 (Part -II), pp59-66 www.ijera.com, DOI: 10.9790/9622-0804025966

Duran, O., Capaldo, A., & Acevedo, P. (2017). Lean maintenance applied to improve maintenance efficiency in thermoelectric power plants. *Journal of Energies*, 2017,10,1653, 1 – 21.

Falk, K., Kamara, A. K., Brathen, E. P., Helle, K., Moe, P. T., & Kokkula, S. (2020). Digitizing the Maintenance Documentation; a System of Systems in Oil and Gas Industry, Conference: 2020 IEEE 15th International Conference of System of Systems Engineering (SoSE). DOI: 10.1109/SoSE50414.2020.9130515 Retrieved from https://www.researchgate.net/publication/342620348

Ferguson, E., Castillo, M., Kazzaz, A., Dunner, T. (2022). Case Study on the Impacts of an Automated Condition Assessment System Deployed Across Offshore Production Facilities. Paper presented at the ADIPEC, Abu Dhabi, UAE. doi: https://doi.org/10.2118/211273-MS

Franciosi, C., Lambiase, A. & Miranda, S. (2017). Sustainable maintenance: a periodic preventive maintenance model with sustainable spare parts management. IFAC-Papers Online 50(1):13692–13697

Hasan, R., & Al-Zu'bi, Z. (2014). Evaluating the relationship between lean manufacturing dimensions and radical product innovation in the Jordanian pharmaceutical sector. *European Scientific Journal*. Oct. ed. vol.10, No.28, ISSN: 1857 – 7881, Pg.230-258

Igwe, C., Mohammadi, A., Nasiri, F., & Hammad, A. (2018). House of Waste and its Implication for Project Management. *Conference: Project management symposium, University of Maryland, Baltimore*. Retrieved from https://www.researchgate.net/publication/325206845

Jameel, A. A (2021). Lean Oil and Gas. Retrieved from https://www.fourprinciples.com/wp-content/uploads/2021/02/Lean-Oil-Gas.pdf

Jongeling, R. & Olofsson, T. (2007). A method for planning of work-flow by combined use of location-based scheduling and 4D CAD, *Automation in Construction* 16 (2007) 189–198 doi:10.1016/j.autcon.2006.04.001

Kariuki, B. & Mburu, D. (2013). Role of lean manufacturing on organization competitiveness. *Industrial Engineering Letters*, ISSN 2224-6096 (Paper) ISSN 2225-0581 (online) Vol.3, No.10, p.81-91. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download . doi=10.1.1.893.5767&rep=rep1.

Kenton, W. (2019). Just In Time (JIT) Retrieved February 15, 2019, from https://www.investopedia.com/terms/j/jit.asp

Korovina, A.A. (2023). Prospects of Lean Production in the Oil and Gas Industry. Vestnik of Samara University. Economics and Management, 2023, vol. 14, no. 2, pp. 55–63. DOI: http://doi.org/10.18287/2542-0461-2023-14-2-55-63 .

Kothari, C.R. (2004). Research methodology: Methods and techniques. (2nd revised ed.). New Age International (P) Limited, Publishers, New Delhi, India.

Lawal, Y. M., Nwoye, M. I. & Ibrahim, U. A. (2023). Project Performance and Critical Success Factors in Nigerian Upstream Oil and Gas Industry: Evidence Based on Sem Approach. Russian Law Journal Volume XI (2023) Issue 10s

Lizak, M. (2016). Methods of measuring the effectiveness of lean management. Retrieved from http://www.qpij.pl/

Madanayake, U. (2015). Application of lean construction principles and practices to enhance the construction performance and flow. *The 4th World Construction Symposium: 2015, Colombo, Sri Lanka.* Retrieved from https://www.leanconstruction.org/learning/publications/lean-construction-journal/

Marshall, M.N. (1996) Sampling for Qualitative Research. Family Practice, 13, 522-525. http://dx.doi.org/10.1093/fampra/13.6.522

Mostafa, S., Dumrak, J., & Soltan, H. (2013). A framework for lean manufacturing implementation. *Production & Manufacturing Research Journal*, ISSN: (Print) 2169-32771:1, 44-64. https://doi.org/10.1080/21693277.2013.862159

Njeru, S.E. (2015). Factors affecting effective implementation of procurement practices in tertiary public training institutions in Kenya. A thesis for the degree of Doctor of Philosophy in the Jomo Kenyatta University of Agriculture and Technology, Kenya.

Omolekan, O.J., Ajayi, E.O., Kazeem-Bayo, O.L., & Babalola, H.B. (2022). Financial Distress Prediction in Nigerian Oil and Gas Industry: A Multivariate Approach, ISSN 1563-0358; eISSN 2617-7161, The Journal of Economic Research & Business Administration. №1 (139). https://be.kaznu.kz 151 Al-Farabi Kazakh National University IRSTI 06.71.03 https://doi.org/10.26577/be.2022.v139.i1.13

Onwughalu, O., Okeke, K., & Henry-Chibor, E. (2017). Lean production and its effect in organizations: A study of selected manufacturing firms in Nigeria. Retrieved from http://www.scholarly-journals.com/SJSRE

Pettersen, J. (2009). Defining lean production: some conceptual and practical issues. *The TQM Journal*, 21(2), 127-142. http://dx.doi.org/10.1108/17542730910938137

Rachna, S., & Peter, T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, Volume 25, Issue 4, Pages 785-805

Rahman, H., Wang, C., & Wui-Lim I. (2012). Waste processing framework for non-value adding activities using lean construction. *Journal of Frontiers in Construction Engineering*, Vol. 1 Iss. 1, PP. 8-13.

Ramiya, S. & Suresh, M. (2021). Factors influencing lean-sustainable maintenance using TISM approach. *International Journal of System Assurance and Engineering Management* 12, 1117–1131. https://doi.org/10.1007/s13198-021-01304-7

Salem, R., Musharavati, F., Hamouda, A., & Al-khalifa, K. (2015). An empirical study on lean awareness and potential for lean implementation in Qatar industries. *International Journal of Advanced Manufacturing Technology*. Retrieved from https://www.researchgate.net/publication/282499813

Tiwari, S., Dubey, R., & Tripathi, N. (2011). The journey of lean, *Indian Journal of Commerce & Management Studies*, ISSN – 2229-5674. Retrieved from, http://www.scholarshub.net/ijcms/vol2/issue2/Paper_21.pdf

Tourki, T. (2010). Implementation of lean within the cement industry. Doctoral Thesis. De Montfort University, UK.

Uzochukwu, O. C., & Ossai, I. F. (2016). Lean production: A frontier for improving performance of oil and gas companies in Nigeria. Retrieved from http://www.pyrexjournals.org/pjbfmr/pdf/2016/may/Uzochukwu-and-Ossai.pdf

Walonick, D. S. (1997). Survival statistics. Bloomington: StatPac, Inc. Retrieved from http://www.statpac.com/statistics_book/order.htm .

Wenchi, S., Wang, J., Wang, X., & Chong, H. (2015). An application of value stream mapping for turnaround maintenance in oil and gas industry: Case study and lessons learned In. *31st Annual ARCOM Conference 2015, Lincoln, UK, Association of Researchers in Construction Management*, 813-822. Retrieved from http://www.arcom.ac.uk/docs/proceedings/49ec9c51ba16c05246993a47b724bb.pdf

Womack, J., & Jones, D. (2003). *Lean thinking: Banish waste and create wealth in your corporation.* London: Free Press.

Womack, J., Jones, D., & Roos, D. (1991). *The machine that changed the world: How Japan's secret weapon in the global auto wars will revolutionize western industry* (1st ed.). New York, NY: Harper Perennial.

About the Authors

Chimezie Henry Achaka, MSc

Owerri, Nigeria

Engr. Chimezie Henry Achaka, M.Sc is a project management practitioner and practitioner with academic affiliations. He possesses an M.Sc. degree in Project Management Technology and a Registered Mechanical Engineer with over (18) years of work experience in the Oil & Gas Industry. He is an AMPP Senior Certified Coatings Inspector, an IRCA Certified Lead Auditor, and an AWS Certified Welding Inspector. He has worked on several International Oil companies' projects; Onshore/Offshore facilities, Rigs/FPSO/Drill Ships at various Technical/Management capacities, providing startup construction & contracts management, maintenance, modification/facility upgrade services. His professional expertise includes; Projects/Contracts Management, Construction, QA/QC, QMS Auditing, NDT & Destructive Welding & Coatings Inspections, Supervision of Technicians on Fabrication & Protective Coatings, HSE Inspection of field operations, Pipeline reticulation project management. His mission is to add value to any

organization by making a good impact and his ideology is to guarantee good performance on the job, with a vision to further develop competencies in his self and career through learning. He can be contacted at achakach@yahoo.com, henryachaka.20164997168@futo.edu.ng.

Benedict Amade, PhD

Federal University of Technology
Owerri, Nigeria

Benedict Amade is a Chartered Project Manager by Profession and a Probationer (Member) of Nigerian Institute of Quantity Surveyors (NIQS). He read and obtained a PhD (Doctor of Philosophy) Degree in Project Management Technology from the Federal University of Technology, Owerri, Nigeria. He is a member of the Project Management Institute (PMI) U.S.A. and presently a Senior Lecturer in the Department of Project Management Technology of the Federal University of Technology, Owerri, Nigeria where he has been lecturing for the past 15 years. His areas of research interest include construction project management, computer-based project management, construction supply chain management and information technology on construction projects. He has authored over 50 scientific publications in international refereed journals indexed in Scopus, Web of Science, Scimago etc. He has presented quality papers at international conferences both home and abroad. He is actively involved in other consultancy works. He can be reached at https://orcid.org/0000-0003-3368-5432; benedictamade@yahoo.com; benedictamade@futo.edu.ng; benedictamade2@gmail.com.

Kevin Aku Okorocha, PhD

Federal University of Technology
Owerri, Nigeria

Kevin Aku Okorocha is a Professor in the Department of Project Management Technology, Federal University of Technology, Owerri, Nigeria. He holds a B.Sc, Estate Management, M.Sc Project Management Technology, MBA in Banking and Finance, M.Sc Economics and Ph.D in Project Management Technology. His areas of research interest include; Project Financing and Investment, Industrial Economics. He is an Associate member of the Nigerian Institute of Estate

Surveyors and Valuers, and a Fellow of the Chartered Institute of Project Managers of Nigeria. Professor Okorocha is currently the Dean of the School of Logistics and Innovation Technology, Federal University of Technology, Owerri, Nigeria. He can be reached at okorocha_kev@yahoo.com.

Emmanuel Chinenye Ubani, PhD

Federal University of Technology
Owerri, Nigeria

Emmanuel Chinenye Ubani is a Professor in the Department of Project Management Technology, Federal University of Technology, Owerri, Nigeria. He holds a B.Sc, M.Eng and Ph.D in Industrial Engineering and Project Management. His areas of research interest include; Engineering Project Management, and Materials Requirement Planning. He is member of the Nigerian Society of Engineers (NSE) and Fellow of the Institute of Industrial Administration. Professor Ubani can be reached at drecubani@yahoo.com.