

REVIEW ARTICLE

Research on Publication Trends for Asset Management of Offshore Facilities Between 1992 to 2022 Using Scientometric Analysis

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Abstract: The demand for monitoring activities has been more evident recently in oil and gas “O & G” activities such as exploration, drilling, production, logistics, or shipping. Consequently, these offshore infrastructures require asset management (or facilities management). This study seeks to understand the research pattern of publications within the domain of asset management in offshore infrastructures with the aim of determining the present state of the field’s research. The paper conducts a scientometric analysis of publications that focus on offshore infrastructures’ asset management published between 1992 and 2022. The employed search query yielded a total of 346 journal articles from the Scopus database and 43 from the Web of Science (WoS) database, respectively. The data analysis of the scientometric investigation explored research authorship, co-occurrence of keywords, number of publications, network mapping, country geographical breakdown, and literature coupling. The paper shows rising interest in monitoring and asset management in the oil and gas industry. It was concluded that the management of these infrastructures requires frequent review with the application of sustainable asset management strategies.

Keywords: Asset Management; Facilities Management; Oil and Gas; Offshore Facility; Scientometric; Bibliometric

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1. Introduction

Every firm tries to ensure that its assets are well-managed and safe for the workers to use. Thus, asset management (AM) has been a useful tool deployed by various firms. Over time, asset management has changed from simple time-based inspections of vital equipment to reliability-centered and risk management systems for all safety-critical elements (SCE), with a focus on the crucial factors and processes for calculating the life extensions of an ageing offshore structure^[1-8]. According to the ISO 55000 standard, asset management is “the coordinated action of an organisation to realise value from assets”^[9]. Having an asset inventory, maintenance, infrastructural design, and replacement costs and spare-parts inventory with the costs to the oil and gas (O & G) industry is still a challenge regarding various resources required. These resources include finances, time, and personnel throughout its life cycle, which is a persistent issue for facility managers and asset integrity managers in the business^[10-14]. In addition to the cost consequences of sustaining these assets, extending their lives, and monitoring them, these concerns also entail developing new platforms that can produce future oil and gas supplies. As demonstrated by various breakthroughs in the sector, asset integrity management includes many components that are essential to the maintenance, serviceability and long-term viability of offshore assets^[14-21].

Asset management also applies to the financial sector for the monitoring of financial assets and investment portfolios to ensure that the assets are well monitored. Amaechi et al.^[22] proposed some guidelines for the asset management of offshore facilities. Using bibliometric analysis to map the literature on asset management, De Filippo et al.^[23] identified 2,449 publications from management, optimization, maintenance, infrastructure, business, and finance research. The analysis techniques are related to previous scientific research that has been carried out, like those on energy efficiency^[23-30]. However, taken as its whole, the offshore sector typically includes a variety of activities, such as transportation, logistics, planning for wind farms, facility maintenance, exploration, drilling, and production^[30-32]. The demand for monitoring activities has been more evident recently in the construction sector, services sector, financial sector as well as the energy sector. In the latter, it is seen in various oil and gas “O & G” activities such as exploration, drilling, production, logistics, or shipping. This implies that these offshore infrastructures require asset management (or

facilities management).

Following the need to meet the sustainable development goals (SDGs) of the United Nations (UN), there is a need to understand the research impact of sustainable marine structures, such as boats and buildings. The use of sustainable building materials that can withstand hard temperatures, high sea depths, unfavourable weather, powerful winds, and high significant wave heights are some of these issues. As a result, a greater understanding of the core variables, hot topics in research, and asset management procedures is needed, as covered in this investigation. This paper considers the publication records for the past three decades, from 1992 to 2022. The structure of the paper is as follows: the first section is the introduction, while the second section gives the materials and methods. The third section gives the results and analysis while the conclusions are given in the fourth section.

2. Materials and Methods

The materials and methods employed to achieve the research goals are presented in this section.

2.1 Data Collection

This study relies on data collection from accessible literature in order to perform a scientometric analysis. This established method for gathering data for this type of method was used in this study. The research approach for selecting useful articles that will be included in the data analysis was deemed important because diverse studies on asset management have covered a variety of technologies used. The data employed in this study was obtained based on criteria, including (a) contemporary and relevance: all works published between 1992 and 2022 were searched, and manually screened using keywords and abstracts; (b) peer-reviewed articles: They were included due to the rigour and reviews to remove mistakes, inaccuracies and errors, (c) the use of a research framework to ensure quality assurance. The database selection was essential for the review of the literature. It was ideal to select the database to acquire the data because of its broad coverage of journal publications and knowledge domain comparison. Operators and wildcards were used in the search. The wildcard character * was used to collect all keyword variations. Based on the purpose of the study, the keywords for the search query were (asset AND management AND of AND offshore AND

facilities), (“asset management*” OR “offshore*” AND (“facilities*”). The database yielded all the articles on asset management of offshore structures that were searchable by terms found in a publication’s title, abstract, or keywords. The 1992–2022 search frame was chosen to capture the ongoing expansion of asset management of offshore structures. Non-English journals were excluded from the articles considered for the data analysis in this study.

2.2 Research Methodology

In order to analyse research patterns from this field, a scientometric analysis is conducted in this study employing a research database and visualization-mapping tools. Scientometrics as employed in this study aimed to disclose the research effect of publications, researchers, journals, and research organisations in a certain field of study. This can be conducted using data-mining tools and analysis software called VosViewer^[22]. Most scientometric investigations in humanities, built environment, sciences, and social sciences utilise scientific citations to provide a deeper understanding of authorship, citations, scientific relevance, and research

engagement^[22–30]. The current study undertakes a scientometric analysis and evaluation of the research trends by using publications relevant to the asset management of offshore facilities. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach includes details on the PRISMA 2020 statement and the PRISMA checklist. The data were synthesized and verified to align with the content of the search query.

Using the streamlined approach helps the investigator acquire a complete grasp of the development of this research topic from 1992 to 2022. To qualitatively validate the bibliometric studies, the methodology was contrasted with some recent bibliometric research cutting across different fields. The application of sampling, visualization, cluster investigation and correlation are newer methods of data analysis that have practical applications for scientometric studies in multidisciplines^[22–30], ranging from the built environment to marine structures and data analysis. On the basis of the results of this scientometrics study, a thorough systematic review is then provided to provide deeper insights into the technology and applications of asset management of offshore facilities. The flowchart of the research search criteria used is presented in Figure 1.

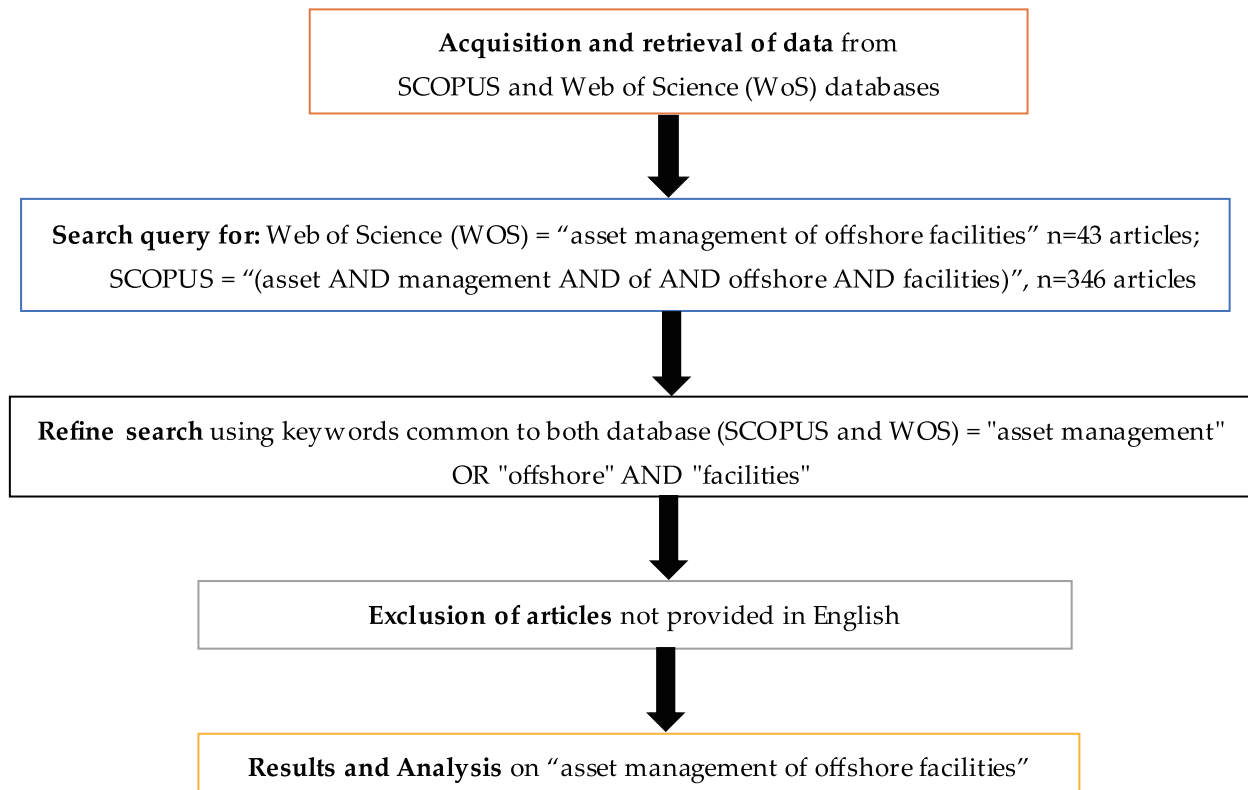


Figure 1. Research methodology on the scientometric review.

3. Results and Analysis

This section presents the results and analysis from the scientometric review.

3.1 Publication Years

The impact of the research, which can be broken down by using the publication years for the topic “asset management of offshore facilities” is the initial aspect of the results for the component meta-analysis. Figure 3 illustrates data from the Scopus database that was gathered in the middle of 2022. When the most recent publications were taken into account, the publishing output from 1992–2022 exhibited a small trend shift. From 1999, there was a more steady increase in the publication rate. In 2004, there was an increase in the publications on asset management of offshore facilities from 4 publications to 11 publications, which is related to the offshore developments that occurred in that year. The output increased from 16 publications in 2013 to 24 publications in 2014 then reduced slightly to 18 publications in 2015 before it increased steeply to 34 publications in 2016, which was the highest recorded publication on the subject area under consideration. Then it reduced to 33 publications in 2017, then reduced further to 25 publications in 2018, which is likely due to the global fall in oil prices from 2016–2017. It then increased slightly to 29 publications in 2019 then it reduced to 23 publications in 2020, but it increased to 25 publications in 2021. However, there was the global COVID-19 pandemic from 2020–2021 (which was due to the prevalence of Coronavirus), and most of the publications that are usually presented in conferences like OTC and ASME conferences were cancelled. This

affected publication output in the oil and gas industry, particularly on offshore facilities. Some of the conferences had to reschedule conferences for 2021/2022 and while a few had to adapt to virtual conference presentations. In 2021, it rose to 29 publications and in 2022, it further rose to 32 publications, as that covers the selected timeline for the research. This reflects the increasing research in this subject area.

Despite these actions, the publication rate decreased from 25 publications in 2020 to 14 publications in 2021 and then 3 publications in mid-2022. Some of the technical conferences held around mid-2022, like the OTC conference that was held in May 2022 and the ASME OMAE was held in June 2022, would have not yet published their journal papers. A similar trend is observed for studies that are extracted for mid-year, however it is estimated that the publication rate at the end of 2020 would increase up to 20, due to recent developments in offshore facilities. Examples are the development of deepwater platforms by different operators like Shell, BP and Norwind Offshore. These include the conversion of new assets and contracts signed on asset management of offshore facilities. From this research, it can be observed that the research on this subject area is a function of economic activity as there were also 8 publications published in 2008 and 2009, which was also a period of a global financial crisis called economic recession. This data shows an overall growing trend in 2009 from 8 publications to 16 publications in 2010 which shows some increased stability in the O & G industry. Importantly, the trend that rose in 2013 coincided with some key developments in the asset management of offshore facilities, which include platform commissioning. This study shows that the number of publications increased at a normal rate but had a pattern of slowly increasing between 1993 and 2021.

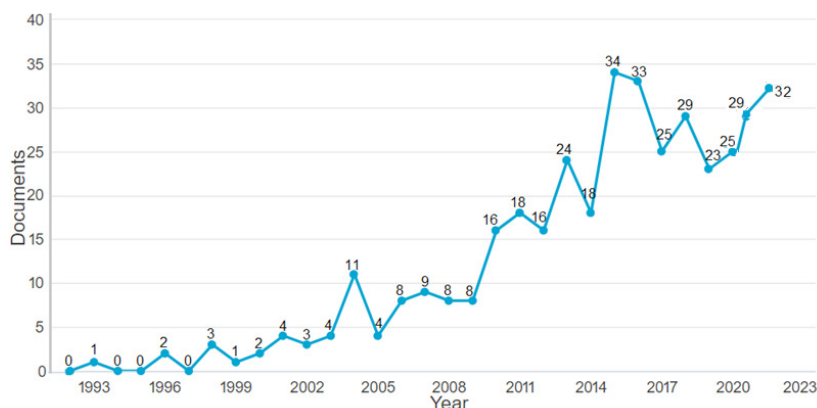


Figure 2. The number of publication records versus publication years.

Source: Scopus Database.

3.2 Publication Authors

Based on the authorship of published works, the analysis of research trends on asset management of offshore facilities includes another component. Determining the research trends from the authors helps to understand the developments made and future research trends in the subject area. A scientometric investigation reveals the impact of authors' records on the subject area, and their publication records provide important insights into the research. Using the data retrieved from the Scopus database, as seen in Table 1, the highest publications by authors were published by Boutrot, J., having 5 publications, followed by Nezamina, A., and Rossi, R., as each had 4 publications. The next author grouping was the authors that had 2 publications, which were: Adeyemi, O.S., Andersen, E.S., Barrios, A., Berger, P.E., Biniwale, S., Briers, J., Ciaraldi, S.W., Gallagher, D., and Hillier, E. Another group of authors, including Ajayi, A., and Akinyemi, O., also had 2 publications each. The study found that the largest group of authors in this subject area were those with a single publication.

The component for the authors is considered the penultimate component in the meta-analysis because it is the authors that carry out the research, analyze the result findings, discuss the results, report them and publish them. The scientific literature on asset management of offshore facilities has been influenced by various researchers. The authorship contributions for asset management of offshore facilities displayed in Figure 4 do not represent the exhaustive list of authors in the field of over 300 authors. The 15 authors are the most published, as obtained from the publication database using the search query in Scopus. The collection of documents has over 200 authors, a number of whom have just 1 publication. Table 1 presents the top 17 authors with their h-index, the number of publications and the citations. The h-index of some of the authors was low despite having a high publication record due to a lack of citations or low citations. Citations show the relevance or significance of the publication on the specialization. While the publication record of the authors may be high, it is also important that these publications get cited and references by other authors, publishers, presenters and publishers. From the record in Table 1, the highest citations were 898, by Amaechi, C.V. with a h-index of 20, followed by 153 citations, by Briers, Jan with a h-index of 5. Conversely, the author with the highest number of publications was Ciaraldi, Stephen W., with 67 documents and a h-index of 4. This showed that the authors' works are relevant based on

the fairly high citations received in the publications for asset management of offshore facilities.

Table 1. List of top 17 authors on "asset management of offshore facilities" research with h-index, publication amount and citations.

Authors	h-index	Publications	Citations
Boutrot, Jonathan	1	8	4
Nezamian, Abe	5	20	54
Rossi, Roberto	4	14	78
Adeyemi, Temitope	2	3	25
Andersen, Erlend Stokstad	3	3	14
Barrios, Andre	0	3	0
Berger, Per Erik	0	3	0
Biniwale, Shripad Suhas	6	30	102
Briers, Jan	5	18	153
Ciaraldi, Stephen William	4	67	28
Gallagher, Daniel	1	7	2
Hillier, Elizabeth	3	5	14
Hopkins, Peter	0	3	0
Legrégeois, Nicolas	1	7	2
Amaechi, Chiemela Victor	20	54	898
Ajayi, Ayodele Abraham	1	3	1
Akinyemi, Olusegun Peter	5	7	80

Source: Scopus Database.

3.3 Publication Subjects

The literature search utilizing published subjects is another focus of the publication trend examination in this paper, as shown in Figures 3 and 4. They represent the categorization of publications on 'asset management of offshore facilities' based on their respective topic matter. In the 2022 data, Energy constituted the largest share (37.6%) at 219 publications, followed by Engineering disciplines (27.1%) at 136 publications, which together accounted for almost a quarter. Then, it was followed by Earth and Planetary Sciences (21.0%) at 122 publications, then it was followed by Chemical Engineering (3.6%) at 21 publications, then it was followed by Materials Sciences (3.4%) at 20 publications. Then, it was followed by Environmental Sciences (2.9%) at 17 publications, then it was followed by Social Sciences (1.4%) at 8 publications. Next was Physics and Astronomy (1.2%) at 7 publications, and Chemistry (1.2%) at 6 publications. Also, it showed that Mathematics (1.0%) scored the lowest at 6 publications, while Others, comprising small subgroups, accounted for 3.4%, demonstrating that there were additional, emerging fields working on asset management of offshore facilities.

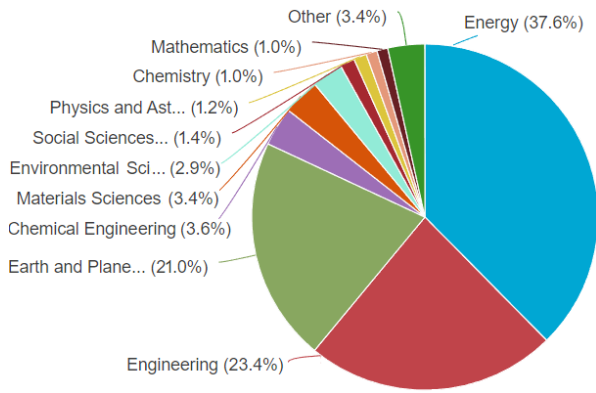


Figure 3. Classifying publications using subjects for ‘asset management of offshore facilities’.

Source: Scopus.

Similarly, we found comparable patterns from the second database called Web of Science data in other relevant domains as shown in Table 2 and the visualizations in Figure 4. According to the visualisation treemap used to display all publications on asset management of offshore facilities, there were 10 publications on Marine Engineering, 7 publications on Ocean Engineering, 6 publications on Energy Fuels, 6 publications on Civil Engineering, 6 publications on Mechanical Engineering, 6 publications on Petroleum Engineering, 5 publications on Industrial Engineering, 4 publications on Chemical Engineering, 4 publications on Oceanography and 4 publications on Engineering Multidisciplinary. A detailed breakdown of the various engineering disciplines, such as Civil Engineering, Mechanical Engineering, and Engineering Multidisciplinary, was also conducted using the tabular data in Table 2. This further illustrates how asset management of offshore facilities, cuts across various facets, such as the drilling, production, transportation, refinery and chemical assets as well as the production lines used for the marine risers



Figure 4. Treemap Visualization showing various areas for ‘asset management of offshore facilities’.

and pipelines. This study also shows the importance of asset management to ensure that new and existing systems such as machine parts, are well maintained using state-of-the-art management systems, sustainable maintenance models and the best expertise for the deployment. It also shows that institutions, companies, training agencies and consultancy firms are invested in this field and their research outputs have influenced interest in engineering courses.

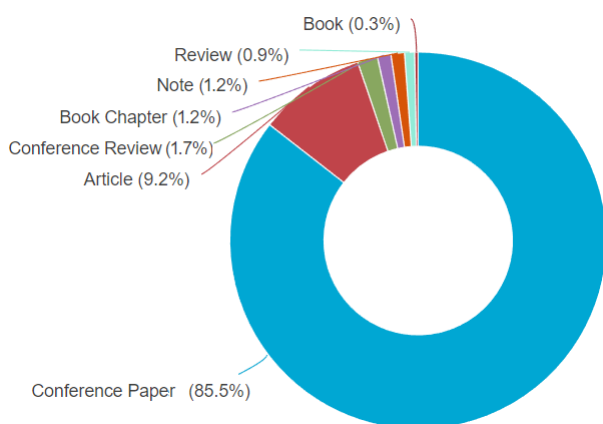
3.4 Publication Type

The scientometric review conducted in this section focuses on the literature search using publication type for asset management of offshore facilities. Figure 5 illustrates the focus of the meta-analysis of the scientometric review considering literature search as per publication type. These sectors in Figure 5 stand for the type-based classification of articles for asset management of offshore facilities. It was found that conference papers come in first at 85.5% with 296 publications, followed by journal papers (or articles) which are second at 9.2% with 32 publications. The next sectors include the conference reviews which were 6 documents at a rate of 1.7%, followed by book chapters at 4 documents at a rate of 1.2%, and notes were 4 publications at the rate of 1.2%. Review papers followed, producing 3 documents at a rate of 0.9%, while books were the least as 1 book was recorded at 1 publication at the rate of 0.3%. The output of the other types, which included data papers, method papers, editorial papers, erratum papers, letter papers, and publication data, were not recorded. This suggests that the volume of published outputs, which are primarily research articles, represent the research classes (classifying the types using details) for asset management of offshore facilities.

Table 2. Data on publication subjects for ‘asset management of offshore facilities’.

Web of Science Categories	Record Count	% of 43	Web of Science Categories	Record Count	% of 43
Engineering marine	10	23.26%	Environmental sciences	2	4.65%
Engineering ocean	7	16.28%	Green sustainable science technology	2	4.65%
Energy fuels	6	13.95%	Management	2	4.65%
Engineering civil	6	13.95%	Computer science information systems	1	2.33%
Engineering mechanical	6	13.95%	Construction building technology	1	2.33%
Engineering petroleum	6	13.95%	Ecology	1	2.33%
Engineering industrial	5	11.63%	Engineering environmental	1	2.33%
Engineering chemical	4	9.30%	Engineering manufacturing	1	2.33%
Engineering multidisciplinary	4	9.30%	Environmental studies	1	2.33%
Oceanography	4	9.30%	Geochemistry geophysics	1	2.33%
Engineering electrical electronic	3	6.98%	Geosciences multidisciplinary	1	2.33%
Operations research management science	3	6.98%	Materials science composites	1	2.33%
Economics	2	4.65%			

Source: WoS Database.

**Figure 5.** Classifying types of publications for ‘asset management of offshore facilities’.

Source: Scopus database.

3.5 Publication Sources

The current meta-analysis focuses on the publishing sources by using two academic databases —Scopus and WoS Core Collection. To confirm the existence of the publications, the h-index of the publications was looked up to confirm the data from the Scimago database. Aside from these choices made, it is important to state that other existing prominent academic databases like PubMed, Science Direct, DOAJ, Engineering Village, etc. could also be utilised in similar studies. It was feasible to draw further conclusions about the examination of asset management of offshore facilities. This was conducted by a thorough, scientific and techno-literary

method using scholarly papers from conferences and journals. Also considered were academic publishers with databases and repositories, like Sage, Springer Link, Taylor & Francis, and Elsevier. Specialist journals like *Ocean Engineering*, which has a high h-index of 109 and an impact factor of 3.7985, *Marine Structures*, which has a high h-index of 71 and also an IF (impact factor) value of 4.52, and international conferences like ASME OMAE, ASCE, SPE, OTC, ISOPE, etc., were also taken into consideration as publications with high significance. From Table 3, it was observed that the majority of publications on asset management of offshore facilities were presented as journal papers from the proceedings of three significant conferences—OTC, SPE, ASME OMAE. The top journals on asset management of offshore facilities were then screened to be included in the final product. In Table 4, the journals that appeared the most frequently were Elsevier’s *Ocean Engineering*, Elsevier’ *Marine Structures*, MDPI’s *Journal of Marine Science and Engineering*, etc. These articles, though, were fewer in number than the ones that appeared in associated Q1 periodicals. The details of this subsequent analysis revealed that the *Offshore Engineer* journal published the highest volume of publications that are journal articles, though it has a low h-index of 4. However, other journals have 1 publication, based on the subject area, but high h-index, such as *Renewable Sustainable Energy Reviews* with an h-index of 337, *Journal Of Hazardous Materials* with an h-index of 307, *Chemical Engineering Journal* with an h-index of 228 and *Reliability Engineering and Systems Safety* with an h-index of 157. This study also showed that the

highest publications were conference papers from Proceedings of the annual Offshore Technology Conference (OTC), with an h-index of 44 and had 41 publications, spread over many years, as seen in Table 3. The second highest publications were conference papers from Proceedings of the Society of Petroleum Engineers (SPE) Annual Technical Conference And Exhibition, with an h-index of 85 and 21 publications. The third highest publications were 10 publications from Proceedings Of The International Conference On Ocean, Offshore Mechanics And Arctic Engineering (OMAE), with a h-index of 10. Further review of these publication lists showed that

comparable areas investigated by researchers studying asset management on offshore facilities, ranging from reliability to management systems. Secondly, the early increased improvements in asset management on offshore facilities, which were observed as early as in 1993, led to the publication of numerous patents between 1992 and 2022 by various inventors. Despite the developments in the offshore industry, the publication sources are still found to be presented in these top technical conferences, and also more recent studies include management systems, and certifications, life cycle, asset management and reliability studies.

Table 3. Publications on top conference proceedings for asset management of offshore facilities.

Source Title	Publications	% of 103	H-index	Database
Proceedings Of The Annual Offshore Technology Conference OTC	41	39.806	44	WoS
Proceedings SPE Annual Technical Conference And Exhibition	21	20.388	85	WoS
Proceedings Of The International Conference On Ocean, Offshore Mechanics And Arctic Engineering OMAE	10	9.709	47	Both
NACE International Corrosion Conference Series	4	3.883	40	WoS
Proceedings Of The International Offshore And Polar Engineering Conference	4	3.883	49	Both
SPE Asia Pacific Oil And Gas Conference	2	1.942	25	WoS
SPE Hydrocarbon Economics And Evaluation Symposium	2	1.942	14	WoS
International Conference On Renewable Energy Research And Applications ICRERA	2	1.942	18	Scopus
Proceedings Of The IADC SPE Asia Pacific Drilling Technology Conference	1	0.971	22	WoS
Proceedings Of The Institution Of Civil Engineers: Forensic Engineering	1	0.971	12	WoS
SPE International Symposium On Oilfield Chemistry Proceedings	1	0.971	37	WoS
Proceedings SPE Symposium On Improved Oil Recovery	1	0.971	50	WoS
Proceedings Annual Convention Gas Processors Association	1	0.971	13	WoS
Proceedings Of The European Petroleum Conference	1	0.971	24	WoS
Safety Reliability And Risk Analysis Theory Methods And Applications	1	0.971	8	Scopus
NAV International Conference on Ship & Shipping Research	1	0.971	5	Scopus
Proceedings of International Business Information Management Association Conference IBIMA	1	0.971	5	Scopus
Proceedings Of The International Conference On Quality Reliability ICQR	1	0.971	3	Scopus
Proceedings Of The Institution Of Mechanical Engineers Part E Journal Of Process Mechanical Engineering	1	0.971	34	Both
Symposium On Loss Prevention And Safety Promotion In The Process Industries	1	0.971	3	Scopus
Annual Reliability And Maintainability Symposium RAMS	2	1.942	44	Both
Advances In Production Management Systems APMS	1	0.971	6	Scopus
International Conference On Health Safety And Environment In Oil And Gas Exploration And Production	2	1.942	14	WoS

Source: Scopus and WoS Databases.

Table 4. Publications on top journals for asset management of offshore facilities using Scopus and WoS Databases.

Source Title	Publications	% of 55	H-Index	Database
Offshore Engineer	3	5.455	4	WoS
Chemical Engineering Transactions	2	3.636	39	Both
Journal Of Marine Engineering And Technology	2	3.636	17	Both
Journal Of Offshore Technology	2	3.636	4	WoS
Journal Of Quality In Maintenance Engineering	2	3.636	59	WoS
Oil And Gas Journal	2	3.636	36	WoS
IFIP Advances In Information And Communication Technology	2	3.636	56	Both
Reliability Engineering And System Safety	1	1.818	157	Both
SPE Production And Operations	1	1.818	56	Both
Journal of Petroleum Technology JPT	2	3.636	36	Scopus
International Journal Of Energy Sector Management	1	1.818	24	Scopus
International Journal Of Oil Gas And Coal Technology	1	1.818	19	Scopus
ABB Review	1	1.818	18	WoS
ASCE ASME Journal Of Risk And Uncertainty In Engineering Systems Part B Mechanical Engineering	1	1.818	14	Both
American Society Of Mechanical Engineers Pressure Vessels And Piping Division Publication PVP	1	1.818	30	WoS
Atmosphere	1	1.818	46	Both
Automation In Construction	1	1.818	138	Both
Chemical Engineering Journal	1	1.818	248	WoS
Global Pipeline Monthly	1	1.818	4	WoS
Hydrocarbon Engineering	1	1.818	12	WoS
Hydrocarbon Processing	1	1.818	28	WoS
Journal of Offshore Mechanics And Arctic Engineering, ASME	1	1.818	49	Both
International Journal Of Automation And Computing	1	1.818	41	WoS
International Journal Of Energy Production And Management	1	1.818	8	WoS
International Journal Of Technology And Human Interaction	1	1.818	20	WoS
Journal Of Hazardous Materials	1	1.818	307	WoS
Journal of Loss Prevention In The Process Industries	1	1.818	88	Both
Malaysian Construction Research Journal	1	1.818	11	WoS
Ocean Engineering	1	1.818	109	Scopus
Marine Structures	1	1.818	71	Both
Applied Ocean Research	1	1.818	74	Scopus
Mathematical Problems In Engineering	1	1.818	68	Both
Neftyanoe Khozyaystvo - Oil Industry	1	1.818	18	WoS
Offshore	1	1.818	11	WoS
Oil Gas European Magazine	1	1.818	17	WoS
Petrophysics	1	1.818	37	Both
Ocean Coastal Management	1	1.818	90	Scopus
Journal of Marine Science and Engineering JMSE	1	1.818	29	Scopus
Journal of Quality In Maintenance Engineering	1	1.818	59	Scopus
Renewable Sustainable Energy Reviews	1	1.818	337	Scopus
Materials Performance	1	1.818	26	WoS
Built Environment Project and Asset Management	1	1.818	24	Scopus
Ecological Economics	1	1.818	220	Scopus
European Journal Of Industrial Engineering	1	1.818	28	Scopus
IEEE access	1	1.818	158	Scopus
IET Renewable Power Generation	1	1.818	84	Scopus

3.6 Publication Affiliation by Oil Companies

The scientometric analysis of publications was conducted on the research contributions by oil companies for asset management of offshore facilities. From the data in Figure 6, the highest contributor in this subject area was found to be Schlumberger having supported 21 publications, followed by Petronas having supported 18 documents. Royal Dutch Shell has supported 12 publications, while Det Norske Veritas & Germanischer Lloyd (DNVGL) has supported 10 publications. Both Chevron and Eni have supported 8 publications each, while Halliburton has supported 7 publications. Bureau Veritas (BV) has supported 6 publications while total has supported 4 publications. Both Saudi Arabian Oil Company and Equinor have supported 4 publications each while Exxon Mobil, BP, Petronas and Abu Dhabi National Oil Company also each have supported 3 publications on the subject area. It should be noted that the extent of the support, based on financial contributions, grant support and project funding was not included in the data obtained from the SCOPUS database. This study indicates that the oil companies are highly invested in training, knowledge and education on asset management of oil companies, as these companies aim to ensure that their offshore assets are well-maintained.

3.7 Publication Affiliation by Universities

The bibliometric analysis results of publications related to the subject area are crucial in understanding

the impact of institutions or organisations, referred to as affiliations, on research. Examining the results of bibliometric studies conducted on publications related to the topic is necessary to gain an understanding of the affiliations, which are the entities that influence the research. It is essential to comprehend the support given by different affiliations to asset management of offshore facilities to perform an analysis of the research effect that was produced by the organisation or institution. This is presented as a breakdown of publication volume produced by various departments. Consequently, the databases yielded results that included papers from a variety of disciplines. Many research organisations, universities, polytechnics, and private companies are currently making contributions to the body of scholarly work compiled on asset management. The scientometric analysis on publications was conducted on the research contributions by higher education academy (or higher institutions) for asset management of offshore facilities. As observed in Figure 7, the document count for twelve (12) top institutions in the subject area showed that the University of Stavanger with 7 publications in WoS and 6 publications in Scopus. This was followed by Universiti Teknologi Petronas with 1 publication in WoS and 3 publications in Scopus, followed by VIA University College with 1 publication in WoS and 3 publications in Scopus. Other universities with 2 publications in this subject area include Cranfield University, University of Adelaide, University of Kent, Tianjin University and University of Bologna. Several other universities have recorded 1 publication in this field, such as China Uni-

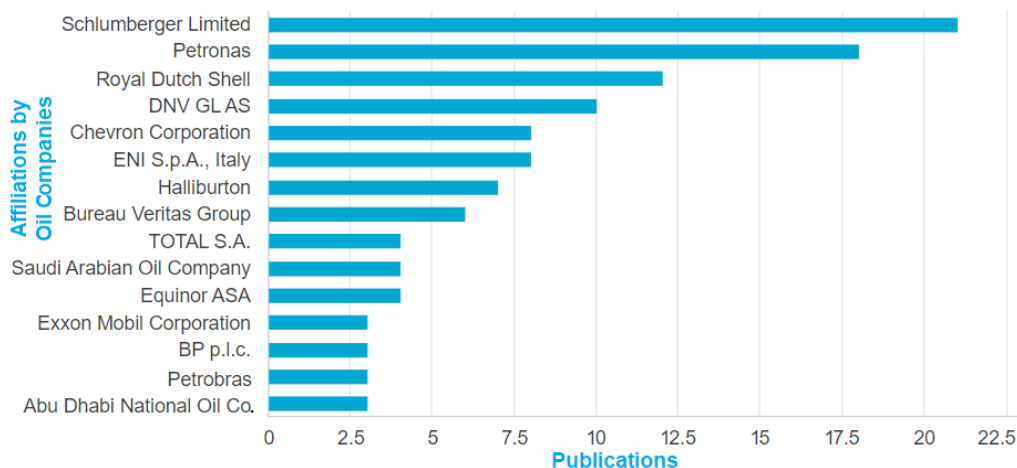


Figure 6. Literature search distribution on the research contributions on affiliation by oil companies for ‘asset management of offshore facilities’.

Source: Scopus Database.

versity of Geosciences, China University of Petroleum, and Astrakhan State Technical University. It was noted that various universities are invested in this research area, due to the need to find solutions on asset management in the offshore industry as well as the oil and gas industry in general. It was also noticed that most of these institutions offer courses related to petroleum engineering, subsea engineering, project management,

asset management, construction management and naval architecture, thereby promoting sustainable research and education in this area. However, there is the need for more institutions to develop a research interest in this area, and apply cutting-edge systems, which will require collaboration between the industry and academia. A detailed list of affiliations on asset management of offshore facilities is provided in Table 5.

Table 5. List of affiliation by universities for research and publications on ‘asset management of offshore facilities’.

Affiliations	Record Count	% of 43	Affiliations	Record Count	% of 43
Universitetet i Stavanger (University of Stavanger)	7	16.279	Natl Tech Univ Athens (NTUA)	1	2.326
Cranfield University	2	4.651	Petrobras R D Cenpes	1	2.326
Delft University of Technology	2	4.651	Reg Maritime Univ	1	2.326
Memorial University Newfoundland	2	4.651	Rzeszow University of Technology	1	2.326
University Of Kent	2	4.651	Southwest Petroleum University	1	2.326
University Of Western Australia	2	4.651	Tianjin university	1	2.326
Astrakhan State Technical University	1	2.326	Udice French Research Universities	1	2.326
Centre National De La Recherche Scientifique (CNRS)	1	2.326	Ulsan National Institute Of Science Technology UNIST	1	2.326
The University Of Adelaide	1	2.326	United States Department Of Defense	1	2.326
China University of Geosciences	1	2.326	United States Navy	1	2.326
China University of Petroleum	1	2.326	Univ Piraeus UNIPI	1	2.326
Cnrs institute of ecology environment inee	1	2.326	Universite de Bretagne Occidentale	1	2.326
Coastal Research and Planning Institute (CORPI)	1	2.326	Universite Paris Saclay	1	2.326
Dalian university of technology	1	2.326	University of Bologna	1	2.326
Ecole des Ponts Paristech	1	2.326	University of Edinburgh	1	2.326
Embry Riddle Aeronautical University	1	2.326	University of Maryland College Park	1	2.326
European Academy OF Bozen Bolzano	1	2.326	University of Sevilla	1	2.326
Heriot Watt University	1	2.326	University of Strathclyde	1	2.326
Hohai University	1	2.326	University of Tun Hussein Onn Malaysia	1	2.326
IFREMER	1	2.326	University System OF Maryland	1	2.326
Institut National de la Recherche Agronomique (INRAE)	1	2.326	VIA University College	1	2.326
Istanbul Technical University	1	2.326	Xi'an University of Architecture and Technology	1	2.326
Klaipeda University	1	2.326	Yokohama national university	1	2.326
Multimedia University	1	2.326			

Source: Scopus and WoS databases.

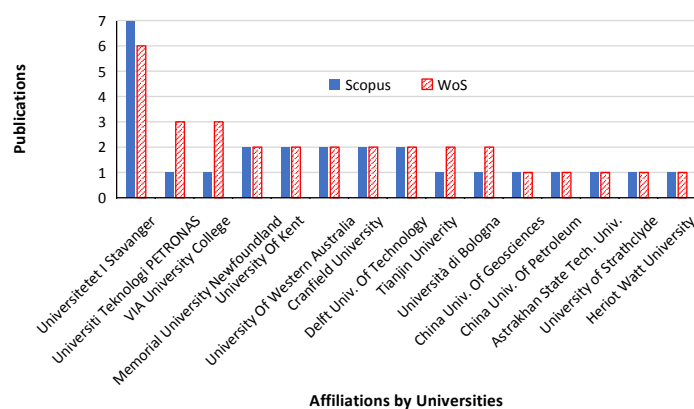


Figure 7. Literature search distribution on the top research contributions on affiliation by universities for ‘asset management of offshore facilities’.

Source: Scopus and WoS databases.

3.8 Publication Funding Agencies/Funders

The bibliometric analysis results of publications related to the subject area demonstrate that funders or funding agencies significantly increase research outputs and enhance sustainable education in higher education academies (HEA) such as universities, as well as research institutions and government organizations. One aspect of this bibliometric study involved validating certain studies by cross-referencing them with their respective funders, and grant numbers, as detailed in Tables 6 and 7. It was noted that oil companies were among the principal funders as Royal Dutch Shell and Schlumberger each funded research in the area three times. Certification also played a crucial role in the asset management of offshore facilities. Australian Research Council followed, having funded research twice, while other entities funded it once, according to the search keywords used. The findings also indicate progress in research within this domain, with a high growth potential, especially with the expansion of offshore wind farms. However, there were significant challenges in obtaining most of the grant numbers for the research works on asset management of offshore facilities. It was also noticed that these funders have helped most institutions to have a high h-index and REF (Research Excellence Framework) index. Furthermore, it was observed that the funders were from various global locations, indicating their collective support for robust asset management which will ensure sustainable drilling, production operations, and energy generation. From this investigation, the asset management certification companies identified and compared, included Det Norske Veritas Holding & Germanischer Lloyd (DNV GL), Bureau Veritas (BV), and Lloyds Regis-

ters. DNV GL had the highest research funding support, received three times the highest, followed by Lloyds Registers twice while BV received it once. Additionally, Table 7 shows that the grant number with the highest contribution in this research area is Ih140100012. It should be noted that 27 records (62.791%) from the funders list and 35 records (81.395%) from the grant numbers’ list based on the grant data obtained from the WoS database were excluded from the study because they did not contain data in the field being analyzed.

3.9 Publication Country

The findings of this research indicated that there are varying interests seen in the publications on asset management of offshore facilities. The distribution of the publication by country on this subject area shown in Figure 8 and Table 8 shows that different countries are interested in publishing on asset management. It was observed that the publications on the subject area, according to Scopus, were mostly published in the United States of America (U.S.A.), with 116 publications, then the United Kingdom (U.K.) with 40 publications then Malaysia with 24 publications. Also, the other top countries identified include Australia, Norway, Italy, Canada, Indonesia, India, France, Saudi Arabia, China, Denmark, Nigeria and Brazil. It was identified that the country with the highest publications—the U.S.A., had more than twice the amount of publications from the country with the second highest publications (U.K.), which shows the extent of research conducted, although it is also understandable because the U.S.A. has a high number of offshore assets in their inventory.

Table 6. List of funding agencies on publications and research contributions by funding agencies/funders for 'asset management of offshore facilities'.

Funding Agencies/Funders	Record Count	Database/Source	Funding Agencies/Funders	Record Count	Database/Source
Australian Research Council	2	WoS	Hibernia management and Development Company	1	Scopus
Abu Dhabi National Oil	1	Scopus	Inail Istituto Nazionale Per L Assicurazione Contro Gli Infortuni Sul Lavoro	1	Both
Agro Paris Tech	1	Both	Japan Society For The Promotion Of Science	1	WoS
Apply Sorco	2	WoS	Kementerian Pendidikan dan Kebudayaan	1	Scopus
The National Research Foundation Of Korea	1	WoS	Open Fund Of State Key Laboratory Of Oil And Gas Reservoir Geology And Exploitation Southwest Petroleum University	1	Both
BHP Billiton	1	Both	Ministry Of Education Culture Sports Science And Technology Japan Mext	1	WoS
BP	1	Both	Naradowa Agenja Wyminany Akademickiej	1	Scopus
Bureau Veritas (BV)	1	Both	National Key Research And Development Program	1	Both
Calce Consortium	1	WoS	National Science And Technology Major Project	1	Both
Changzhou Science And Technology Program	1	Both	Natural Science Foundation Of Jiangsu Province	1	Both
Chevron	1	Scopus	Natural Sciences And Engineering Research Council Of Canada Nserc	1	Both
China Postdoctoral Innovative Talents Support Program	1	Both	Niger Delta Development Commission (NDDC)	1	Scopus
CHINA National Petroleum Corporation	1	WoS	Net Zero Technology Centre	1	WoS
CNOOC (China National Offshore Oil Corporation)	1	WoS	O G Operator Company	1	WoS
Department For Applied Science University And Research Of The Autonomous Province Of South Tyrol Italy	1	WoS	UK Robotics And Artificial Intelligence Hub For Offshore Energy Asset Integrity Management Orca Hub	1	WoS
Direktorat Jenderal Pendidikan Tinggi	1	Scopus	Lloyds Register	2	WoS
Det Norske Veritas Holding & Germanischer Lloyd (DNV GL)	3	WoS	Polish National Agency For Academic Exchange Nawa	1	Both
Engineering Physical Sciences Research Council EPSRC	1	Both	PTTEP (PTT Exploration and Production)	2	Both
Equinor	1	WoS	Research Development Corporation Rdc Of Newfoundland And Labrador	1	Both
Exxon Mobil Corporation	1	WoS	Research Project Interreg Iva Valmer	1	Both
Fondation De France	1	WoS	Royal Dutch Shell	3	Both
H2020 European Commission Project Paris Reinforce	1	WoS	Schlumberger	3	Both
Harbor Energy	1	WoS	Scientific Research Starting Project Of Swpu	1	Both
Shell Nigeria Exploration Production Company Limited	1	Both	UK Research Innovation UKRI	1	WoS
Taqa	1	WoS	OML	1	WoS
Telekom Malaysia Research Development	1	WoS	Ulsan National Institute Of Science And Technology	1	WoS
Total Sa	1	Both	Woodside Energy	1	WoS

Source: Scopus and WoS databases.

Table 7. List of some grant numbers showing research contributions by funding agencies/funders on ‘asset management of offshore facilities’.

Grant Numbers	Record Count	% of 43	Grant Numbers	Record Count	% of 43
lh140100012	2	4.651	Bk20150249	1	2.326
1.160046.01	1	2.326	Bx20190292	1	2.326
15k12459	1	2.326	Ccl2012tjpxxs0053	1	2.326
2016zx05028-001-006	1	2.326	Cj20159053	1	2.326
2018qhz017	1	2.326	Ep/r026173/1	1	2.326
2018yfc0310201	1	2.326	Nrf-2014r1a1a1003653	1	2.326
73/40.3	1	2.326	Pln201827	1	2.326
820846	1	2.326	Tm Rnd Mmue/160021	1	2.326

Source: WoS database.

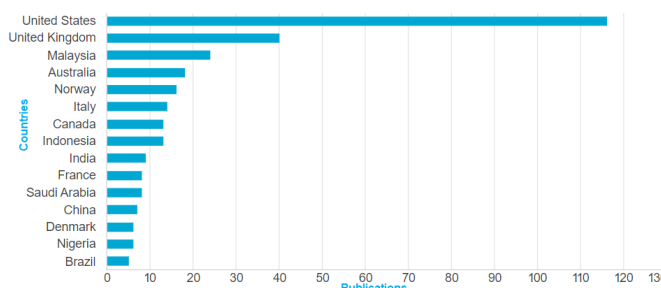


Figure 8. The top 15 countries on “asset management of offshore facilities”.

Source: Scopus database.

Table 8. The research engagements by countries that are the most relevant on “asset management of offshore facilities”.

Countries/Regions	WoS	Scopus	% of Scopus Sum (1998)	% of WoS Sum (1526)
USA	6	116	13.953	4.033
Norway	8	16	18.605	5.377
UK	10	40	23.256	2.688
China	4	7	9.302	2.688
Nigeria	1	6	2.326	0.672
Australia	3	18	6.977	2.017
France	3	8	6.977	2.017
Italy	3	14	6.977	2.017
Malaysia	3	24	6.977	2.017
Brazil	2	5	4.651	1.344
Canada	2	13	4.651	1.344
Netherlands	2	5	4.651	1.344
Spain	2	3	4.651	1.344
Belgium	1	4	2.326	0.672
Denmark	1	6	2.326	0.672
Ghana	1	1	2.326	0.672
Greece	1	1	2.326	0.672
Japan	1	1	2.326	0.672
Lithuania	1	1	2.326	0.672
Myanmar	1	1	2.326	0.672
Angola	1	1	2.326	0.672
Poland	1	1	2.326	0.672
Russia	1	2	2.326	0.672
South africa	1	1	2.326	0.672
South korea	1	1	2.326	0.672
Thailand	1	1	2.326	0.672

Source: Scopus and WoS databases.

3.10 Publication Keywords' Word Cloud

The findings of this research indicated that there has been an increase in publications on asset management of offshore facilities in recent times. The keywords used to generate the word cloud were sampled publications on the search query. Also, the word cloud was developed using Free Word Cloud Generator, available at: <https://www.freewordcloudgenerator.com/generatewordcloud>. The wordlist for the keywords

“asset management of offshore facilities” can be seen in Table 9 and Figure 9. It shows that “management” is the word with the highest frequency (31), followed by “asset” with a frequency of 22, followed by “risk” with a frequency of 13, followed by “assessment” with a frequency of 8. The lowest frequency of 1 had been noticed across a range of keywords including offshore, monitoring, mapping, bibliometric, energy, risers, pipelines, flowlines, etc.



Figure 9. The word cloud for keywords on “asset management of offshore facilities”.

Table 9. The wordlist for keywords on “asset management of offshore facilities”.

Frequency	Word	Frequency	Word	Frequency	Word	Frequency	Word
31	management	4	sustainability	3	strategy	1	industry
22	asset	4	maintenance	3	making	1	sustainable
13	risk	4	life	3	system	1	monitoring
8	assessment	4	systems	3	iso	1	flowlines
7	corrosion	4	integrity	3	cycle	1	offshore
5	decision	4	strategic	3	performance	1	text
3	budget	2	project	2	materials	1	review
3	analysis	2	oil	2	control	1	motives
3	uncertainty	2	gas	2	support	1	barriers
2	literature	2	safety	2	reliability	1	flowline
2	physical	2	practice	1	resilience	1	downstream
2	infrastructure	2	subsurface	1	engineering	1	pipelines
1	rehabilitation	1	deterioration	1	scientometrics	1	environmental
1	real	1	bibliometric	1	analytics	1	risers
1	estate	1	mapping	1	metro	1	energy
1	property	1	optimisation	1	urban	1	railway

3.11 Publication Research Themes

The findings of this research include the identification of research themes on asset management, which also showed an increase in the research area. One observation made is that asset management could also

be used to refer to facilities management, depending on the domain. However, asset management has given rise to various management techniques because it is a vital part of the oil and gas sector. It ensures adequate monitoring of these offshore facilities, considering the lifespan, life extension, serviceability, ageing, and other

aspects of asset management [33-41]. The offshore sector has recently faced challenges related to a number of issues, including the structural integrity of offshore assets [42-47]. Other issues include offshore asset monitoring [48-50], asset life extension [49-52], risk assessments [53-56], Health, Safety and Environment (HSE) [57-62], sustainability indicators [63-66] and asset management [67-70]. Among the metrics applied to offshore facilities are the following: the design of an offshore platform, production activities, management system models, and the location of the oil field. Since the operational life expectancy of a significant percentage of the offshore infrastructure is currently approaching or has already passed, this particular niche has seen an increase in life extension schemes for offshore buildings and other marine structures [71]. However, various factors affect the asset management approach that will be applied as well as the metrics and indicators that will be employed to assess the offshore facility. The historical background of oil and gas exploration is also available in the literature [72-82]. The use of offshore platforms in deep water locations creates significant challenges for oil operators in the O & G sector, which should also be considered to ascertain asset life extensions [83-90]. High sea depths, severe weather, extremely windy circumstances, and high significant wave heights are some of these difficulties [91-97]. As a result, facilities management is required, which may lead to additional factors including the development, deployment, and commissioning of offshore facilities [98-103]. Based on the scope of this research, some studies were also identified that cover similar scientometric reviews in related areas. However, it is noteworthy to state the PRISMA 2020 statement was considered in this study [104-110] because it provides guidelines on scientometric analysis and shows details on the tools used in preparing the analysis.

However, the research trends are affected by various global issues and developments in the oil and gas industry. Notable trend shifts were observed during the 2016/2017 decline in oil prices and the 2020/2021 global COVID-19 pandemic, which affected work and sustainable supply chains in various industries [111-121]. The study also found related scientometric works on Sustainable Marine Structures which shows an evolving trend in the journal [122-124]. While there are studies that reflect that risk management is important as seen in the construction sector [125-127], another set of themes that is increasing in the sector involves the monitoring of assets [22,127] as this helps to satisfy the industry's needs in managing assets considering the perspective

of the operators [127-130]. One key advantage of proper asset management is that it enables the decommissioning process to be achieved successfully [22,127,130].

The study also showed that there were different funders that support research on asset management of offshore facilities which shows some collaboration between industry and academia. The study also highlighted that different funders support research on asset management of offshore facilities, demonstrating some collaboration between industry and academia. Additionally, several oil companies support the research area, which is indicative of their investment in research and development. However, the successful operation of monitoring these offshore facilities using various asset management systems will enable the oil multinationals and various operators to pursue sustainable oil exploration and related operations.

4. Conclusions

In this paper, the scientometric analysis of asset management of offshore facilities is carried out based on research trends. The data used in this investigation were retrieved from Scopus and Web of Science (WoS) databases. This study presents the results for publication history, citations, publication type, publication subject categories, authorship, affiliations funders, and keyword correlations. The scientometric analysis employs state-of-the-art methods of scientific literature review to investigate the research patterns on asset management of offshore facilities. This research comprises recent scholarly articles from academic publication databases covering both journal papers and conference papers from conference proceedings.

The findings of this research show that the USA was the country that produced the highest publications on asset management of offshore facilities. It also revealed that the location for most of the technical conferences held was in the USA, such as the OTC, SPE and ASME's OMAE conferences. The results indicated that there has been an increase in publications on asset management of offshore facilities in recent times. However, the research trends are affected by various global issues and developments in the oil and gas industry. Notable trend shifts were observed during the 2016/2017 decline in oil prices and the 2020/2021 global COVID-19 pandemic, which affected work and sustainable supply chains in various industries. The study also found related scientometric works on Sustainable Marine Structures which shows an evolving trend in the journal. The study also showed that different funders support research on

asset management of offshore facilities which shows some collaboration between industry and academia. The study also highlighted that different funders support research on asset management of offshore facilities, demonstrating some collaboration between industry and academia. Additionally, several oil companies support the research area, which is indicative of their investment in research and development. Successful operation of offshore facilities using various asset management systems will enable oil multinationals and operators to pursue sustainable oil exploration and related operations. To prevent failure while being subjected to various loadings, these offshore platforms must be meticulously constructed, and then regularly maintained, monitored and inspected. Thus, this research contributes to the body of knowledge on asset management.

Based on the results on authorship, the top authors on asset management of offshore facilities presented authors with different values on their h-index, as the highest h-index was 5. The h-index was chosen as the metric indicator because it relates to the citation and significance of the research works conducted by a diverse range of authors across the globe. It was observed that the author with the highest number of publications was author Boutrot, J., with 5 publications on asset management of offshore facilities, though this author was not within the top five authors that have the highest h-index. The paper concludes that the management of these infrastructures requires frequent review with the application of sustainable asset management strategies. It also shows rising interest in monitoring and asset management in the oil and gas industry. However, the lack of access to high-quality data, transparency, adopting innovative technology, and providing effective decision support, are key issues in asset management. Thus, further work in the area can include the use of Artificial Intelligence (AI) and the Internet of Things (IoT) in asset management.

Author Contributions

Conceptualization, C.V.A.; software, C.V.A., S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; methodology, C.V.A., S.B.B.; investigation, S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; validation, C.V.A., S.B.B.; formal analysis, C.V.A., S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; resources, C.V.A., S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; writing—original draft preparation, C.V.A.; writing—reviewing draft, C.V.A., S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; funding acquisition, C.V.A., S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; project administration, C.V.A., S.B.B., A.R., D.B.M., I.A.J., A.S., A.K.O.; data

curation, C.V.A., S.B.B.; visualization, C.V.A., S.B.B.; supervision, C.V.A., S.B.B.

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Data Availability

The supplementary data is also made available herewith. The link for the supplementary data used is <https://data.mendeley.com/datasets/f4nf3wng4d>.

The data citation is "Amaechi, C.V. (2022), "Supplementary Data for the Scientometric Analysis on Asset Management of Offshore Facilities", Mendeley Data, V1, doi: 10.17632/f4nf3wng4d.1".

Conflicts of Interest

All authors disclosed no conflict of interest.

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