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ARTIFICIAL INTELLIGENCE IN PROJECT MANAGEMENT RESEARCH: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Projects are critical to organizations' success; hence improving project management (PM) is imperative. Artificial intelligence (AI) has revolutionized many disciplines, including PM. Applying AI techniques in PM can lead to more control for the project manager and better management of projects. One of the inherent problems faced in PM is related to human error by the project managers leading to project failure. Project managers use PM software and tools to improve their tasks. In this paper, we demonstrate the application of AI in project management through a bibliometric analysis and keyword analysis to show the state of the art of research on AI in PM in the past decade. We extracted 106 articles from the Web of Science database published between 2012 and 2021 and analyzed the data. VOSviewer provided visual maps revealing research hotspots in the field of AI in the HE knowledge base. Our analysis focuses on publication and citation trends, the geographic distribution of articles, analysis of papers by source in which they were published, h-index analysis, and keyword analysis. Results show that research in AI-based PM is widely distributed geographically, by the publisher, and by discipline or field. Furthermore, research in the corpus in the past decade has centered around four themes. The first theme relates to applying AI techniques to improve accuracy, precision, and prediction in software projects, project management, and development estimation. The second theme focuses on the application and development of AI for decision-making in PM. The third theme highlights the benefits of applying AI in PM, such as dealing with uncertainty, improving efficiency, scheduling, and stakeholder management. The last theme shows how AI manages risks and improves cost management in engineering, procurement, and construction (EPC) projects. This research makes valuable contributions to the corpus by highlighting opportunities, challenges, and future research directions in AI in education. The study highlights its limitations and future research areas.
Keywords: *Project Management, Artificial Intelligence, Bibliometric Analysis, Machine Learning*

1. INTRODUCTION

Project management (PM) evolved from the engineering and construction fields, and the past decades have witnessed increased application across various private and public practice fields. A project is a temporary endeavor undertaken to create a unique product, service, or result by effectively organizing available resources to meet the stated objectives[1]. Entities deliver complex and advanced technological solutions, systems, or services through projects. Through PM, entities conceive ideas, develop them, and provide new products to the customers. Projects play an essential role in an organization and are vehicles by which entities grow. Schoper et al.[1] showed the importance of projects in modern societies and how the share of project-related work in advanced economies is one-third and rising. Archibald and Prado[2] posit that projects generate a third of the world's economy, and empirical evidence supports the claim that most implemented projects are unsuccessful.

The volatile nature of the 21st-century economy and stiff competition force organizations to complete projects within tighter schedules and limited resources but still produce top-quality outcomes[3]. Organizations must ensure that PM aligns with the strategic goals and efficient use of resources since projects play a

vital role in the business environment[4]. Projects are critical to organizations' success; hence improving PM is imperative[4]. Project performance has been a subject of interest for a long time[5]. Although projects have been implemented for thousands of years, it was only in the 20th century that PM became a recognized discipline[6].

Artificial intelligence (AI) refers to developing "computing systems that can engage in human-like processes such as learning, adapting, synthesizing, self-correction and using data for complex processing tasks." AI has changed how jobs and tasks are performed, bringing about automation and transformation. AI techniques are being relentlessly applied in numerous fields such as medicine, finance, gaming, robotics, language understanding, vehicle control, speech recognition, and planning and scheduling. Shapiro and Eckroth[7] state that the first AI programs developed in the 1950s could not solve complex problems, but they enhanced the intelligent understanding of problem-solving[7]. In the 1980s, the advancements in AI systems made their use more cost-effective for government and industry purposes. Experts predict that by 2030, over 80% of repetitive and mundane tasks representing the bulk of PM work will be eliminated by collaboration between humans and intelligent machines[8]. While AI is the deployment of computing systems that can learn, adapt, synthesize, self-correct and make decisions. Applying AI in PM is not new. Based on previous knowledge, Foster[9] posited that AI could be successfully applied in PM by analyzing large datasets to find patterns, trends, and problems that need attention.

Furthermore, AI could be used to monitor how the project is going and make changes to future activities if needed[9]. AI integration in PM lies in the intersection of knowledge, learning, adaptation, and decision making. PM and AI integration will administer projects with a minimum human intervention using smart machines and large volumes of data to automate decision-making, task management, and prediction. With the help of AI, PM tasks can be automated, and AI can direct a project and help make related decisions.

Early scholars who studied AI application in PM noted that AI could analyze large data sets to discover trends and patterns and use that information to support decision-making processes[10]. More recently, Ong and Uddin[11] note a wide range of AI applications in projects that reduce project risks, track project progress, and identify irregularities and outliers in projects. AI integration in PM can help estimate costs, handle schedules, manage activities and follow-ups, and plan resources[12]. With AI's help, PM tasks can be done automatically, and AI can direct a project and help make related decisions[13]. There is evidence of research on using AI methods for specific PM tasks. For example, AI can be used in project forecasting, costing, and scheduling success[14]. AI applications in PM can be categorized into four types: autonomous management of projects, Chabot assistance, integration and automation, and machine-learning-based[15].

Bibliometric studies are different from systematic literature reviews. Systematic literature reviews examine the content of research papers to identify the corpus's issues and patterns. On the other hand, bibliometric studies involve mapping out a corpus by exploring papers to discover trends and uncover critical features, patterns, and relationships of variables in a particular field. De Bellis[16] described bibliometrics as quantitative methods that analyze scientific literature using bibliometric data. Descriptive data may be used in bibliometric studies such as the author and the journal's productivity index, collaborations, and citation analysis.

Bibliometric analysis is a cross-disciplinary science that uses statistical methods to analyze knowledge and identify a particular domain's development, growth, and future research orientations[17]. Non-grey literature articles are retrieved and analyzed through quantitative and qualitative analysis to measure author distribution patterns, keywords, citations, institutions, and researchers' performance from a single database[18]. However, analyzing bibliometric indicators and literature mapping on multiple databases is often challenging. Bibliometric analysis is a methodological approach for collecting and analyzing quantitative data concerning emerging or consolidated research topics[19]. It is used in different research fields, such as journal performance, collaboration trends, and uncovering emerging trends in articles and the extant literature[20].

The popularity of bibliometric analysis studies can be attributed to the advancement,

availability, and accessibility of bibliometric software such as CiteScore and VOSviewer, scientific databases such as Scopus and Web of Science, and the cross-disciplinary pollination of the bibliometric methodology from information science to business research[20]. By applying the guidelines given by Donthu et al.[20] on bibliometric analysis, the research study was developed to identify and analyze the following performance analysis indicators :

- The number of publications on AI in PM published between 2012 and 2021;
- The geographical publication trends in the period under review;
- The citations received by the selected articles;
- The distribution of articles by publisher and discipline (field);
- The research themes in the area.

Several studies on the application of AI in different fields exist, for example – education (Hinojo-Lucena et al.[21]), medicine (Guo et al.[22], Tran et al.[23]), operations (Dhamija and Bag[24]), wastewater treatment (Zhao et al.[25]), higher education (Maphosa and Maphosa[26]). Furthermore, bibliometric studies have been done in PM; for example, de Souza and Gomes[26] and Lechler and Yang[27].

AI is likely to shape PM and play a significant role in its development[27]. Nevertheless, there is no bibliometric study related to AI application in PM to our knowledge. The study aims to analyze research on the application of AI in PM, realizing the importance of artificial intelligence in transforming most fields, such as PM. This study, therefore, provides a baseline for researchers and scientists to plan and research the integration of these two fields. This study seeks to answer the following questions:

- What is the state of the art of research in AI in PM?
- Which countries have contributed the most to the in the domain?
- Which are the research hotspots and emerging areas of research in the corpus?

The rest of this paper is structured as follows: Section 2 outlines the methodology we followed, how we collected data, and analyzed the data. Section 3 presents the results using descriptive methods and the outcomes from analysis done on VOSViewer version 1.6.18. Section 4 discusses the results' implications and reinforces our claims about AI growth in PM. Finally, in Section 5, we summarise the main findings of the bibliometric analysis.

2. METHODOLOGY

We used bibliometric analysis, a scientific computer-assisted review methodology, to identify core domains or authors and map their relationships by highlighting all the publications related to a given topic or domain, thereby enhancing the understanding of the overall intellectual landscape[16 36]. We chose the Web of Science database because it is the most extensive citation and abstract database of peer-reviewed publications. The Web of Science is a reputable and widely used database that is easily accessible, providing a basis for answering the research questions posed in the previous sections. The Web of Science has comprehensive search tools and options that enable the researcher to apply several Boolean operators, promoting an extensive search query. Bibliometric data from the search query can be analyzed and exported to other bibliometric analysis software such as CiteSpace and VOSViewer. For this study, we used VOSViewer. In April 2022, we searched and collected data with the initial search string selecting articles focused on artificial intelligence and project management. We searched articles containing the terms "artificial intelligence" and "project management" in the titles, abstracts, and keywords. This search yielded 406 articles.

We then filtered the results to include articles published between 2012 and 2021. One hundred six articles were excluded leaving 300 articles. We filtered by the article type, excluding editorials and corrections, leaving 292 articles. Finally, we filtered by language to include articles published in English. Four articles were excluded leaving 288 articles. The authors exported the remaining 288 articles and the abstracts to M.S. Excel for analysis. The analysis involved reading the titles and abstracts for each of these articles. Publications not related to artificial intelligence and project management were excluded, leaving 106 articles that were analyzed. Figure 1 shows the article selection process.

We downloaded data on 106 articles from the Web of Science database in text format. We then exported the abstract and keywords to VOSviewer, a free bibliometric tool with

visualization and text-mining abilities. The Web of Science database has embedded analytic functions for citation, subject analysis, and h-index analysis and supports the direct export of data into VOSviewer and Excel. VOSviewer provides network visualizations and density maps[28].

3. RESULTS

This study demonstrates the state of AI application in PM, and the opportunities contributed by integrating the two areas. This study aims to comprehensively understand AI applications in PM using bibliometrics to analyze research conducted in the past decades. This study explores the publication and citation trends, the geographic distribution of publications, the analysis of publications by top publishers, and the leading research topics.

Table 1 shows the document types of the articles retrieved. Journal articles (90.6%) are the majority of the documents retrieved. Review articles account for 9.4%. This section presents the results of this study: the distribution of publications by number published and citations per year, the geographic distribution of articles, distribution by publishers, analysis of publications by field, and keyword analysis.

Table 1. Document types of the articles retrieved

Document Type	Count	Percentage of 106
Articles	96	90.6
Review Articles	10	9.4
Early Access	4	3.8
Data Papers	1	0.9
Proceedings Papers	1	0.9

3.1 Distribution of Articles by Publications and Citations

Figure 2 plots the publications and citation trends. Between 2012 and 2019, less than ten articles were published yearly, steadily increasing from 2020 to 2021. In terms of citations, there were no citations in 2012. 2013 and 2014 had four and eight citations, respectively. 2015 to 2018 saw a rise in citations, each year having more than 35 and less than 88. The last three years saw astronomical growth in citations, with 2019 having 147, 2020 having 218, and 2021 having 420. Interest in AI research in PM has grown, with 2019, 2020, and 2021 has about 70% of all publications. Similarly, citations have risen astronomical, with the past three years accounting for more than 77% of all citations in the decade. The year 2021 accounted for nearly 42% of all citations.

3.2 Geographic Distribution of Articles by Country

It is essential to consider that for an item to be accounted for in a country's production, at least one of the authors must be associated with a teaching or research institution in the related country. Thus, the same scientific article may be accounted for in more than one country[29]. The articles' geographic distribution shows that 47 countries are represented. Table 2 gives the geographic distribution of publications, and there are currently three dominant countries: China (18), the United States (17), and England (13). Noteworthy is the absence of representation of Africa among the top 15 most productive countries. Africa has only three representatives (Morocco, Egypt, and Tunisia).

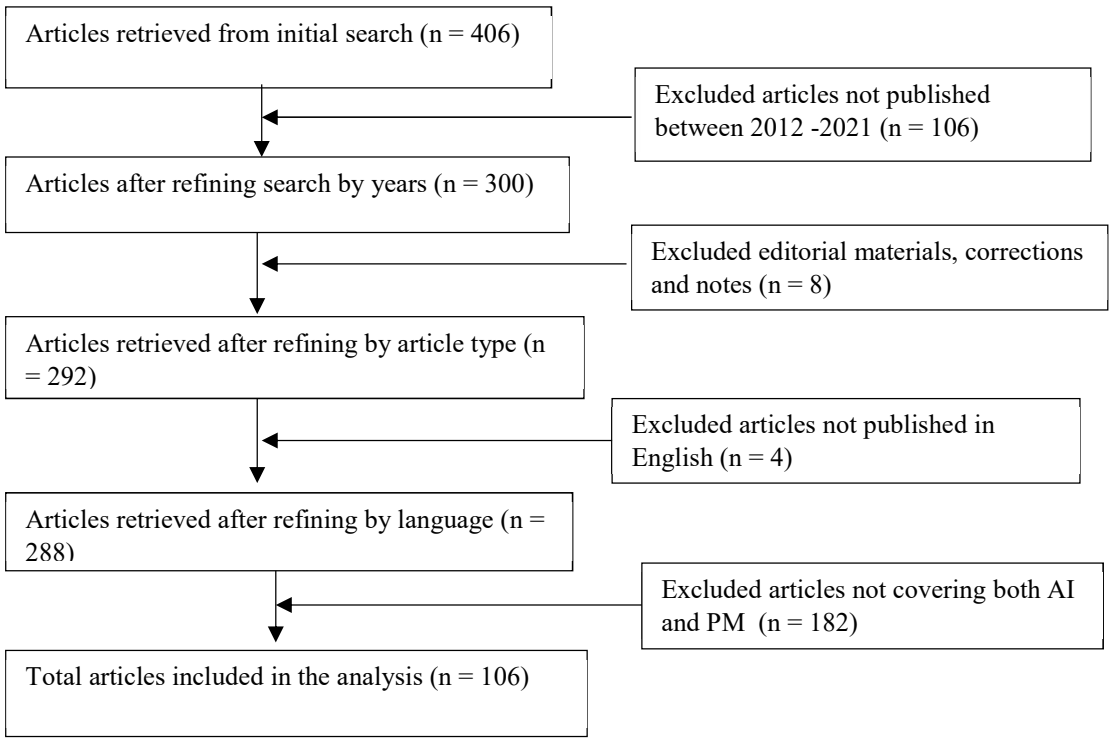

Figure 1. Article Selection Process [30]

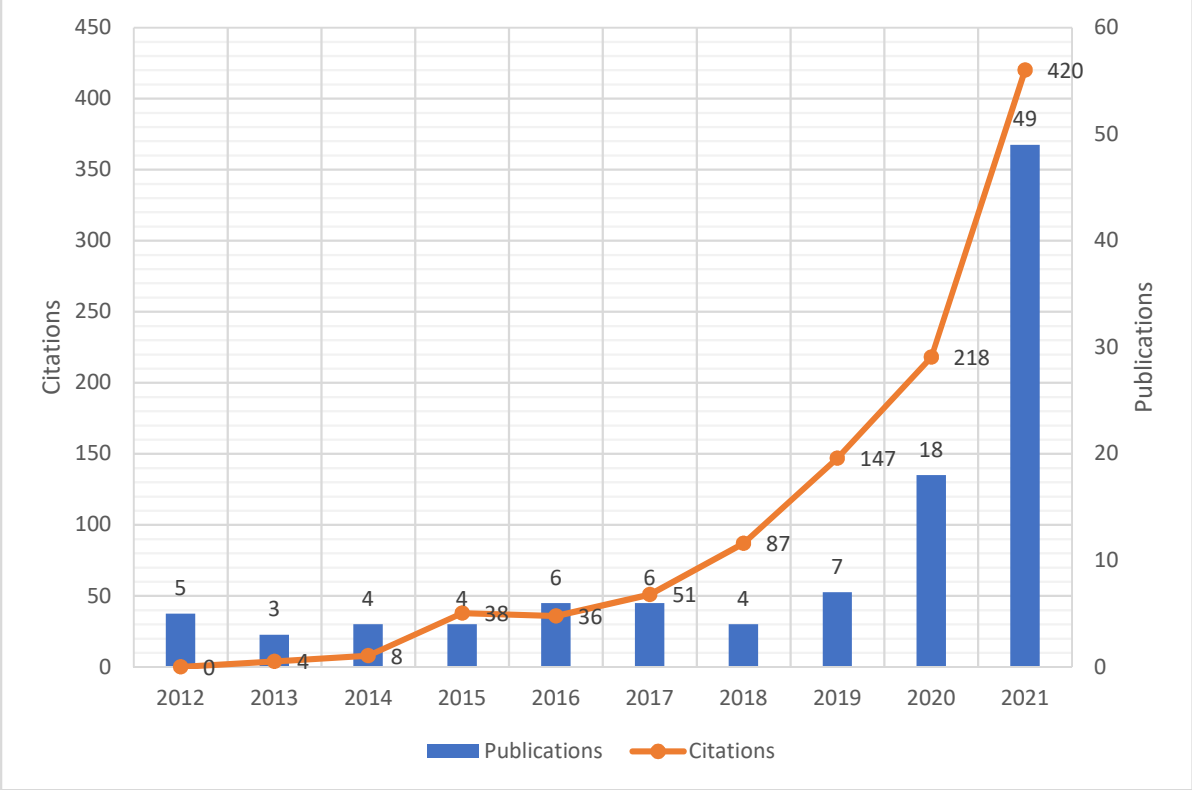

Figure 2. Trends Of Articles Published And Citations Per Year

Researchers from Sub-Saharan Africa did not contribute any articles written, which will negatively impact the successful implementation of projects requiring these skills.

Table 2. Articles Published Per Country

Rank	Country	Publications
1	China	18
2	USA	17
3	England	13
4	Canada	8
5	Spain	8
6	Taiwan	8
7	South Korea	7
8	India	6
9	Jordan	6
10	Australia	4
11	Vietnam	4
12	Belgium	3
13	France	3
14	Iran	3
15	Iraq	3
16	Malaysia	3
17	Morocco	3
18	Singapore	3
19	UAE	3
20	Cuba	2
21	Egypt	2
22	Germany	2
23	Greece	2
24	Pakistan	2
25	Poland	2
26	Portugal	2
27	Sweden	2
28	Austria	1
29	Brazil	1
30	Chile	1
31	Croatia	1
32	Cyprus	1
33	Finland	1
34	Hungary	1
35	Iceland	1
36	Italy	1
37	Japan	1
38	Lebanon	1
39	Mexico	1
40	New Zealand	1
41	Norway	1
42	Romania	1
43	Saudi Arabia	1
44	Scotland	1
45	Serbia	1
46	Tunisia	1
47	Turkey	1

3.3 Distribution of Articles by Publisher

Thirty different publishers published 106 research articles. Table 3 shows the leading publishers of research on AI and PM. Elsevier dominated with 31 articles, followed by 'MDPI' with 18 articles and then Springer Nature with 10. IEEE has five publications, and the American Society of Civil Engineers, Emerald Group Publishing, Hindawi Publishing Group, and Wiley have four. The distribution by publishers shows that AI in PM is widespread across different sectors.

Table 3. Leading publishers

Rank	Publisher	Publications
1	Elsevier	31
2	MDPI	18
3	Springer Nature	10
4	IEEE	5
5	American Society of Civil Engineers	4
6	Emerald Group Publishing	4
7	Hindawi Publishing Group	4

8	Wiley	4
9	Atlantis Press	2
10	IOS Press	2
11	Taylor and Francis	2
12	Vilnius Gediminas Technical University	2

3.4 Analysis of Articles by Discipline

Table 4 shows the leading disciplines with ten or more publications. Altogether, 37 fields or disciplines are represented in the 106 articles retrieved, indicating that PM is indeed a multi-disciplinary field and AI's acceptance in the PM field. Computer science - artificial intelligence has the most significant publications, with 20 articles accounting for 18.8%, followed by civil engineering, with 16 papers (15.1%), then computer science information systems with 14 articles (13.1%). Computer science and engineering are among the leading fields in implementing AI in PM. This is expected, given that AI is inherently a computer science subfield.

Table 4. Leading Disciplines

Rank	Field	Count
1	Computer Science Artificial Intelligence	20
2	Engineering Civil	16
3	Computer Science Information Systems	14
4	Construction Building Technology	13
5	Computer Science Software Engineering	12
6	Management	12
7	Engineering Electrical Electronic	11
8	Engineering Multidisciplinary	10
9	Environmental Sciences	10

3.5 H-Index

The 106 articles were cited 1 042 times and 1 016 when excluding self-citations between 2012 and 2021. Each article has been cited with an average of 11.08. The retrieved research papers have an h-index of 21. The h-index of 21 means that of the 106 research articles, 21 have received at least 21 citations.

3.6 Keyword Analysis

This sub-section analyses the keywords used in articles and abstracts using VOSviewer. Keyword analysis has been a prominent research theme in bibliometric studies and involves counting the frequency of keywords to determine hot spots within a particular research area[28]. To highlight the topics AI addresses in PM, we analyzed 3 310 terms in the titles and abstracts of the 106 articles related to AI use in PM to establish the co-occurrence network. Figure 3 shows the keyword co-occurrence network visualization of high-frequency terms extracted from titles and abstracts. Of the 3 310 terms extracted, 124 had more than five occurrences, and 74 met the co-occurrence threshold (top 60% with the highest relevance). The link strength between two items shows the co-occurrence frequency – a quantitative depiction of the items' relationship. The total link strength of an item is the item's full link strength over all other items. Table 5 shows the top 10 keywords in terms of frequency. The table also shows the total link strength of the keywords. The term 'accuracy' has thicker lines with 'algorithm' (16), 'machine' (14), 'error' (11), and 'prediction' (9). In VOSviewer, the stronger the link between two items, the thicker the line used to display the link [28]. This indicates a strong relationship between the terms' problem' and 'algorithm,' perhaps pointing to the fact that algorithms (a component of machine learning and AI) are gaining prominence in solving PM-related problems. The relationship between 'algorithm' and 'machine,' 'development' and 'industry' is quite strong.

Table 5: Top 10 Keywords And Their Total Link Strength

Rank	Keyword	Occurrence	Links	Total Link Strength
1	Accuracy	32	71	265
2	Algorithm	31	69	230
3	Machine	29	64	220
4	Application	21	61	160
5	Dataset	18	50	135
6	Development	17	54	140

7	Construction	16	60	138
8	Prediction	16	51	107
9	Number	16	52	104
10	Type	15	53	108

Using VOSviewer, we generated four clusters associated with the research topic from the 74 terms. As shown in figure 3, the size of the circle represents the frequency of the occurrence of the term. The color of the circle represents the cluster. The red and green clusters are the biggest; each has 23 keywords, the blue cluster has 19, and the yellow cluster is the smallest with 11. The red cluster covers the research on AI-based PM for improving accuracy, precision, and prediction in software projects, project management, and software development estimation. The cluster also compares the performance of different algorithms used in AI. The green cluster represents keywords related to the application and development of AI for decision-making in PM and practitioners and researchers' role in adapting available technology such as big data. The blue cluster highlights the benefits of applying AI in PM, such as dealing with uncertainty, improving efficiency, scheduling, and stakeholder management. The yellow cluster shows the use of AI in managing risks and improving cost management in engineering, procurement, and construction (EPC) projects.

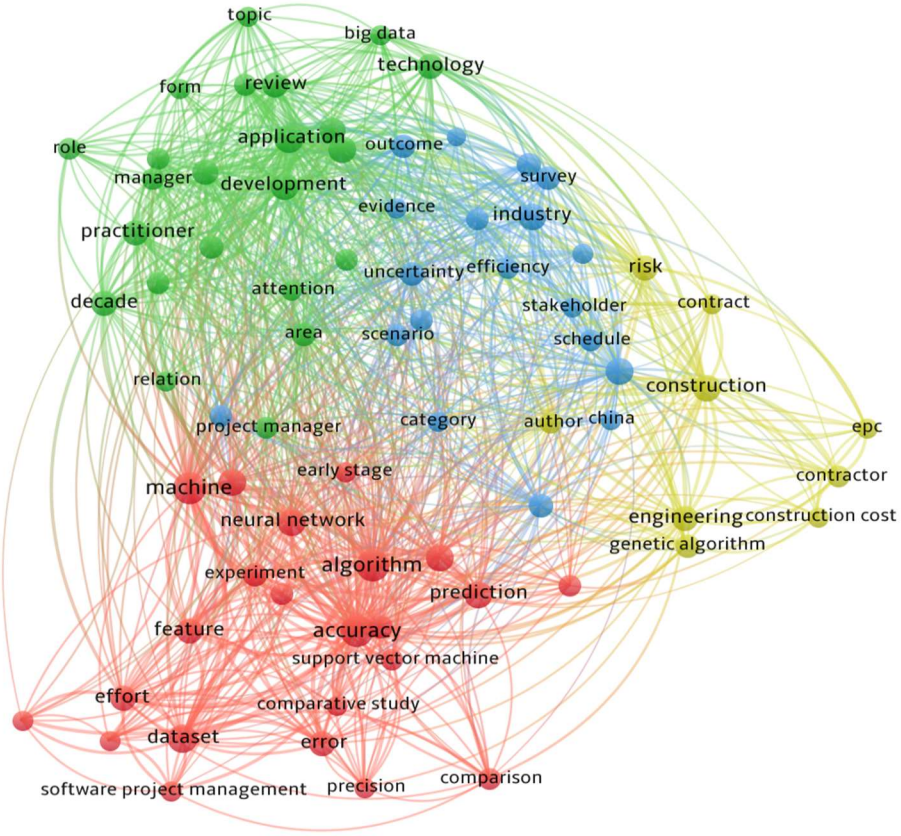

Figure 3. Keyword Co-Occurrence Network Visualization Of High-Frequency Terms

The keyword density visualization map is shown in Figure 4. Density maps are valuable for understanding the corpus organization and can help draw attention to the map's most critical areas[32]. In VOSviewer, colors indicate the density of terms, ranging from green (lowest density) to red (highest density)[33]. The red area keywords appear more frequently, and the green color area keywords appear less often. Two research hotspots focused on accuracy, algorithm, machine, prediction, neural networks, and support vector machines. The other hotspot is centered around application, development, and outcome. Besides the hotspots, the map also shows that

research is growing to unexplored topics and areas such as contract management, comparison of different techniques, EPC, and big data.

4. DISCUSSION

This study aimed to conduct a bibliometric analysis of the application of AI in PM. This study contributes to the emerging literature on AI usage in PM using bibliometric analysis. The bibliometric analysis provides an insight into the application of AI in PM. It shows how innovatively AI is being applied in many non-traditional applications to improve the success of projects.

4.1 The state of the art of research in the field of AI in PM

Project success is essential in the world economy; it is crucial to understand research applying AI in PM. There is a noticeable increase in the number of publications in 2020 and 2021 and citations between 2019 and 2021. This increase indicates the general acceptance of AI tools and PM techniques, especially in the past decade. Given the increasing number of citations for articles on AI application in PM, we expect research in this area to increase.

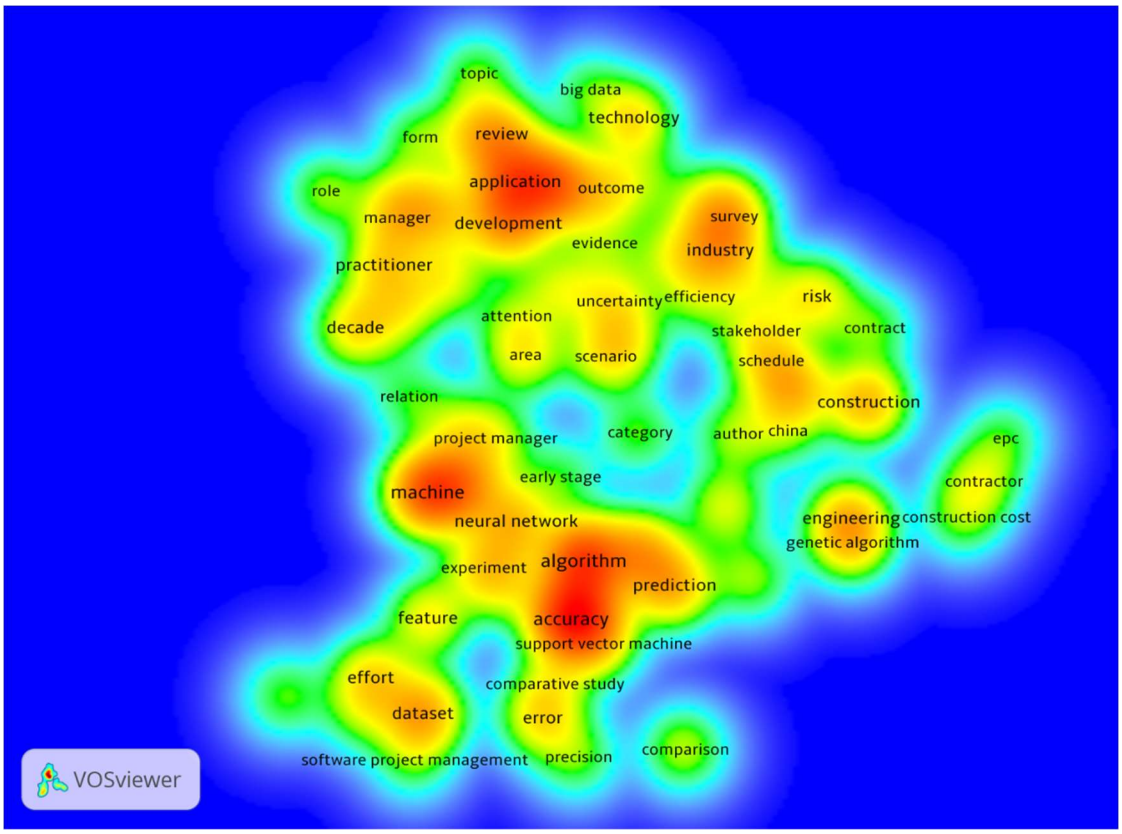

Figure 4. Keyword Density Visualization Map

With 106 articles in AI-based PM published in the past decade is an indication that this research domain is yet to mature. The spike in publications between 2019 and 2021 shows that the field is growing. AI is poised to transform the field of project management significantly. The wide range of publishers publishing articles on AI in PM shows the interest that the field of AI in PM is receiving, indicating its widespread acceptance across the different fields.

Analysis of the publishers reveals that leading publishers are publishing research. Over 90% of the articles on AI in PM are journal type and were published in the past decade. This demonstrates the quality of the research being done as journals have rigorous and stringent requirements for

publishing. Furthermore, the quality of these articles is evidenced by the h-index of 21 and the citations the articles have received.

4.2 Research by countries

Advanced computer applications have allowed applications such as AI to permeate the industrial, services, and manufacturing sectors' ecosystems through innovative solutions. China and the USA lead in AI in PM research, the two most industrialized and the world's largest economies. There is very little research on Africa and the Middle East. Computer Science and Engineering disciplines dominate studies on the application of AI in PM. Overall, this study's findings indicate that AI techniques in PM are still in infancy but growing. This growth is shown by the increasing number of publications and citations in other research articles.

4.3 Research hotspots and emerging areas

Our results show that neural networks, algorithms, big data, and machine learning are popular AI techniques used in project management. Additionally, the resources used to proffer technological solutions. PM is an applied field, and this is shown by the wide variety of fields that published articles about the application of AI in PM. The two dominant fields are computer science and engineering. This is expected as AI is a subfield of computer science.

One would expect distinct subfields to emerge as the application of AI grows. Ong and Uddin (2020) noted that the current AI and data science applications remain preliminary with room for improvement. In PM, there is a need for software and tools that are proactive and not reactive. These need to predict future scenarios using 'what if' analysis and alert the project manager before issues arise[33]. This will undoubtedly change the role of a project manager as we know it today. Currently, the usage of AI tools in PM by project managers is low, according to a study by the International Project Management Association (IPMA) and PricewaterhouseCoopers (PwC)[34].

There is an increase in incorporating chatbots and machine learning techniques in project management. Adopting AI in project management assists project managers in effectively and efficiently managing their daily tasks. AI-based project management also improves accuracy, insight, decision-making, and strategy, thus improving productivity. Machine learning techniques use predictive and corrective analysis techniques in project planning and management[35]. Expert systems can assist project managers in grasping experiences of managing previous projects to share experiences easily. Project managers face challenges in predicting future scenarios and proactively taking corrective measures, and predictive analytics improves predicting 'what if' developments and uncovering real-time insights.

Some of the failures in PM are a direct result of human limitations. The use of AI can reduce the mistakes project managers make. According to Price Water House Coopers [34], AI is one of the breakthroughs that will disrupt PM by creating AI-enabled PM tools that enhance decision making. We expect an increase in project success rates as PM and AI become increasingly integrated. Critical to this development is the role of research.

5. LIMITATIONS

Although great effort went into conducting this study, there are inherent shortcomings. One shortcoming emanates from using one database (Web of Science), meaning any limitations in the database may apply to the study in turn. Thus, valuable grey literature and publications not indexed to the Web of Science have been excluded. This results in the underestimating research trends in most developing countries whose authors cannot publish in top journals indexed with the database due to their rigor and high standards. Each document is counted once per author in the Web of Science database. There is an overlap when counting authors with different affiliations, possibly over-estimated active authors and countries. Thus countries with authors involved in collaboration research are counted even if the author is a co-author and not the principal author. This may misrepresent patterns, trends, and patterns in the field. Another limitation stems from filtering grey literature, such as articles relating to reviews, letters, and patents in the study.

6. CONCLUSION

To the authors' knowledge, this is the first bibliometric analysis of AI in PM research by scholars from sub-Saharan Africa. This study's findings provide insight into AI in PM and show a sharp rise in research articles published in the last three years. The data analysis from the Web of Science database provided insights into the distribution of the retrieved articles by year, geographic region, publisher, and field. The results show a widespread uptake of AI tools in PM across

different countries and diverse fields. The keyword analysis determined the research topics and trends in AI applications in PM.

Our research contributes to the application of AI in PM and encourages further research on this important topic for the future. There is a need to evaluate how advances in quantum computing and cognitive technologies can be employed in project management. The study findings suggest that there are still research gaps in the field. One dominant research subfield relating to applying AI techniques to solve PM's inherent problems can be seen clearly in the density visualization map (figure 4) – algorithms to improve accuracy, prediction, and machine learning techniques. One distinct subfield's presence is a perhaps justifiable observation given the relative newness of AI applications in PM. This finding elucidates a need for further research in the less distinct subfields, including but not limited to AI's impact on PM in these fields. Future research should evaluate the project managers' knowledge of AI and how they are prepared to work with AI.

The world is experiencing a sharp increase in applying new technologies in the industrial and services sectors. While this study has provided an overview of AI applications in PM, there is a need to quantitatively measure the impact of AI application usage on general project success. This study provides literature on the application of AI in project management and an understanding of the critical relationships between the two fields. Our study aimed to stimulate and attract more research interest in AI application in PM. This study provides valuable insight for researchers and policymakers in PM and AI

REFERENCES:

[1] Y. Schoper, A. Wald, H. Ingason and T. Fridgeirsson, "Projectification in Western economies: A comparative study of Germany, Norway, and Iceland," International Journal of Project Management, vol. 36, no. 1, pp. 71-82, 2018.

[2] R. D. Archibald and D. Prado, "The importance of knowing your project, programme and portfolio management maturity," *Project Management World Journal,* vol. 3, no. 11, 2014.

[3] R. Wagner, "Organisational competence in project management — new perspectives on assessing and developing organisations," *Journal of Project, Programme and Portfolio Management,* vol. 3, no. 1, 2012, pp. 45-57.

[4] M. Mullaly, "If maturity is the answer, then exactly what was the question? " International Journal of Managing Projects in Business, vol. 7, no. 2, pp. 169-185, 2014.

[5] G. Garel, "A history of project management models: From pre-models to the standard models," International Journal of Project Management, vol. 31, pp. 663-669, 2013.

[6] M. Voss, "Impact of customer integration on project portfolio management and its success — Developing a conceptual framework," International Journal of Project Management, vol. 30, pp. 567-581, 2012.

[7] S. C. Shapiro and D. Eckroth, Encyclopedia of Artificial Intelligence, New York: Wiley, 1987.

[8] R. van der Meulen, "Smart Machines To Take Over Most Routine PPM Work," 2017. [Online]. Available: https://www.gartner.com/smarterwithgartner/smart-machines-to-take-over-most-routine-ppm-work/. [Accessed 01 February 2022].

[9] A. Foster, "Artificial intelligence in project management," Cost Engineering, 30(6), 21., vol. 30, no. 6, pp. 21-30, 1988.

[10] R. Levitt and J. Kunz, "Using artificial intelligence techniques to support project management," AI EDAM, vol. 1, no. 1, pp. 3 - 24, 1987.

[11] S. Ong and S. Uddin, "Data science and artificial intelligence in project management: The past, present, and future," *The Journal of Modern Project Management,* vol. 7, no. 4, 2020, pp. 1-9.

[12] M. Somasundaram, K. Junaid and S. Mangadu, "Artificial Intelligence (AI) Enabled Intelligent Quality Management System (IQMS) For Personalized Learning Path," *Procedia Comput. Sci.,* vol. 172, 2020, pp. 438–442.

[13] M. Munir, "How artificial intelligence can help project managers," *Global Journal of Management and Business Research,* vol. 19, no. 4, 2019, pp. 29-35.

[14] M. Wauters and M. Vanhoucke, "A comparative study of Artificial Intelligence methods for project duration forecasting," Expert systems with applications, vol. 46, pp. 249-261, 2016.

[15] Q. Wang, "How to apply AI technology in project management," PM World Journal, vol. 8, no. 3, 2019, pp. 1-12.

[16] N. De Bellis, Bibliometrics and Citation Analysis: From the Science Citation Index to Cybermetrics, Plymouth: The Scarecrow Press Inc, 2009.

[17] J. Merigó, "Academic research in innovation: A country analysis. Scientometrics," vol. 108, p. 559–593, 2016.

[18] A. Van Raan, "Advances in bibliometric analysis: research performance assessment and science mapping," Bibliometrics Use and Abuse in the Review of Research Performance, p. 17–28, 2014.

[19] G. Fusco, "Twenty years of common agricultural policy in Europe: A bibliometric analysis," Sustainability, vol. 13, no. 19, pp. 1-15, 2021.

[20] S. Donthu, "How to conduct a bibliometric analysis: An overview and guidelines," Journal of Business Research, vol. 133, pp. 285-296, 2021.

[21] F. J. Hinojo-Lucena, I. Aznar-Díaz, M. P. Cáceres-Reche and J. M. Romero-Rodríguez, "Artificial intelligence in higher education: A bibliometric study on its impact in the scientific literature," Education Sciences, vol. 9, no. 1, p. 51, 2019.

[22] Y. Guo, Z. Hao, S. Zhao, J. Gong, and F. Yang, "Artificial intelligence in health care: Bibliometric analysis," Journal of Medical Internet Research, vol. 22, no. 7, p. e18228, 2020

[23] B. X. Tran, R. S. McIntyre, C. A. Latkin, H. T. Phan, G. T. Vu, H. L. Nguyen, K. K. Gwee, C. S. Ho and R. Ho, "The current research landscape on the artificial intelligence application in the management of depressive disorders: A bibliometric analysis," International Journal of Environmental Research and Public Health, vol. 16, no. 12, 2019, pp. 2150-2160.

[24] P. Dhamija and S. Bag, "Role of artificial intelligence in operations environment: A review and bibliometric analysis," The TQM Journal, 2020.

[25] L. Zhao, T. Dai, Z. Qiao, P. Sun , J. Hao and Y. Yang, "Application of artificial intelligence to wastewater treatment: A bibliometric analysis and systematic review of technology, economy, management, and wastewater reuse," Process Safety and Environmental Protection, vol. 133, pp. 169-182, 2020.

[26] V. Maphosa, M. Maphosa, "The Trajectory of Artificial Intelligence Research in Higher Education: A Bibliometric Analysis and Visualisation," in International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD), Durban, South Africa, 2021, pp. 1-7.

[27] T. Fridgeirsson, H. Ingason, H. Jonasson and H. Jonsdottir, "An authoritative study on the near future effect of artificial intelligence on project management knowledge areas," Sustainability, vol. 13, no. 4, pp. 2345-2354, 2021.

[28] N. J. van Eck and L. Waltman, "VOSviewer manual: Manual for VOSviewer version 1 .6.11," Leiden University, Leiden, 2017

[29] R. Côrtes, "A bibliometric study on "education for sustainability," Brazilian Journal of Science and Technology, vol. 3, no. 1, pp. 1-17, 2016.

[30] A.A Selçuk, "A Guide for Systematic Reviews: PRISMA," Turk Arch Otorhinolaryngol, vol. 57, no. 1, 2019, pp. 57-8.

[31] C. Huai and L. Chai, "A bibliometric analysis on the performance and underlying dynamic patterns of water security research," Scientometrics, vol. 108, no. 3, pp. 1531-1551, 2016.

[32] N. V. Chawla and D. A. Davis, "Bringing big data to personalised healthcare: A patient-centered framework," *Journal of General Internal Medicine,* vol. 28, no. 3, 2013, pp. 660-665.

[33] T. G. Lechler and S. Yang, "Exploring the role of project management in the development of the academic agile software discourse: A bibliometric analysis," Project Management Journal, vol. 48, no. 1, pp. 3-18, 2017.

[34] IPMA and PwC, "Artificial Intelligence impact in Project Management," IPMA and PwC, 2020.

[35] R. Prieto, "Impacts of Artificial Intelligence on Management of Large Complex Projects," PM World Journal, vol. 8, no. 5, pp. 1-20, 2019.

[36] V. Maphosa, "Rethinking Sustainability: A Bibliometric and Visualisation of e-waste Management in Africa, "Journal of Higher Education Theory and Practice, vol 22, no. 1, pp 123-135, 2022.

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Appendix A. Steps for Analysing using VOSviewer

1. Download VOSviewer (https://www.vosviewer.com/download)
2. Install VOSviewer
3. Download the bibliometric data in plain text from the Web of Science database or another source and save it in a single folder.
4. Start VOSviewer, click the "Create" button, and select the second option, "Create a map based on bibliographic data," on the chosen data type.
5. Click the "Next" button and select the first option, "Read data from bibliographic database files," on the chosen data source.
6. Click the 'Next" button, select the file step, and select the file downloaded from the database.
7. Click the "Next" button, and on the next step, "Choose the type of analysis and counting method step," select type of analysis – Co-occurrence, Unit of Analysis - All keywords and Counting Method: - full counting.
8. Click finish