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EMERGING TRENDS AND FUTURE DIRECTIONS IN GREEN PROJECT MANAGEMENT: A BIBLIOMETRIC AND THEMATIC ANALYSIS (2015–2025)

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Abstract: **The global push towards sustainable development has intensified the demand for green project management frameworks that incorporate environmental, technological, and socio-political dimensions. This study aims to systematically analyse the trends, research hotspots, and future directions in green project management, with a particular focus on the integration of emerging technologies such as Artificial Intelligence (AI), Building Information Modelling (BIM), and the Internet of Things (IoT), as well as governance challenges in the Global South. A bibliometric analysis was conducted using Scopus-indexed articles published between 2015 and 2025, complemented by qualitative content analysis to identify prevailing themes and research gaps. Results reveal that while research output has significantly increased peaking in 2025, however key contributions have concentrated on environmental science, engineering, and business management. The findings also highlight that most studies are concentrated in high-income countries, with limited empirical work addressing socio-cultural dynamics in developing contexts. Prominent authors and institutions have emerged from China, Malaysia, and Indonesia, contributing to key journals such as Sustainability and Journal of Cleaner Production. However, few studies have developed comprehensive frameworks that integrate digital innovations with life cycle assessments and localized governance models. The study recommends future research to prioritise longitudinal studies, stakeholder-driven approaches, and assessments of digital twin and circular economy scalability in diverse contexts. By identifying these gaps and emerging trends, this research provides a foundational roadmap for scholars and practitioners aiming to enhance the effectiveness, inclusivity, and technological integration of green project management practices worldwide.**

Keywords: **Green project management, Sustainability, Emerging technologies, Bibliometric analysis, Governance models**

I. INTRODUCTION

Over the past decade, the imperative for sustainable development has catalysed a significant transformation in project management practices, giving rise to the specialized field of Green Project Management (GPM) (Khater, 2021). This evolution reflects a global consensus on the need to integrate environmental considerations into the lifecycle of projects, particularly in sectors like construction, infrastructure, and energy (Kim et al.,2021). The adoption of GPM is driven by a confluence of factors, including heightened awareness of climate change, regulatory pressures, and the pursuit of corporate social responsibility (Albasteki, 2021).

The European Green Deal, launched in 2020, exemplifies policy-level commitment to sustainability, aiming to make the European Union climate-neutral by 2050 (Wang et al., 2024). This initiative emphasizes the role of comprehensive frameworks in steering large-scale environmental

objectives. Similarly, the International Green Construction Code (IgCC) provides guidelines to enhance the sustainability of buildings throughout their design, construction, and operation phases, emphasizing the importance of standardized practices in achieving environmental goals (Wang et al., 2024).

Technological advancements have further propelled GPM by introducing tools that enhance efficiency and environmental performance (Skofronick-Jackson et al., 2018). The integration of Building Information Modelling (BIM), Internet of Things (IoT), and digital twins into project management processes facilitates real-time monitoring and optimization, leading to more sustainable outcomes (Baghalzadeh Shishehgarkhaneh et al., 2022). These technologies enable stakeholders to simulate and assess the environmental impact of projects before implementation, thereby reducing resource consumption and emissions (Baghalzadeh Shishehgarkhaneh et al., 2022).

In the realm of supply chain management, the concept of Green Supply Chain Management (GSCM) has gained prominence (Singh & Trivedi, 2016). GSCM involves incorporating environmental considerations into supply chain operations, from product design and material sourcing to manufacturing and end-of-life management (Burke et al., 2023). This approach not only minimizes environmental impact but also enhances organizational efficiency and competitiveness. Despite these advancements, challenges persist, particularly in the Global South, where socio-political and economic factors can hinder the adoption of GPM practices. Research indicates that while countries like China have made significant strides in sustainability research output (Shi &Yin, 2023) other nations in the Global South face obstacles such as limited access to technology, funding constraints, and inadequate policy support.

To address these challenges and capitalize on the opportunities presented by GPM, a holistic understanding of the field's evolution, current trends, and future directions is essential. This study employs a systematic literature review and bibliometric analysis to examine GPM research from 2015 to 2025, aiming to identify key contributors, thematic areas, and geographical distributions. Through synthesizing existing knowledge and highlighting gaps, this research seeks to inform policymakers, practitioners, and academics on effective strategies for advancing sustainable project management globally.

II. METHODOLOGY

Systematic Literature Review and Bibliometric Analysis Approach

This study employed a hybrid approach that combines a Systematic Literature Review (SLR) with bibliometric analysis to comprehensively examine the evolution of green project management (GPM) research from 2015 to 2025. The SLR was utilized to synthesize key themes, emerging concepts, and gaps in scholarly discourse, while bibliometric techniques were applied to quantitatively analyse citation patterns, co-authorship networks, research hotspots, and the geographical distribution of contributions. This integrated methodology facilitates a deeper understanding of both conceptual developments and quantitative research trends within the GPM domain, offering empirical rigor and theoretical breadth.

Database Selection

The Scopus database was selected as the sole source of bibliographic data due to its extensive coverage of peer-reviewed literature across multidisciplinary domains including environmental science, engineering, business, and sustainability. Scopus also provides robust citation metrics and analytical tools suitable for mapping intellectual structures in emerging research fields such as GPM.

Search Strategy

A structured Boolean search was constructed using the following keywords: “green project management” OR “sustainable construction” OR “green infrastructure” OR “green innovation” in the title, abstract, and keyword fields. The search was restricted to journal articles and conference papers published between 2015 and 2025 and written in English. This search initially yielded 5,410 documents. After refining based on relevance, duplication removal, and access to full text, a final set of eighty-four(84) articles was selected for in-depth analysis.However, an additional six (6) documents were selected from outside Scopus due to their relevance to this review.

Inclusion and Exclusion Criteria

Table 1 outlines the criteria used to select studies for this review. These ensured the inclusion of rigorous, high-quality research directly related to the scope of green project management and excluded unrelated or non-peer-reviewed content.

Table 1: Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Time Frame	Articles published between 2015 and 2025	Articles published before 2015
Document Type	Peer-reviewed journal articles and conference papers	Bbook chapters, editorials
Language	English-language publications	Non-English publications
Topic Relevance	Studies focusing on GPM, green innovation, sustainable construction	Studies on unrelated themes (e.g., general project management)
Accessibility	Full-text availability through Scopus	Articles without accessible full text

Bibliometric Analysis

This bibliometric analysis examined the evolution and structure of green project management (GPM) research from 2015 to 2025. It revealed a growing body of literature, especially after 2020, driven by global sustainability efforts and post-pandemic priorities. Key metrics such as publication trends, citation impact, and co-authorship networks highlighted leading authors, institutions, and research hubs, with China, Malaysia, and Indonesia emerging as major contributors. Keyword mapping and thematic clustering uncovered dominant themes, including green certifications, smart technology integration, and circular economy models. Despite regional advances, contributions from Africa and Latin America remain limited, underscoring the need for more inclusive and globally representative research. The analysis provides critical insights into past developments and future directions in GPM.

Data Extraction and Thematic Synthesis

In the systematic literature review (SLR) phase, the selected articles were rigorously coded to extract key information, including research objectives, methods used, principal findings, theoretical underpinnings, and geographic focus. The extracted data were then organized into coherent thematic categories, reflecting recurring and emerging focal areas in green project management (GPM). These themes included the integration of advanced technologies such as Building Information Modelling (BIM), Internet of Things (IoT), and digital twins; green supply chain practices; stakeholder involvement and collaboration dynamics; the role of public-private partnerships (PPPs); and the socio-political dimensions of green policies in the Global South. This thematic synthesis allowed for a comprehensive comparison of research trends, identification of knowledge gaps, and recognition of areas where theoretical and empirical development is still needed, thus providing a roadmap for future research in the evolving field of GPM.

Limitations

Although the Scopus database offered a robust and multidisciplinary platform for data collection, relying solely on it may have inadvertently excluded pertinent studies indexed in other major databases such as Web of Science, IEEE Xplore, or Google Scholar. This could result in a partial representation of the research landscape, particularly in interdisciplinary or emerging areas of green project management (GPM). Furthermore, the restriction to English-language publications introduced a linguistic bias that potentially disregarded important insights from non-Anglophone regions many of which are actively advancing sustainability efforts but may publish in local or regional languages. Such exclusions could skew the global perspective, particularly by under representing contributions from Latin America, Eastern Europe, and parts of Asia and Africa. Future reviews should consider adopting a more inclusive approach by integrating multiple databases and accounting for language diversity through multilingual search strategies and translation tools. This would ensure a more comprehensive, balanced, and globally representative synthesis of the GPM literature.

Trend of annual publications

The temporal distribution of documents from 2015 to 2025 reveals a progressive increase in scholarly activity, with notable fluctuations across the years. Between 2015 and 2019, the number of documents remained relatively low, ranging from 2 to 5 annually, indicating limited research engagement during this early period. A substantial rise was observed in 2020, with the document count increasing to 11, suggesting a shift towards heightened academic or institutional interest. This upward trend continued, peaking in 2022 with 15 documentsthe highest in the datasetpotentially reflecting intensified research efforts, increased funding opportunities, or a policy-driven focus on the subject area. Although a slight decline followed in subsequent years, the figures stabilized at a relatively high level (ranging from 9 to 11 documents annually between 2020 and 2025), indicating sustained scholarly engagement. Overall, the data demonstrate a maturation of research

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interest over the decade, with 2022 marking a pivotal year of heightened academic output.

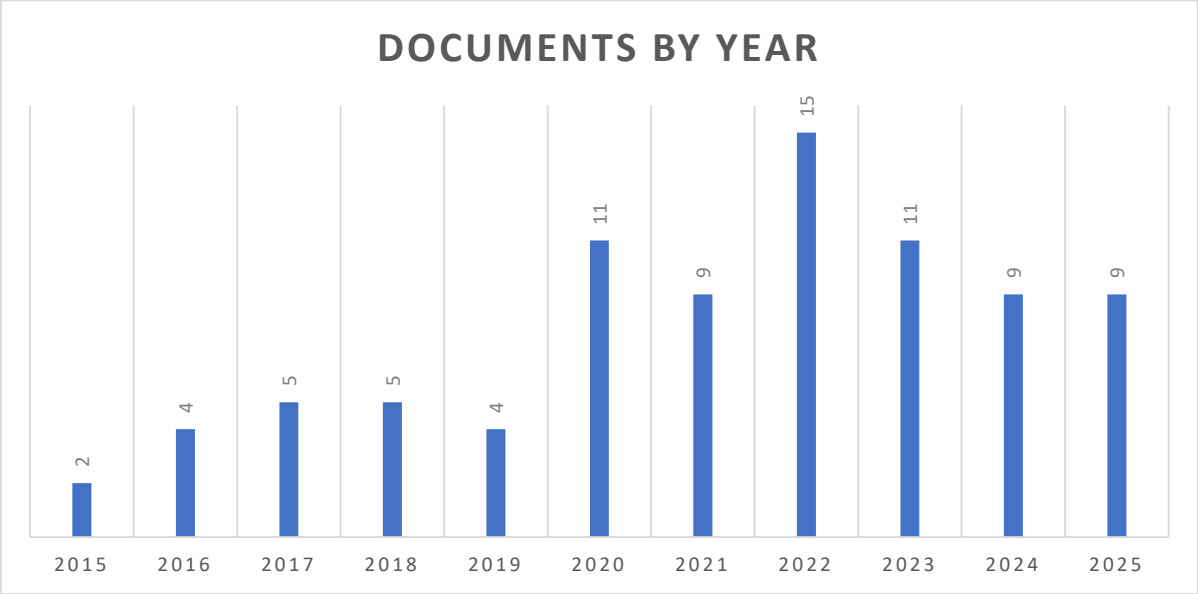

Figure 1: Annual distribution of documents from 2015 to 2025, illustrating a progressive increase in research output with a peak in 2022, followed by sustained scholarly activity in subsequent years.

Publication Trend by Country

The distribution of documents by country reveals significant geographic disparities in research output. China leads overwhelmingly with 18 documents, accounting for the majority of contributions, which underscores its dominant role and possible prioritization of the research topic at the national or institutional level. Indonesia follows with 10 documents, indicating a relatively high level of engagement compared to other countries. In contrast, countries such as Russia, India, South Africa, Spain, the United Arab Emirates, and the United States contributed fewer documents, ranging from 1 to 4 each. Notably, the United States, typically recognized as a major contributor to global research, appears underrepresented in this dataset. This uneven distribution suggests a concentration of scholarly interest and productivity in selected countries, particularly within Asia, while other regions demonstrate more limited or emerging research activity in the field. The observed trend may reflect differences in national research priorities, funding availability, or institutional focus. Here we selected top 15 countries for this analysis. The rest of the countries had 1 publication each.

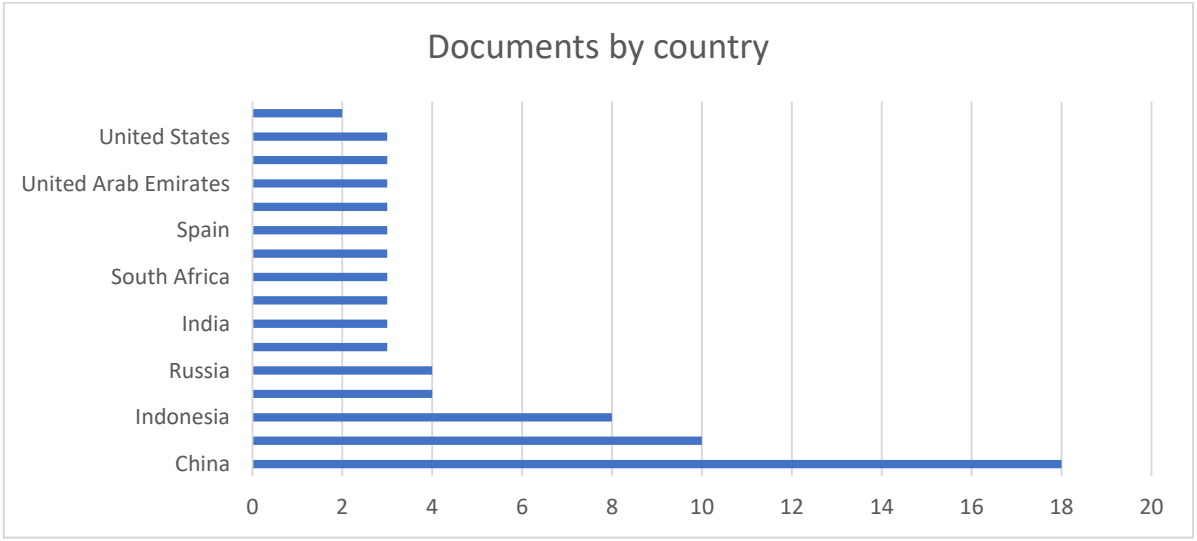

Figure 2: Publication Trend by Country

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Table 2 presents a comprehensive overview of the key sources, thematic focus areas, contributors, institutional affiliations, and geographic distribution of scholarly publications within the scope of the study. Among the journals, Sustainability leads with six publications, followed by the Journal of Cleaner Production (4) and three journals with three publications each, namely International Multidisciplinary Scientific Geo-conference Surveying, IOP Conference Series: Earth and Environmental Science, and Journal of Project Management (Canada). These journals are predominantly focused on interdisciplinary and applied research, which reflects the multi-sectoral nature of the research area.

Table 2: Top ten journals, research areas, authors, affiliations, and countries in bibliographical metrics

Journals (a)	Research areas (b)	Authors (c)	Affiliations (d)	Countries (e)
Sustainability(06)	Engineering (38)	Handayani, N.U. (03)	Universiti Teknologi MARA(05)	China (18)
Journal of Cleaner Production (04)	Environmental Science (26)	Wibowo, M.A. (03)	Universitas Diponegoro(04)	Malaysia (10)
International Multidisciplinary Scientific Geoconference Surveying (03)	Business, Management and Accounting (21)	Amade, B. (02)	Universiti Malaysia Perlis (03)	Indonesia (08)
Iop Conference Series Earth And Environmental Science (03)	Social Sciences (20)	Chang, A.P. (02)	Universiti Sains Malaysia (02)	Nigeria (04)
Journal of Project Management Canada (03)	Energy (18)	Chu, T.J. (02)	Federal University of Technology, Owerri (02)	Russia (04)
E3s Web of Conferences(02)	Computer Science (14)	Gabriella, T. (02)	University of Northumbria(02)	Australia (03)
International Journal of Supply Chain Management (02)	Earth and Planetary Sciences (09)	Hwang, C.L. (02)	Nanjing Normal University (02)	India (03)
Journal of Engineering And Applied Science (02)	Decision Sciences (08)	Ismail, Z.A. (02)	Politecnico di Milano (02)	Italy (03)
Lecture Notes in Civil Engineering (02)	Materials Science (05)	Lin, J.D. (02)	National Central University (02)	South Africa (03)
Malaysian Construction Research Journal (2)	Mathematics (04)	Rinawati, D.I. (02)	National Taiwan University of Science and Technologys (02)	South Korea (03)

The most prominent research domains include Engineering (38), Environmental Science (26), and Business, Management and Accounting (21), highlighting the cross-cutting relevance of sustainability and infrastructure-related studies. Other significant fields such as Social Sciences, Energy, and Computer Science further underscore the multidisciplinary nature of the scholarship.

In terms of authorship, Handayani, N.U. and Wibowo, M.A. are among the most prolific contributors with three publications each, while several other authors, including Amade, B., Chang, A.P., and Chu, T.J., each have two publications. The leading affiliations include Universiti Teknologi MARA (5), Universitas Diponegoro (4), and Universiti Malaysia Perlis (3), reflecting strong institutional involvement from Southeast Asian universities. Additionally, affiliations such as the Federal University of Technology, Owerri, and Politecnico di Milano signal a wider international collaboration.

Geographically, China dominates with (18) contributions, followed by Malaysia (10) and Indonesia (8), indicating a

strong research presence from Asian countries. Countries such as Nigeria, Russia, Australia, India, Italy, South Africa, and South Korea have more modest representation but collectively contribute to a diverse international research landscape. This distribution reflects the global but regionally concentrated interest in the subject matter, likely influenced by differing national research priorities, institutional capacities, and funding mechanisms.

Highly Cited Articles from Selected Subject Areas

The bibliometric profile presented in the table provides an insightful overview of the most cited scholarly contributions to the field of green and sustainable project management. The articles span from 2016 to 2022, indicating a steady rise in academic interest over the past decade. The most cited article, Hwang et al. (2017), published in the Journal of Cleaner Production, has accrued 79 citations as of May 2025. This study addresses the barriers and potential solutions in managing green business parks and highlights the infrastructural and managerial complexities of sustainable development projects. The high citation count reflects the article's relevance and influence within the discourse on sustainable infrastructure.

Notably, three of the top-cited articles Hwang et al. (2017), Zhang and Mohandes (2020), and Ibrahim et al. (2020)were published in the Journal of Cleaner Production, underscoring the journal's central role in advancing the frontiers of sustainable project research. These articles collectively explore themes of risk management, occupational health and safety, and green governance, offering a multidisciplinary perspective that bridges environmental science, engineering, and project management. Ibrahim et al.'s (2020) study, which examines Australia's largest integrated storm water management project, emphasizes the role of governance and institutional integration in the success of green infrastructure initiatives.

The contributions by Liu et al. (2016) and Fernando et al. (2018) extend the conversation by incorporating international case studies and sector-specific insights. Liu et al. explore blue-green infrastructure in Beijing and Copenhagen, providing a comparative lens on urban water management strategies. Fernando et al. examine the interplay between project risk and green supply chain management in the automotive industry, signalling the increasing industrial relevance of sustainable practices.

Meanwhile, more recent studies such as Lenderink et al. (2022) delve into the role of procurement and innovation in public sector green projects, highlighting the importance of institutional mechanisms in fostering sustainability. Additionally, papers published in Sustainability (Switzerland), including those by Kim et al. (2016), Chou et al. (2017), and Wu et al. (2019), focus on operational aspects such as supplier capabilities, project evaluation criteria, and quality enhancement in highway engineering, showcasing the diverse applications of green principles across project phases and sectors.

Table 3:Highly cited articles from selected subject areas

Authors	Source title	Titles	Year	Citation (08/05/2025)
Hwang et al. (2017)	Journal of Cleaner Production	Green business park project management: Barriers and solutions for sustainable development	2017	79
Zhang and Mohandes (2020)**s**	Journal of Cleaner Production	Occupational Health and Safety in green building construction projects: A holistic Z-numbers-based risk management framework	2020	71
Ibrahim et al. (2020)	Journal of Cleaner Production	Green infrastructure needs green governance: Lessons from Australia's largest integrated stormwater management project, the River Torrens Linear Park	2020	61
Liu et al. (2016)	Water (Switzerland)	Blue-green infrastructure for sustainable urban stormwater management-lessons from six municipality-led pilot projects in Beijing and Copenhagen	2016	57
Fernando et al. (2018)	International Journal of Managing Projects in Business	Managing project success using project risk and green supply chain management: A survey of automotive industry	2018	47
Maskil-Leitan et al. (2020)	Buildings	BIM management measure for an effective green building project	2020	32

Lenderink et al. (2022)	Journal of Purchasing and Supply Management	Procurement and innovation risk management: How a public client managed to realize a radical green innovation in a civil engineering project	2022	30
Kim et al. (2016)	Sustainability (Switzerland)	Environmental capabilities of suppliers for green supply chain management in construction projects: A Case Study in Korea	2016	30
Chou et al. (2017)	Sustainability (Switzerland)	Building criteria for evaluating green project management: An integrated approach of DEMATEL and ANP	2017	28
Wu et al. (2019)	Sustainability (Switzerland)	Improving the impact of green construction management on the quality of highway engineering projects	2019	24

The temporal distribution of scholarly articles reveals a notable trend in the increasing volume of publications addressing sustainable project management and green infrastructure over the past decade. The peak publication year is 2022, with 15 relevant articles, indicating heightened global attention on environmental sustainability, governance, and project efficiency following the COVID-19 pandemic. A substantial number of studies also appeared in 2023 (12 articles), 2020 (11 articles), and 2024 (9 articles), which collectively reflect the growing scholarly engagement with sustainable development goals (SDGs) and environmental policy implementation.

From 2015 to 2017, publication output remained relatively modest, with 2 to 5 papers annually. These early works, however, laid the foundational frameworks for green construction principles and ecological project design. A gradual increase is observed starting in 2018, likely due to global climate commitments and the mainstreaming of green certifications and building information modelling (BIM) in practice.

The years 2020 to 2025 represent a marked acceleration in research, driven by technological advancement, increased funding for climate resilience, and the urgency of sustainable development. Notably, the year 2025 (though ongoing) has already produced eight impactful studies, suggesting the momentum is being sustained and further diversified in terms of disciplinary and regional engagement.

Table 4: Summary of documents included in this review

Year	Articles number	References
2025	8	Kissi et al. (2025), Alharbi (2025), Istri Mas Pertiwi et al. (2025), Kuang and Qi (2025); Shen et al. (2025); Aljaaidi et al. (2025); Onubi and Carpio (2025); Lyu (2025)
2024	9	Han and Yang (2024), Mandičák and Spišáková (2024), Chen (2024), Laktionova et al. (2024); Gunawan et al. (2024); Gremo et al. (2024); Satrio et al. (2024); Yousef and Qutechate (2024); Darabad et al. (2024)
2023	12	Gunanandhini et al. (2023), Rosengart et al. (2023), Huo et al. (2023), Malik et al. (2023); Nusa et al. (2023); Tolkachev et al. (2023) Mukattash and Hyarat (2023); Koc et al. (2023); Allenykh and Anisimova (2023); Huang et al. (2023); Tian et al. (2023); Wijayaningtyas et al. (2023)
2022	15	(Wang et al., 2022), Chakravarthy et al. (2022),To and Lam (2022), Lenderink et al. (2020), Tryhuba et al. (2022), Wang et al. (2022), Mechiche-Alami et al. (2022), Feng (2022), Mahat et al. (2022), Adindu et al. (2022), Zakaria et al. (2022); Tightiz and Yoo (2022); Yusof et al. (2022); Abdelkhalik and Azmy (2022); Lian et al. (2022)
2021	9	Abidin and Azizi (2021); Sharifah NurFarhana et al. (2021); Amade (2021); Xiao et al. (2021); Wardani et al. (2021); Ismail (2021); Orsi et al. (2021); Handayani et al. (2021); Scafuto et al. (2021)
2020	11	Zhang and Mohandes (2020);Orsi et al. (2021); Mee-Ngoen et al. (2020); Oxoli D et al. (2020); Dzobelova et al. (2020); Yazici (2020); Ibrahim et al. (2020); Amade et al. (2020); Maskil-Leitan et al. (2020); Ismail (2020); Dong (2020)
2019	5	Bakar et al. (2019), Andenaes et al. (2019); Liu et al. (2019); Wu et al. (2019); Handayani et al. (2019)
2018	5	Akhmadiev et al. (2018); Wan (2018); Fernando et al. (2018); Maseko et al. (2018); Krasniqi et al. (2018)

2017	5	Novakova et al. (2017), Hwang et al. (2017); Chou et al. (2017); Trebukhin and Lemesheva (2017); Liu andYou (2017)
2016	4	Al Rumaithi and Beheiry (2016); Rwelamila and Purushottam (2016); Torrens et al. (2016); Kim et al. (2016);
2015	1	Chang et al. (2015)

Future Research Agenda

Despite significant advancements in green project management, sustainability science, and eco-innovation, several critical gaps persist that require targeted academic inquiry. Notably, there remains a lack of integrative frameworks that fully harness the potentials of emerging technologies such as Artificial Intelligence (AI), Building Information Modelling (BIM), and the Internet of Things (IoT) throughout the green project life cycle. Current applications of these technologies are often fragmented and limited to specific phases such as design or monitoring, rather than providing a holistic, interoperable system from project conception to decommissioning. AI-driven predictive analytics could, for example, optimize material use and reduce carbon footprints, while BIM can serve as a platform for real-time collaboration and decision-making. Similarly, IoT sensors can monitor building performance and environmental compliance, yet there is insufficient scholarly focus on how these tools can be collectively operationalized within a sustainability assessment framework.

Moreover, the socio-political dimensions of sustainability transitionsparticularly in the Global Southremain underexplored. Issues such as governance fragmentation, institutional inertia, corruption, and community disenfranchisement hinder the successful localization of green policies and projects. There is a pressing need for future studies to explore how locally embedded governance models can align with national and global sustainability objectives while respecting cultural, economic, and social contexts. Longitudinal impact assessments of previously implemented green infrastructure projects should be conducted to evaluate their performance, community acceptance, and scalability over time. This can help identify policy misalignments, technological shortcomings, and implementation barriers.

The future research agenda should also expand on the scalability and adaptability of advanced frameworks such as digital twins and circular economy principles in the construction sector. Digital twinvirtual replicas of physical assetsoffer promising avenues for simulating energy consumption, lifecycle costs, and resource loops, but their applicability in resource-constrained settings is rarely addressed. In addition, empirical studies are urgently needed to investigate stakeholder engagement models and risk-sharing mechanisms in public-private partnerships, which are central to financing and executing large-scale sustainable infrastructure projects. Cultural norms, behavioral patterns, and traditional ecological knowledge also play a vital role in shaping how green technologies are perceived and adopted, yet these factors are often absent from technical analyses.Addressing these research gaps through multidisciplinary, context-sensitive, and methodologically diverse approaches will not only contribute to theory development but also provide actionable, evidence-based insights for governments, developers, and civil society. A systematic exploration of the interplay between technology, governance, and cultural context will enhance the practical relevance and effectiveness of green project management, ultimately supporting the realization of the United Nations Sustainable Development Goals and global climate targets.

III. CONCLUSION

This study has systematically examined the evolution of green project management research over the decade spanning 2015 to 2025, providing a comprehensive overview of the field's trajectory through bibliometric and thematic analyses. The study findings reveal a growing body of literature emphasizing the intersection of engineering, environmental science, and business management as key pillars driving sustainability-focused project practices. A significant portion of scholarly output originates from China, Malaysia, and Indonesia, indicating a regional concentration of academic and practical engagement with green project management. These contributions have predominantly explored themes such as sustainable construction, green procurement, environmentally responsible supply chains, and performance measurement frameworks.

Despite these advances, critical gaps persist. Notably, the integration of frontier technologies such as Artificial Intelligence (AI), Building Information Modelling (BIM), the Internet of Things (IoT), and digital twin systems into green project life cycle assessments remains nascent. Such technologies offer transformative potential for optimizing resource use, enhancing real-time decision-making, and improving transparency and accountability across project phases. Moreover, the broader socio-political and cultural dimensions that shape green innovation uptake particularly in the Global Southare underrepresented in current literature. Issues such as institutional capacity, regulatory inconsistencies, local knowledge systems, and cultural perceptions of sustainability need deeper investigation to tailor interventions to regional realities.

The study reaffirms the thesis that green project management is not only a technical challenge but also a

deeply contextual and interdisciplinary endeavour. Going forward, research must focus on longitudinal assessments of completed green projects, the design of locally appropriate green governance models, and empirical evaluations of technology adoption pathways. In doing so, scholars and practitioners can co-produce knowledge that is both scientifically robust and practically relevant, thereby advancing the global sustainability agenda with equity and inclusivity at its core.

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