

RESEARCH IN BRAZIL AND THE INTERNATIONAL LITERATURE: A COMPARATIVE SYSTEMATIC MAPPING OF RESEARCH TRENDS AND PUBLICATION ECOSYSTEMS

A PESQUISA NO BRASIL E A LITERATURA INTERNACIONAL: UM MAPEAMENTO SISTEMÁTICO COMPARATIVO DE TENDÊNCIAS DE PESQUISA E ECOSSISTEMAS DE PUBLICAÇÃO

LA INVESTIGACIÓN EN BRASIL Y LA LITERATURA INTERNACIONAL: UN MAPEO SISTEMÁTICO COMPARATIVO DE LAS TENDENCIAS DE INVESTIGACIÓN Y LOS ECOSISTEMAS DE PUBLICACIÓN

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ABSTRACT: This study examines how Brazilian publications on Building Information Modeling for Facility Management (BIM-FM) compare with those published in internationally indexed journals. A comparative systematic mapping was conducted using four thematic protocols addressing (i) smart technologies in Facility Management, (ii) BIM capability and organizational maturity, (iii) semantic interoperability and data integration, and (iv) building operation, maintenance, and asset management. Thirty peer-reviewed studies published between 2022 and 2026 were analyzed through an integrated framework combining thematic, qualitative, scientometric, bibliometric, and traceability analyses. Studies were assessed according to Innovation Level, Scientific Contribution, and Alignment with the BIM-FM Knowledge Frontier, alongside journal rankings, indexing coverage, and citation metrics. The findings indicate that internationally indexed publications show stronger alignment with emerging BIM-FM trends, particularly the integration of BIM with Digital Twins, Artificial Intelligence, Internet of Things technologies, semantic interoperability, predictive maintenance, and intelligent asset

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management. Brazilian publications predominantly address BIM adoption, organizational maturity, information structuring, interoperability, and process digitalization. Analysis of Brazilian researchers' publication profiles suggests that these differences are not necessarily attributable to limited scientific capability, as several researchers also publish internationally on frontier topics. Instead, publication visibility, indexing, and research evaluation mechanisms may influence the international circulation of Brazilian BIM-FM knowledge.

Keywords: Building Information Modeling (BIM). Facility Management (FM). Scientometric Analysis.

RESUMO: Este estudo examina como as publicações brasileiras sobre Building Information Modeling aplicado à Facility Management (BIM-FM) se comparam às publicadas em periódicos indexados internacionalmente. Foi realizada uma revisão sistemática comparativa, baseada em quatro protocolos temáticos: (i) tecnologias inteligentes aplicadas à Facility Management; (ii) capacidade BIM e maturidade organizacional; (iii) interoperabilidade semântica e integração de dados; e (iv) operação, manutenção e gestão de ativos. Foram analisados 30 estudos revisados por pares, publicados entre 2022 e 2026, combinando análises temática, qualitativa, cientométrica, bibliométrica e de rastreabilidade. Os estudos foram avaliados quanto ao Nível de Inovação, Contribuição Científica e Alinhamento à Fronteira do Conhecimento em BIM-FM, além de indicadores de periódicos, indexação e citações. Os resultados indicam maior alinhamento das publicações internacionalmente indexadas às tendências emergentes, especialmente na integração do BIM com Digital Twins, Inteligência Artificial, Internet das Coisas, interoperabilidade semântica, manutenção preditiva e gestão inteligente de ativos. As publicações brasileiras concentram-se em adoção do BIM, maturidade organizacional, estruturação da informação, interoperabilidade e digitalização de processos. A análise dos pesquisadores brasileiros indica que essas diferenças não refletem necessariamente menor capacidade científica, mas podem estar relacionadas à visibilidade das publicações, indexação e mecanismos de avaliação da pesquisa, que influenciam a circulação internacional do conhecimento em BIM-FM.

Palavras-chave: Modelagem da Informação da Construção (BIM). Gestão de Instalações (FM). Análise Cientométrica.

RESUMEN: Este estudio examina cómo las publicaciones brasileñas sobre Building Information Modeling aplicado a Facility Management (BIM-FM) se comparan con las publicadas en revistas indexadas internacionalmente. Se realizó una revisión sistemática comparativa mediante cuatro protocolos temáticos sobre (i) tecnologías inteligentes en Facility Management, (ii) capacidad BIM y madurez organizacional, (iii) interoperabilidad semántica e integración de datos, y (iv) operación, mantenimiento y gestión de activos. Se analizaron treinta estudios revisados por pares, publicados entre 2022 y 2026, mediante un marco que combinó análisis temático, cualitativo, cientométrico, bibliométrico y de trazabilidad. Los estudios fueron evaluados según el Nivel de Innovación, la Contribución Científica y la Alineación con la Frontera del Conocimiento en BIM-FM, además de indicadores de indexación y citas. Los resultados indican que las publicaciones internacionalmente indexadas presentan mayor alineación con tendencias emergentes, especialmente en la integración del BIM con Digital Twins, Inteligencia Artificial, Internet de las Cosas, interoperabilidad semántica, mantenimiento predictivo y gestión inteligente de activos. Las publicaciones brasileñas se centran principalmente en adopción del BIM, madurez organizacional, estructuración de información, interoperabilidad y digitalización de procesos. Estas diferencias no necesariamente reflejan una capacidad científica limitada, sino que pueden estar relacionadas con la visibilidad, indexación y evaluación de las publicaciones.

Palabras clave: Modelado de Información de la Construcción (BIM). Gestión de Instalaciones (FM). Análisis cienciométrico.

INTRODUCTION

The integration of Building Information Modeling (BIM) and Facility Management (FM) has emerged as an important research frontier in the built environment, reflecting the global shift toward data-driven digital transformation and extending BIM beyond design and construction to support integrated asset management throughout the building life cycle (ABIDEEN et al., 2022). This convergence also contributes to the United Nations Sustainable Development Goals (SDGs) 9, 11, and 12 by promoting technological innovation, more efficient building operation, and improved resource management (ABIDEEN et al., 2022).

Despite advances in BIM-FM integration and interoperability through IFC and OpenBIM, persistent challenges remain, including data fragmentation, outdated information models, limited process maturity, and difficulties in maintaining consistent information throughout the asset life cycle (OTRANTO; JUNIOR; PELLANDA, 2025). Existing buildings present additional challenges related to data acquisition and the alignment between BIM models and operational requirements (KERN; ROSA; BRAGANÇA, 2024). Moreover, emerging technologies such as IoT, Digital Twins, and Extended Reality still require more mature integration frameworks, validation methods, and operational workflows for large-scale implementation (WIJERATHNA et al., 2024).

These technological differences are also reflected in the scientific literature. Brazilian research has predominantly focused on BIM adoption, implementation barriers, organizational maturity, and localized applications, whereas international research increasingly investigates integrated solutions combining IoT, Digital Twins, Artificial Intelligence, Extended Reality, and open data frameworks for operation and maintenance (ROSÁRIO DA SILVA et al., 2024), this distinction is accompanied by differences in publication visibility and dissemination, particularly given the concentration of advanced BIM-FM research in internationally established journals (PAIVA; BRITO, 2019).

However, this pattern is not unique to Brazil. Research communities in countries such as China, Argentina, Mexico, and South Africa have developed different trajectories of scientific internationalization, influenced by institutional, linguistic, and structural factors (BEIGEL, 2021; DOS SANTOS; RODRIGUES; DA SILVA NEUBERT, 2023). While

internationalization can increase visibility and integration into global scientific networks, studies indicate that researchers from emerging scientific communities may still experience differences in citation and recognition compared with researchers from the Global North (MENEHINI; PACKER; NASSI-CALÒ, 2008; VAN LEEUWEN et al., 2001). South Africa, for example, combines relatively high levels of internationalization with strong participation in international collaboration networks (ODHIAMBO; NTENGA, 2015; SOORYAMOORTHY, 2010). Thus, the Brazilian case can be understood within broader dynamics of scientific internationalization rather than as an isolated phenomenon.

Against this background, this study addresses the following research question: How does the technological and thematic profile of BIM-FM research published in Brazilian journals compare with that observed in internationally disseminated research, and how do these profiles coexist with differences in publication visibility, indexing, and scientific dissemination?

To address this question, the study adopts a comparative systematic mapping approach, using BIM-FM research as the unit of analysis. Rather than seeking to represent the entire body of BIM-FM literature, the study examines a systematically constructed corpus based on predefined eligibility criteria, focusing on thematic orientation, technological development, and publication ecosystems. This approach enables a comparative examination of Brazilian and international research beyond conventional measures of productivity or scientific impact.

METHODOLOGY

Research Design And Analytical Framework

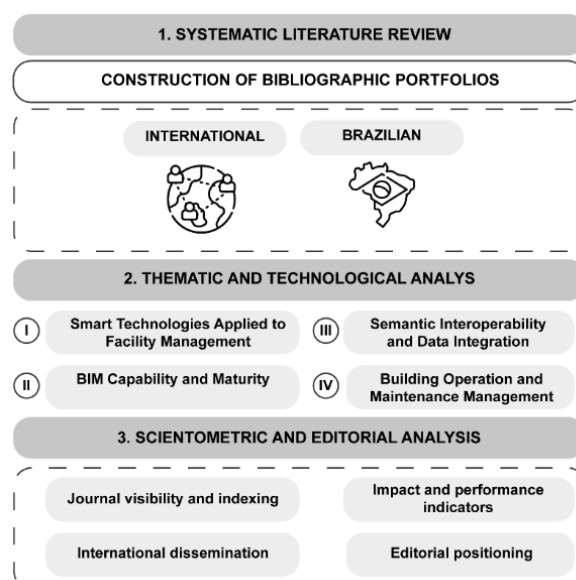
This study adopted a comparative systematic mapping approach combined with the construction of a purposive bibliographic corpus and complementary thematic, qualitative, scientometric, and editorial analyses. The methodological design was developed to characterize and compare Brazilian and internationally disseminated research in Building Information Modeling for Facility Management (BIM-FM), with particular attention to technological development, research themes, and patterns of scientific dissemination.

The systematic mapping approach was used to identify, organize, and characterize relevant publications according to predefined thematic protocols and eligibility criteria. Rather

than seeking to provide an exhaustive or statistically representative review of the BIM-FM literature, the study aimed to construct two analytically comparable bibliographic portfolios capable of revealing recurring research patterns within the Brazilian and international publication ecosystems.

The methodological procedure was organized into three complementary analytical layers, as illustrated in Figure 1. The first comprised the identification, screening, and thematic organization of publications according to four BIM-FM domains: (i) Smart Technologies Applied to Facility Management; (ii) BIM Capability and Organizational Maturity; (iii) Semantic Interoperability and Data Integration; and (iv) Building Operation, Maintenance, and Asset Management. The second layer consisted of the thematic and qualitative characterization of the selected studies according to their objectives, methodological approaches, technologies, applications, scientific contributions, Innovation Level, and Alignment with the BIM-FM Knowledge Frontier. The third layer comprised the scientometric and editorial characterization of the publication environments associated with the selected studies, considering indexing coverage, SJR quartiles, Google Scholar h5-index, citation counts, Qualis classification, and database coverage.

Figure 1 - Methodological and analytical framework of the comparative systematic mapping



Source: Authors

The Brazilian and international portfolios were constructed using complementary search sources reflecting their respective publication ecosystems. International studies were identified primarily through Scopus and Web of Science, whereas Brazilian studies were identified through SciELO, the CAPES Journal Portal, and complementary manual searches in Brazilian journals. This differentiated search strategy was adopted because database coverage and indexing structures vary substantially between Brazilian and internationally established journals.

SEARCH STRATEGY

Search Protocol Design

An exploratory search was initially conducted using the LeapSpace platform to identify recurring terminology, emerging topics, and alternative keywords in the international BIM-FM literature. Based on this preliminary assessment, the review was organized into four thematic protocols: Protocol I – Smart Technologies Applied to Facility Management; Protocol II – BIM Capability and Maturity; Protocol III – Semantic Interoperability and Data Integration; and Protocol IV – Building Operation and Maintenance Management.

Each protocol was implemented using specific search strategies while maintaining conceptual equivalence between Brazilian and international databases. Protocol I addressed BIM integration with IoT, Artificial Intelligence, machine learning, monitoring, and predictive maintenance (HAIYIRETE; ZHANG; GAO, 2024); Protocol II focused on BIM capability, maturity, governance, and implementation models (KHALEEL; HILAL, 2023); Protocol III addressed interoperability, semantic modeling, ontologies, and data integration (AKBARIEH; TETERVOV, 2026); and Protocol IV covered operation, maintenance, decision support, and Facility Management applications (PATACAS; DAWOOD; KASSEM, 2020).

The international searches were conducted in English using the following exact strings:

- **Protocol I – Scopus:** (((BIM OR "building information modeling" OR "BIM-FM") AND (IoT OR sensor OR monitoring) AND ("artificial intelligence" OR "machine learning") AND ("predictive maintenance" OR "fault detection")))
- **Protocol I – Web of Science:** ((BIM OR "building information modeling") AND (IoT OR sensor OR monitoring) AND ("artificial intelligence" OR "machine learning") AND ("predictive maintenance" OR "fault detection"))

- **Protocol II – Scopus/Web of Science:** ("BIM FM" OR "BIM-FM" OR "BIM for facilities management" OR "facility management" OR "BIM") AND ("BIM capability" OR "capability assessment") AND ("BIM maturity" OR "maturity model" OR "BIM maturity assessment" OR "O&M maturity")
- **Protocol III – Scopus/Web of Science:** ((BIM OR "building information modeling" OR "BIM-FM") AND (interoperability OR "information exchange" OR "data integration") AND (ontology OR "semantic modeling"))
- **Protocol IV – Scopus/Web of Science:** (("BIM" OR "building information modeling" OR "BIM-FM") AND ("facility management" OR "asset management") AND ("building operation" OR "operational management"))
- **Protocol IV – Scopus/Web of Science:** (("BIM" OR "building information modeling" OR "BIM-FM") AND ("facility management" OR "asset management") AND ("decision making" OR "decision support system" OR "decision support") AND ("operations" OR "maintenance"))

For the Brazilian databases, the search strings were simplified and, where necessary, translated or adapted into Portuguese because direct application of the international strings produced zero-result retrievals. The core concepts and thematic boundaries of each protocol were retained. The Brazilian searches included, among others, the following exact expressions:

- **Protocol I:** (BIM OR "Building Information Modeling") AND (IA OR "inteligência artificial" OR "machine learning" OR "aprendizado de máquina"); (BIM OR "building information modeling") AND ("indústria 4.0" OR IoT OR monitoramento); (BIM OR "building information modeling") AND ("predictive maintenance" OR "manutenção preditiva" OR inspeção); (BIM OR "Building Information Modeling") AND (manutenção predial OR manutenção).
- **Protocol II:** ("BIM-FM" OR "Facility Management" OR "Gestão de Facilidades" OR "Operação e Manutenção") AND ("BIM" OR "Building Information Modeling"); BIM AND (CAPACIDADE OR MATURIDADE); BIM AND CAPACIDADE AND MATURIDADE; (BIM) AND (Capacidade OR Maturidade).
- **Protocol III:** ((BIM OR "modelagem da informação da construção") AND (interoperabilidade OR "troca de informação" OR "integração de dados") AND (ontology OR "modelagem semântica")); ((BIM OR "modelagem da informação da construção" OR "BIM-FM") AND (interoperabilidade OR "troca de informação" OR "integração de dados")); ((BIM OR "modelagem da informação da construção" OR "BIM-FM") AND (ontologia OR "modelagem semântica")).
- **Protocol IV:** (("BIM") AND ("manutenção" OR "maintenance") AND ("management" OR "gestão")); ((BIM) AND ("gestão da manutenção" OR maintenance management)); BIM AND decision making OR decision support OR decisions; ("BIM" AND "manutenção"); ("BIM" AND "manutenção e operação de edifícios").

Search Strategy and Study Selection

Searches were adapted to the indexing structure of each database. Scopus and Web of Science used TITLE-ABS-KEY fields, while Brazilian databases searched across available fields. Records were filtered by document type, publication period, and subject area, followed by duplicate removal. The review included peer-reviewed journal articles on BIM applications in Facility Management, including operation and maintenance, interoperability, BIM maturity, digital transformation, and asset management, while excluding reviews, conceptual studies, unrelated built-environment research, and studies focused exclusively on design or construction.

Eligible studies from 2022–2026 were then purposively selected using thematic relevance and bibliometric/editorial indicators, including Google Scholar h5-index, SJR quartile, Qualis classification, and citation counts. When no eligible study was available for a given year, the second-ranked article from the preceding year was used to maintain temporal continuity.

Construction of the Analytical Corpus

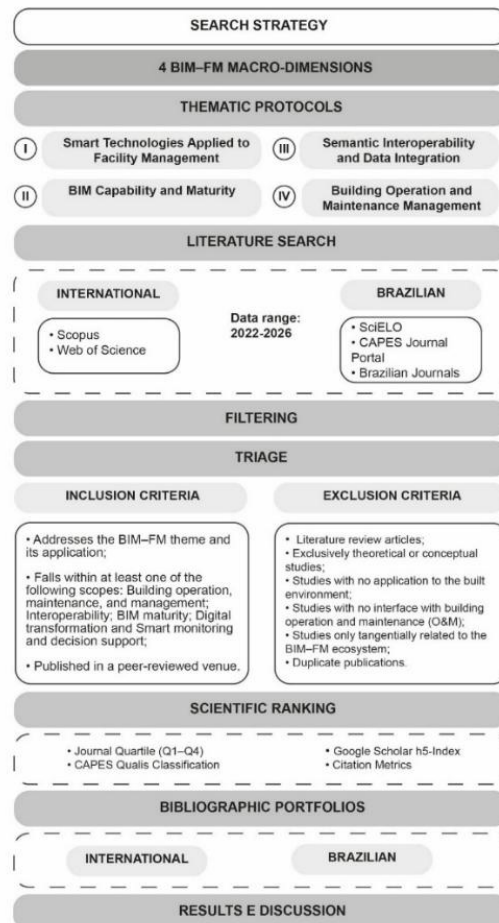
The final corpus was established through duplicate removal, thematic refinement, eligibility screening, and purposive selection. Rather than pursuing exhaustive literature coverage or a predetermined sample size, the procedure prioritized information-rich studies with strong thematic relevance, scientific significance, methodological diversity, and potential to support comparisons between Brazilian and international BIM-FM research.

Scientometric and Editorial Characterization of the Bibliographic Portfolios

The selected studies were characterized using complementary scientometric and editorial indicators, including journal indexing, SJR quartiles, Google Scholar h5-index, citation counts, and coverage in Scopus, Web of Science, SciELO, and the CAPES Journal Portal. These indicators were considered jointly to characterize differences in scientific visibility, editorial positioning, and dissemination environments rather than to rank individual publications or assess scientific quality through a single metric. Together, the thematic, scientometric, and editorial analyses provided the basis for comparing technological

developments and publication ecosystems in Brazilian and international BIM-FM research. The overall methodological sequence is summarized in Figure 2.

Figure 1 - Integrated methodological framework adopted in the study.



Source: Authors

Consolidation Of The Bibliographic Portfolios

Following bibliographic consolidation, thematic refinement, duplicate removal, and eligibility screening, the four thematic protocols resulted in 19 international and 11 Brazilian studies, forming a final corpus of 30 peer-reviewed journal articles. The portfolios were constructed to provide an analytically coherent basis for comparing research orientation, technological integration, and publication environments rather than to represent the complete BIM-FM literature. The unequal portfolio sizes reflect differences in the availability and indexing of Brazilian BIM-FM publications. Complementary national and manual searches

were therefore used to expand the Brazilian portfolio while maintaining the predefined thematic and eligibility criteria. These differences in database coverage represent an inherent methodological limitation and should be considered when interpreting comparisons between the two ecosystems.

Because the study aimed to map thematic trends, technological development, and publication ecosystems rather than evaluate intervention effectiveness, no formal methodological quality assessment of individual studies was conducted. Methodological rigor was instead supported through transparent search procedures, explicit eligibility criteria, systematic portfolio construction, and the integration of thematic, qualitative, scientometric, and editorial analyses. Accordingly, the 30 studies constitute an analytically constructed comparative corpus rather than statistically representative samples of Brazilian and international BIM-FM research. As shown in Figure 3, the portfolios were developed through a sequential process of identification, filtering, screening, eligibility assessment, and inclusion, providing a transparent and reproducible basis for the comparative analysis.

Figure 2 - Study selection workflow and construction of the Brazilian and international bibliographic portfolios

CONSOLIDATION OF THE BIBLIOGRAPHIC PORTFOLIO						
PROTOCOL						
	SOURCE	I	II	III	IV	TOTAL
IDENTIFY	INTERNATIONAL	83 results	31 results	527 results	156 results	797 results
	BRAZILIAN	2 668 results	100 results	158 results	173 results	3099 results
FILTER	INTERNATIONAL	19 results	9 results	84 results	60 results	172 results
	BRAZILIAN	38 results	26 results	6 results	63 results	133 results
TRIAGE	INTERNATIONAL	13 results	6 results	20 results	42 results	81 results
	BRAZILIAN	6 results	8 results	1 result	29 results	44 results
ELIGIBILITY	INTERNATIONAL	7 results	4 results	16 results	11 results	38 results
	BRAZILIAN	6 results	4 results	1 result	6 results	17 results
INCLUSION	INTERNATIONAL	5 results	4 results	5 results	5 results	19 results
	BRAZILIAN	4 results	4 results	1 result	2 results	11 results
TOTAL						30 results

Source: Authors

Methodological Limitations

This study has limitations related to the construction and comparison of bibliographic portfolios from distinct publication ecosystems. The smaller Brazilian corpus and differences in database indexing required complementary manual searches, but some relevant studies may remain unidentified. The portfolios were also constructed using different combinations of bibliographic sources, which may have influenced their composition. Moreover, the 30-study corpus was designed for comparative analytical purposes rather than statistical representativeness, so the observed patterns should not be generalized to the entire BIM-FM research field.

The qualitative classifications of Innovation Level, Scientific Contribution, and Alignment with the BIM-FM Knowledge Frontier also involve interpretive judgment. Although predefined criteria and author consensus were used, these categories do not constitute formally validated measurement instruments and should therefore be understood as analytical classifications rather than objective measures of research quality. Finally, indicators such as SJR, h5-index, citation counts, database indexing, and Qualis classification capture different dimensions of publication visibility and should not be treated as interchangeable measures of scientific quality or impact. The observed relationships between publication ecosystems and research profiles are likewise associative rather than causal. Future studies could address these limitations through larger longitudinal datasets, harmonized retrieval strategies, formal inter-rater reliability procedures, and comparisons involving additional national research ecosystems.

Qualitative Evaluation Criteria

A qualitative assessment was conducted to examine the technological evolution, scientific contribution, and alignment with the BIM-FM research frontier. Three dimensions were considered: Innovation Level, Scientific Contribution, and Alignment with the BIM-FM Knowledge Frontier, based on each study's objectives, methodology, technologies, results, and contributions. Assessments were conducted independently by the authors and consolidated through consensus.

Innovation Level and Alignment with the BIM–FM Knowledge Frontier were classified as low, medium, or high. Innovation Level reflected technological novelty and digital integration, while Alignment assessed the incorporation of emerging trends such as Digital Twins, Artificial Intelligence, IoT, semantic interoperability, and integrated digital asset management. Scientific Contribution was evaluated qualitatively according to the study's potential to advance BIM–FM knowledge through novel methods, conceptual models, empirical evidence, or practical applications. These criteria complemented the thematic and scientometric analyses by providing a broader assessment of technological development and the scientific positioning of the selected studies within Brazilian and international BIM–FM research ecosystems.

Bim-fm research themes

Characterization of the scientific portfolios

The scientific portfolio was characterized according to authors, publication year, journal, country of origin, and thematic protocol. The complete characterization of the 30 selected studies, including identification numbers and thematic classifications, is available as supplementary material in the Zenodo repository: <https://doi.org/10.5281/zenodo.23042114>.

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The international portfolio presents a relatively balanced distribution across the four protocols, with emphasis on semantic interoperability, Digital Twins, Artificial Intelligence (AI), Internet of Things (IoT), and intelligent decision support for building operation and maintenance. In contrast, the Brazilian portfolio focuses mainly on process digitalization, BIM maturity assessment, and operational management, indicating a narrower technological scope.

Differences are also observed in publication venues and research groups. International studies are predominantly published in journals such as *Automation in Construction*, *Energy and Buildings*, *Computers in Industry*, and *SoftwareX*, with recurring contributions from established research groups, including those led by Haidar Hosamo and Gokcen Yilmaz. Brazilian publications are more dispersed across journals and, despite recurring contributors such as Sergio Scheer, tend to emphasize the adaptation and application of established technologies.

Overall, the portfolios indicate a distinction in research orientation: international studies increasingly explore integrated digital ecosystems and emerging technologies, whereas Brazilian studies emphasize methodological consolidation and the implementation of BIM in specific application contexts.

Thematic and technological analysis of bim-fm research

To provide a more detailed characterization of the selected studies, a comparative analysis of their thematic and technological attributes was conducted. The analysis considers the technologies employed, Facility Management (FM) applications, level of innovation, degree of digital integration, research topic, scientific contribution, and alignment with the BIM-FM research frontier. The qualitative classifications were assigned based on the assessment framework described in Section 2.5, which was grounded in an integrated analysis of the objectives, methodology, technologies, results, and contributions reported in each study.

The complete thematic and technological analysis of the 30 studies included in the systematic literature review is available as supplementary material in the Zenodo repository, available at: <https://doi.org/10.5281/zenodo.23046660>. The supplementary material provides the detailed assessment of each study, including its FM application, thematic contribution, associated technologies, degree of digital integration, innovation level, and alignment with the BIM-FM research frontier.

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The findings suggest a paradigm shift within the BIM-FM ecosystem, in which BIM is evolving from a tool primarily used for modeling and documentation into a central data infrastructure supporting asset life-cycle management. The international portfolio demonstrates a high degree of technological convergence, characterized by data-driven and interoperable digital architectures. This pattern is consistent with the observations of Luo et al. (2021), who emphasized the need for interoperable ecosystems to support life-cycle information management, and Hakimi and Abudayyeh (2024), who identified these technologies as representing the current research frontier in BIM-FM.

In contrast, the Brazilian portfolio is predominantly oriented toward process digitalization, information structuring, and the development of organizational BIM maturity. This emphasis appears to reflect the current stage of BIM adoption in Brazil, particularly within the public sector, where institutional, regulatory, and managerial conditions remain

essential prerequisites for successful implementation (DE ASSIS SANTOS WANDERLEY; LORDSLEEM; ROCHA, 2023; SCHERY et al., 2023).

Consistent with this interpretation, Brito et al. (2021) argued that BIM adoption depends on the consolidation of critical regulatory, managerial, technological, and process-related success factors. Similarly, Salume et al. (2021) demonstrated that digital maturity is closely associated with the development of organizational capabilities, including strategy, operations, organizational culture, and technology. Collectively, these findings suggest that the Brazilian literature continues to emphasize organizational and implementation-related challenges, whereas the international portfolio is increasingly focused on interoperable digital ecosystems, Digital Twins, and intelligent operation and maintenance systems.

Comparative discussion of the brazilian and international research portfolios

Protocol I — Smart Technologies Applied to BIM-FM

International studies show a strong convergence toward integrated digital architectures in which BIM functions as a central information infrastructure, increasingly combined with Digital Twins, IoT, AI, and semantic technologies to support predictive maintenance, continuous monitoring, and operational optimization (HODAVAND et al., 2025; HOSAMO et al., 2022, 2023a). Despite these advances, interoperability, scalability, semantic standardization, sensing infrastructure, and cloud dependence remain important challenges, while applications are still concentrated in specific building systems and facility types. Brazilian studies, in contrast, primarily focus on BIM digitalization, information organization, maintenance, and heritage documentation, with limited integration between digital models and operational systems. Although some studies advance BIM-FM frameworks and predictive energy simulation (PUSHPANATHAN et al., 2026), the Brazilian portfolio shows limited adoption of IoT, Digital Twins, semantic interoperability, and continuous synchronization. This difference reflects distinct research priorities: international research increasingly explores intelligent, data-driven ecosystems, whereas Brazilian research remains more focused on establishing the organizational, technological, and informational foundations for BIM-FM implementation.

Protocol II — BIM Capability and Maturity

International research increasingly develops BIM capability and maturity models specifically oriented toward FM and O&M, moving beyond general BIM adoption toward process-level assessment, information requirements, and continuous improvement (ABIDEEN et al., 2025; YILMAZ; AKCAMETE; DEMIRORS, 2023). Tools such as BIM-CAREM, BIM-CAP, and quantitative maturity assessment approaches seek to reduce subjectivity and support systematic organizational improvement. However, reliable information, interoperability, and consistent information requirements remain critical challenges. Brazilian studies primarily address organizational BIM maturity, adoption barriers, and digital transformation, with comparatively limited attention to FM-specific capabilities. Research highlights constraints related to training, software and infrastructure costs, organizational capacity, and workflow reorganization (ROCHA; CÂNDIDO; BARROS NETO, 2025; VASCONCELOS; GERMANO, 2023). Although Brazilian studies have advanced automated maturity assessment and BIM-Lean integration, the literature remains largely focused on consolidating the organizational and technological foundations required for more specialized BIM-FM applications.

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Protocol III — Semantic Interoperability and Ontologies

International studies identify information fragmentation, semantic limitations of OpenBIM standards, and risks to data integrity during information exchange as major barriers to BIM-FM integration. Semantic Web technologies, ontologies, IoT integration, and automated reasoning are increasingly proposed to address these limitations by improving semantic consistency, interoperability, information retrieval, and automated decision-making. In contrast, only one Brazilian study identified within the predefined search protocol addressed ontologies and semantic interoperability, indicating that this research area remains underrepresented in the Brazilian BIM-FM literature. This limited representation may be associated with the interdisciplinary expertise required across BIM, FM, data science, Semantic Web technologies, and information systems (OLIVEIRA SENA et al., 2024). Consequently, the limited development of semantic approaches may constrain information reuse and interoperability throughout the asset life cycle.

Protocol IV — Building Operation, Maintenance, and Asset Management

International studies increasingly integrate BIM with Digital Twins, IoT, AI, optimization algorithms, and AR to support predictive maintenance, fault detection, work-order management, interoperability, and operational decision-making (HOSAMO et al., 2023b; KAMAL; TAGHADDOS; METVAEI, 2022; PALHA; HÜTTL; DA COSTA E SILVA, 2024; ZHAO et al., 2022). Nevertheless, high implementation costs, data standardization, professional expertise, and maintenance of accurate as-built models remain relevant barriers. Brazilian studies, in contrast, primarily focus on information requirements, conceptual frameworks, interoperability, and process standardization. Wojciechowski and Schramm (2025) propose a COBie-based information-requirement model for maintenance management, while Teixeira and Scheer (2024) demonstrate the practical application of BIM, terrestrial laser scanning, and automated rule checking for space management. However, neither incorporates emerging technologies such as Digital Twins, AI, or IoT. Overall, Brazilian research remains focused on consolidating the informational and organizational foundations of BIM-FM, whereas international research increasingly emphasizes automation, real-time monitoring, and predictive maintenance.

Explaining the international visibility gap between brazilian and international bim-fm research

Before examining the bibliometric indicators, we considered the possibility that the differences observed between the Brazilian and international portfolios might be explained by differences in the scientific capacity of the researchers involved. To explore this possibility, we examined the Scopus Author ID profiles of the authors of studies published in Brazilian journals. In all selected studies, at least one author had Scopus-indexed publications addressing the same research topic as the study included in this review, including articles published in international journals.

As illustrative examples, we identified publications by Eloísa Dezen-Kempter on Digital Twins and Heritage Building Information Modeling (HBIM), as well as studies by Bianca Maria Vasconcelos on Machine Learning applications for accident prevention in the construction industry. Although these examples do not support broad generalizations, they indicate that researchers affiliated with the Brazilian research ecosystem contribute to

emerging BIM-related technologies and successfully publish in high-impact international journals.

These findings do not support the hypothesis that the observed differences between the Brazilian and international portfolios are primarily attributable to the scientific capacity of Brazilian researchers. Instead, they suggest that the analysis should focus on factors associated with the editorial ecosystem, research evaluation mechanisms, and publication strategies that may influence the international visibility of Brazilian BIM-FM research.

Traceability and international visibility of scientific production

To complement the bibliometric analysis, the traceability and visibility of the selected studies were examined across major scientific databases. Detailed article-level bibliometric and indexing data are provided as supplementary research material in the Zenodo repository. The aggregated results are presented in Table 1.

Table 1 - Traceability and Visibility Indicators for the Brazilian and International Bibliographic Portfolios

Traceability Indicator	Brazilian Portfolio	International Portfolio
Articles indexed in Google Scholar	100.0%	100.0%
Articles indexed in Scopus	9.1%	100.0%
Articles indexed in Web of Science	9.1%	100.0%
Articles indexed in SciELO	72.7%	0.0%
Articles available through the CAPES Journal Portal	90.9%	89.5%
Open-access articles	100.0%	63.2%
Average number of indexed databases per article	2.82 databases/article	3.89 databases/article

Source: Authors

The aggregated indexing results show that the principal difference between the Brazilian and international portfolios concerns international traceability rather than accessibility. All international studies were indexed in Scopus and Web of Science, whereas only 9.1% of the Brazilian studies were indexed in each database. Conversely, Brazilian studies showed strong representation in SciELO (72.7%) and the CAPES Journal Portal (90.9%), indicating a stronger connection with the national publication ecosystem. All Brazilian studies were open access, compared with 63.2% of international studies, while the average number of indexed databases per article was 2.82 and 3.89, respectively.

These differences indicate that the Brazilian and international portfolios operate within distinct publication and indexing environments. The evidence also shows that Brazilian researchers publish internationally on related BIM topics, while studies selected from Brazilian journals tend to emphasize incremental applications, BIM adoption, organizational maturity, and contextual implementation. However, the present evidence does not establish that publication strategies or evaluation systems cause these differences.

Research evaluation and publication strategies

Qualis Periódicos is the principal journal evaluation instrument used by CAPES in the assessment of Brazilian graduate programs. Although it was not designed as a direct measure of journal scientific quality (BRASIL, 2023), its use as an indicator of editorial prestige may influence publication strategies. Its methodology incorporates indicators such as the Google Scholar h5-index, which has broader coverage than Scopus and Web of Science. Consequently, high Qualis classifications do not necessarily correspond to equivalent levels of international indexing, citation visibility, or scientific dissemination.

Similar tensions between national evaluation systems and international bibliometric indicators have been reported in China (HUANG et al., 2021; WANG; HALFFMAN; ZHANG, 2023), Russia (TRETYAKOVA, 2023), and Indonesia (YUSUF, 2026). Conversely, the Strategy Evaluation Protocol (SEP) adopted in the Netherlands illustrates a more formative approach that emphasizes research diversity and societal relevance rather than journal rankings (BRASIL; TREVISOL, 2025).

The Brazilian case can therefore be interpreted as part of a broader challenge in research evaluation: balancing the strengthening of national scientific ecosystems with international

visibility. In BIM-FM, this challenge involves increasing the international indexing and dissemination of Brazilian journals while encouraging research addressing emerging technological developments. However, longitudinal and comparative studies are required to determine whether evaluation systems directly influence research orientation and publication strategies.

Proposed framework

The comparative analysis indicates that the advancement of Brazilian BIM-FM research depends on interconnected factors involving research evaluation, internationalization, technological alignment, and knowledge transfer. Based on these findings, a strategic framework was developed to translate the identified challenges into actionable directions for strengthening the Brazilian BIM-FM research ecosystem. The framework is presented in Table 2.

Table 2 - Strategic Framework for Advancing Brazilian BIM-FM Research Toward the Global Research Frontier

Strategic Axis	Identified Challenge	Proposed Actions	Expected Impact
Alignment of Research Evaluation Incentives	Partial misalignment between the Qualis Periódicos evaluation system and the international visibility of scientific journals.	Refine research evaluation criteria by incorporating indicators of internationalization, article-level impact, international collaboration, technological innovation, and knowledge transfer, while maintaining support for Brazilian journals.	Greater alignment between the Brazilian research evaluation system and the international competitiveness of Brazilian scientific research.
Internationalization of Scientific Production	Limited international visibility of Brazilian journals and BIM-FM publications.	Expand journal indexing in Scopus and Web of Science, encourage publication in English, strengthen journal internationalization, and promote international research networks and co-authorship.	Increased international visibility, dissemination, and scientific impact of Brazilian BIM-FM research.

Technological Alignment with the Research Frontier	Predominance of studies focused on BIM maturity, information digitalization, and information management, with limited exploration of emerging technologies.	Prioritize research on BIM–IoT–Digital Twin architectures, IFC/ifcOWL-based interoperability, semantic ontologies, Artificial Intelligence (AI), predictive maintenance, and real-time data integration.	Stronger alignment of Brazilian research with the international BIM–FM research frontier and enhanced technological innovation.
Strengthening Technology Transfer	Limited collaboration among universities, industry, and Facility Management (FM) stakeholders, restricting the validation and practical adoption of proposed solutions.	Develop Living Labs, university–industry collaborative projects, shared operational and maintenance datasets, and validation of BIM–FM solutions in instrumented buildings.	Increased technological maturity, enhanced knowledge transfer to industry, and improved international competitiveness of Brazilian BIM–FM research.

Source: Authors

CONCLUSIONS

This study compared Brazilian and internationally disseminated BIM–FM research from technological, thematic, scientometric, and editorial perspectives. The findings indicate that the international portfolio shows stronger alignment with the contemporary BIM–FM research frontier, particularly through the integration of Building Information Modeling (BIM), Digital Twins, the Internet of Things (IoT), Artificial Intelligence (AI), ontologies, semantic interoperability, and predictive maintenance. In contrast, the Brazilian portfolio predominantly addresses BIM adoption, organizational maturity, process digitalization, information structuring, and context-specific operational applications.

These differences should not be interpreted as evidence of limited scientific capacity among Brazilian researchers. The analysis identified Brazilian authors with internationally indexed publications addressing the same emerging technological domains, indicating that the

technological profile of studies published in Brazilian journals should not be equated with the technological capabilities of the national research community.

The integrated thematic, qualitative, bibliometric, and traceability analyses indicate that differences in publication environments, indexing coverage, citation structures, research evaluation practices, and internationalization are associated with differences in the dissemination of BIM-FM research. However, the study does not establish a causal relationship between evaluation mechanisms, publication strategies, and technological research orientation. The findings should therefore be interpreted as patterns within the selected publication ecosystems rather than as direct measures of research quality or technological capability.

The study has several limitations. The analysis was based exclusively on the scientific literature and did not experimentally validate the identified technologies or solutions. In addition, the relatively small Brazilian corpus and differences in database coverage and indexing may have influenced portfolio composition. The 30 selected studies constitute an analytically constructed comparative corpus rather than a statistically representative sample of the BIM-FM literature. Finally, the classifications of Innovation Level, Scientific Contribution, and Alignment with the BIM-FM Knowledge Frontier involve interpretive judgment and were not formally validated as measurement instruments.

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Future research should employ larger and more harmonized datasets, longitudinal comparisons, and broader analyses of national research evaluation and publication systems to investigate whether the patterns identified here persist across different contexts and periods. From a practical perspective, strengthening the international indexing of Brazilian journals, improving editorial practices, and expanding the dissemination of research addressing emerging BIM-FM technologies may contribute to greater international visibility. These potential effects should, however, be empirically investigated rather than assumed.

STATEMENT ON ARTIFICIAL INTELLIGENCE

During the manuscript preparation process, ChatGPT-5 was used exclusively for language revision and improvement of textual clarity and cohesion in portions of the manuscript. All AI-assisted revisions were reviewed, edited, and validated by the authors, who

take full responsibility for the accuracy, integrity, and originality of the content presented. All empirical analyses and interpretations were conducted by the authors.

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