

Bim in Public Investment Projects: Adoption, Impact, Policies and Future Directions

Jorge Pablo Aguilar Zavaleta

Faculty of Engineering and Architecture, Professional School of Architecture, César Vallejo University, Peru

ABSTRACT

The digital transformation of the public construction sector is a strategic imperative for governments seeking to optimize resources and make processes transparent. Building Information Modeling (BIM) emerges as a central methodology in this transition, integrating multidisciplinary data to manage projects throughout their life cycle. Globally, the BIM market reached USD 8.85 billion in 2024, projecting growth of 11.2% annually until 2034. In Latin America, eight countries make up the BIM Network of Latin American Governments, evidencing a regional commitment to accelerate the digitalization of the public sector. Methodology, this study adopts a systematic review approach, analyzing literature indexed in high-impact scientific databases (Scopus Q1-Q2), complemented by technical reports from multilateral organizations such as the IDB and recent sectoral reports (2021-2025). Implementation experiences in Spain, Chile, Brazil and Peru were examined, identifying adoption patterns, persistent barriers and critical success factors through multilevel comparative analysis. Results and Discussion, empirical evidence demonstrates significant quantifiable impacts: reduction of deadlines between 15-25%, reduction of costs of 10-30%, and elimination of design errors by up to 70% through early detection of interferences. Spain recorded a 230% increase in BIM tenders between 2017-2020 after implementing mandatory mandates, while Chile consolidated its regional leadership through the BIM Plan integrated with academia and industry. However, substantial barriers persist in emerging economies: high initial investment, shortage of skilled professionals (affecting 50-65% of organizations), and outdated contractual frameworks that hinder collaboration. 4D/5D BIM applications demonstrate transformative potential, reducing unbudgeted costs by up to 40% and integrating time scheduling with real-time cost estimation. Digital twins represent the technological frontier, with the potential to improve public sector efficiency by 20-30%. Conclusions, the successful adoption of BIM in public investment requires holistic strategies that combine regulatory mandates, economic incentives, professional capacity building, and collaborative contractual frameworks. Context-specific policies, university curriculum integration, and standardization through ISO 19650 are key pillars for overcoming regional disparities and maximizing the return on investment in public infrastructure.

*Corresponding author

Jorge Pablo Aguilar Zavaleta, Faculty of Engineering and Architecture, Professional School of Architecture, César Vallejo University, Peru.

Received: January 13, 2026; **Accepted:** January 21, 2026; **Published:** February 28, 2026

Keywords: BIM, Public Investment Projects, Policies

Introduction

Building Information Modeling (BIM) is increasingly mandatory in public investment projects worldwide, with significant advances in Spanish-speaking countries such as Spain, Chile and Brazil. While these requirements drive improvements in project efficiency, cost management, and quality of outputs, the adoption process is hampered by challenges such as high upfront investments, lack of training, technology interoperability issues, and outdated contractual frameworks. Advanced BIM applications, particularly 4D/5D implementations, as well as enhanced digital integrations such as digital twins and IoT, are emerging to address these challenges. However, there are conflicting views on the severity of financial and organizational readiness issues, creating a dynamic landscape that requires context-specific policy instruments and holistic implementation strategies.

Overview of BIM in Public Investment

Building Information Modeling (BIM) is a digital methodology that integrates multidisciplinary data to create, manage, and visualize building and infrastructure projects throughout their life cycle. In public investment projects, BIM is increasingly recognized as a strategic tool to improve the efficiency, transparency, and modernization of public works. Governments around the world, particularly Spanish-speaking ones, are demanding BIM to drive industry transformation, improve project outcomes, and align with global digitalization trends. Despite its potential, the adoption of BIM in the public sector faces persistent challenges, such as organizational readiness, technical interoperability, and regulatory adaptation, which condition the pace and effectiveness of its implementation [1, 15,17].

Table 1: Quantified Impact of BIM on Public Project Performance Indicators

| Performance Indicator | Improvement with BIM (%) | Source/Year |
|--|--------------------------|---------------------------------------|
| Reduction of execution times | 15-25% | Das et al. (2025); Gharaibeh (2024) |
| Reduced project costs | 10-30% | Hosny (2023); Autodesk India (2024) |
| Reduction of design errors | 21-70% | Hosny (2023); IJCRT (2025) |
| Reduction of RFIs (requests for information) | 25-40% | Das et al. (2025); Sompolgrunk (2023) |
| Decrease in rework | 21-25% | Hosny (2023); Ismail (2025) |
| Improved labor productivity | 75-240% | Chowdhury (2024) |
| Reduction of material waste | 11-25% | Autodesk India (2024); Hosny (2023) |
| Positive ROI reported by users | 66-87% | McGraw Hill; Sompolgrunk (2023) |

Global and Regional Adoption of BIM in Public Sector Projects
Global Trends and Government Mandates

- **Mandates and roadmaps:** Many governments have established BIM mandates for public projects, with the aim of standardizing processes, improving project execution, and driving digital transformation. These mandates are often accompanied by national roadmaps focusing on digital management, skills development, policies and ecosystems [1, 3, 15,21].
- **Regional disparities:** While adoption is high in countries with strong political support (e.g., UK, Singapore, Spain), developing countries lag behind due to financial, technical, and organizational barriers [3,4].

BIM for Peru

- **Improved project performance:** BIM improves cost control, quality, and collaboration between stakeholders during the design and construction phases [89].
- **Sustainability and efficiency:** BIM supports sustainable practices by integrating multidisciplinary data throughout a project's lifecycle, enabling informed decision-making and efficient management [90,91].
- **Collaboration:** BIM encourages cooperation between all project participants, including owners, architects, engineers, and contractors [91,92].

Challenges in Implementation

- **Initial investment:** Significant upfront hardware and software costs are a barrier to BIM adoption [89,93].
- **Training and education:** Lack of qualified professionals and insufficient investment in training hinder the effective implementation of BIM [93].
- **Organizational readiness:** Public agencies often face challenges related to organizational and managerial readiness for BIM adoption [94].
- **Resistance to change:** Reluctance to abandon traditional methods and processes is common in developing countries. [93].

Adoption of BIM in Spain: Frameworks and Instruments

- **Mandatory requirements:** Since 2018 (building) and 2019 (infrastructure), BIM is mandatory in Spanish public tenders. This has led to a 230% increase in BIM-related tenders (2017-2020) [2, 5,25].
- **Implementation Frameworks:** Spain employs a framework approach in public procurement, which helps authorities select BIM implementation instruments based on client maturity and project value. Training (especially in Revit) and university integration are key factors [25-27].
- **Persistent barriers:** High upfront investment, lack of training, and insufficient collaboration processes remain

significant hurdles, with many organizations planning multi-year adaptation schedules [2].

Comparative analysis: Brazil and Chile

- **Brazil:** Federal decrees since 2018 have boosted the adoption of BIM, focusing on professional training and gradual implementation. However, the level of maturity remains low, with most organizations having basic BIM levels and less than 5% adherence in some regions. The main challenges include fragmented information, lack of standardization, and cultural resistance [28-30].
- **Chile:** Since 2015, government mandates and the Plan BIM initiative have integrated the academic, public, and private sectors, leading to greater maturity in public infrastructure (in particular, bridges and railways) and the adoption of advanced methodologies such as BIM and digital twins [4,31].
- **Lessons learned:** Government mandates, multi-stakeholder collaboration, and long-term strategic planning are critical to driving BIM maturity. Brazil can take advantage of Chile's experience to improve its own strategies [4,31].

Table 2: Status of BIM Adoption in Spanish-Speaking Countries (2024)

| Country | Year of BIM Mandate | Adoption Status | Main achievements |
|-----------|---|-----------------|---|
| Spain | 2018 (building) / 2019 (infrastructure) | Advanced | 230% increase in BIM tenders (2017-2020) |
| Chile | 2015 (initiative) / 2020 (mandatory) | Advanced | Regional leader; Integrated Academia-Industry BIM Plan |
| Brazil | 2018 (decree) / 2021 (mandatory) | In development | Decree 9983/EB-BIM; 3-phase implementation |
| Peru | 2019 (BIM Plan) / 2024 (Law 32069) | In development | General Contracting Law promotes BIM |
| Colombia | 2020 (National Strategy) | In development | Active member of the BIM Network Latin American Governments |
| Argentina | 2019 (initiative) | Incipient | Founding member of the BIM Gob Latam Network |
| Mexico | 2019 (strategy) | Incipient | Regional initiatives under development |

The Role of BIM Integration at the University Level

- **Education as a catalyst:** Integrating BIM at university level prepares a skilled workforce and directly supports adoption in the public sector by equipping graduates with practical BIM skills and collaborative competencies [32-34].
- **Macro-micro linkages:** Effective adoption at the macro (public sector) level is influenced by organizational dynamics at the micro level, which is strengthened by university education and professional development [32,35].
- **Regional impact:** In Latin America, greater BIM maturity (supported by education) correlates with greater value generation in public projects, highlighting the importance of academic integration [33,36].

Global and regional experiences underscore the importance of policy mandates, tailored frameworks and educational integration to drive BIM adoption. However, persistent barriers, especially in developing economies, require context-sensitive strategies and sustained capacity building.

Table 3: Main Barriers and Critical Success Factors for BIM Implementation

| Category | Main Barriers | Critical Success Factors |
|----------------|---|---|
| Organizational | Lack of training (45-60%); Resistance to change | Committed leadership; Culture of innovation |
| Technological | Software interoperability (35-50%); Information silos | ISO 19650 standards; IFC Open Formats |
| Financial | High initial investment (40-55%); Training costs | Government incentives; Demonstrable ROI |
| Contractual | Obsolete frames; Ambiguity in BIM roles | IPD Contracts; specific BIM clauses |
| Regulatory | Unclear mandates; Lack of compliance | National roadmaps; Integrated policies |
| Human Capital | Shortage of BIM professionals (50-65%) | University curricular integration; Certifications |

Methodology

Efficiency, COST, AND Quality Results

- **Quantified impacts:** Implementing BIM in public projects reduces lead times by ~20%, costs by ~15%, and design errors by ~30%. Requests for information (RFIs) decrease by ~25%, reflecting an improvement in efficiency and quality [17].
- **Collaboration and risk management:** BIM improves stakeholder collaboration, design visualization, and risk assessment, leading to more informed decisions and optimized project performance [17,37].
- **Profitability and Lean Construction:** BIM supports Lean principles, eliminating waste, improving productivity and project quality. Empirical evidence attributes approximately 52% of the overall project success to BIM implementation [19,20].
- **Challenges:** High upfront costs, resistance to change, and skills gaps persist, particularly in medium- and low-rise projects and in developing contexts [37-39].

Advanced BIM applications: 4D and 5D

- **4D BIM (Scheduling):** Improves planning, visualization,

and tracking of construction progress, reducing delays and improving coordination [11,40].

- **5D BIM (Cost Management):** Integrates cost data with 3D/4D models, enabling real-time budget tracking and reducing unbudgeted costs by up to 40% in some cases [11,12,41].
- **Combined benefits:** 4D/5D BIM facilitates resource allocation, dynamic project control, and proactive risk mitigation, resulting in better schedule and cost performance. [42-44].
- **AI and digital twins:** Integration with AI and digital twins further improves accuracy in cost and time predictions and lifecycle management [13,14].

BIM Execution Plans and Collaboration

- **Role of BEPs:** BIM execution plans (BEPs) define roles, workflows, and protocols for data exchange, improving collaboration and information management [45,46].
- **Risk Management:** BEPs support risk mitigation by enabling effective control of progress and costs, and improving safety management [47,48].
- **Challenges:** The inconsistent content of the BEP and limited stakeholder participation, especially in developing countries, hinder the full realization of benefits [49,50].

Comparative International Experiences

- **Developed vs. developing contexts:** Developed countries benefit from clear policies, norms, and contractual frameworks, while developing countries face IT literacy gaps, lack of national programs, and socioeconomic constraints [51-53].
- **Cost-benefit evidence:** Czech public sector projects report a cost-benefit ratio >4.5 due to BIM, with reductions in renovations and improved facilities management [54].
- **Legal and contractual risks:** The coordination, documentation, and challenges of public agencies require greater legal awareness and management [55].

BIM demonstrably improves efficiency, cost, and quality in public investment projects, especially when using advanced applications and collaborative frameworks. However, uneven implementation and persistent barriers highlight the need to disseminate best practices and offer tailored support.

Results

Policy Frameworks, Standards and Guidelines for BIM in Public Projects

Global policy Instruments and Mandates

- **Policy combinations:** Governments use regulatory, economic, cooperative and communicative instruments to promote BIM, as seen in Hong Kong and other leading regions [15].
- **Mandates and incentives:** Mandates drive adoption, but they can create tiered industry responses; combining mandates with incentives and capacity building is more effective [56].
- **Critical success factors:** Frameworks such as Brazil's Decree 10.306/2020 prioritize contractual, regulatory, technological, and procedural aspects [57-59].

Guidelines for the Operation and Maintenance Phases

- **Current shortcomings:** Most guidelines focus on design and construction, with less emphasis on operation and maintenance (O&M). The lack of systematic approaches and BIM-FM integration make it difficult to manage assets throughout their lifecycle [52,60,61].
- **Best practices:** Owner information requirements, iterative formalization of BIM requirements, and digital-physical integration are recommended for effective operation and maintenance [62].

- Organizational capabilities: A trained workforce, a supportive culture, and political commitment are essential to the success of the operations and maintenance phase [63].

Policy Instruments in Low-Income Economies

- Successful strategies: Programs to improve BIM competencies, integration in education, contractual frameworks, and financial aid are effective in overcoming readiness barriers [59,64].
- Soft vs. hard strategies: Soft strategies (training, awareness) influence organizational factors, while hard strategies (regulation) mainly impact technology [64].
- Comprehensive approaches: Policy combinations that combine mandates, incentives, and collaborative environments are the most effective [65].

Combined Mandates and Incentives in Spanish-Speaking Countries

- Spain's experience: Legal frameworks, European directives and national laws promote BIM in public procurement, overcoming market maturity barriers [5,66].
- Economic incentives: Tax breaks and simplified permits incentivize adoption, especially where government support is low [16].
- SME challenges: Financial constraints and lack of regulatory compliance require tailored support for SMEs [67,68].

The effective adoption of BIM in public projects depends on a combination of mandates, incentives, and specific guidelines. Addressing gaps in operations and maintenance, supporting organizational readiness, and designing context-appropriate policies are critical to sustained progress.

Discussion

Main Barriers to BIM Adoption

- Organizational and managerial readiness: lack of training, experience, and clear roles; resistance to change; and insufficient standards/guidelines [8,58-71].
- Technological barriers: software incompatibility, interoperability issues, and information silos [6,72-74].
- Financial and contractual barriers: high costs, outdated contracts, and legal ambiguities, especially in developing countries [8,9,75,76].
- Regulatory ambiguity: Unclear mandates and lack of compliance hinder adoption [9,77-79].

Technology Interoperability Problems and Solutions

- Key issues: standards/protocol incompatibility (e.g. BACnet, Modbus), lack of interoperability between BIM, GIS, BAS and other systems, and fragmented data management. [6,7,72].
- Effective solutions: Systematic data integration architectures, open/closed source environments, middleware tools, and ontological alignment (e.g., IFC with ontology) [6,73,80].
- Organizational solutions: improved collaboration standards, training, and phased implementation strategies [72,81].

Financial and Contractual Barriers in Developing Countries

- Financial constraints: Limited investment in tools, training, and ongoing costs; High upfront and recurring expenses [8,76,82,83].
- Contractual issues: ambiguity in roles, lack of specific BIM clauses, and reluctance to adopt collaborative contracts

[9,75,79,84].

- Legal uncertainties: need for clear protocols, dispute resolution and intellectual property provisions [9,77,85,86].

Evolving Contractual Frameworks for BIM

- Best practices: Integrated project delivery (IPT), risk and reward sharing, and adaptation of standard contracts with BIM-specific clauses [78,79].
- Legal evolution: Frameworks should clarify accountability, data integrity, and intellectual property, and be flexible to local contexts [10,87,88].

Future Opportunities and Recommendations

- Digital integration: Leverage digital twins, AI, and IoT for predictive maintenance, cost forecasting, and lifecycle management [21-24].
- Public-private-university collaboration: foster partnerships for training, research and capacity building.
- Customized frameworks: Develop context-specific guidelines and phased implementation strategies.
- SME empowerment: Providing financial incentives and contractual support to accelerate adoption in smaller organizations.

Summary

Overcoming barriers to BIM adoption requires a holistic approach that combines technical solutions, organizational changes, financial support, and legal accommodation. Future opportunities lie in digital inclusion, collaborative frameworks and targeted policy interventions.

Conclusion

Summary of Perspectives and Implications

BIM is transforming public investment projects by improving efficiency, cost management, and the quality of results. Global mandates and regional initiatives, especially in Spanish-speaking countries, are accelerating their adoption, but significant challenges remain, particularly in organizational readiness, technological interoperability, and contractual adaptation. Advanced BIM applications (4D/5D, digital twins, AI) offer promising solutions; however, its full potential depends on context-appropriate policies, strong training and collaborative frameworks.

For policymakers and practitioners, the evidence underscores the need to:

- Integrated policy approaches: combining mandates, incentives and capacity development.
- Standardized yet flexible guidelines: address all phases of the project, especially operation and maintenance.
- Investment in training and education: leveraging universities and career development.
- Contract Innovation: Update frameworks to reflect the collaborative and digital nature of BIM.
- Integrating digital ecosystems: Adopt emerging technologies for lifecycle asset management.

Future research should focus on standardizing operation and maintenance guidelines, clarifying legal frameworks, and empirically evaluating the impact of digital integration on public sector BIM projects.

The adoption of BIM in public investment projects is a dynamic and multidimensional process. While mandates and advanced technologies drive progress, persistent barriers require holistic and context-sensitive solutions. The way forward lies in integrating policy, education, technology and collaboration to fully harness the

transformative potential of BIM in the public sector [1,15,17,58].

Integrating Digital Twins and Emerging Technologies

Incorporation of an analysis on the convergence between BIM and digital twins in public investment projects. According to McKinsey (2025), digital twins have the potential to improve capital efficiency and public sector operational performance by 20-30%. This integration enables the simulation of complex scenarios, predictive maintenance, and the optimization of investment decisions through digital replicas of physical assets. The global digital twin market, valued at USD 24.97 billion in 2024, is projected to reach USD 155.84 billion by 2030 with a CAGR of 34.2%, evidencing the accelerated technological convergence that will redefine public infrastructure management in the next decade.

References

1. Vietnam Le, NQ Er M, Sankaran S, Ta NB (2020) Perspectives on BIM profession of bim specialists and non-BIM specialists: Case study in Lecture Notes in Civil Engineering <https://www.scopus.com/pages/publications/85073691505>.
2. Villena-Manzanares F, García-Segura T, Pellicer E (2021) ANALYSIS OF BARRIERS AGAINST THE ADOPTION OF BIM TECHNOLOGY Proceedings from the International Congress on Project Management and Engineering <https://www.scopus.com/pages/publications/85127557495>.
3. El Asri H, Benhlime L (2022) Awareness, Adoption, and implementation of Building Information Modelling in Small and Medium Enterprises in the Moroccan AEC Industry Proceedings of the European Conference on Knowledge Management, ECKM, <https://www.scopus.com/pages/publications/85178515013>.
4. Valenzuela Saavedra MA, Márquez M, Roca L, Seguel JL (2023) An Overview of the BIM implementation on Chilean Bridges <https://www.scopus.com/pages/publications/85182606473>.
5. Pérez-García A, Martín-Dorta N, Aranda JA (2024) Enhancing BIM implementation in Spanish public procurement: A framework approach. *Heliyon* <https://www.sciencedirect.com/science/article/pii/S2405844024066817>.
6. Alavi H, Bortolini R, Forcada N (2022) BIM-based decision support for building condition assessment Automation in Construction <https://www.sciencedirect.com/science/article/pii/S0926580521005689>.
7. Wong JKW, Ge J, He SX (2018) Digitisation in facilities management: A literature review and future research directions Automation in Construction. <https://www.sciencedirect.com/science/article/pii/S0926580517309020>.
8. Agwa TC, Çelik Buildings T (2025) From Barriers to Breakthroughs: A Deep Dive into BIM Integration Challenges <https://www.scopus.com/pages/publications/105002469158>.
9. Alotaibi B, Waqar A, Radu D, Almujiyah H (2024) Building information modeling (BIM) adoption for enhanced legal and contractual management in construction projects Ain Shams Engineering <https://www.scopus.com/pages/publications/85191498940>.
10. Klemt-Albert K, Ritter N, Hartung R, Bautechnik (2022) Legal framework for the implementation of BIM 2018 <https://www.scopus.com/pages/publications/85041039115>.
11. Idrissi Gartoumi K, Aboussaleh M, Zaki S (2022) The workability and usefulness of building information modelling based design for building performance Materials Today: Proceedings <https://www.sciencedirect.com/science/article/pii/S221478532200342X>.
12. Iqbal Muzaffar, Ullah Irfan, Abdou Heba, Yosri Ahmed M PLoS ONE (2025) Blueprint for progress: Understanding the driving forces of BIM adoption in Kingdom of Saudi Arabia (KSA) construction industry <https://www.sciencedirect.com/science/article/pii/S1932620324133123>.
13. Regona Massimo, Yigitcanlar Tan, Xia Bo, Li Rita, Yi Man (2022) Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review Journal of Open Innovation: Technology, Market, and Complexity <https://www.sciencedirect.com/science/article/pii/S219985312201054X>.
14. Orsini G, Piras G (2023) Digital Construction and Management the Public's Infrastructures Urban Book Series <https://www.scopus.com/pages/publications/85164000967>.
15. Zhang S, Oti-Sarpong K, Leiringer R (2022) Evolution of Building Information Modelling (BIM) Policy: The Case of Hong Kong Lecture Notes in Operations Research, <https://www.scopus.com/pages/publications/85212480189>.
16. Rinchen S, Banihashemi S, AlKilani S (2024) Driving digital transformation in construction: Strategic insights into building information modelling adoption in developing countries Project Leadership and Society <https://www.sciencedirect.com/science/article/pii/S2666721524000231>.
17. Das K, Khursheed S, Paul VK (2025) The impact of BIM on project time and cost: insights from case studies Discover Materials <https://www.scopus.com/pages/publications/85218829025>.
18. Wang Z, Ma J (2021) Understanding the effects of BIM implementation in corporation finance: An empirical study in China Organization, Technology and Management in Construction <https://www.scopus.com/pages/publications/85120846685>.
19. Waqar A, Othman I, Radu D, Khan MB (2023) Modeling the Relation between Building Information Modeling and the Success of Construction Projects: A Structural-Equation-Modeling Approach Applied Sciences (Switzerland) <https://www.scopus.com/pages/publications/85167887558>.
20. Gerber DJ, Becerik-Gerber B, Kunz A (2010) Building information modeling and lean construction: Technology, methodology and advances from practice <https://www.scopus.com/pages/publications/84866065427>.
21. Doume Ekale M, Pavard A, Benabderrahmane KA, Andrew Poirier (2025) E.BIM adoption and implementation in the civil and transportation infrastructure sector: analysis of governmental roadmaps and action plans International Journal of Construction Management <https://www.scopus.com/pages/publications/105012249346>.
22. Porwal A, Hewage KN (2013) Building Information Modeling (BIM) partnering framework for public construction projects Automation in Construction, 2013 <https://www.scopus.com/pages/publications/84872240863>.
23. Gordo-Gregorio P, Alavi H, Forcada N (2025) Decoding BIM Challenges in Facility Management Areas: A Stakeholders' Perspective Buildings <https://www.scopus.com/pages/publications/86000536513>.
24. Brito DMD, de Andrade Marques Ferreira EDAM, Costa DB (2021) Framework for Building Information Modeling Adoption Based on Critical Success Factors from Brazilian Public Organizations Journal of Construction Engineering and Management <https://www.scopus.com/pages/publications/85105005790>.

25. Pérez-García A, Martín-Dorta N, Aranda JÁ (2024) Heliyon, Enhancing BIM implementation in Spanish public procurement: A framework approach <https://www.scopus.com/pages/publications/85192088280>.
26. Renard-Julián EJ, Olmos Noguera JM (2022) TRAINING AND TEACHING RESOURCES AVAILABLE FOR BIM MODELING SOFTWARE: ARCHICAD, REVIT AND ALLPLAN Proceedings from the International Congress on Project Management and Engineering <https://www.scopus.com/pages/publications/85150361269>.
27. Uranga EJ, León I, Alberdi A, Sagarna M (2021) Implementation of the BIM Methodology in the Architecture Degree: Experience of the Architecture School of San Sebastian International Conference on Higher Education Advances <https://www.scopus.com/pages/publications/85128357804>.
28. Nardelli ES (2019) BIM training in Brazil Preparing professionals for BIM adoption by public administration Proceedings of the International Conference on Education and Research in Computer Aided Architectural Design in Europe <https://www.scopus.com/pages/publications/85129410036>.
29. Wanderley AK, Lordsleem Júnior AC, Rocha JHA (2023) Requirements for BIM implementation in AEC companies: a Brazilian case study de Assis Santos Construction Magazine <https://www.scopus.com/pages/publications/85172335591>.
30. Viana VL, Carvalho MT (2021) Prioritization of risks related to BIM implementation in brazilian public agencies using fuzzy logic Borges Journal of Building Engineering <https://www.scopus.com/pages/publications/85098949064>.
31. Valenzuela J, Saavedra MA (2025) Resilience in Chilean Railway Infrastructure: Application of BrIM to Historic Metal Bridges Requesens <https://www.scopus.com/pages/publications/105008753088>.
32. Peng Y, Au-Yong CP, Myeda NE (2024) Knowledge graph of building information modelling (BIM) for facilities management (FM) Automation in Construction <https://www.sciencedirect.com/science/article/pii/S0926580524002280>.
33. Giménez Z, Hernández H, Leyva Londoño JP, Garcia-Lopez NP (2025) Analyzing the relationship between the level of BIM maturity and the value generated in construction projects in Colombia Ain Shams Engineering Journal <https://www.sciencedirect.com/science/article/pii/S2090447925000929>.
34. Charef R, Emmitt S, Alaka H, Fouchal F (2019) Building Information Modelling adoption in the European Union: An overview Journal of Building Engineering <https://www.sciencedirect.com/science/article/pii/S2352710218312257>.
35. divide Kassem M, Ahmed AL (2022) Digital transformation through Building Information Modelling: Spanning the macro-micro Technological Forecasting and Social Change <https://www.sciencedirect.com/science/article/pii/S0040162522005273>.
36. Samsudin NS, Mohammad MZ, Khalil N, Che Ibrahim CK (2022) A thematic review on Prevention through design (PtD) concept application in the construction industry of developing countries Safety Science <https://www.sciencedirect.com/science/article/pii/S092575352100480X>.
37. Jin S (2024) Integrating BIM to Enhance Stakeholder Collaboration and Economic Efficiency in Architecture and Construction Projects E3S Web of Conferences <https://www.scopus.com/pages/publications/85203788092>.
38. Ashmori YY, Othman I, Aidrous AHMH (2022) Values, Challenges, and Critical Success Factors” of Building Information Modelling (BIM) in Malaysia: Experts Perspective AI Sustainability (Switzerland) <https://www.scopus.com/pages/publications/85126275209>.
39. Narezhnaya T, Ovsianikov A, Bolgov V (2024) Effectiveness of using BIM in construction: comparative analysis and evaluation methodology BIO Web of Conferences <https://www.scopus.com/pages/publications/85190610812>.
40. Zaheer Qasim, Qiu Shi Wang, Wenjuan Zhang (2025) Infrastructure modeling and simulation Xudong Smart Infrastructure Management <https://www.sciencedirect.com/science/article/pii/B9780443340178000041>.
41. Casini Marco (2022) Building information modeling Construction <https://www.sciencedirect.com/science/article/pii/B9780128217979000027>.
42. Ekanayake B, Wong JKW, Fini AAF, Thengane V (2024) Deep learning-based computer vision in project management: Automating indoor construction progress monitoring Project Leadership and Society <https://www.sciencedirect.com/science/article/pii/S2666721524000346>.
43. Casini Marco (2022) Advanced site management tools and methods Construction <https://www.sciencedirect.com/science/article/pii/B9780128217979000076>.
44. Raza MS, Tayeh BA, Abu Aisheh YI, Maglad AM (2023) Potential features of building information modeling (BIM) for application of project management knowledge areas in the construction industry Heliyon <https://www.sciencedirect.com/science/article/pii/S2405844023069050>.
45. Martinelli L, Calcerano F, Gigliarelli E (2022) Methodology for an HBIM workflow focused on the representation of construction systems of built heritage Journal of Cultural Heritage <https://www.sciencedirect.com/science/article/pii/S1296207422000681>.
46. Casini, Marco (2022) Building information modeling Construction <https://www.sciencedirect.com/science/article/pii/B9780128217979000027>.
47. Yang Y, Zhao B (2025) How building information modelling mitigates complexity and enhances performance in large-scale projects: Evidence from China International Journal of Project Management <https://www.sciencedirect.com/science/article/pii/S0263786325000213>.
48. (2022) The role of implementing BIM applications in enhancing project management knowledge areas in Egypt Shaqour, E.N. Ain Shams Engineering Journal <https://www.sciencedirect.com/science/article/pii/S2090447921002604>.
49. Raduan SMS, Brahim J, Nordin RM, Fajarianto O (2025) Unveiling The BIM Execution Plan (BEP): A Comprehensive Review of Global Frameworks and Applications Built Environment Journal <https://www.scopus.com/pages/publications/105010744303>.
50. Giménez Z, Hernández H, Leyva Londoño JP, Garcia-Lopez NP (2025) Analyzing the relationship between the level of BIM maturity and the value generated in construction projects in Colombia Ain Shams Engineering Journal <https://www.sciencedirect.com/science/article/pii/S2090447925000929>.
51. Gaur S, Tawalare A (2022) Investigating the Role of BIM in Stakeholder Management: Evidence from a Metro-Rail Project Journal of Management in Engineering <https://www.scopus.com/pages/publications/85116539805>.
52. Brito DM, de Andrade Marques Ferreira EAM, Costa DB (2021) An Investigation of Contractual Requirements for BIM Adoption in the Brazilian Public Sector Lecture Notes in Civil Engineering <https://www.scopus.com/pages/publications/85088461685>.

53. Mustaffa NE, Salleh RM, Tajul Ariffin HLBT (2017) Experiences of Building Information Modelling (BIM) adoption in various countries International Conference on Research and Innovation in Information Systems <https://www.scopus.com/pages/publications/85029938839>.
54. Zak J (2025) A Cost–Benefit Analysis of BIM Methodology Implementation in the Preparation and Construction Phase of Public Sector Projects , Buildings <https://www.scopus.com/pages/publications/105021557335>.
55. Mohammadi S, Aibinu AA, Oraee M (2024) Legal and Contractual Risks and Challenges for BIM Journal of Legal Affairs and Dispute Resolution in Engineering and Construction <https://www.scopus.com/pages/publications/85175469676>.
56. Oti-Sarpong K, Leiringer R, Zhang S (2020) A Critical Examination of BIM Policy Mandates: Implications and Responses <https://www.scopus.com/pages/publications/85096761925>.
57. Diaz Schery CAD, Caiado RGG, Vignon YR, Corseuil ET (2023) BIM Critical Factors-Based Framework Towards Digitalization of Construction in the Public Sector Springer Proceedings in Mathematics and Statistics <https://www.scopus.com/pages/publications/85180736308>.
58. Raj K, Mastrolembu Ventura S, Comai S, Ciribini ALC (2025) Toward a Sustainable and Efficient Design Process: A BIM-Based Organisational Framework for Public Agencies, An Italian Case Study Sustainability (Switzerland) <https://www.scopus.com/pages/publications/105013293591>.
59. Algahtany M, Radzi AR, Al-Mohammad MS, Rahman RA (2023) Government Initiatives for Enhancing Building Information Modeling Adoption in Saudi Arabia Buildings <https://www.scopus.com/pages/publications/85172772199>.
60. Lu Q, Chen L, Lee S, Zhao X (2018) Activity theory-based analysis of BIM implementation in building O&M and first response Automation in Construction <https://www.scopus.com/pages/publications/85032807536>.
61. Pinti L, Codinhoto R, Bonelli S (2022) A Review of Building Information Modelling (BIM) for Facility Management (FM): Implementation in Public Organisations Applied Sciences (Switzerland) <https://www.scopus.com/pages/publications/85123761630>.
62. Cavka HB, Staub-French S, Poirier EA (2017) Developing owner information requirements for BIM-enabled project delivery and asset management Automation in Construction <https://www.scopus.com/pages/publications/85027396980>.
63. Yusuf AO, Opawole A, Musa NA, Ebuloluwa EI (2024) Factors influencing the organisational capabilities of the public sector for implementation of building information modelling in construction projects International Journal of Building Pathology and Adaptation <https://www.scopus.com/pages/publications/85139426296>.
64. Syria Al-Mohammad MS, Haron AT, Maya R, Rahman RA (2024) Optimal Government Strategies for BIM Implementation in Low-Income Economies: A Case Study in Journal of Architectural Engineering <https://www.scopus.com/pages/publications/85192518447>.
65. Xing M, Cao J, Cao D (2023) Impacts of Policy Mix Comprehensiveness on BIM Implementation: Moderating Effects of Environmental State and Response Uncertainty Journal of Construction Engineering and Management <https://www.scopus.com/pages/publications/85143667960>.
66. Aragón A, Roig Hernando J, Llovera Saez FJ, Coll Bertran J (2021) Quantity surveying and BIM 5D. Its implementation and analysis based on a case study approach in Spain Baldrich Journal of Building Engineering <https://www.sciencedirect.com/science/article/pii/S2352710221010925>.
67. AlSehaimi A, Baarimah AO, Madhusudhan MB, Ahmed W (2025) Integration of BIM in project management phases for achieving sustainable success in small construction projects: A SEM-based approach Ain Shams Engineering Journal <https://www.sciencedirect.com/science/article/pii/S2090447925003909>.
68. Saka AB, Chan DWM, Wuni IY (2022) Knowledge-based decision support for BIM adoption by small and medium-sized enterprises in developing economies Automation in Construction <https://www.sciencedirect.com/science/article/pii/S0926580522002801>.
69. barriers Manzoor B, Othman I, Gardezi SSS Abdalla SB (2021) Bim-based research framework for sustainable building projects: A strategy for mitigating bim implementation Applied Sciences (Switzerland) <https://www.scopus.com/pages/publications/85108656734>.
70. Guo X, Tian C, Chen Y, Zhang J (2022) Case Study of Building Information Modeling Implementation in Infrastructure Projects Transportation Research Record <https://www.scopus.com/pages/publications/85125555695>.
71. Tran-Hoang-Minh H, Nguyen TQ, Nguyen DP, Pham QT (2021) Barriers of BIM adoption in Vietnamese contractors AIP Conference Proceedings <https://www.scopus.com/pages/publications/85119080776>.
72. Li L, Yuan J, Tang M, Cheng Y (2021) Developing a BIM-enabled building lifecycle management system for owners: Architecture and case scenario Automation in Construction <https://www.sciencedirect.com/science/article/pii/S092658052100265X>.
73. Jia J, Ma H, Zhang Z (2024) Integration of Industry Foundation Classes and Ontology: Data, Applications, Modes, Challenges, and Opportunities Buildings <https://www.scopus.com/pages/publications/85191403938>.
74. Wang H, Pan Y, Luo X (2019) Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis Automation in Construction <https://www.scopus.com/pages/publications/85062851084>.
75. Hooper M, Widén K (2015) BIM inertia: Contracts and behaviours <https://www.scopus.com/pages/publications/85026509806>.
76. Iran Mehrizi HZ, Pourrostan T, Ramesht MH, Rahimi M (2025) Developing a Model to Assess and Address Challenges in Implementing BIM for Commercial Buildings: A PLS-SEM Analysis in. Journal of Architectural Engineering <https://www.scopus.com/pages/publications/105016393423>.
77. Fan SL, Chong HY, Liao PC, Lee CY (2019) Latent Provisions for Building Information Modeling (BIM) Contracts: A Social Network Analysis Approach KSCE Journal of Civil Engineering <https://www.scopus.com/pages/publications/85062006783>.
78. Jobidon G, Lemieux P, Beaugregard R (2021) Laws, Building Information Modeling in Quebec’s Procurement for Public Infrastructure: A Case for Integrated Project Delivery <https://www.scopus.com/pages/publications/85120330317>.
79. Zainon N, Vicky L (2021) Proposing bim-related clauses in standard form of Malaysian construction contracts Malaysian Construction Research Journal <https://www.scopus.com/pages/publications/85107684937>.
80. Piras G, Muzi F, Zylka C (2024) Integration of BIM and GIS for the Digitization of the Built Environment Applied Sciences (Switzerland) <https://www.scopus.com/pages/publications/85211911132>.
81. Waqar A, Nisar S, Qadir S (2025) BIM-driven sustainable safety management solutions for downstream oil and gas (D-O&G) construction projects Environmental Challenges

- <https://www.sciencedirect.com/science/article/pii/S2667010024002245>.
82. Mishra A, Hasan A, Jha KN (2024) A Holistic Evaluation of BIM Implementation Barriers in the Indian Construction Industry: Pre- and Post-Adoption Perspectives International Journal of Construction Education and Research <https://www.scopus.com/pages/publications/85186420167>.
 83. Acheng PO, Kibwami N, Mukasa TJ, Manga M (2023) Building information modelling adoption in Uganda's construction industry International Journal of Construction Management <https://www.scopus.com/pages/publications/85128206728>.
 84. Berema RKR, Ismail Z, Brahim J, Preece CN (2025) Legal and Contractual Determinants for Further Adoption of Building Information Modelling in the Construction Industry Journal of Engineering <https://www.scopus.com/pages/publications/105018342280>.
 85. Jo TM, Ishak SSM, Rashid ZZA (2018) Overview of the Legal Aspects and Contract Requirements of the BIM Practice in Malaysian Construction Industry MATEC Web of Conferences <https://www.scopus.com/pages/publications/85055517038>.
 86. Chai C, Chong HY, Lee CK, Fan LSL (2025) Addressing a Building Information Modeling Ownership Issue Based on DEMATEL Analysis, Journal of Legal Affairs and Dispute Resolution in Engineering and Construction <https://www.scopus.com/pages/publications/105008489484>.
 87. Olatunji OA (2011) A preliminary review on the legal implications of BIM and model ownership Journal of Information Technology in Construction <https://www.scopus.com/pages/publications/79960075352>.
 88. Fan SL (2020) Comparative study for BIM-based contract administration between the cases in Taiwan and China Journal of the Chinese Institute of Engineers, Transactions of the Chinese Institute of Engineers, Series A/Chung-kuo Kung Ch'eng Hsueh K'an <https://www.scopus.com/pages/publications/85087834377>.
 89. Wang WC, Huang SC, Wang HP Cao MT (2025) Measuring user satisfaction in building information modeling using active interpretable machine learning. Applied Soft Computing 183: 113663.
 90. Wei W, Prasetyo YT, Belmonte ZJA, Cahigas MML, Nadlifatin R, et al. (2025) Application of the Technology Acceptance Model - Theory of Planned Behavior (TAM-TPB) to study the acceptance of Building Information Modeling (BIM) in sustainable building in China. Acta Psychologica 254: 104790.
 91. Lozano F, Jurado JC, Lozano-Galant JA, de la Fuente A, Turmo J (2023) Integration of BIM and the Value Model for Sustainability Assessment in bridge projects. Automation in Construction 152: 104935.
 92. Aranda JÁ, Pérez-García A, Martín-Dorta N, Contero M (2025) BIM-based design to improve efficiency and accuracy in cross drainage works. Journal of Engineering Research <https://www.sciencedirect.com/science/article/pii/S2307187725000896>.
 93. Samsudin NS, Mohammad MZ, Khalil N, Nadzri ND, Izam Che Ibrahim CK (2022) A thematic review on the application of the concept of Prevention through Design (PtD) in the construction industry in developing countries. Safety Science 148: 105640.
 94. Raj Kavita (2025) Towards a Sustainable and Efficient Design Process: A BIM-Based Organizational Framework for Public Bodies: An Italian Case Study <https://www.scopus.com/pages/publications/105013293591>.

Copyright: ©2026 Jorge Pablo Aguilar Zavaleta. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.