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BIM Adoption and Implementation Challenges in Mongolia

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Abstract

The primary aim of this research is to identify and address the key barriers to Building Information Modeling (BIM) adoption and implementation within the Mongolian construction industry, serving as a case study for developing economies. BIM offers significant benefits and represents a key technological innovation shaping the future of the Architecture, Engineering, Construction (AEC), and Infrastructure sector towards Digital Transformation. However, there are substantial challenges in BIM adoption and implementation in the construction industry. To identify the barriers to BIM adoption in Mongolia's construction sector, this study conducts a comprehensive analysis of the industry's current state and the status of BIM adoption, supported by a review of relevant literature and case-specific data. The comprehensive analysis utilizes SWOT (Strengths, Weaknesses, Opportunities, and Threats) and PESTLE (Political, Economic, Social, Technological, Legal, and Environmental) analysis approach to identify the key challenges, including technical and policy, socio-economy, human resource related factors. Then, framework to address those challenges is developed based on the analysis results and data. Also, the framework draws insight from the review and comparison study of global BIM implementation best practices. This study contributes to filling the knowledge gap regarding BIM adoption in developing economies and offers practical insights that can aid in developing BIM adoption models for countries with similar economic and industry conditions.

Keywords: BIM, BIM adoption challenges, Mongolian construction industry, SWOT, PESTLE analysis, BIM implementation strategy.

1 Introduction

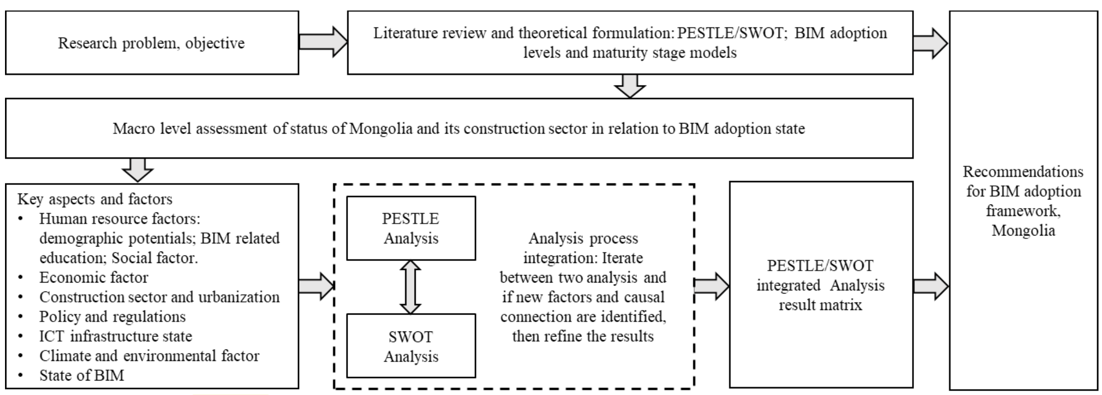
Digital transformation in the construction industry involves adopting digital technologies and processes to modernize and enhance various aspects of construction projects. This transformation integrates data, automation, and digital tools to improve project management, design, construction, and operation. Technologies such as Building Information Modeling (BIM), project management software, IoT devices, and drones streamline processes, reduce errors, and enhance collaboration. Developed countries are increasingly focusing on digital transformation to boost efficiency and productivity, reduce costs, and promote sustainability. By leveraging digital tools, they can better track and manage environmental impacts, enhance safety through real-time monitoring, and remain competitive in the global market. BIM, in particular, is a cornerstone of this transformation, offering significant benefits in terms of efficiency, cost reduction, collaboration, and sustainable practices. The advantages of BIM extend beyond the initial delivery of constructed assets to their ongoing management and operations. Numerous studies have highlighted the benefits of embracing BIM during the initial delivery phase of an asset, providing different estimates of the return on investment (ROI) and overall value derived from its implementation. Despite current limitations in digital transformation, forward-looking studies project significant cost savings and productivity gains through comprehensive digital adoption. For instance, vertical construction could achieve cost savings of 10 to 25%, while infrastructure projects could see even higher reductions (Gerbert et al., 2016). Additionally, McKinsey estimates that the industry has the potential to increase overall productivity by 50 to 60% through design-to-manufacturing processes supported by digital information (Barbosa et al., 2017). Countries with comprehensive BIM strategies, like the UK, have already reported notable decreases in public construction costs, achieving a 15 to 20% reduction through a BIM mandate on all public projects (Cabinet Office, 2011). Furthermore, case studies on open BIM adoption highlight benefits such as cost reductions, improved quality, and shorter project delivery times. Meanwhile, developing economies fall behind in the adoption of BIM, mostly because of the particular difficulties they encounter. For example, a study by Al-Sarafi et al. (2022) reveals that BIM, despite its potential to revolutionize construction practices, faces significant adoption barriers in developing countries. Their work identifies five key obstacles hindering wider BIM implementation: resistance to changing established industry practices, the high cost of implementation, insufficient client demand, inadequate collaboration among stakeholders, and a general lack of awareness regarding BIM's potential benefits. These points are further supported by developing country cases. Fitriani et al. (2019) identified the high initial cost of software and hardware as the most significant barrier against the BIM adoption in Indonesia. Studies on the Malaysian construction industry, such as the one by Enegbuma et al. (2015), have identified a need for greater awareness and understanding regarding BIM adoption. Despite the growing body of knowledge on BIM adoption barriers and benefits, further studies are essential to address the specific contexts of a broader range of developing countries.

As such, Mongolia, a developing country with a rapidly growing construction sector, requires further investigation to understand its unique context regarding BIM adoption. Given the limited availability of data and research on BIM adoption in Mongolia, this study aims to initiate a discussion to advocate the need for data availability, that will create the baseline for accurately assessing BIM’s current adoption state. By employing an integrated SWOT and PESTLE analysis approach, this research identifies the core internal and external factors influencing BIM adoption in Mongolia's construction sector. The insights gathered from this analysis will inform a targeted recommendation framework, designed to guide future studies and strategic actions to support and measure BIM adoption more effectively.

2 Research Methodology

This study follows a structured approach to assess BIM adoption challenges and opportunities in Mongolia's construction sector, beginning with the comprehensive macro-level assessment of Mongolia's construction sector, examining key factors that could influence BIM adoption. This phase involves surveying critical aspects and evaluating factors that will populate the PESTLE (Political, Economic, Social, Technological, Legal, and Environmental) and SWOT (Strengths, Weaknesses, Opportunities, and Threats) analyses. The assessment is specifically tailored to Mongolia's unique economic, regulatory, and technological landscape to ensure relevance and accuracy in capturing the country's BIM adoption potential. The core of the analysis lies in the integration of PESTLE and SWOT, creating an iterative process where insights from one framework inform and refine the other. This iterative integration involves continuously revisiting each framework; if new factors or causal relationships emerge, the findings are updated to capture a more nuanced and interconnected view of Mongolia's BIM adoption environment. This process results in an integrated PESTLE/SWOT matrix, which synthesizes both macro and micro factors into a cohesive analysis (see Figure 1).

Finally, using insights from the PESTLE/SWOT analysis and guided by BIM adoption and maturity stage models, the study proposes a recommendation framework tailored to Mongolia. This framework addresses specific stages and levels necessary for advancing BIM adoption, providing actionable steps aligned with the maturity needs and sectoral context of Mongolia's construction industry.



Integrated PESTLE/SWOT matrix result

PESTLE/SWOT	Internal/External	
	Strengths (Positive)	Weaknesses (Negative)
Policy	P.S.	P.W.
Economic	Ec.S.	Ec.W.
Social	S.S.	S.W.
Technological	T.S.	T.W.
Legislative	L.S.	L.W.
Environmetal	En.S.	En.W.

PESTLE/SWOT	Internal/External	
	Opportunities (Positive)	Threats (Negative)
Policy	P.O.	P.T.
Economic	Ec.O.	Ec.T.
Social	S.O.	S.T.
Technological	T.O.	T.T.
Legislative	L.O.	L.T.
Environmetal	En.O.	En.T.

Figure 1: Research design based on the integration of the SWOT, PESTLE analysis

SWOT and PESTLE tools was selected for this study because these are proven tools for strategic planning, that provides a structured framework. Despite some criticisms, such as being labeled "atheoretic" by Grant (2008), SWOT remains a widely used and effective strategic tool. Coman and Ronen (2009) highlight its ability to distill strengths and weaknesses into core competences and core problems, which can then be linked into a plan of action. Evans and Wright (2009) also emphasize its usefulness but suggest combining it with other tools like Porter's 5-Forces analysis for a more comprehensive strategic planning process. For our study we combine with PESTLE.

3 Macro Level Assessment of Status of Mongolia and Its Construction Sector in Relation to BIM Adoption State

3.1 Demographic Profile of Mongolia

Mongolia's population of 3,457,500 presents a unique demographic profile, characterized by a prominent youth bulge (National Statistics Office of Mongolia, 2022). As of 2022, nearly 43.59% of the population falls within the 20-49 age group (see Figure 2). This age group plays a significant role in the country's workforce, consumer market, and overall social dynamics. In many countries younger generations are quick to adapt and learn to utilize new technologies, thus this status is potential benefit for Mongolia when it comes to BIM adoption. Because younger generations tend to be more comfortable with technology and have a greater aptitude for learning new software and digital tools. Also they are more likely to be aware of and interested in emerging technologies and trends shaping the future of the construction industry.

Age	Population (Thousand persons)	Age group %
Under 1 year	66.9	1.93
1 to 4	299.5	8.66
5 to 9	396	11.45
10 to 14	342.4	9.9
15 to 19	233.2	6.74
20 to 24	231.1	6.68
25 to 29	241.7	6.99
30 to 34	306.1	8.85
35 to 39	280	8.1
40 to 44	236.8	6.85
45 to 49	211.5	6.12
50 to 54	179.2	5.18
55 to 59	152.1	4.4
60 to 64	118.8	3.44
65 to 69	71.3	2.06
70+	90.9	2.63
Total	3457.5	100
Age group % from 20 to 49		43.59

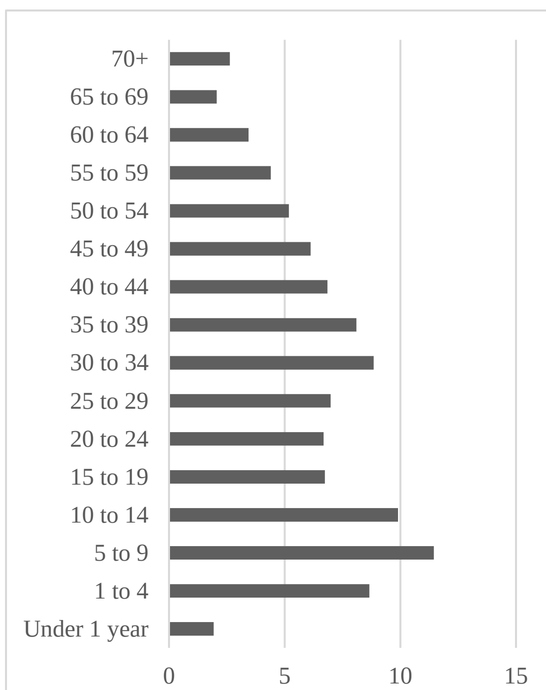


Figure 2: Population of Mongolia by age group (2022)

3.2 Economic Profile of Mongolia

In 2022, Mongolia's economy experienced significant challenges, largely due to the global impacts of the COVID-19 pandemic and other global events that occurred in recent years. As the year progressed, conditions started to improve, leading to an increase in mineral exports. As shown in the Table 1, the growth rate for 2022 was 4.8%, a substantial improvement from 1.6% in 2021 and a contraction of 4.6% in 2020 (World Bank, 2023; National Statistics Office of Mongolia, 2022). Despite the ongoing recovery, Mongolia's economy remains susceptible to external impacts. However, it is gradually transitioning towards economic growth in the post-pandemic era. BIM adoption in Mongolia's construction sector can significantly enhance cost effectiveness, which is crucial given the sector's substantial role in the national economy and its impact on controlling foreign debt and inflation. By providing precise cost estimates and streamlining budget management throughout a building's lifecycle, BIM minimizes financial risks associated with construction cost overruns, often a source of escalating debt. Furthermore, BIM's accurate modeling enables efficient resource allocation and reduces material waste, ensuring that projects stay within budget and timelines, which collectively fosters economic stability and mitigates inflationary pressures.

Indicators	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Growth Rate (%)	12.3	11.6	7.9	2.4	1.5	5.6	7.7	5.6	-4.6	1.6	4.8
Inflation Rate (%) Consumer prices	14	10.5	12.3	5.7	0.7	4.3	6.8	7.3	3.8	7.4	15.1
GDP (Billion. $)	12.2	12.5	12.2	11.7	11.1	11.4	13.18	14.21	13.31	15.29	16.81
Gross Foreign Debts (Billion. $)	13.65	15.05	16.42	22.71	24.62	27.41	28.7	30.7	32.2	33.2	33.6

Table 1: Primary Economic Evaluation of Mongolia 2012-2022

3.3 Climate Profile of Mongolia

Mongolia is a country with a high altitude, cold temperatures, and dry climate. It has an extreme continental climate with long, cold winters and short summers, during which most precipitation falls (Climate Change Knowledge Portal, 2024). The country experiences 257 sunny days a year, and it is typically located at the center of a region of high atmospheric pressure. Due to its short warm season and longer cold seasons, about 6 months of the year is suitable for the construction work (see Figure 3) activities without additional heating cost. Number of ways BIM adoption can improve Mongolia's construction industry in relation to the harsh climate:

1) BIM's virtual environment and precise simulations allow architects and engineers to test designs for extreme weather conditions like blizzards and scorching heat, optimizing for thermal performance and structural integrity before breaking ground. This can save time and money during construction, as well as prevent costly problems down the line.

2) By facilitating prefabrication and modular construction techniques, BIM streamlines the building process in areas with short construction seasons due to harsh winters. This reduces exposure to the elements and ensures projects are completed quickly and efficiently.

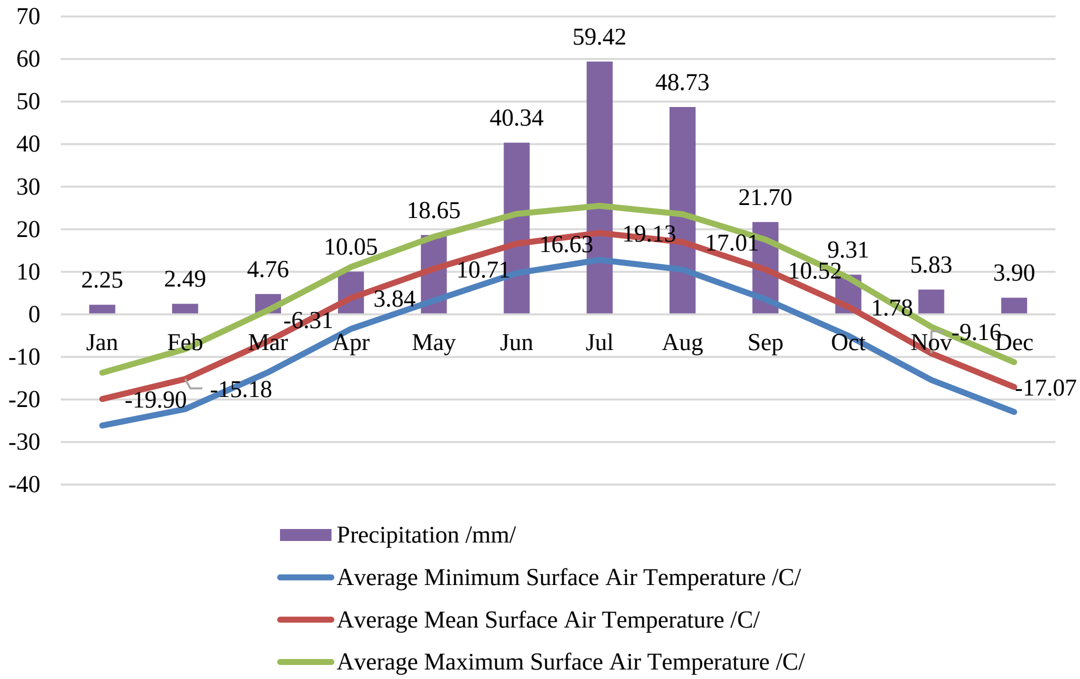


Figure 3: Monthly Average Min, Max, Mean Surface Air Temperature and Precipitation 1991-2020, Mongolia

3.4 Mongolia's Construction Sector Market

National Statistics Office of Mongolia sizes the Construction sector market in regards of Construction, Capital Repairs and Maintenances budgets of the sector. Economic operations aimed at creating, renovating, repairing, or extending fixed assets in the form of buildings, engineering-style land improvements, and other similar engineering works like roads, bridges, dams, and so forth are referred to as construction and capital repairs. The trend of new construction is still taking high percentage in the Construction Industry Market of Mongolia. This trend has been constant for the past 12 years as seen in Figure 4. This is related to the urbanization trend of Mongolia. As previously mentioned, Mongolia's economy grew by 4.8% in 2022 compared to 2021. The industry and construction sector contributed 0.5 percentage points to this growth. While the output of construction, capital repairs and maintenance at price of year 2022 increased by 37.4%. When we see from the table of last 5 years' stats of construction, capital repairs and maintenance of Mongolia, there can be seen a steady rise in this sector. Even considering the minor dip in the stats between 2020 to 2021, when the global pandemic COVID19 affected global economy, the construction, capital repairs and maintenance sector of Mongolia still maintained its size.

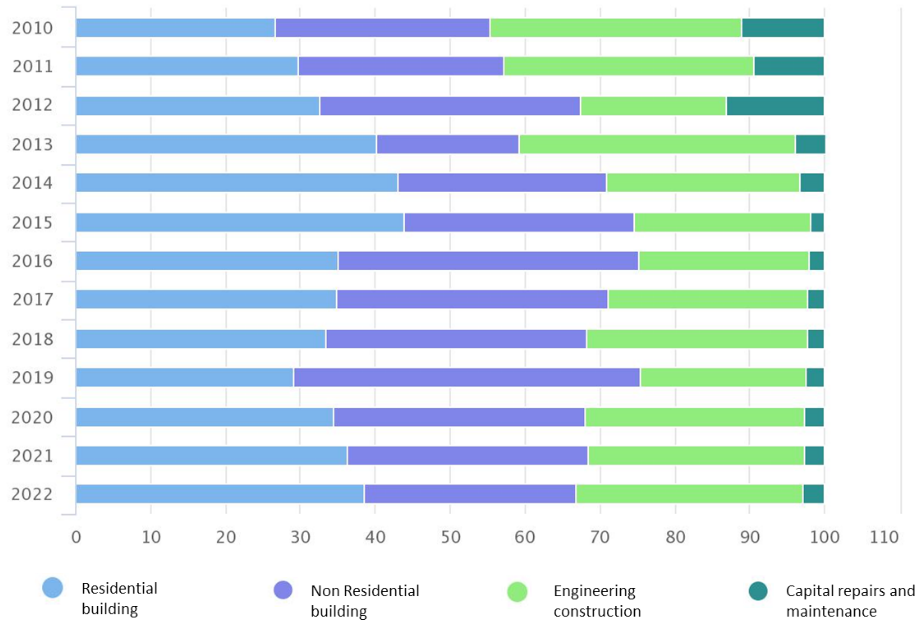


Figure 4: Construction, Capital repairs and maintenance, by type of construction and year in percentage

3.5 Mongolia's Construction Sector Regulations

To access the regulatory status of construction sector of Mongolia, 12 legislations that are relevant to the sector was surveyed. And 27 construction work related permits was also surveyed for this research. In the result, current regulatory environment is handling 2D CAD process but not ready to deal with information model in the scope of all aspects of construction related works. There are 27 types of construction work-related permits regulated by the Urban Development Agency of Capital City Administration of Mongolia. These permits require 2D-based design drawings for various construction work permissions, which later act as records in the urban database. The laws listed in above and other relevant policies serve as the basis for these permits. As Mongolia aims to become a digital nation according to the VISION 2050 policy document, BIM adoption will be a key digitization factor in the construction sector and the urban development sector. Thus, efforts to update necessary regulations with digitization-related factors should be expected to be done in the long run. While construction permits will have to focus on including Information Modelling in conjunction with traditional 2D-based CAD design drawings for recording and archiving purposes.

3.6 Status of BIM Utilization, Education and Understanding in Mongolia

According to our survey findings regarding the BIM education in Mongolia, so far two organizations publicly demonstrated activities to develop education curriculum and environment that supports BIM authoring tools training. The major public university that educates the Mongolian AEC industry professionals, the Mongolian University of Science and Technology, have started paying attention to BIM education from 2014. In 2015, cooperation agreement was made for opening the Autodesk training center branch at the school of Civil Engineering and Architecture, Mongolian University of Science and Technology. Then the Autodesk training center was opened in 2016, with focus of training Autodesk Revit in the beginning. By 2022, the training center prepared estimated number of 302 participants, from which 178 were certified in Autodesk Certification, 56 took training for advancing the professional status of Engineering, and 62 participants with Autodesk Training center issued certificate (BIM-Forum Mongolia, 2022).

A private sector Design Firm in Mongolia launched their own BIM authoring tool training center with name “Model Development Training Center”. From their public engagement in the scope of BIM-Forum participation information, their education training is focused on utilizing Revit. The efforts are not minor, but the effects of those efforts are yet to be seen in the future. Judging from the training nature, these efforts appear to be focusing only on training the participants in certain BIM authoring tools. Hence, there is still a need for a training center that focuses on preparing BIM managers and an education curriculum at universities related to the introduction of BIM and advanced-level BIM understanding.

Since 2016, Mongolian Ministry of Construction and Urban Development has been pursuing on preparation for BIM adoption for Mongolia. While private sector is increasing their interest in understanding BIM in order to maintain their competiveness on the market. But the understanding and utilization still remains at the level of BIM authoring tool utilization (BIM-Forum Mongolia, 2022-2023).

3.7 ICT Infrastructure Status of Mongolia

According to the Global Competitiveness Index 4.0, Mongolia ranks 14th out of 21 countries in terms of ICT adoption in Asia, with a score of 96.38 out of 100. In terms of companies embracing disruptive ideas, Mongolia ranks 17th out of 21 countries in the region of Asia, with a score of 41.43 out of 100. Other ICT infrastructure related statistics are shown in the Table 2.

Name	Mongolia	World Rank	Country Ranked 1st in the World		Data year
Mobile Connectivity Index: Infrastructure: Network coverage: 2G coverage, score (0-100, higher is better)	100	1st/168	100	Mongolia	2022
Mobile Connectivity Index: Infrastructure: Network performance: Mobile download speeds, score (0-100, higher is better)	11.47	126th/168	100	Australia	2022
Global Competitiveness Index 4.0: Electricity infrastructure, score (0-100, higher is better)	91.49	93rd/139	100	Bahrain	2019
Mobile Connectivity Index: Infrastructure: Network coverage: 4G coverage, score (0-100, higher is better)	85.46	118th/168	100	Bahrain	2022
Mobile Connectivity Index: Infrastructure: Network performance: Mobile upload speeds, score (0-100, higher is better)	27.38	116th/168	100	China	2022
Mobile Connectivity Index: Infrastructure: Network performance, score (0-100, higher is better)	39.02	130th/168	97.65	Qatar	2022
Mobile Connectivity Index: Infrastructure, score (0-100, higher is better)	63.12	77th/168	97.94	Denmark	2022
Mobile Connectivity Index: Infrastructure: Network coverage: 3G coverage, score (0-100, higher is better)	95	103rd/168	100	Bahrain	2022
Secure Internet servers (per 1 million people)	1.7k	63rd/184	280k	Denmark	2020

Table 2: Mongolia’s Information and Communications Technology (ICT) sector’s Infrastructure and Capacity details and scoring

4 Integrated PESTLE and SWOT Analysis for Mongolian Construction Industry in Relation to BIM Adoption

This chapter presents a detailed analysis of the factors affecting BIM adoption in Mongolia's construction sector. By iteratively applying PESTLE and SWOT frameworks, we uncover the complex interplay between external and internal factors. This integrated approach enables us to identify key challenges and opportunities, as well as potential causal relationships between different factors. The resulting PESTLE/SWOT matrix provides a solid foundation for developing actionable recommendations (see Table 3).

PESTLE/SWOT	Internal factors	
	Strengths (Positive)	Weaknesses (Negative)
Political	Government support for technological advancement	Limited government support for BIM-specific initiatives Lack of clear and standardized policies for BIM adoption.
Economic	Growing economy Increasing demand for infrastructure. Potential for foreign investment	Financial constraints for smaller firms Limited access to funding for BIM adoption.
Social	Young and tech-savvy population Growing urbanization Positive public perception about BIM	Lack of awareness about BIM benefits Resistance to change Cultural barriers
Technological	Potential for technological advancement	Limited ICT infrastructure Skills gap: Limited educational programs and training opportunities specific to BIM. Lack of technological expertise
Legal		Lack of clear regulations and standards for BIM Potential data security concerns Existing regulatory environment not ready for regulating new disruptive technological changes
Environmental	Potential for sustainable construction practices	Lack of clear environmental regulations specific to BIM
SWOT/PESTLE	External factors	
	Opportunities (Positive)	Threats (Negative)
Political	Government interest for technological advancement Potential for public-private partnerships	Political instability

Table 3: Integrated PESTLE and SWOT Analysis output matrix

SWOT/PESTLE	External factors	
	Opportunities (Positive)	Threats (Negative)
Economic	Growing economy is driving opportunities for BIM adoption by increasing the demand for construction projects and attracting foreign investment.	Economic downturns can reduce construction activity and limit investment in new technologies like BIM.
	Infrastructure development	Fluctuations in market demand
	Foreign investment: Foreign investment in Mongolia can bring in expertise, technology, and funding for BIM adoption.	Limited International Collaboration
Social	The increasing demand for construction projects in urban areas presents opportunities for BIM adoption to address the challenges of urban development.	Cultural barriers: Cultural attitudes or beliefs within Mongolian construction sector that influences the acceptance or rejection of BIM.
	Changing lifestyles: Changes in lifestyles and preferences can drive the demand for efficient and sustainable construction practices, which BIM can support.	Resistance to change: Resistance to adopting new technologies due to ingrained traditional practices, a lack of awareness about BIM's benefits, or a reluctance to change established workflows.
Technological	Technological advancements: Advancements in BIM technology and its integration with other technologies can enhance its capabilities and attractiveness for adoption.	Inadequate internet connectivity, lack of access to advanced technology, and insufficient IT resources.
	Through integration with other technologies, promotion of other new technologies	Cybersecurity risks
		Technological obsolescence: BIM technology may become outdated over time, requiring regular updates and upgrades to ensure its effectiveness.
Legal	Potential for favorable regulations	Changes in regulations
	Clear contractual considerations	Unclear liability issues
Environmental	Demand for sustainable construction practices.	Environmental regulations: Strict environmental regulations might pose challenges for BIM adoption, but they can also drive innovation in sustainable construction practices.
	Potential for green building certifications	Natural disasters, climate change

Table 3: Integrated PESTLE and SWOT Analysis output matrix (continued)

5 BIM Implementation Roadmap Strategic Framework Proposal

Given the government's ability to influence and regulate technology diffusion through strategies such as knowledge building, knowledge deployment, subsidies, mobilization, standard setting, and innovation directives (King et al., 1994), it is evident that public authorities will play a leading role in the adoption of Building Information Modeling (BIM) strategies. Thus, our proposed framework emphasizes the government's leading role in the adoption and diffusion of Building Information Modeling (BIM) technologies. And the proposed framework as the recommendations are derived from a careful analysis of the interconnected factors revealed by the PESTLE/SWOT matrix. By understanding how these factors influence each other, we can identify specific actions to address the key challenges and opportunities. For instance, if the matrix highlights the need for stronger legal frameworks to support BIM's regulatory consistency, this will be a key component of the proposed framework.

5.1 Maturity Stage Model Based Recommendation for Mongolia

Figure 5 provides a visual representation of the timeline for the targeted implementation of Building Information Modeling (BIM) stages within the construction sector. It demonstrates the phased approach followed by many developed countries when mandating BIM adoption. These stages often align with the legal system's progression, ensuring a systematic and structured implementation process.

The first stage involves conducting pilot projects to test and assess the feasibility of BIM in real-world scenarios. This will allow for the identification of potential challenges and the development of best practices and guidelines. Following the pilot phase, guidelines are established to provide a framework for BIM implementation, addressing key aspects such as data standards, interoperability, and collaboration protocols. Once the guidelines are in place, the mandatory implementation phase begins. The public building sector is often at the forefront of this implementation, adopting BIM practices approximately five years earlier than the infrastructure facility sector, which includes projects related to roads, railways, and other public infrastructure.

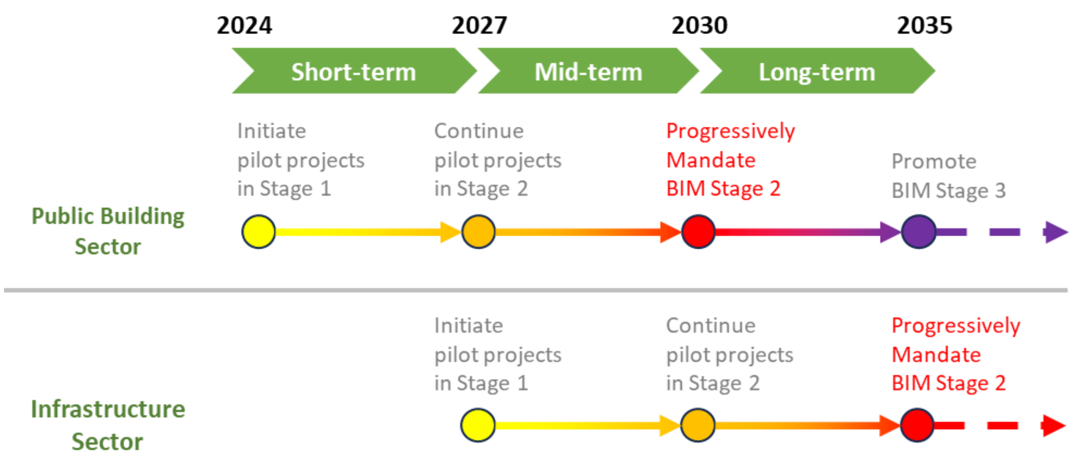


Figure 5: Target maturity stage by phase and construction sector

5.2 Recommended Strategic Goals for Mongolia by Phase and Action Framework

The strategic goals to achieve for each of the maturity stage described in Section 5.1 can be set as shown in Figure 6 and brief of each strategic goals are as follows.

Short-term goal: Establish fundamentals and begin 3D coordination in limited project domains by 2027. The goal of the short-term goal is to initiate the implementation of BIM in the construction industry, beginning with a simple use case - 3D model-based coordination. This serves as an entry point for the industry to understand the benefits of BIM and begin integrating it into their current workflows. To promote BIM adoption during this phase, it is essential to establish the necessary fundamentals, such as developing standardized guidelines and legal documents. In addition to creating guidelines and legal documents, it is also important to improve the legal system to ensure the availability of qualified BIM engineers. The legal system plays a critical role in enforcing regulations and guidelines, and promoting the adoption of BIM requires the support of a qualified workforce.

Mid-term goal: Mongolia should aim to be ready for implementation of BIM Stage 2 by 2030. The objective of the mid-term goal is to elevate the construction industry in Mongolia to an international level by achieving Stage 2 maturity in BIM implementation. This stage focuses on expanding the use and capabilities of BIM beyond simple 3D model-based coordination, laying the foundation for more advanced BIM practices. To meet this goal, it is crucial that government authorities responsible for construction projects are prepared to use BIM even before it becomes mandatory. This proactive approach ensures that the industry is ready to embrace advanced BIM practices as mandated by international standards. During this phase, technical infrastructures such as Common Data Environment (CDE) operation (ISO 19650), internet-based communication, hardware, and software will be widely utilized. These technological tools facilitate information sharing, coordination, and collaboration among various stakeholders in the construction industry.

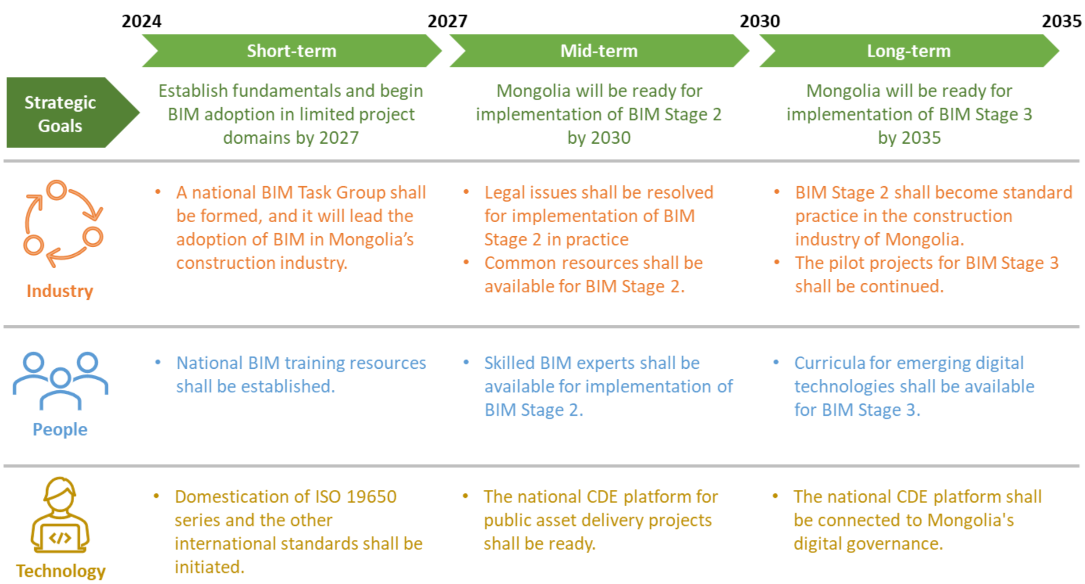


Figure 6: Strategic goals by phase and action framework

Close collaboration with relevant government departments is crucial to the success of this phase. This collaboration ensures that government policies and initiatives support and align with the adoption of BIM practices. It also helps in streamlining processes and removing any barriers or challenges that may hinder the successful implementation of BIM in the construction industry.

Long-term goal: Mongolia should be ready for implementation of BIM Stage 3 by 2035. The objective of the long-term goal is to finalize the digital transformation of the construction industry in Mongolia, marking a significant milestone in the adoption and integration of advanced technologies. This phase is in alignment with the strategies of advanced countries in expanding the applications of model-based construction information to reach the highest level of the BIM maturity model. With BIM technology firmly established in the construction industry, this phase aims to shift the focus towards leveraging model-based information to increase productivity and ensure safety throughout the entire lifecycle of built environments. By harnessing the power of digital information, stakeholders can make informed decisions, streamline processes, and optimize resource utilization from design to construction to facility management. Research and development efforts will play a crucial role during this phase as stakeholders seek to adopt and implement new technologies. Researchers will be at the forefront of driving innovation by exploring emerging technologies, conducting pilot projects, and validating the potential impact of these technologies on the construction industry in Mongolia.

Finally, the framework is separated into three aspects.

1) The first aspect is industry, which covers the requirements and plans for promoting BIM implementation in the construction industry of Mongolia.
2) The second aspect is people, which deals with policies and plans for upskilling human resources as enabling components for BIM implementation in the industry.
3) The third aspect is technology, which describes the technical infrastructures necessary for implementing BIM.

6 Conclusions

This study presents a structured approach to advancing BIM adoption in Mongolia's construction sector through an integrated SWOT and PESTLE analysis, forming the basis of short-, mid-, and long-term strategic goals aligned with BIM maturity stages.

- The short-term goal aims to establish foundational BIM practices, focusing on 3D coordination by 2027, supported by standardized guidelines, legal frameworks, and a qualified BIM workforce.
- The mid-term goal targets BIM Stage 2 maturity by 2030, with expanded applications and digital infrastructure, like Common Data Environments, enabling more advanced BIM practices. This phase emphasizes collaboration with government to ensure alignment of policies and infrastructure with industry needs.
- The long-term goal envisions full digital transformation and readiness for BIM Stage 3 by 2035, integrating BIM across the lifecycle of construction projects to maximize productivity and safety. Research and development will be essential in this phase, promoting ongoing innovation and alignment with global standards.

The recommended framework addresses BIM adoption across industry, people, and technology, offering a balanced pathway for Mongolia’s construction sector to progress through each maturity stage, align with international standards, and establish a foundation for sustainable digital transformation. While this study provides a comprehensive macro-level analysis of BIM adoption in Mongolia using SWOT and PESTLE frameworks, the limited availability of specific data on BIM implementation about Mongolia suggests that future research should focus on micro-level studies to validate these findings and offer more actionable insights.

Acknowledgments

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