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Critical BIM Adoption Barriers in Design and Build Projects: A Delphi Study from Nepal

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ABSTRACT
Building Information Modeling (BIM) has the potential to significantly enhance coordination, efficiency, and decision-making in construction projects. However, the use of BIM is still limited especially in Design and Build (D&B) procurement processes where strong coordination between project stakeholders is required. The construction industry in Nepal is slowly shifting to digital transformation, but the major obstacles that prevent the implementation of BIM in D&B projects have not been fully investigated. This study aims to identify and prioritize the most important obstacles to the adoption of BIM in Design and Build projects in Nepal. A Delphi technique was used to achieve agreement among professionals in the Architecture, Engineering, and Construction (AEC) sector of Nepal. The Delphi study was conducted in three rounds. The initial round established possible barriers to BIM adoption based on qualitative contributions of professionals. These barriers were quantified and narrowed down in the subsequent rounds through structured questionnaires and descriptive statistics, such as mean scores, interquartile range, and percentage agreement, to find a consensus. The findings reveal that organizational and technical factors are the most important impediments to the BIM implementation in Design and Build projects in Nepal. It is evidenced by the existence of a high degree of expert consensus. The most important barriers are the lack of technical infrastructure (93%) and the lack of national BIM standards (93%). They are followed by weak management commitment (87%) and financial incentives (87%). Another issue of concern is the Lack of BIM training and skills (80%). Mandatory BIM policy (73%), software interoperability issues (67%), and uncertainty of return on investment (67%), received lower agreement. Overall, the ranking is: lack of technical infrastructure = lack of BIM standards > weak management commitment = financial incentives > Lack of BIM training and skills> Mandatory BIM policy > software interoperability issues= uncertainty of return on investment. These findings suggest that technological preparation and institutional encouragement matter more than matters of money and implementation. The ranking is also useful in clearly differentiating the importance of the various barriers from each other.

Keywords: Building Information Modeling (BIM), Design and Build (D&B), BIM barriers to adoption, Delphi approach, Nepalese AEC Industry.

1. INTRODUCTION

BIM is a rapidly growing digital technology that has been identified as a revolution in the construction sector. It allows the coordination of project information and enhances the process of design, communication, and decision-making throughout the project life cycle. BIM also facilitates the management of time, cost, and quality in the delivery of a project [1]. BIM has been embraced by many developed nations to enhance productivity, eliminate design mistakes, and improve collaboration of the project [2], [3]. Consequently, BIM has turned into standard practice in some of the developed construction markets. However, the situation is different in most developing countries.

The implementation of BIM is still a slow process because it lacks institutional backing, lacks technical capacity, and faces organizational change resistance. These issues limit the shift of the traditional project delivery approaches to the digital construction approaches [4]. In most instances, the construction industry continues to depend on disjointed work processes and paper-based records, which restrict the value of the digital technologies available. Previous study has revealed that the use of BIM in developing countries is affected by various barriers. They are the lack of qualified specialists, high cost of implementation, absence of national standards, and doubt on the payback period [5]. Moreover, not all organizations have the technical infrastructure and managerial dedication necessary to successfully implement BIM.

Design and Build (D&B) procurement system is a procurement system that has gained popularity in construction projects since both design and construction are seriously handled in a single contractual agreement. The strategy has the potential to enhance coordination, minimize conflicts, and decrease the delivery time of projects. Nonetheless, Design and Build projects heavily rely on the exchange of information and cooperation among the stakeholders. BIM has the potential to facilitate this integration through a common digital platform on which design coordination, clash identification, and visualization of the project can be done [6]. The BIM is demonstrated to enhance coordination and minimize design conflicts in integrated delivery systems in several international projects. As a case in point, the Heathrow Airport Terminal 5 project (UK) has become more coordinated with the help of integrating the design using BIM. Clash detection and multidisciplinary coordination involved in the Cross-rail project (UK) made use of BIM and minimized design errors. On the same note, the Marina Bay Sands project (Singapore) utilized BIM to enhance the coordination of the stakeholders and the construction efficiency.Despite these benefits, the use of BIM in Design and Build projects is low in most developing countries. Research indicates that adoption of BIM in developing countries is usually less than 30 percent, whereas in developed countries, the adoption is over 70 percent [3]. Such a gap is largely attributed to institutional, technical, and financial limitations. Regarding the situation in Nepal, the construction industry remains in the initial digital transformation phase. Most projects still stick to a traditional design process and disjointed communication systems. Thus, BIM is considering relatively new technology in Nepal, and its application is not yet supported by the institutions in the Architecture, Engineering, and Construction (AEC) industry. The research conducted in the past has found a number of impediments to BIM in developing nations. These are the lack of qualified BIM practitioners, the high cost of training and software, the absence of national standards, and resistance to change [1], [7]. Empirical results also indicate that shortage of professional competence and high costs of implementation have remained in the list of the top barriers, with an average score of over 4.0 out of 5.0. [1], [7]. But in Nepal, there is less empirical investigation regarding the adoption of BIM. Specifically, there is very limited research on the application of BIM under Design and Build procurement systems, where the aspect of integrated digital collaboration is particularly significant. Thus, there is still no explicit insight into the key obstacles that influence the adoption of BIM in Design and Build projects in Nepal. It is significant to identify such barriers to enhance digital transformation in the Nepalese construction industry and contribute to more effective project delivery.To fill this research gap, this study uses the Delphi method to determine and rank the BIM adoption barriers in Design and Build projects in Nepal. The Delphi technique is the most appropriate method to execute this kind of research, as it enables the structured consultation with the specialists and assists in the development of the consensus due to the repetitive cycle of checks [8]. The study seeks to identify the most important obstacles that inhibit the use of BIM by gathering professional views of professionals in the Nepalese AEC industry.

The adoption of Building Information Modeling (BIM) in Nepal is underdeveloped, even though the AEC industry is becoming more aware of it. The present study determines that organizational preparedness, technical capability, and policy facilitation are the most vital determinants affecting BIM application in the Design and Build (D&B) projects. The major obstacles are a lack of appropriate technical infrastructure, a lack of competent professionals, and a lack of national BIM guidelines [10]. Although the issue of financial constraints should be mentioned, institutional and organizational issues are more important. The results reveal a distinct discrepancy in the use of BIM in the whole procurement systems, like D&B [9]. These challenges can be overcome by means of specific policy frameworks, capacity formation, and strategic adoption, which will help to accelerate the uptake of BIM and foster the digital transformation of the Nepalese construction industry [8].

2. LITERATURE REVIEW

2.1 BIM Implementation in Construction Project: BIM is a significant digital construction technology. It enables the project stakeholders to develop, administer, and disseminate project data within a shared online platform. BIM enhances visualization, design coordination, and communication between project participants during the project life cycle [9].

Some studies have found BIM to enhance project performance. According to [2], better cost control and risk management are aided by BIM in the delivery of projects. In the same way, [6] discovered that BIM can reduce design errors and project rework by detecting clashes at an early stage and enhancing the planning. These benefits lead to scheduled performance and project coordination.

Numerous developed nations have strongly supported BIM uptake through both national policy and industry programs. Nations like the United Kingdom, Singapore, and Finland have also established national strategies and guidelines for BIM to facilitate digital construction [9]. These programs have enhanced the adoption of BIM and standardization in the construction industry.

Nevertheless, the adoption of BIM in the developing countries is not even. Research has shown that institutional capacity, market preparedness, and technological infrastructure vary between these areas, which affect the implementation of BIM [8]. Consequently, the degree of BIM diffusion in construction markets is very different around the world.

2.2 Barriers to BIM Adoption: Irrespective of its advantages, BIM implementation has some challenges. Past research has established various forms of barriers that influence the adoption of BIM in construction projects. These obstacles are usually categorized as technical, organizational, financial, and policy-related [1].

Lack of proper hardware and software systems, interoperability among various BIM systems, and a low level of technical support are technical barriers [1]. Collaboration and information exchange can also be impacted by compatibility between the software used by various stakeholders of the project.There are significant organizational obstacles to the implementation of BIM, which are pointed out in the literature. Nepal Construction firms and the AEC organizations are usually characterized by a slow adoption rate. This is primarily because of resistance to change, insufficient management commitment, and poor awareness of BIM [10]. Moreover, most of the organizations have a problem of locating competent BIM professionals who have the relevant technical knowledge. These are additional problems that slow down the adoption of BIM in the industry.Another significant issue is financial barriers. The implementation of BIM is known to be highly costly in terms of initial costs for software, training, and integration of systems. Small and medium-sized firms (SMEs) within the construction industry may find these costs quite demanding [6]. Moreover, the lack of confidence in the payback of investment can deter organizations from using BIM.Diffusion of BIM is also influenced by policy and regulatory hurdles, particularly in developing nations. The lack of national standards of BIM, insufficient regulatory measures, and poor government support may delay systematic adoption of BIM practices [11]. According to several studies, effective BIM implementation depends on leadership in the government and industry guidelines.Implementation of Building Information Modeling (BIM) in the Nepalese construction sector is associated with several challenges that are critical. These obstacles restrict their broader use. They are broadly categorized into technical, organizational, financial, and policy-related factors [1]. Technologically, inadequate hardware and software, a problem in interoperability, and insufficient technical competence inhibit the useful application of BIM [1]. The construction companies are resistant to change, lack BIM awareness, and management support, which hampers digital transition on the organizational level [10]. Monetary problems also have a significant part. Software, training, and system integration are expensive, and this deters their adoption, particularly among medium and small-sized companies [6]. Furthermore, there are no national standards of BIM and regulatory frameworks, which also restrict systematic implementation [11]. Altogether, these issues demonstrate that the use of BIM in Nepal is at its initial phase and needs firm encouragement from both industry and policymakers.In the case of Design and Build (D&B) projects, it is even more difficult. These projects involve a lot of coordination and exchange of information, which can be easily facilitated by BIM [6]. Nevertheless, the application of BIM in D&B projects in Nepal is very small. Most of the current literature is concerned with the general adoption of BIM and does not address the problem of procurement [8]. This poses a knowledge gap in the application of BIM in integrated delivery systems, such as D&B. Thus, the proposed research will analyze the application of BIM in D&B projects in Nepal and find the main obstacles. The results will be useful to the policy makers, practitioners, and researchers in that they will offer practical insights to support policy formulation and enhance the adoption of BIM in integrated project delivery.The methodology employed in the study is the Delphi method, which is employed to come up with expert consensus on complicated issues [12]. It entails several cycles of questionnaires where feedback is controlled between one cycle and another [5]. This is being done to ensure that the opinions of experts are revised and fine-tuned with time. The approach is common in the study of construction to establish the critical factors and obstacles [13]. It is appropriate in this paper since BIM implementation in Nepal is in its infancy and is not based on hard facts. Judgment of experts is thus significant. The Delphi method guarantees a systematic and trustworthy way of data collection and analysis, which enhances the quality of the research.

2.3 Research Gap

Despite the extensive research done on BIM, most of it has concentrated on the developed world. There is a paucity of empirical research on BIM applications in developing nations [12]. The construction industry in Nepal has some distinctive institutional, economic, and technological issues that can affect the implementation of BIM.Moreover, there is scant literature on the adoption of BIM in Design and Build procurement systems. Design and Build projects entail integrated project delivery wherein design and construction are under one contract. BIM is especially applicable in such projects, as it involves a high level of coordination and information dissemination between the stakeholders.Nevertheless, past research has largely used questionnaire research or case studies. Minimal literature has used consensus-based expert techniques to systematically detect and rank BIM adoption barriers. The Delphi method is one of the most well-known methods of structured knowledge collection and the formation of a consensus on complex issues among experts [13].Consequently, research in which the Delphi technique is used to determine and rank barriers to BIM adoption in Design and Build projects in Nepal is timely and even required. This study addresses this gap by giving expert opinions on the most important barriers that influence the implementation of BIM in the Nepalese construction industry.

3. METHODOLOGY

3.1 Research Design: This study adopted the Delphi research methodology to establish barriers to Building Information Modeling (BIM) adoption within Design and Build projects in Nepal and prioritize them. The Delphi technique is prevalent in achieving expert opinion on complicated issues where there is inadequate empirical evidence [12].

The study adopted a sequential qualitative-quantitative research design. The initial round of Delphi gathered qualitative views from the experts on the barriers to BIM adoption. The outputs of this step were then converted into quantifiable statements. These statements were then assessed quantitatively in the second and third round to establish the degree of expert consensus.

The Delphi method was chosen in the sense that it provides the opportunity to consult experts in a structured manner with a series of feedback and preserves anonymity among the participants. The process assists in the refining of the experts' opinions and the creation of consensus on the crucial matters [5].

3.2 Expert Panel and Sampling Strategy: The Delphi panel comprised 15 professionals in the Nepal Architecture, Engineering, and Construction (AEC) industry. Participants were selected using a purposive method in which the participants had knowledge and experience in BIM implementation and Design and Build procurement systems.

The selection criteria used to choose experts were:

• 10 years of professional experience in construction projects.
• First-hand experience of BIM application or Design and Build projects.
• Work experience in construction management, civil engineering, architecture, or other related areas on a professional or academic level.

The panel consisted of industry practitioners as well as academics. This mix was to provide a balanced view of the challenges of BIM adoption in Nepal.

The 15 experts' sample size is in line with suggestions in Delphi research, whereby the panel of experts is between 10-20 individuals [4].

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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3.3 Instrument Development and Validation.

The research tool was created based on a literature review on the barriers to BIM adoption. It was found that the challenge of BIM implementation in construction projects has been studied in the literature, and that the possible factors of barriers were identified.

In Delphi Round 1, the open-ended questions required the experts to explain the key issues that influence the adoption of BIM in Design and Build projects in Nepal. Thematic analysis was used to analyze the responses, and common responses were put into common barrier categories. The results of Round 1 were applied to design a systematic questionnaire in Round 2. The questionnaire had statements that were used to identify the barriers.

The questionnaire was pre-tested by two BIM researchers and two industry professionals to ensure it was clear and reliable.

The level of agreement with every barrier statement was measured using a five-point Likert scale:

1 – Strongly Disagree
2 – Disagree
3 – Neutral
4 – Agree
5 – Strongly Agree

3.4 Data Collection Procedure

The Delphi method was done in three rounds among the expert respondents.

During Round 1, the professionals were invited to provide their views on the adoption barriers of BIM using open-ended questions. The data were gathered via email communication and summarized to be analyzed qualitatively.

During Round 2, the structured questionnaire that was created based on the results of Round 1 was distributed to the same panel of experts. The participants were requested to rate each barrier on a five-point Likert scale.

During Round 3, the participants of Round 2 were told the outcomes. The statements that failed to achieve the necessary degree of consensus were reconsidered. Experts had a chance to reconsider their responses with reference to the group feedback.

This cyclic process enabled the research to polish the opinions of experts and reach a consensus.

3.5 Data Analysis

Descriptive statistical analyses were done to analyze the responses of the Delphi Round 2 and 3. SPSS was used for the analysis. The relative importance of each barrier was measured using the mean score. Mean values are higher, which is more important. Median was used to determine the central tendency and stabilize the responses. The variation in opinions of the experts was measured using standard deviation. The level of consensus was measured using the interquartile range (IQR), with lower values showing strong agreement. Moreover, the percentage agreement was computed to depict the level of the experts who considered each barrier to be high. The agreement was to be confirmed at 80 percent. Those barriers that failed to pass this mark were reassessed in Delphi Round 3. These statistical indicators were used to acknowledge and prioritize the greatest obstacles to BIM adoption in Design and Build projects in Nepal.

4. RESULT AND ANALYSIS

4.1 Determination of BIM Adoption Barrier Categories

The initial phase of the Delphi research was to determine the significant obstacles that influence the adoption of BIM in Design and Build projects in Nepal. Open-ended questions were posed to the experts to express their opinions regarding the key issues related to BIM implementation.

Thematic analysis was used to analyses the responses. Similar responses were separated into larger themes denoting typical obstacles to BIM adoption. There were four significant categories of barriers:

1. Organizational and technical barriers.
2. Policy and regulatory obstacles.
3. Financial and economic obstacles.
4. Barriers to implementation and structure.

These categories are indicative of the multidimensional characteristics of the BIM adoption issues in the construction industry. The same classifications have been observed in past BIM adoption research [9], [11], [14]. The categories identified were utilized to create the structured questionnaire in the Delphi Round 2.

4.2 Round 2 Delphi Statistical Findings

The respondents in Delphi Round 2 rated the identified barriers based on a five-point Likert scale by the experts. The answers were evaluated with the help of descriptive statistics such as the mean scores, interquartile range (IQR), and percentage agreement.

Table 4.1 displays the levels of consensus that were achieved on barriers to BIM adoption that were selected.

Table 4.1: Expert Consensus on BIM Adoption Barriers (Round 2)

Barrier	Category	% Agreement	Interpretation
Lack of technical infrastructure	Organizational & Technical	93%	Very high consensus
Weak management commitment	Organizational	87%	High consensus
Lack of BIM training and skills	Organizational	80%	Moderate to high consensus
Software interoperability issues	Technical	67%	Moderate consensus
Lack of national BIM standards	Policy & Regulatory	93%	Very high consensus
Mandatory BIM policy	Policy & Regulatory	73%	Moderate consensus
Financial incentives for BIM adoption	Economic	87%	High consensus
Uncertainty about return on investment	Economic	67%	Moderate consensus

The findings show that the absence of technical infrastructure was the most agreeable (93%), meaning that technological preparedness is a significant challenge in implementing BIM in Nepal. The same results have been observed in other developing nations where digital infrastructure and BIM skills are at an early stage of development [2].

Weak management commitment also had a high level of agreement (87%), which implies that organizational leadership is a crucial factor that aids in digital transformation. Other studies in the past have also highlighted that the success of BIM adoption depends on a high level of managerial support [15].

Among the crucial barriers identified by experts, there was also a high level of consensus concerning the lack of skills in BIM professionals and a deficiency in training (80%). This observation means that the BIM education and professional training programs should be enhanced to facilitate the adoption of BIM in Nepal.The results indicate that the most affecting factors in the adoption of BIM in Design and Build projects in Nepal are organizational preparedness and technical capacity. The importance of management commitment, technical infrastructure, and skilled professionals is stressed by high consensus on these factors. This implies that the implementation of BIM should be supported by organizational support and strong technical competence.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
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4.3 Policy and Regulatory Barriers: The experts cited policy-related issues as significant impediments to the implementation of BIM. The experts were at a high consensus (93%) when it comes to the absence of national BIM standards and guidelines. This observation implies that the lack of a concrete regulation framework constrains the systematic implementation of BIM in the construction industry.

Most of the professionals underlined that national policies on BIM might enhance coordination and standardization of construction projects. The implementation of national BIM mandates in countries has had a positive effect on faster digital transformation in the construction industry[16]. The degree of consensus on the mandatory BIM policies, however, was reduced (73%). This disparity shows that professionals have divergent opinions on the issue of when and how BIM mandates can be enforced in Nepal. Other experts are convinced that the industry is not yet ready to implement mandatory BIM because of the lack of technical capacity and finances.

The findings are in line with the past research in developing nations. The Nepal context, however, is more dependent on the government. Specifically, policy making and institutional arrangements are important in supporting the use of BIM.

4.4 Economic Barriers: Economic factors were also considered a major obstacle to BIM adoption. There was a high level of agreement between the experts (87% on the relevance of financial incentives to facilitate the implementation of BIM). This observation indicates that financial sponsorship tools may prompt organizations to implement BIM technologies.

On the other hand, doubt about the payback of the investment (ROI) drew moderate consensus (67%). This difference points to the fact that, although there are those professionals who see the long-term advantages of BIM, others are still wary of the financial costs of implementation. This issue is especially applicable to small and medium-sized construction companies that might have problems investing in BIM software, training, and system integration.

The same issues were reported in earlier research, which also states that the high initial cost of investment usually discourages organizations from using BIM technologies [6].

All in all, the results suggest that it is necessary to enhance organizational capacity, increase professional training, and create effective BIM policies. The measures will be able to speed up the implementation of BIM in the Nepalese construction industry.

5. PRACTICAL IMPLICATIONS

The results of this research have several practical implications for policymakers, industry practitioners, and academic institutions that are concerned with the construction industry.Firstly, the findings suggest that there is a necessity to establish national BIM standards and implementation guidelines in Nepal. An effective regulation framework may offer guidance to industry players and promote a more uniform uptake of BIM in construction projects.Second, there should be increased capacity building and professional training programs to overcome the lack of skilled BIM professionals. Universities, professional institutions, and industry organizations can be of significant help in incorporating BIM education and training as part of engineering and construction management programs.Third, funding systems can contribute to the minimization of the obstacles to the initial investment in BIM software, training, and system integration. Small and medium-sized firms can also be encouraged to use BIM technologies by government incentives or industry support programs.

Fourth, companies should encourage commitment to digital transformation at the management level. Leadership support is also needed in terms of resource allocation, organizational learning encouragement, and resistance to new technologies.

Lastly, BIM adoption in Nepal can be enhanced by a staged adoption approach. A phased adoption would enable organizations to develop technical capacity and acquire the required skills prior to large-scale BIM integration.

6. CONTRIBUTIONS OF THE STUDY

This research has several contributions to the body of knowledge.

First, it provides empirical data regarding the obstacles to the adoption of BIM in the Nepalese construction sector, where little research has been done before. The study enhances the knowledge of the challenges that influence digital transformation in the context of developing countries by identifying and prioritizing the most critical barriers.

Second, the research specifically examines Design and Build procurement systems that have not been addressed in relation to BIM adoption research. In Design and Build projects, coordination between design and construction teams is very high. Thus, it is especially relevant to understand the BIM adoption barriers in this procurement system.

Third, the paper uses Delphi method to achieve consensus among experts regarding barriers to BIM adoption. Although questionnaire surveys are used in many of the earlier studies, the Delphi method enables structured consultation with the more experienced professionals and assists in identifying the most significant barriers with the help of repetitive evaluation.

Lastly, the results give ground to future studies on the strategies of BIM implementation in developing nations. The findings can be helpful in shaping policy-based and industry-wide guidelines to adopt BIM in Nepal and other construction sectors.

7. LIMITATIONS AND FUTURE RESEARCH

Although this study contributes, it has a few limitations.

To begin with, the Delphi panel comprised 15 experts, which is adequate in the context of Delphi research but might restrict the extrapolation of the results to the whole construction industry. A more diverse and bigger expert panel could be used in future research.

Second, the research was specific to D&B procurement systems. The challenges of BIM adoption in other procurement approaches applied in construction projects might be experienced differently.

Third, the study considered obstacles to the adoption of BIM but failed to assess long term performance effects of BIM implementation. Future studies may explore the impact of BIM adoption on project outcomes in terms of cost efficiency, schedule performance, and quality enhancement. The longitudinal studies of BIM adoption over time can also shed more light on the digital transformation of the construction industry in developing countries.

8. CONCLUSIONS

This paper analyzed the obstacles to BIM implementation in the Design and Build projects in Nepal through Delphi research. The findings reveal that the readiness of the organization, technical infrastructure, and policy support are the most effective factors that influence BIM implementation.

The results indicate that management commitment, professional skills, and national standards of BIM are important to enhance BIM adoption. Although the role of financial barriers cannot be ignored, organizational and institutional factors seem to be a more prominent issue in the context of Nepalese construction industry.

This research has valuable information for policy formulators, the construction industry, and other stakeholders in the industry by identifying and ranking the main obstacles to BIM adoption. The results can be used to recommend strategies to enhance the application of BIM and speed up the digital transformation in the Nepalese construction industry.

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