Investigating Key Steps and Actions to Implement BIM in Construction Industry of Pakistan through Mixed Methods Approach

FINAL YEAR PROJECT UG – 2020

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CERTIFICATION

This is to certify that the

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ABSTRACT

Building Information Modelling (BIM) represents a transformative technology with the potential to revolutionize the construction industry by enhancing collaboration, minimizing errors, and boosting efficiency. Despite its advantages, the adoption of BIM within Pakistan's construction sector has been sluggish due to various obstacles. This study aims to identify these specific barriers and propose concrete actions to overcome them, employing a triangular approach that integrates surveys, interviews, and real-time case studies to develop a comprehensive action framework. The research uncovers barriers and actions through the lens of Kotter's 8-Step Model, offering a structured plan for BIM adoption in Pakistan. The key barriers identified include a lack of awareness, high initial costs, and resistance to change. The study underscores the critical role of government support, the need for education and training, and the cultural shift towards viewing BIM as a standard practice. It concludes that a multifaceted approach is essential to surmount these obstacles, which involves creating a sense of urgency, building a guiding coalition, developing a strategic vision, and maintaining momentum. The findings highlight that sustaining BIM implementation is paramount, achievable through leveraging credibility from previous projects, implementing KPIs to assess effectiveness, and forming a strategic vision. Additionally, the study stresses the importance of government policies and regulations in supporting BIM adoption and advocates for a fundamental change in construction project management. Overall, this study presents a thorough framework for BIM adoption in Pakistan, detailing the specific barriers and necessary actions to overcome them. The findings have significant implications for policymakers, industry leaders, and practitioners aiming to implement BIM in Pakistan, providing a roadmap for successful adoption and implementation.

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INTRODUCTION

1.1 Recent Advancement in BIM around the world

In recent years, Building Information Modeling (BIM) has emerged as a promising technology in the construction industry, fundamentally altering the dynamics of the sector (Takim et al., 2013a). BIM facilitates enhanced collaboration, improves project efficiency, and reduces costs, marking a significant shift from traditional manual methods to digital processes in the construction industry (Girginkaya Akdag & Maqsood, 2020a). It enables stakeholders to visualize the construction process comprehensively during its execution and provides critical information about the project before its actual construction (Chang-Liu et al., 2018). This transition to BIM has been notably embraced by construction industries in the United States, United Kingdom, and Singapore, where it has become a standard practice (Volk et al., 2014). However, despite its proven benefits, the adoption of BIM in Pakistan’s construction industry remains limited and faces numerous barriers (Farooq et al., 2020a).

1.2 Challenges and Benefits of BIM adoption in Pakistan

The construction industry in Pakistan is confronted with significant challenges in adopting innovative project management approaches such as BIM. These approaches have the potential to revolutionize project efficiency and sustainability but are hindered by a reluctance to move away from traditional practices (Richesin, 2011). This resistance has resulted in a significant gap between global advancements in project management and the practices currently prevalent in Pakistan. The implementation of BIM is not just a technological shift but a crucial step towards improving project outcomes and meeting the evolving needs of Pakistan's construction sector. BIM technologies offer several advantages, including enhanced collaboration, improved project visualization, and streamlined workflows, which collectively have a profound impact on project efficiency and quality (Haas et al., 2019).

Despite the clear benefits, several barriers impede the widespread adoption of BIM in Pakistan. These include a lack of awareness about BIM, insufficient support from stakeholders, low industry motivation, and a shortage of technical expertise (Sacheva, 2009). Addressing these barriers is essential to unlocking the full potential of BIM in Pakistan's construction industry. A comparative analysis between traditional construction processes and BIM methodologies highlights significant efficiency gains and technical improvements that BIM adoption can bring to the Architecture, Engineering, and Construction (AEC) sector (Wilson et al., 2015). For instance, while traditional methods often lead to design errors, delays, and increased costs due to change orders, BIM's integrated approach helps mitigate these issues, leading to better project outcomes (Einur Azrin Baharuddin et al., 2019).

Globally, the construction industry has experienced a paradigm shift with the adoption of BIM. In countries like the United States, the United Kingdom, and Singapore, BIM has become integral to construction projects, driven by government mandates and industry standards (Volk et al., 2014). These countries have demonstrated that BIM not only improves efficiency but also enhances project predictability, reduces costs, and improves overall project quality. For example, in the United Kingdom, the government's BIM Level 2 mandate has led to widespread adoption, resulting in substantial cost savings and improved project delivery times. These countries have established comprehensive frameworks and support systems to facilitate BIM adoption, including training programs, certification processes, and incentives for early adopters.

In contrast, the construction industry in Pakistan has been slow to adopt BIM, largely due to a combination of cultural inertia, lack of technical skills, and insufficient stakeholder engagement (Farooq et al., 2020a). This slow adoption is despite the potential for BIM to address many of the chronic issues facing the sector, such as project delays, cost overruns, and poor project coordination. The lag in adoption can be attributed to the deeply ingrained traditional practices that dominate the industry, coupled with a fragmented regulatory environment that lacks the push needed to drive widespread change.

1.3 Impediments in adoption of BIM in Pakistan

The barriers to adopting BIM in Pakistan are varied and complex. Firstly, there is a notable lack of awareness regarding BIM and its potential benefits. Many stakeholders in the construction industry, such as contractors, architects, and clients, either do not know about BIM or hold misconceptions about its uses and advantages (Sacheva, 2009). This lack of awareness is exacerbated by insufficient training and educational opportunities related to BIM. Few institutions in Pakistan offer comprehensive BIM training programs, resulting in a shortage of skilled professionals capable of implementing and managing BIM projects. Without a critical mass of knowledgeable professionals, BIM adoption is likely to remain limited.

Secondly, there is a lack of support from key stakeholders, including government bodies, construction firms, and clients. The absence of regulatory mandates and incentives for BIM adoption means there is little motivation for firms to invest in BIM technologies and training. In countries where BIM has been successfully implemented, government policies and incentives have played a crucial role in encouraging adoption (Volk et al., 2014). In Pakistan, the lack of such policies and incentives is a significant barrier. Additionally, the fragmented nature of the construction industry, which comprises numerous small and medium-sized enterprises (SMEs) that may lack the resources to invest in new technologies, further complicates BIM adoption.

Moreover, the construction industry in Pakistan is characterized by a high degree of fragmentation and a reliance on traditional methods. This fragmentation makes it challenging to achieve the level of collaboration and integration required for effective BIM implementation.

Traditional methods, although familiar and well-established, are often inefficient and do not provide the same level of accuracy and predictability as BIM. The inertia associated with these traditional methods is a significant impediment to adopting innovative approaches like BIM.

Another critical barrier to BIM implementation is the absence of standardized procedures and protocols. This situation is akin to running a race without knowing the start and endpoint, leading to each organization adopting practices based on their own benefits, which can result in inefficiencies. Establishing a standard framework by a regulatory authority is crucial for maximizing BIM integration..

1.4 Opportunities in adoption of BIM

Despite these challenges, the potential benefits of BIM for Pakistan's construction industry are substantial. BIM can significantly enhance the efficiency and effectiveness of construction projects. By offering a detailed and accurate digital representation of a project's physical and functional characteristics, BIM allows for better project planning and management. This can result in fewer errors and rework, shorter project durations, and reduced costs (Einur Azrin Baharuddin et al., 2019).

Additionally, BIM can improve collaboration among the various stakeholders involved in a project. By providing a common platform for information sharing, BIM enhances communication and coordination, thereby reducing the chances of misunderstandings and conflicts. This is particularly crucial in Pakistan, where poor communication and coordination often lead to project delays and cost overruns. Enhanced collaboration can lead to more cohesive project teams, better decision-making, and ultimately, more successful project outcomes.

Another significant opportunity lies in BIM's potential to drive modernization and innovation within the industry. As the global construction industry evolves with technological advancements, it is essential for Pakistan’s industry to follow suit to remain competitive and relevant. The adoption of BIM can serve as a gateway for integrating other technologies in the construction industry, such as artificial intelligence, machine learning, and the Internet of Things (IoT). This technological synergy can further boost project efficiency, safety, and sustainability, enhancing the reputation of Pakistan’s construction industry as a forward-thinking sector and presenting a positive image on the global stage.

1.5 Strategies to overcome barriers to BIM Adoption

To overcome the barriers to BIM adoption in Pakistan, a comprehensive strategy involving all stakeholders is essential to highlight the importance of BIM and maximize its benefits. One crucial strategy is to educate and train individuals about BIM, emphasizing its significance in the construction industry. This can be achieved by incorporating BIM courses into the curricula of engineering, architecture, and construction management programs in educational institutions. Additionally, workshops and training sessions conducted by certified professionals can help new entrants enhance their skills.

Government intervention is also vital for the successful implementation of BIM. Developing policies that mandate the use of BIM in both public and private sector projects can serve as a catalyst for its adoption. Providing financial support to companies investing in BIM technology can encourage small and medium-sized enterprises to integrate BIM into their operations.

Finally, joint ventures between the government, educational institutions, and industry can create a supportive ecosystem for BIM. Establishing a proper framework and guidelines for BIM can set industry benchmarks, fostering a more cohesive and efficient construction sector.

1.6 Kotter’s 8 step for BIM in Pakistan’s Construction Industry

Additionally, BIM can enhance the quality of construction projects by promoting better design and construction practices. By simulating various aspects of a project before construction starts, BIM allows for the early identification and resolution of potential issues, leading to higher quality outcomes. This not only boosts client satisfaction but also enhances the reputation of construction firms that implement BIM. Furthermore, BIM's capability to integrate sustainability considerations into the design and construction process supports more environmentally friendly and sustainable practices, which are increasingly crucial in the current context of climate change and environmental degradation.

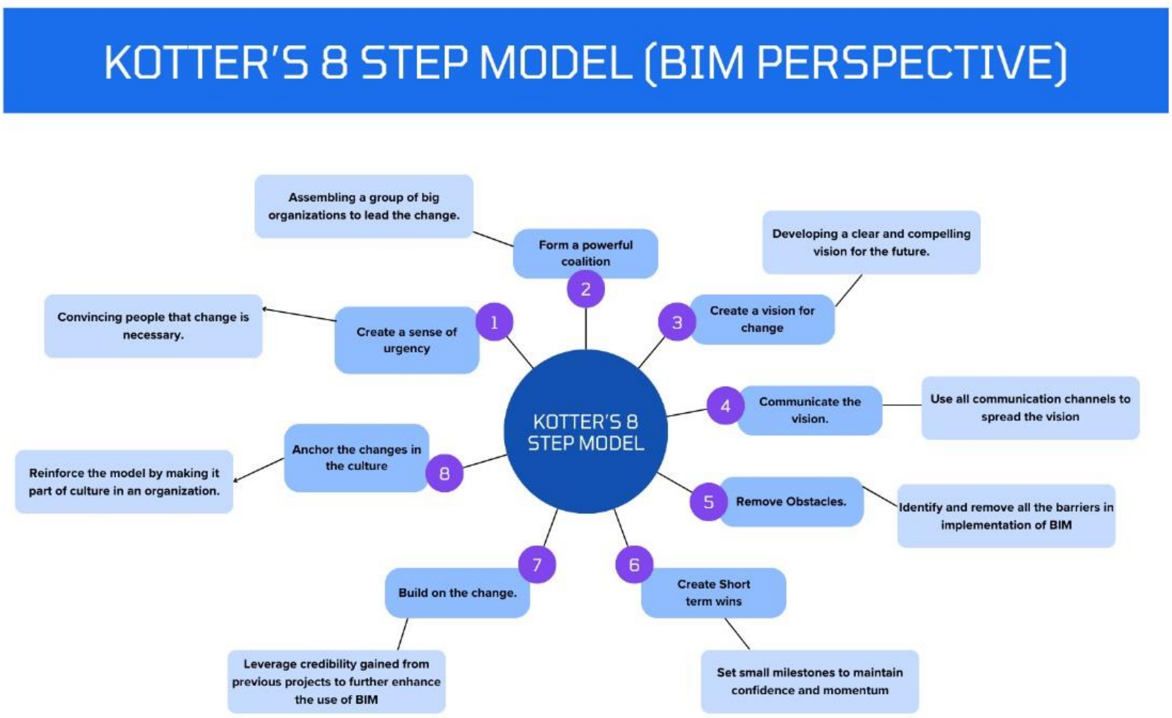


Figure 1: Kotter's 8 Step Model

Key points of Kotter’s 8 step model are:

i. Create a Sense of Urgency: Highlight the importance of adopting BIM to stakeholders by showcasing its potential benefits and the risks of not adopting it. For example, present case studies from countries like the UK and the US where BIM has led to significant improvements in project outcomes. Creating a sense of urgency helps communicate the disadvantages of using traditional methods despite the presence of new technology. This can be presented through data driven presentations that will compare the projects and their outcomes with and without BIM usage. Highlighting the problems faced through traditional methods such as project delays, cost overruns, and disputes between contractors and clients can encourage the change from traditional to the latest technology. Involving the industry leaders in highlighting the importance of BIM can also speed up the process of transitioning from traditional to new methods.

ii. Form a Powerful Coalition: Assemble a group of influential stakeholders who can champion the adoption of BIM and drive the change process. This coalition could include representatives from government bodies, leading construction firms, educational institutions, and industry associations. The coalition should have members who are not only powerful and influential but should also be passionate regarding innovation and technology. This group should have a clear vision and should have the authority to make decisions. The group should have a range of people having different perspectives to get different ideas regarding implementation of BIM.

iii. Create a Vision for Change: Develop a clear vision and strategy for how BIM will be implemented and how it will benefit the organization. This vision should be compelling and easy to understand, articulating the future state of the industry with BIM adoption. The visions should be detailed, and provide the timeline for specific goals and it should address how shifting to BIM from traditional methods can solve the issues of project delays, cost overrun etc. displaying the vision through visual graphics such as videos or roadmaps can make it more interesting.

iv. Communicate the Vision: Use every possible channel to communicate the vision and strategy to all stakeholders, ensuring that they understand and are on board with the change. This could involve workshops, seminars, online resources, and one-on-one meetings. The key to effective communication should be a multifaceted strategy. The vision can be maintained by regular updates via letters, seminars etc. Deeper stakeholder engagement can be achieved through discussion, feedback and different sessions. The message should be sent to segments of audience such as top and middle management.

v. Remove Obstacles: Identify and address barriers to BIM adoption, including lack of awareness, technical expertise, and stakeholder support. This may involve developing training programs, securing funding for BIM implementation, and addressing regulatory hurdles. A detailed assessment of internal and external barriers can help in outlining out of date procedures which could mean revising outdated policies and ensuring access to all the necessary software and hardware

vi. Create Short-Term Wins: Set achievable goals related to BIM implementation and celebrate small successes to build momentum. For example, start with pilot projects that demonstrate the benefits of BIM and use these successes to build broader support. Demonstrating short-term wins can be done by selecting such projects which can show the value of BIM in a short time. Celebrating these wing through awards and ceremonies can result in the team getting more motivated and getting a feeling that their investment in BIM is bearing fruit.

vii. Build on the Change: Use the credibility gained from short-term wins to tackle bigger challenges and continue improving BIM adoption. This involves continuously evaluating and refining the implementation process based on feedback and lessons learned. Increasing the efforts after gaining credibility through short term wins is important to scale up BIM usage. Regular trainings and seminar can ensure that the team is keeping up with the evolving BIM practices. A proper system for monitoring and evaluation is also required for long-term success.

viii. Anchor the Changes in Corporate Culture: Ensure that BIM becomes an integral part of the organization’s culture by embedding it in policies, procedures, and practices. This could involve revising job descriptions, performance metrics, and reward systems to align with BIM objectives. Anchoring changes is like incorporating BIM in the DNA of the organization. This can be done by incorporating BIM in required skills of jobs and the organizations can also require its employees to attend trainings or seminars to get familiar with BIM.

In summary, adopting BIM in Pakistan's construction industry is both essential and challenging. The advantages of BIM, including increased project efficiency, cost reduction, and improved collaboration, are evident. However, significant barriers impede its widespread implementation. Overcoming these obstacles through a structured change management approach, such as Kotter’s 8-Step Change Model, can facilitate a sustainable transformation in the industry. With government support, collaborative ventures, and educational initiatives, Pakistan can harness the potential of BIM and embark on a path toward technological advancement..

CHAPTER 2

LITERATURE REVIEW

2.1 Recent Industrial advancement and adoption of BIM across the globe

Building Information Modeling (BIM) is rapidly revolutionizing the design, construction, and management of buildings globally. BIM is a digital representation of a facility's physical and functional characteristics, extending beyond traditional 2D drawings by creating a 3D model with intelligent objects containing parametric data. This intelligent data facilitates collaboration, improves decision-making throughout the building lifecycle, and ultimately enhances project outcomes (Yasser Yahya Al-Ashmori, 2020).

The United States is a leader in BIM, developing and utilizing most of the BIM software, with this expertise often transferring to developing nations. Interestingly, Finland has also become a global leader in BIM implementation, even creating BIM software like Tekla and Vicosoft. While the US maintains a strong position, other countries such as the United Kingdom, Hong Kong, Singapore, South Korea, and Australia are also advancing towards national BIM adoption, showcasing a global shift towards this technology (Takim et al., 2013b).

Several factors contribute to this widespread adoption. Government initiatives that promote BIM use, including mandates for public projects, have been crucial (Succar, 2009). Additionally, industry standardization efforts by organizations like buildingSMART have facilitated interoperability between different BIM software platforms (Kelly et al., n.d.). Lastly, the increasing awareness of BIM's benefits, such as improved design efficiency, better clash detection, and enhanced facility management, has driven industry-wide adoption (Azhar et al., 2011).

2.1.1 Major hurdles in adoption of BIM in Pakistan

However, BIM implementation faces challenges around the world. One major hurdle is the high initial investment required for BIM software, hardware, and training, which can be a significant barrier for smaller firms (Succar, 2009). Additionally, the lack of standardized BIM workflows and data formats, often referred to as a lack of interoperability, can hinder collaboration across different project teams using various software (Kelly et al., n.d.). Another significant challenge is the skill shortage. Successful BIM implementation requires a skilled workforce with expertise in BIM software and processes. However, many countries face a lack of training programs and qualified professionals, hindering BIM adoption (Siddiqui, 2019a). Pakistan's construction industry stands to gain significant benefits from BIM adoption. However, the country faces several challenges that mirror those seen elsewhere. Limited awareness about BIM's capabilities among stakeholders like clients, architects, and contractors is a major hurdle (Olawumi et al., 2018).

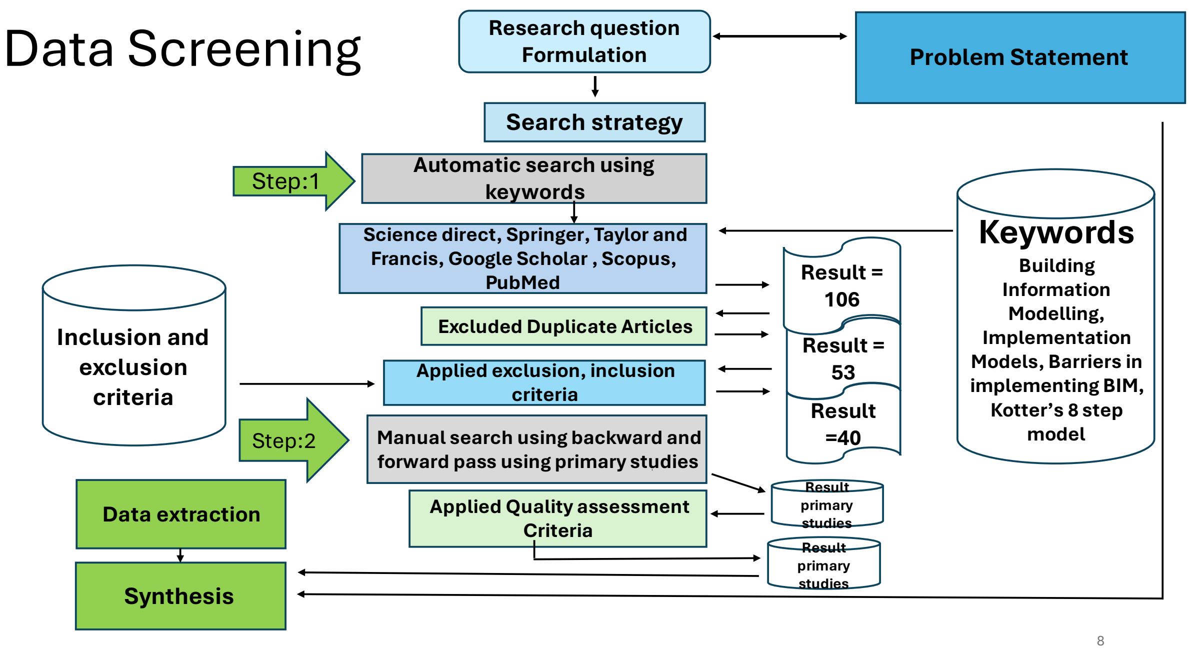


Figure 2: Literature Review Process

Many stakeholders still perceive BIM as simply 3D modeling, failing to grasp its potential for improved collaboration and information management. Additionally, the high initial investment cost for BIM software, hardware, and training can be a significant barrier for small and medium-sized enterprises (SMEs) that constitute majority of the construction sector (Siddiqui, 2019a). The lack of standardized BIM workflows and data formats within Pakistan can further exacerbate these challenges, creating interoperability issues between different project teams (Succar, 2009). Furthermore, a significant skills gap exists in the construction workforce regarding BIM software and processes. Limited training opportunities, particularly outside major cities, and a lack of emphasis on BIM education in universities contribute to this skills gap (Archchana & Pan, 2023). Finally, Pakistan's construction industry's fragmented structure, with numerous small, independent firms, hinders collaboration and standardization efforts essential for successful BIM implementation (Farooq et al., 2020c). This fragmented structure makes it challenging to establish common workflows and data exchange protocols across the industry.

2.2 The potential benefits of BIM adoption in Pakistan

Despite these challenges, the potential benefits of BIM are undeniable. Studies by (Waqar et al., 2023) highlight improved project efficiency, reduced rework, and better cost estimation as key advantages of BIM adoption. To overcome the hurdles and unlock BIM's potential in Pakistan, a multi-pronged approach is needed. Industry associations like the Pakistan BIM Council (Farooq et al., 2020c)) and government agencies can work together to raise awareness about BIM benefits through workshops, conferences, and educational programs (Succar, 2009). Financial incentives like tax breaks or subsidies from the government can encourage BIM adoption by SMEs (Howard et al., 2017). Establishing national BIM standards and guidelines, like efforts undertaken in developed countries, would promote interoperability and collaboration. Initiatives fostering BIM training for architects, engineers, and construction workers are crucial for building a skilled workforce (Muhammad & Shehzad, 2022).

Universities can integrate BIM modules into their curricula, and professional organizations can offer BIM certification programs. Finally, cloud-based BIM collaboration platforms can facilitate communication and data exchange within the fragmented construction industry (Manzoor et al., 2021). These platforms can help bridge the gap between geographically dispersed teams and promote a more collaborative approach to construction projects. But despite having so many benefits and information still BIM could not be implemented properly because proper framework is not given to it.(Almuntaser et al., 2018).

2.3 Different Implementation models used for adoption and Kotter's 8 step

A change model is a structured approach or framework designed to guide organizations through the transition from a current state to a desired future state. These models facilitate organizational change, help manage its impact on people, and ensure effective and sustainable implementation.

Kurt Lewin's Change Management Model, developed in the 1940s, is one of the earliest and most influential models in change management. It is based on three stages: Unfreeze, Change, and Refreeze. In the Unfreeze stage, the organization prepares for change by creating awareness about the need for change, dismantling the existing status quo, and overcoming resistance. The Change stage involves implementing new processes, structures, or behaviors, focusing on effective communication, support, and employee involvement. Finally, the Refreeze stage seeks to stabilize the changes made, embedding new practices into the organizational culture and ensuring their sustainability through reinforcement mechanisms such as policies, procedures, and ongoing support.

John Kotter introduced his 8-Step Change Model in 1996, outlining eight essential steps for successful organizational change. The steps begin with creating urgency by highlighting the need for change and identifying potential threats and opportunities to garner initial support.

Forming a powerful coalition involves assembling a group of influential people who support the change initiative, helping drive the effort. Creating a vision for change entails developing a clear and compelling vision to guide the change effort, aligning and motivating people. This vision must be consistently and frequently communicated across the organization. Removing obstacles involves identifying and eliminating barriers to change, whether structural, procedural, or cultural. Creating short-term wins by planning for and achieving visible, short-term successes helps build momentum and demonstrate the benefits of change. Building on the change means continuing to drive deeper and broader changes after initial successes, avoiding the premature declaration of victory. Finally, anchoring the changes in corporate culture ensures that new behaviors are rooted in shared values and norms, reinforcing the changes through integration into the organization's culture.

The ADKAR Model, developed by Prosci, focuses on individual change and is an acronym for Awareness, Desire, Knowledge, Ability, and Reinforcement. It emphasizes that successful organizational change occurs when individuals change. The model begins with ensuring individuals are aware of the need for change, communicating why change is necessary and the risks of not changing. Creating a desire among individuals to support and participate in the change is achieved by addressing personal motivations and potential benefits. Providing the knowledge needed to implement the change involves training, education, and access to information. Ensuring individuals have the skills and capabilities to apply the knowledge involves hands-on practice, coaching, and support. Finally, implementing mechanisms to reinforce and sustain the change includes recognition, rewards, and feedback to ensure the change sticks.

The McKinsey 7-S Model, developed by McKinsey & Company consultants in the late 1970s, identifies seven interdependent factors that must be aligned for successful change: Strategy, Structure, Systems, Shared Values, Skills, Style, and Staff. The model emphasizes that these seven elements are interconnected and must be balanced for effective organizational change. Strategy refers to the plan devised to maintain and build competitive advantage. Structure involves the way the organization is structured, including reporting lines and decision-making authority. Systems encompass the daily activities and procedures staff use to get the job done. Shared Values are the core values of the company, evidenced in the corporate culture and general work ethic. Skills refer to the capabilities and competencies within the company. Style pertains to the adopted leadership style. Staff involves the employees and their general capabilities.

William Bridges' Transition Model focuses on the emotional and psychological transition people undergo during change. It highlights three stages: Ending, Losing, and Letting Go; the Neutral Zone; and the New Beginning. The first stage involves helping people deal with their losses and let go of old ways, acknowledging the end of an era to begin the transition. The Neutral Zone is a critical psychological space where the old has ended, but the new hasn't fully begun, marked by confusion but also creativity and innovation. In the final stage, the New Beginning, people accept the change and begin to embrace new ways, marked by renewed energy, commitment, and future focus.

The Burke-Litwin Model of Organizational Change provides a comprehensive framework for understanding organizational change, identifying 12 key drivers of change and their interrelationships, emphasizing cause-and-effect relationships. The model includes External Environment, Mission and Strategy, Leadership, Organizational Culture, Structure, Management Practices, Systems, Work Unit Climate, Task and Individual Skills, Individual Needs and Values, Motivation, and Performance. External Environment factors outside the organization affect its performance. Mission and Strategy refer to the organization's purpose and how it plans to achieve it. Leadership involves the behavior and influence of the organization's leaders. Organizational Culture encompasses the collective norms and values.

Structure refers to the organization’s arrangement, including roles and responsibilities. Management Practices are the methods managers use to operate the organization. Systems are the procedures and processes guiding operations. Work Unit Climate is the atmosphere within work units. Task and Individual Skills refer to specific skills required for roles and tasks. Individual Needs and Values involve employees' personal motivations and values. Motivation encompasses the internal and external factors stimulating people to take action. Performance includes the outputs and outcomes of organizational processes and practices.

These models offer various perspectives and tools for managing change, helping organizations navigate transitions effectively by addressing both technical and human aspects of change.

2.4 Importance of Kotter’s 8 Step Model

John Kotter introduced his 8-Step Change Model in 1996 in his book "Leading Change." Kotter, a professor at Harvard Business School and a leading authority on organizational change, developed this model to address the high failure rate of change initiatives in organizations. He observed that most change efforts fail not because of the change strategy itself but because of the failure to engage and manage the people involved in the process. His model emphasizes the importance of a comprehensive, step-by-step approach to change management that considers both the rational and emotional aspects of change.

The 8-Step Change Model consists of the following stages: Create Urgency, Form a Powerful Coalition, Create a Vision for Change, Communicate the Vision, Remove Obstacles, Create Short-Term Wins, Build on the Change, and Anchor the Changes in Corporate Culture. The first step, Create Urgency, involves making the need for change visible and urgent. This step is crucial as it helps to build initial momentum and encourages the organization to start the change process. By identifying potential threats and opportunities, leaders can galvanize support for the change initiative. This sense of urgency needs to be genuine and well-communicated to ensure buy-in from all levels of the organization.

Form a Powerful Coalition, the second step, involves assembling a group of influential people who support the change. These individuals should represent different levels and functions within the organization and should have the credibility, skills, and influence to drive the change process. This coalition works together to build momentum and support for the change, ensuring that the initiative has the necessary backing to succeed. Having a strong coalition helps in overcoming resistance and provides a unified front that can effectively lead the change effort.

The third step, Create a Vision for Change, is about developing a clear and compelling vision that guides the change effort. This vision provides direction and helps align the organization's efforts towards the common goal. It is essential that this vision is simple, understandable, and inspiring. A well-crafted vision helps in motivating employees and serves as a constant reminder of the reasons for the change. Along with the vision, a strategic plan is developed to outline how the change will be implemented, detailing the steps and actions required to achieve the desired outcomes.

Communicating the Vision is the fourth step, emphasizing the importance of effective communication in the change process. The vision and strategy need to be communicated clearly and frequently to all stakeholders. This involves not just formal communication through meetings and presentations but also informal methods such as conversations and discussions. Consistent and transparent communication helps in reducing uncertainties and aligns the organization's members with the change objectives. It is crucial to address any concerns or questions that arise and to provide regular updates on the progress of the change initiative.

Removing Obstacles, the fifth step, focuses on identifying and eliminating barriers to change.

These obstacles can be structural, procedural, or cultural, and addressing them is critical for the success of the change initiative. This might involve changing existing processes, reallocating resources, or addressing attitudes and mindsets that hinder progress. By removing obstacles, leaders can ensure that the path to change is clear and that employees feel supported and empowered to embrace the new ways of working.

The sixth step, Create Short-Term Wins, involves planning for and achieving visible, short-term successes. These quick wins help build momentum and provide evidence that the change initiative is on the right track. Celebrating these early successes boosts morale, builds confidence in the change process, and helps to sustain the momentum needed for longer-term goals. It is important that these short-term wins are well-publicized and that the contributions of individuals and teams are recognized and rewarded.

Building on the Change, the seventh step, is about maintaining the momentum and driving deeper and broader changes after the initial successes. It is crucial not to declare victory too early but to continue pushing forward, consolidating gains, and identifying areas for further improvement. This step involves refining and expanding the change efforts, ensuring that the organization continues to progress towards its ultimate objectives. By maintaining focus and dedication, leaders can prevent the organization from slipping back into old habits and can ensure that the changes are fully embedded.

Finally, the eighth step, Anchor the Changes in Corporate Culture, emphasizes the importance of embedding the new behaviors and practices into the organizational culture. This step ensures that the changes are sustained over time and become part of the organization's DNA. It involves reinforcing the new ways of working through continuous support, recognition, and adaptation of organizational policies and procedures. By aligning the change with the organization's core values and norms, leaders can ensure that the new behaviors are not only maintained but also evolve as the organization grows.

The importance of Kotter's 8-Step Change Model lies in its comprehensive and structured approach to managing change. It provides a clear roadmap for organizations to follow, ensuring that each critical aspect of the change process is addressed. By focusing on both the rational and emotional elements of change, Kotter's model helps to build a strong foundation for successful change initiatives. The model emphasizes the importance of leadership, communication, and employee engagement, all of which are crucial for overcoming resistance and driving sustainable change.

Kotter's 8-Step Change Model has been widely used in various industries and organizations around the world. It has been applied in diverse contexts, from corporate restructurings and mergers to technological implementations and cultural transformations. For instance, in the corporate sector, companies have used Kotter's model to navigate significant changes such as entering new markets, launching new products, or adopting new technologies. The model's emphasis on building a powerful coalition and creating a compelling vision has been particularly valuable in aligning diverse stakeholders and driving coordinated efforts.

In the public sector, government agencies and non-profit organizations have utilized Kotter's model to implement policy changes, improve service delivery, and enhance operational efficiencies. The model's focus on creating urgency and communicating the vision has helped these organizations to garner public support and build momentum for their initiatives. By removing obstacles and creating short-term wins, public sector organizations have been able to demonstrate progress and maintain public trust.

Educational institutions have also adopted Kotter's model to manage changes such as curriculum reforms, technological upgrades, and organizational restructuring. The model's structured approach has enabled these institutions to engage faculty, staff, and students in the change process, ensuring that the transitions are smooth and effective. The emphasis on anchoring changes in the organizational culture has been particularly important in educational settings, where sustaining changes over time is crucial for long-term success.

Healthcare organizations have used Kotter's 8-Step Change Model to implement changes aimed at improving patient care, enhancing operational efficiencies, and adopting new technologies. The model's focus on creating a vision for change and communicating it effectively has been instrumental in aligning healthcare professionals and staff with the change objectives. By removing obstacles and creating short-term wins, healthcare organizations have been able to build momentum and demonstrate the benefits of change to both staff and patients.

Overall, Kotter's 8-Step Change Model has proven to be a versatile and effective tool for managing organizational change across a wide range of contexts. Its structured approach helps organizations to navigate the complexities of change, ensuring that each critical aspect of the process is addressed. By focusing on both the rational and emotional elements of change, the model helps to build a strong foundation for successful and sustainable change initiatives.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

This research employs a mixed methods strategy to develop a holistic view of Building Information Modeling within the construction field. By combining quantitative and qualitative data gathering methods, to overcome the methodological constraints of singular methodologies, The current study is demarcated into different steps. Each step contributes to the unification of an interpretive mosaic.

3.1.1 Mixed Research Approach

A thorough literature review forms the foundation. Examination of academic journals, industry publications, and conferences gives the researchers a comprehensive background on current BIM practices. Moreover, they access a series of case studies and best practices, which in turn point them to proven methods of BIM application in various construction settings. Additionally, the first probe reveals the areas that require more research. Are there aspects of BIM applications that have not received the required attention up to this point? Identification of this knowledge gap helps the panelists to narrow this unbiased energy into areas where most questions exist and little research has been conducted in the use of BIM technologies.

Finally, the literature review informs the development of a robust research framework. This framework guides the subsequent data collection and analysis stages, ensuring a targeted approach that focuses on the most critical aspects of BIM implementation.

Following the groundwork laid by the literature review, the study employs a quantitative data collection method – a survey – to gather broader insights into BIM adoption within the industry. A carefully crafted questionnaire is distributed to a representative sample of construction professionals, encompassing individuals with varying roles and experience levels. This survey aims to quantify the prevalence of BIM within the chosen study population. It captures data on the current state of BIM utilization across different project types and company sizes. Additionally, the survey instrument incorporates targeted questions to understand the key factors influencing adoption. These factors might include perceived benefits, organizational readiness for BIM, and potential challenges associated with implementation. By analyzing the survey responses through statistical techniques, researchers can identify statistically significant relationships between various variables. For instance, the survey might reveal a correlation between project complexity and the likelihood of BIM adoption.

While the survey provides valuable insights into the prevalence and drivers of BIM adoption, the mixed method approach delves even deeper by incorporating qualitative data collection techniques. This phase involves conducting in-depth interviews with key stakeholders directly involved in BIM implementation on construction projects. These interviews provide a platform to explore the personal experiences of industry professionals with BIM, encompassing both successes and challenges. Unlike a survey, interviews allow for detailed discussions, capturing the nuances of BIM adoption that wouldn't be readily apparent from pre-defined survey questions. Researchers gain a richer understanding of the "why" behind the adoption patterns observed in the quantitative data by delving into the motivations and perceptions of practitioners. Interview participants might highlight unforeseen hurdles or unexpected benefits associated with BIM implementation. This qualitative approach allows the study to uncover information that might have been missed by a purely quantitative approach.

The triangulation of data—integrating findings from the literature review, survey, and interviews—provides a deep understanding that goes beyond a simple snapshot of BIM adoption. By harnessing the strengths of both quantitative and qualitative research methodologies, this mixed-method approach offers a more comprehensive picture, capturing both the extent of BIM use within the construction industry and the qualitative experiences that shape the impact of this transformative technology.

This approach is particularly effective in addressing the complexities of BIM adoption as a significant organizational change process. By strategically combining quantitative and qualitative data, the study delivers a thorough understanding of the driving forces behind BIM adoption and the critical steps necessary for successful implementation.

The quantitative survey allows researchers to gather a broader perspective on BIM utilization within the industry. It paints a clear picture of the prevalence of BIM across various project types and company sizes, offering valuable insights into current trends. Furthermore, the survey can be designed to identify key factors influencing adoption decisions. This includes capturing data on perceived benefits, the level of organizational readiness for BIM, and potential challenges anticipated during implementation. By analyzing this quantitative data through statistical techniques, researchers can identify statistically significant relationships between different variables. For example, the survey might reveal a correlation between the project's complexity and the likelihood of BIM adoption.

The qualitative data gleaned from in-depth interviews with key stakeholders adds a crucial layer of richness and context. Unlike a survey with its pre-defined questions, interviews provide a platform for detailed discussions that delve into the personal experiences of industry professionals with BIM. These discussions can capture the nuances of BIM adoption that wouldn't be readily apparent from a survey alone. Researchers gain a deeper understanding of the "why" behind the observed adoption patterns by exploring the motivations and perceptions of practitioners. Interview participants might highlight unforeseen hurdles or unexpected benefits associated with BIM implementation. This qualitative approach allows the study to uncover valuable information that might have been missed by a purely quantitative approach, offering insights that can inform the development of targeted strategies for overcoming common challenges.

By utilizing a process of triangulation, the integrated findings from the literature review, survey, and interviews create a comprehensive understanding that goes beyond a simple snapshot of BIM adoption. This mixed-method approach provides a holistic view, capturing both the prevalence of BIM use within the construction industry and the qualitative experiences that influence the impact of this transformative technology. Ultimately, this approach offers a detailed and nuanced understanding of the BIM adoption process, which can guide the development of effective change management strategies within organizations, facilitating a smoother and more successful BIM implementation journey (Berg 2001, Liang et al., 2021).

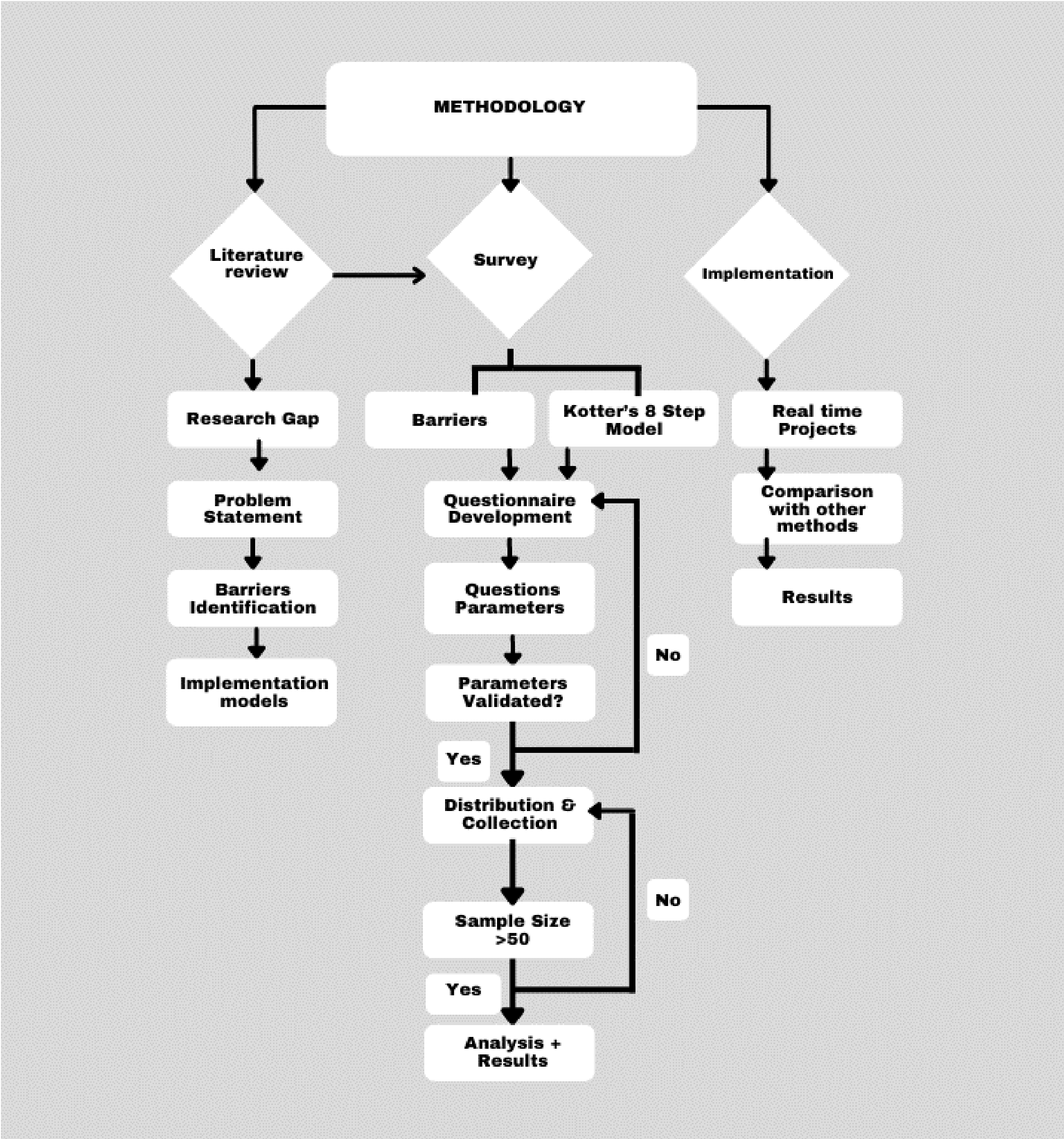


Figure 3: Research Methodology

3.2 Identification of Barriers

The adoption and implementation of Building Information Modeling (BIM) in Pakistan encounter significant hurdles, primarily related to the acceptance and awareness of BIM technology. Our surveys, combined with insights from various credible studies in the construction industry, have underscored these challenges extensively. Notably, the acceptance and awareness of BIM in Pakistan pose substantial obstacles, largely due to the early stage of BIM integration within the country's Architecture, Engineering, and Construction (AEC) sector.

From the literature review and empirical data gathered through surveys with experienced engineers and professionals, barriers to BIM implementation have been classified into fifteen distinct categories. These categories include costs, expertise, regulations, interoperability, awareness, cultural factors, processes, management practices, market demand, project scale, technological considerations, skills gaps, training needs, contractual issues, and standardization of BIM practices. This classification draws from benchmark studies conducted by Siddiqui (2019b) and Aizat et al. (2019).

Costs represent a significant barrier, encompassing the initial investment required for BIM software and training, which can be particularly prohibitive for small and medium-sized enterprises (SMEs) in Pakistan. The expense of acquiring BIM tools, along with ongoing costs for updates and maintenance, presents a financial challenge that many firms struggle to overcome.

The experts category reflects a dearth of BIM professionals in Pakistan. The limited availability of individuals proficient in BIM technology hinders its widespread adoption, making it challenging for firms to implement BIM effectively and leverage its full potential. Legal barriers exist because the legal framework in Pakistan does not currently support or mandate the use of BIM. The absence of legal requirements results in a lack of motivation among stakeholders to transition from traditional methods to BIM-based approaches. Interoperability issues, or compatibility problems between different BIM software and traditional tools, pose significant challenges. These problems can lead to data loss and errors, reducing the efficiency and effectiveness of BIM implementation. Awareness about the benefits and functionalities of BIM is still low among industry professionals in Pakistan. Many stakeholders are not fully informed about how BIM can enhance project efficiency, reduce costs, and improve collaboration. The traditional working culture in Pakistan's construction industry is resistant to change, favoring conventional methods over new technologies like BIM. This mindset makes it difficult to shift towards modern, innovative practices. Implementing BIM requires significant changes in existing workflows and processes, and resistance to altering established practices is a major barrier. Management issues arise because effective BIM implementation necessitates robust support from top management. However, there is often a lack of commitment to invest in and support BIM initiatives, which hampers its adoption. Demand for BIM in Pakistan is not strong enough to drive widespread adoption. Without significant demand from clients and stakeholders, there is little incentive for firms to invest in BIM technology. The scale of projects in Pakistan can influence BIM adoption, as large-scale projects are more likely to adopt BIM due to their complexity and potential for cost savings and efficiency improvements. Conversely, smaller projects may not see the immediate benefits, leading to lower adoption rates. The technology infrastructure in Pakistan may not fully support BIM, with issues such as inadequate hardware, software, and internet connectivity impeding effective use of BIM tools. The current workforce often lacks the necessary skills to use BIM software effectively, highlighting the need for comprehensive training programs to equip professionals with required competencies. Insufficient training opportunities and programs hinder the development of necessary skills among professionals, limiting their ability to fully utilize BIM technology. Traditional contracting methods in Pakistan do not align well with BIM processes, and the absence of BIM-friendly contract provisions can obstruct its implementation. Lastly, the lack of standardized BIM protocols and guidelines in Pakistan creates confusion and inconsistency in its adoption. Standardization is essential to ensure uniformity and compatibility in BIM practices across the industry. These barriers, identified through both literature review and surveys, provide a comprehensive understanding of the challenges faced in the adoption and implementation of BIM in Pakistan's construction industry. Addressing these impediments requires concerted efforts from industry stakeholders, policymakers, and educational institutions to foster a conducive environment for BIM integration.

High initial investment	(Succar, 2009) (Leśniak et al., 2021) (Zhou et al., 2019) (Babatunde et al., 2020) (Saka & Chan, 2021) (Sriyolja et al., 2021)
Lack of standardized BIM workflow	(Kelly et al., n.d.). (Leśniak et al., 2021) (Zhou et al., 2019) (Saka & Chan, 2021) (Sriyolja et al., 2021)
Limited training opportunities	(Archchana & Pan, 2023) (Leśniak et al., 2021) (Sriyolja et al., 2021)
Fragmented structure	(Farooq et al., 2020b) (Leśniak et al., 2021)
Limited awareness about BIM's capabilities among stakeholders like clients, architects, and contractors	(Olawumi et al., 2018) (Leśniak et al., 2021) (Saka & Chan, 2021)
Improper framework	(Waqar et al., 2023) (Leśniak et al., 2021) (Sriyolja et al., 2021)
Skills gap	(Archchana & Pan, 2023) (Leśniak et al., 2021) (Sriyolja et al., 2021)
Lack of training programs and qualified professionals	(Siddiqui, 2019a) (Leśniak et al., 2021) (Sriyolja et al., 2021)
Lack of resources and insurance provisions	(Zhou et al., 2019) (Sriyolja et al., 2021)

3.3 Questionnaire design for determining barriers

Barriers were first identified from the literature, and the most prominent factors among all the barriers were listed down. We designed the written survey to meet all the standards of a good survey. The scale selected for our survey was an agreement continuum, following the best practices in survey design. This continuum allowed us to gauge the level of agreement or disagreement among respondents regarding various barriers to BIM implementation. After meticulously designing the survey to ensure clarity, relevance, and comprehensiveness, we proceeded to distribute it among construction engineering professionals. A total of 65 professionals were targeted for this survey to gather a diverse range of insights and experiences. The survey execution involved sending the questionnaires electronically to these selected professionals, ensuring that they had ample time and support to provide their responses. Out of the 65 professionals approached, 57 responded, yielding a high response rate that underscored the relevance and importance of the topic to the participants. The data collected from these responses provided valuable insights into the perceived barriers to adoption and implementation of BIM in Pakistan, reflecting both the challenges identified in the literature and the real-world experiences of industry professionals. This robust response rate also ensured that the findings were representative and could be reliably used to inform strategies for overcoming the barriers to BIM integration in Pakistan's construction industry.

3.4 Applying Kotter’s 8 step change model for the implementation of BIM

We have used Kotter's 8-Step Change Model for implementing BIM in organizations, based on its widespread recognition and applicability across various sectors, including healthcare, non-profit organizations, and educational institutions. The model's versatility and adaptability make it a suitable framework for guiding change initiatives in diverse organizational settings. Kotter's model provides a organized method to handle change by outlining a series of steps that help organizations in overcoming the challenges associated with implementing change. Figure-4 explains that the model explains the importance of creating a sense of urgency, building a steering committee, developing a vision, communicating clearly and effectively, empowering employees, generating short-term wins, consolidating achievements, and institutionalizing change. By following these steps, organizations can proficiently manage the transition to new methodologies like BIM, ensuring a smoother and more successful implementation process (Sampaio & Azevedo, 2018)

Kotter's model is particularly well-suited for complex projects like BIM implementation, where multiple stakeholders, processes, and technologies need to be aligned to achieve successful outcomes. By leveraging Kotter's model, organizations can address opposition to change, foster collaboration among team members, and drive sustainable transformation in their operations (Khankhoje M, 2016)

The advantages of using Kotter's 8-Step Change Model for BIM implementation are manifold. Firstly, the model provides a systematic approach to change management, ensuring that every necessary step is taken in a logical order. This helps in avoiding common pitfalls and challenges that often arise during change initiatives. Secondly, Kotter's model highlights the significance of communication and stakeholder involvement, which are crucial aspects of successful BIM implementation. By effectively communicating the vision and goals of BIM adoption, organizations can secure buy-in from employees and stakeholders, leading to smoother implementation and higher success rates. Overall, the structured approach of Kotter's model, coupled with its focus on leadership, communication, and employee empowerment, makes it a valuable tool for organizations seeking to implement BIM and drive positive change within their operations (Khankhoje M, 2016).

Kotter’s 8-Step Model is a framework for leading change within an organization. In the context of implementing Building Information Modeling (BIM) in the Pakistani industry, particularly in the Architecture, Engineering, and Construction (AEC) sector, the 8 steps can be applied as follows:

1. Create a Sense of Urgency: Highlight the advantages of BIM, such as enhanced collaboration, reduced errors, and increased efficiency. Emphasize the importance of adopting

BIM to remain competitive in the worldwide marketplace. (Usama et al., n.d.)

2. Form a Powerful Coalition: Gather key stakeholders, including government officials, industry leaders, and BIM experts, to support the implementation of BIM in Pakistan. Powerful coalition can advocate for the adoption of BIM, provide guidance and support, and help overcome any resistance or barriers (Sriyolja et al., 2021).

3. Create a Vision for Change: Establish a clear and compelling vision for the future of the AEC industry in Pakistan, incorporating the use of BIM as a key component. Highlight how BIM can revolutionize the construction processes and contribute to the development of sustainable infrastructure in Pakistan. Define the long-term benefits and outcomes of integrating BIM, such as enhanced project delivery, cost savings, and improved building performance (Girginkaya Akdag & Maqsood, 2020b).

4. Communicate the Vision: Share the vision with all stakeholders, including employees, clients, and suppliers, to ensure everyone understands the importance of the change. This can be done through workshops, seminars, and awareness campaigns to educate and inform stakeholders about the benefits of BIM and its potential impact on the industry in Pakistan.(Chan et al., 2019).

5. Remove Obstacles: Identify and address barriers to BIM implementation, such as lack of awareness, high initial costs, and resistance to change. Implement incentive programs and subsidies to alleviate the initial costs and provide financial support for companies adopting BIM. Offer resources and support to help professionals overcome technical challenges and concerns related to transitioning to BIM. This will demonstrate a commitment to overcoming obstacles and encourage wider acceptance and participation in the adoption of BIM within Pakistan's construction industry. (Farooq et al., 2020b)

6. Create Short-Term Wins: Implement small-scale BIM projects to demonstrate the

benefits and generate momentum for further adoption. For instance, pilot BIM projects can be initiated in collaboration with willing stakeholders to showcase the immediate benefits of BIM in terms of improved coordination, reduced errors, and cost savings. These successful pilot projects can serve as proof of the viability and benefits of BIM implementation, encouraging more widespread adoption in the Pakistani construction industry. (Liu, 2021)

7. Build on the Change: Consolidate gains from the initial successes and continue to expand the use of BIM across the industry. Building a BIM Culture: Develop a comprehensive strategy to embed BIM in the organizational culture of Pakistani construction firms. This involves integrating BIM into workflows, updating job roles and responsibilities to include BIM proficiency, and fostering a collaborative environment that values BIM expertise. Additionally, provide ongoing support and resources to ensure the continuous development of BIM competencies within the organization. (Zaini et al., 2020)

8. Anchor the Changes in the Culture : Integrate BIM into the standard operating procedures of the AEC industry, making it an integral part of the way business is conducted in Pakistan. By integrating BIM into regular workflows, job roles, and processes, the AEC industry in Pakistan can establish a long-term culture of BIM adoption and implementation. This would involve updating industry standards and codes to align with BIM practices and promoting the application of BIM in construction projects as a standard requirement. Consistent reinforcement of the benefits and successes of BIM across various projects and organizations will further solidify its position within the culture of the industry. (Farooqui et al., 2008)

The specific advantages of using Kotter's 8-Step Change Model for the implementation of Building Information Modeling (BIM) in organizations include:

i. Structured approach: Kotter's model provides a systematic and systematic approach to managing change, ensuring that all necessary steps are followed in a logical sequence. (Khankhoje M, 2016)

ii. Emphasis on communication and stakeholder engagement: Kotter's model reinforces the significance of effective and communication and stakeholder engagement, which are crucial aspects of successful BIM implementation. By effectively communicating the vision and goals of (Khankhoje M, 2016)

iii. Leadership and empowerment: Kotter's model emphasizes the importance of leadership in advocating change and empowering employees to drive the change process. This approach helps in addressing resistance to change and fostering collaboration among team members, leading to more successful BIM implementation (Khankhoje M, 2016)

iv. Short-term wins and consolidation: Kotter's model emphasizes the importance of producing short-term wins and preserving gains to build momentum and maintain momentum throughout the change process. This approach helps in making sure that the change process stays on track and that progress is visible to all stakeholders (Khankhoje M, 2016)

v. Institutionalization of change: Kotter's model focuses on institutionalizing change to ensure that it becomes a part of the organization's culture and is sustained over time. This approach helps in ensuring that BIM implementation is a continuous process that is integrated into the organization's ongoing operations and processes(Khankhoje M, 2016)

Overall, the structured approach, emphasis on communication and stakeholder engagement, leadership and empowerment, short-term wins and consolidation, and institutionalization of change provided by Kotter's 8-Step Change Model make it a handy tool for organizations seeking to put BIM into practice and drive positive change within their operations (Khankhoje M, 2016).

After the validation of the barriers from surveys from multiple sources, we developed a comprehensive strategy to address these barriers and promote the successful implementation and adoption of BIM in the industry. To address the barriers, we have used a different approach instead of determining actions directly (Almuntaser et al., 2018) and chose to apply implementation model. They focus on addressing the barriers systematically and strategically. From different implementation models, such as as the UTAT model, the ADKAR model, the Hedonic model, and others, we selected the Kotter's 8-step change model to address the barriers and ensure successful BIM implementation and adoption.

We took the 8 steps of Kotter's change model and devised actions that would reinforce those 8 steps and effectively overcome the identified barriers (Arayici et al., 2011). Some of these actions include: creating a clear vision and communicating it to all stakeholders; and highlighting the benefits of BIM adoption, Table-2 explains actions identified from the literature review, that can be taken to address the barriers using Kotter's 8 step model. Establishing a cross-functional team dedicated to BIM implementation and adoption, providing training and education programs to enhance the skills and knowledge of staff, developing standardized processes and protocols for BIM implementation, promoting collaboration and information sharing among project stakeholders, providing support and resources for the acquisition of necessary software and hardware, integrating BIM into university curriculum to ensure future generations are well-prepared, and fostering a innovation-focused culture and continuous improvement within the organization. These actions aim to address the major hurdles to BIM implementation, such as lack of competent staff, unawareness of the technology, and lack of accessibility of the parametric library (Wong & Gray, 2019). By implementing these actions, we can overcome the identified barriers and ensure a smooth transition towards successful BIM implementation and adoption. These actions were put under each Kotter 8-step change model.

Table 1: Actions that can be taken to address the barriers using Kotter's 8 step model

Financial incentives like tax breaks or subsidies	(Howard et al., 2017). (Babatunde et al., 2020b)
Establishing national BIM standards and guidelines	[uhammad & Shehzad, 2022). (Almuntaser et al. 2018) (Zhou et al., 2019) (Liu et al. 2015)
Initiatives fostering BIM training for architects, engineers, and construction workers	[uhammad & Shehzad, 2022 (Zhou et al., 2019) (Babatunde et al., 2020b) (Liu et al. 2015)
Cloud-based BIM collaboration platforms	[anzoor et al., 2021)
Universities can integrate BIM modules into their curricula	(Manzoor et al., 2021) (Almuntaser et al. 2018)
BIM certification programs	[anzoor et al., 2021) (Sriyolja et al., 2021)
Raise awareness	(Saka & Chan, 2021)
Government initiatives	ıccar, 2009).
Industry standardization	zhar et al., 2011).
Pilot Projects	(Almuntaser et al. 2018)
Allocating resources	(Almuntaser et al. 2018)

3.5 Questionnaire design

We designed the survey by determining the best possible actions that fall under the Kotter-8 step change model. We got 69 responses to the survey, and both open-ended and option-based questions were used for predictive validity. Evaluative and rankings scales were added to the survey design for ease of the respondents (Best Practices in Survey Design, n.d.). Multiple options of actions that can be taken were mentioned and the best were evaluated by conducting a survey. A total of 129 responses were collected for both surveys. Both survey responses 57 and 69, were deemed sufficient for such type of study (Richesin, 2011). In addition, collected 44 responses in the survey of Kotter's 8 Step change model.

3.6 3D Models of Real Time Projects

Figure 4: Residential 01 3D Model

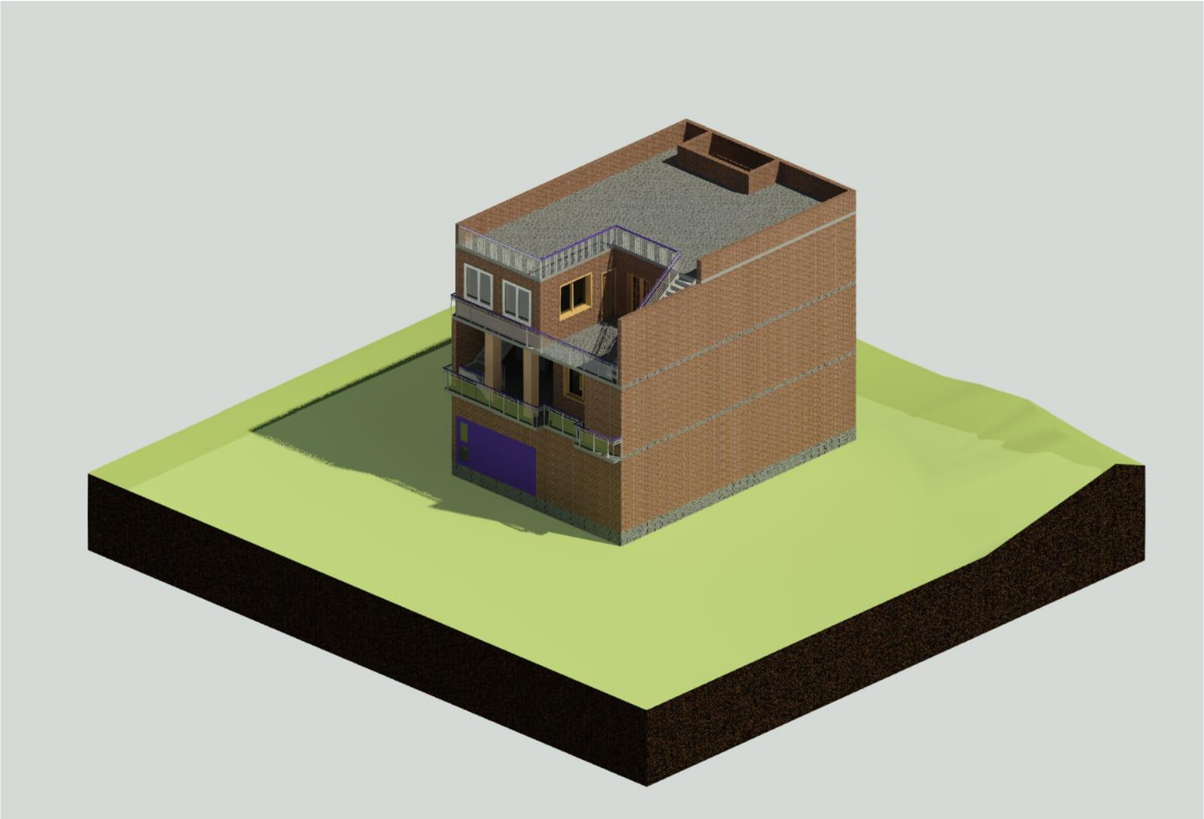


Figure 5: Residential 02 3D Model

Figure 6: Residential 03 3D Model

The implementation of real-time Building Information Modeling (BIM) projects has revolutionized the architecture, engineering, and construction (AEC) industries by providing unparalleled accuracy, efficiency, and collaboration. Through our hands-on experience with real-time BIM projects, we have observed firsthand the transformative impact on project delivery and management. By enabling the integration of various project stages—from initial design to construction and facility management—real-time BIM allows for continuous updates and real-time data access, ensuring that all stakeholders are working with the latest information. This synchronization mitigates the chances of errors and discrepancies that can lead to costly delays and rework. Additionally, real-time BIM facilitates enhanced visualization and simulation, enabling teams to foresee potential issues and resolve them proactively. For instance, clash detection within a BIM model helps in identifying and rectifying conflicts between different building systems before actual construction begins. The collaborative nature of real-time BIM fosters better communication among architects, engineers, contractors, and clients, leading to more informed decision-making and improved project outcomes. Our comparative analysis of projects utilizing real-time BIM versus traditional methods unequivocally demonstrates significant improvements in efficiency, cost savings, and overall project quality. Thus, the significance of real-time BIM in the AEC industry cannot be overstated, as it not only enhances productivity but also drives innovation and sustainability in building practices.

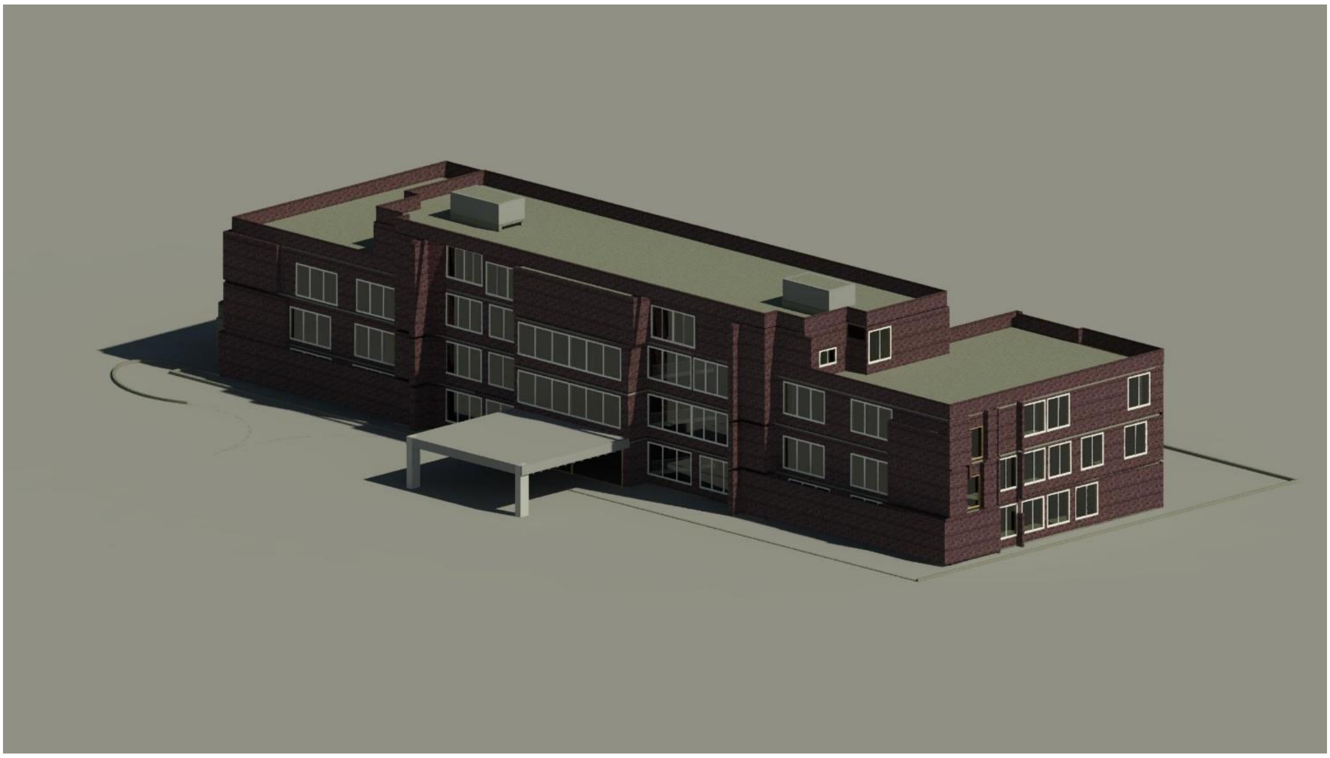


Figure 7: New CIPS Building 3D Model

3.7 Clash Detection

As part of the BIM implementation strategy for the new CIPS building project, we conducted a comprehensive clash detection process. This process involved using advanced BIM software to determine and address potential clashes between different building systems and components before commencement of work. By simulating the project in a virtual environment, we were able to detect clashes between structural elements, mechanical systems, electrical installations, and plumbing. This proactive approach allowed us to address issues early, preventing costly delays and modifications during the construction phase. The clash detection process not only improved the overall efficiency of the project but also enhanced the coordination among various teams, ensuring a smoother workflow and better communication.

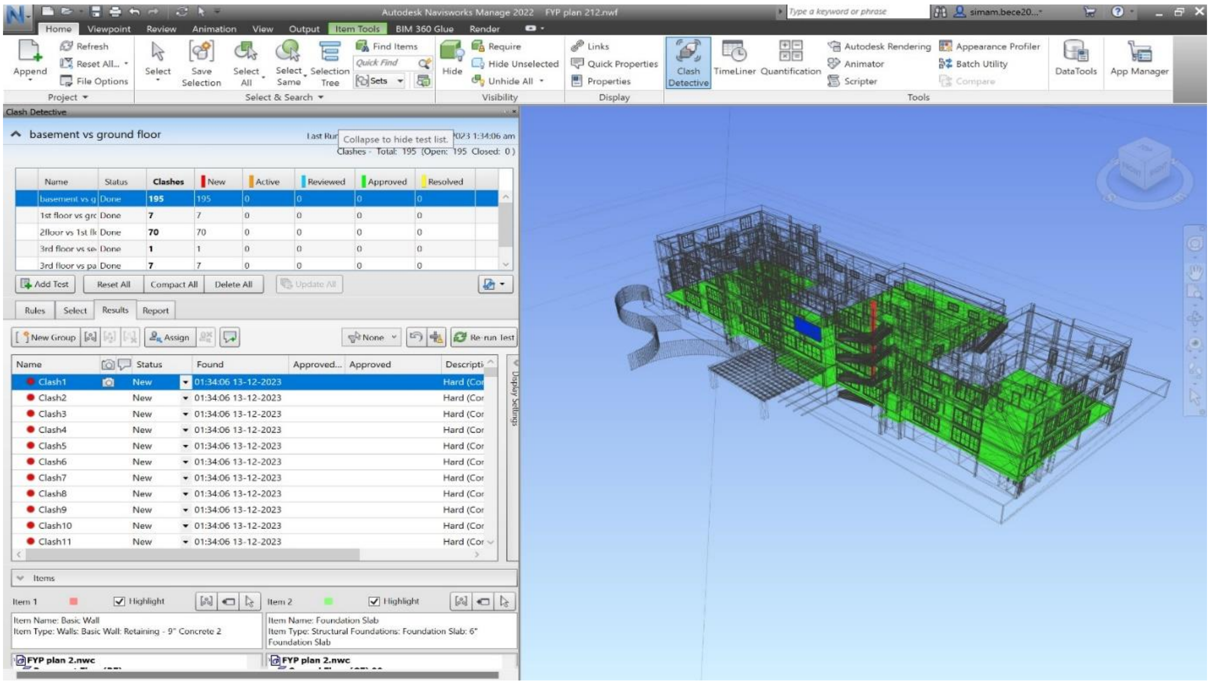


Figure 8: Clash Detection of New CIPS Project

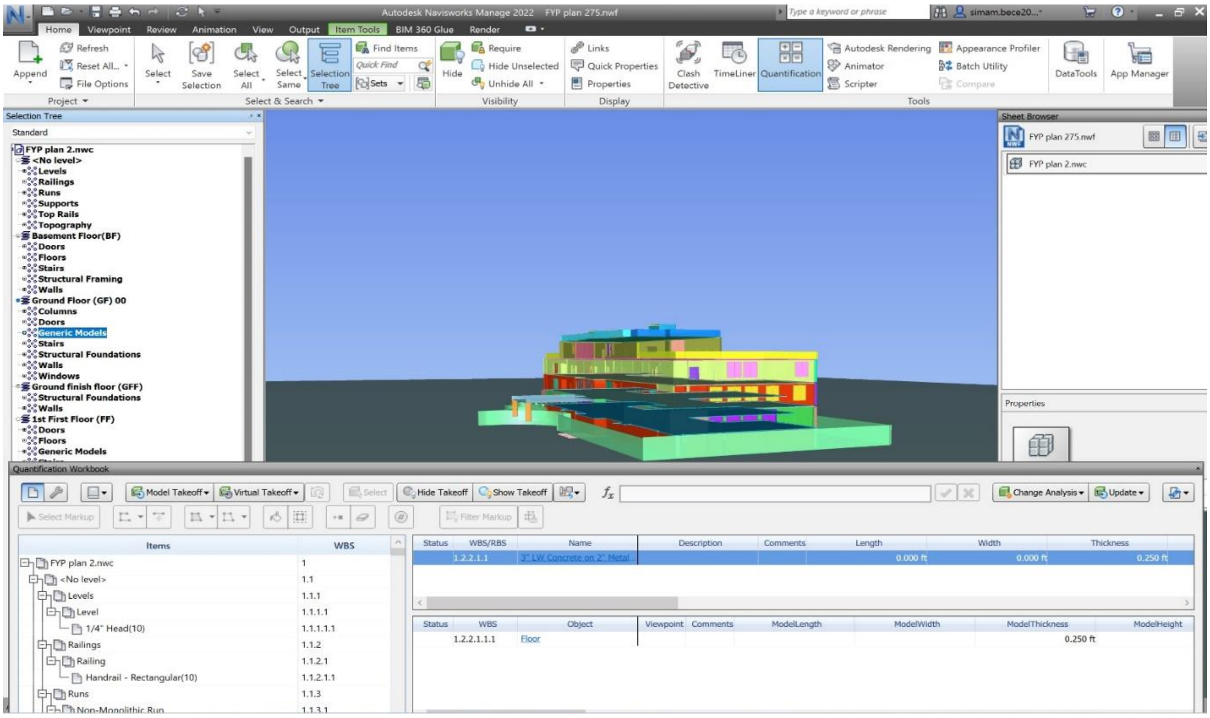


Figure 9: Clash Detection of CIPS Project 02

The results of the clash detection process were significant, revealing several critical areas where design modifications were necessary. By resolving these clashes ahead of time, we were able to optimize the design, reduce the risk of errors, and ensure that all systems could be installed as intended without interference. This contributed to a higher quality construction outcome, as potential problems were mitigated before they could impact the project timeline or budget. Overall, the clash detection exercise underscored the value of BIM in enhancing project planning and execution, demonstrating how technology can drive efficiency and accuracy in complex construction projects like the new CIPS building.

3.8 4D Simulation in BIM

4D simulation in Building Information Modeling (BIM) integrates the dimension of time into the traditional 3D model, offering a dynamic visualization of the construction process over the project's lifecycle. This advanced technique enhances project management by linking the construction schedule directly with the 3D model elements, allowing stakeholders to visualize and assess the construction sequence, project progress, and potential delays in real-time. The ability to simulate the construction timeline provides significant advantages in planning and coordination. For instance, construction managers can identify and mitigate potential bottlenecks and conflicts before they occur, optimizing resource allocation and ensuring timely project completion. Moreover, 4D BIM enables more accurate forecasting and monitoring of the construction phases, which is critical for maintaining adherence to project timelines and budgets.

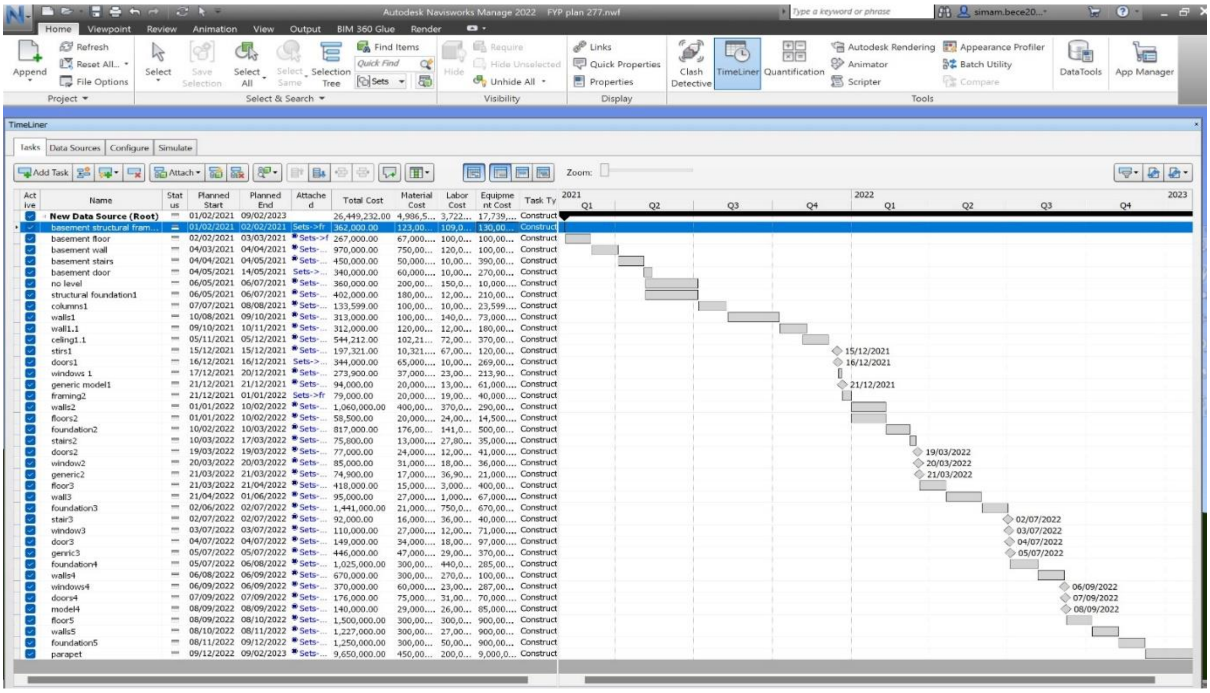


Figure 10: 4D Scheduling of New CIPS Project

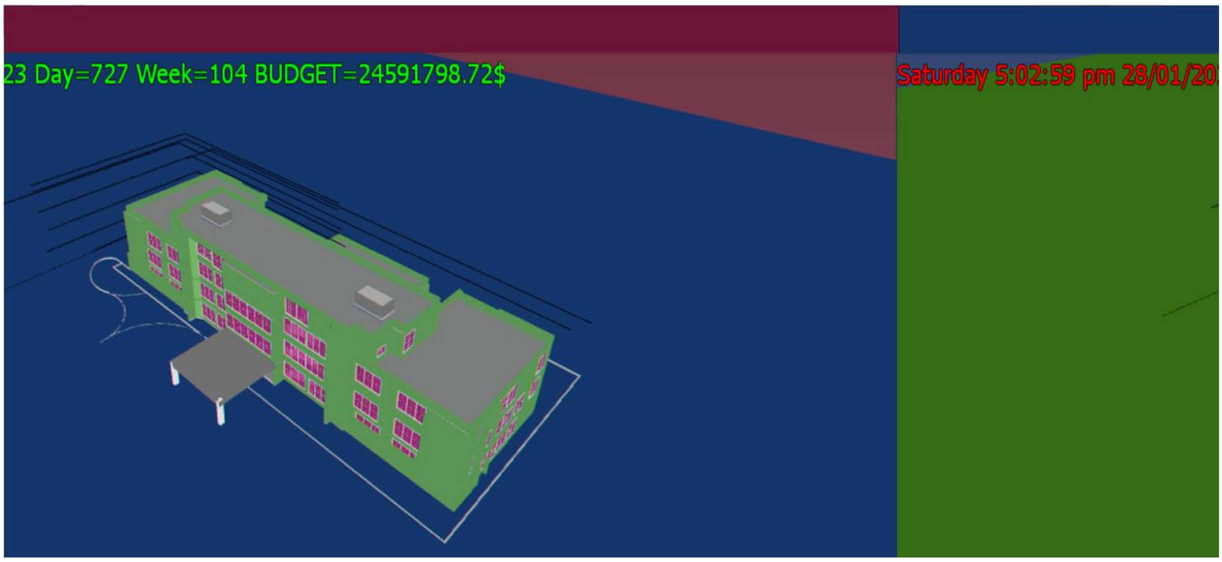


Figure 11: 4D Animation of New CIPS Project

By visualizing the construction process, teams can better understand the interdependencies of various tasks, leading to more informed decision-making and streamlined workflows. This level of detail is particularly beneficial in complex projects where multiple contractors and subcontractors are involved, as it fosters improved communication and collaboration, reducing the likelihood of miscommunication and errors. Overall, 4D simulation transforms the construction planning and execution process, offering a more comprehensive and intuitive approach to project management that enhances efficiency, reduces risks, and improves overall project outcomes.

3.9 5D Simulation in BIM

Building upon the advancements of 4D simulation, 5D BIM adds the critical dimension of cost, integrating financial data with the 3D model and project schedule. This comprehensive approach allows project teams to conduct detailed cost analysis and budgeting in conjunction with time and spatial dimensions, providing a holistic view of the project's financial health at any given point. With 5D BIM, stakeholders can visualize and analyze the cost implications of design decisions, construction methods, and material selections in real-time. This real-time cost estimation and tracking capability is instrumental in enhancing financial management and control throughout the project lifecycle. For example, any changes in the design or schedule can immediately reflect in the cost model, allowing project managers to assess the impact on the overall budget and make informed decisions to avoid cost overruns. Additionally, 5D BIM facilitates more accurate and transparent bidding processes by providing detailed and itemized cost breakdowns, leading to more competitive and realistic bids from contractors. The integration of cost data also aids in value engineering, enabling teams to explore cost-saving alternatives without compromising on quality or performance. Furthermore, 5D BIM supports better financial reporting and forecasting, helping stakeholders maintain financial accountability and transparency. The synergy of 3D visualization, time scheduling, and cost management within 5D BIM significantly enhances project planning, execution, and control, making it an invaluable tool for achieving successful project delivery in terms of both budget and schedule.

When comparing Building Information Modeling (BIM) with conventional construction methods in terms of cost, the advantages of BIM become evident through various stages of a project's lifecycle. Conventional methods often rely on fragmented processes with disparate teams working in silos, leading to inefficiencies, miscommunication, and costly errors. In contrast, BIM offers a cohesive and integrated approach that significantly reduces these issues, resulting in substantial cost savings. One of the main cost-related advantage of BIM is its capacity to enhance design accuracy and coordination through 3D modeling and simulation. This reduces the likelihood of costly rework caused by design errors and omissions that are common in traditional 2D drawings. Moreover, BIM's clash detection capabilities enable early recognition and resolution of clashest between different building systems, preventing expensive on-site fixes and delays.

3.10 COMPARITIVE ANALYSIS

Building Information Modeling (BIM) stands as a transformative technology in the construction industry, revolutionizing the methods used in project planning, execution, and management. Its multidimensional approach, encompassing 3D modeling along with time (4D) and cost (5D) dimensions, presents a paradigm shift in project management. As we delve deeper into its applications across various stages of a project, the manifold perks of BIM in terms of cost efficiency become increasingly evident.

During the construction phase, the integration of BIM's 4D and 5D simulations plays a pivotal role in optimizing cost and schedule management. The 4D simulation, incorporating the time dimension, allows stakeholders to picture the construction process over time, identifying potential clashes and sequencing issues early on. By simulating the construction schedule, project managers can mitigate delays, consequently minimizing labor costs and enhancing overall productivity. Moreover, the 4D model enables better resource allocation and utilization, reducing idle time and ensuring optimal efficiency across all stages of construction.

Complementing the temporal aspect, the inclusion of the cost dimension through 5D BIM provides real-time insights into project expenditures. Through the integration of cost data within the BIM environment, project managers gain the ability to track expenses dynamically, enabling informed decision-making to prevent budget overruns. This real-time cost tracking not only fosters transparency but also empowers stakeholders to implement proactive measures to maintain cost control throughout the project lifecycle. Additionally, the detailed and accurate cost estimates generated by BIM contribute to the development of competitive bids, minimizing the risk of unexpected expenses and fostering a more streamlined procurement process.

Transitioning to the operational phase, BIM continues to yield cost benefits through enhanced facility management practices. The digital model acts as a centralized storehouse of building information, facilitating maintenance and repairs by providing comprehensive insights into asset condition and performance. By leveraging BIM for facility management, stakeholders can adopt a proactive approach towards maintenance, thus extending the lifespan of the building and minimizing long-term operational costs. Furthermore, BIM streamlines regulatory compliance by providing detailed documentation that regulatory authorities increasingly recognize and accept, thereby reducing the time and costs associated with permitting and approvals.

In essence, while the initial adoption of BIM may necessitate a higher upfront investment compared to traditional methods, the long-term cost benefits are profound. BIM's ability to enhance design and construction efficiency, coupled with its capacity to minimize rework and delays, ensures substantial cost savings over the project lifecycle. From accurate cost estimation and real-time budget management to improved facility operations and streamlined regulatory compliance, BIM emerges as a strategic investment that promises significant returns through improved project outcomes and lifecycle cost efficiencies.

Through its holistic approach to project management, BIM transcends mere digitization, fundamentally reshaping the construction industry's landscape. As stakeholders continue to embrace this technology-driven evolution, the realization of its full potential in driving cost efficiency and project success becomes increasingly palpable. Thus, the transition to BIM signifies not only a shift in tools but a transformation in mindset—one that heralds a new era of innovation, collaboration, and sustainable growth in the built environment.

	BIM	Conventional method	Difference	Saving %
Millat Tiles, Lahore				
Concrete (cft)	54071	57573	3502	6.08
Reinforcement bars (kg)	193853	206254	12401	5.98
Bricks (cft)	6524	6777	253	3.7
Millat Tiles, Multan				
Concrete (cft)	28474	30580	2106	6.88
Reinforcement bars (kg)	11065	13660	2595	10.5
Bricks (cft)	6377	6830	453	6.63
Attock oil city				
Concrete (cft)	31300	30302	998	3.2
Reinforcement bars (kg)	1051775	1325240	273465	15.6
Bricks (cft)	79515	82070	2555	3.11

3.11 VR Integration

Virtual Reality (VR) technology is an immersive computing experience that enables us to interact with digital environments in a simulated three-dimensional space. Unlike traditional computer interfaces, which rely on monitors or screens, VR places us directly within the virtual environment, allowing for a more immersive and engaging experience. Our VR systems typically consist of motion tracking sensors, a head-mounted display (HMD), and handheld controllers, all of which work together to create a sense of presence and immersion for the user. By simulating a realistic environment, VR technology offers us a diverse range of applications across different industries, including gaming, entertainment, education, healthcare, and, notably, architecture and construction.

Integrating virtual reality (VR) with Revit, a leading architectural design software, has revolutionized the way we present and visualize projects to clients and stakeholders. One of the standout advantages of this integration is the remarkable enhancement in project appeal and comprehension during client interactions.

Imagine a scenario where a potential client walks into our office for a project discussion. Instead of traditional static presentations or 2D renderings, we can offer them a VR headset and controllers. With this simple setup, they can step into a virtual world where they're not just looking at images on a screen but actively exploring and experiencing the project firsthand.

They can traverse through each room, getting a feel for the space and scale in a way that's impossible with conventional presentations. Want to see how natural light filters into the living room at different times of the day? Just point the controller and adjust the virtual sun. Curious about the flow between the kitchen and dining area? Walk from one space to the other, just like you would in real life.

This level of immersion provides clients with a deeper understanding of the project's architectural nuances, from the layout and spatial arrangement to the finer design details. They can appreciate the building's style and aesthetics by virtually roaming inside it, which significantly aids in decision-making processes, whether it's signing off on a design proposal or finalizing contract details.

However, achieving this seamless integration wasn't without its challenges. Connecting VR technology with Revit presented technical hurdles that required innovative solutions and meticulous troubleshooting. From ensuring compatibility between software versions to optimizing performance and visual fidelity, our team had to invest time and effort to iron out these issues.

Through perseverance and collaboration, we successfully overcame these obstacles, resulting in a robust integration that seamlessly bridges the gap between architectural design and immersive visualization. Now, when we hand a client a VR headset, we're not just showcasing a project; we're inviting them to step into a vision of what could be, igniting their imagination and enthusiasm in ways that traditional presentations simply can't match.

CHAPTER 4

RESULTS AND ANALYSIS

This research investigated the barriers hindering Building Information Modeling (BIM) adoption in Pakistan's construction industry and the actions that should be taken to implement it. A key finding was the lack of understanding and acceptance of BIM technology, highlighting the need for educational programs and outreach initiatives. Further analysis identified several specific barriers through literature review and validated by a survey of construction professionals. These range from financial constraints, like software costs and training expenses, to a lack of skilled professionals and established legal frameworks supporting BIM use as shown in Table-2. Additionally, cultural resistance to change, challenges with integrating BIM into existing workflows, and unclear contractual terms regarding BIM deliverables all contribute to the slow adoption rate.

4.1 Identification of barriers

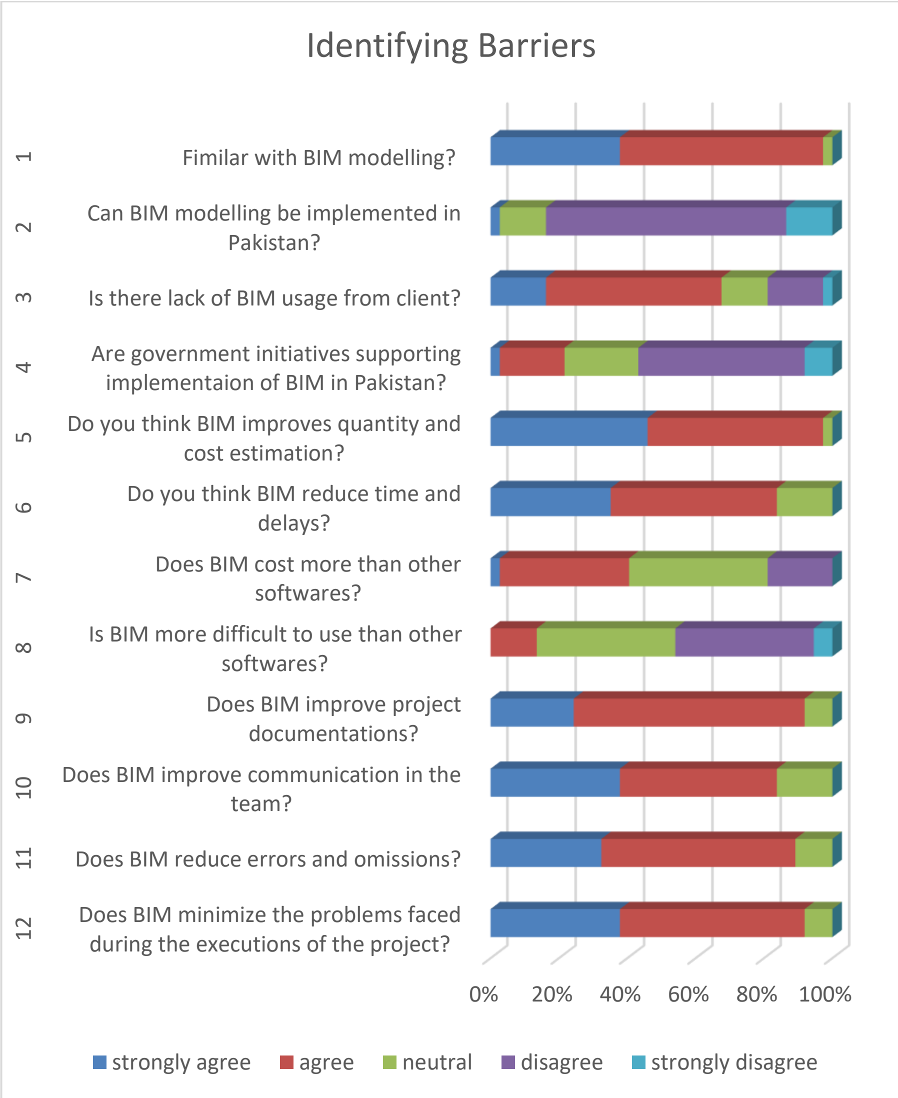


Figure 12: Barriers identification survey results

The data indicate a general familiarity with BIM among the respondents, with a significant majority recognizing its potential benefits. Notably, there is a strong consensus that BIM can improve quantity and cost estimation, reduce project time and delays, enhance project documentation, improve team communication, and minimize errors and omissions. These findings underscore the perceived advantages of BIM in enhancing project efficiency and accuracy.

Despite these positive perceptions, several challenges and uncertainties were identified. A significant portion of respondents expressed doubts about the feasibility of implementing BIM in Pakistan. Concerns about client adoption were prominent, with many agreeing that there is a lack of BIM usage from clients. Additionally, skepticism about government support was evident, as a notable number of respondents disagreed or strongly disagreed with the statement that government initiatives are supporting BIM implementation.

Cost and usability also emerged as critical issues. Many respondents perceived BIM as more expensive compared to other software options, and there were mixed opinions on its ease of use. This suggests that while the technical benefits of BIM are acknowledged, its cost and complexity may hinder wider adoption.

To address these challenges and unlock the potential of BIM, a multi-pronged approach is recommended. Hence after studying all verified implementation models, we chose the application of Kotter's 8-Step Change Model for BIM implementation. This model provides a structured framework for addressing the identified barriers. Specific actions were mapped to each of the eight steps, targeting areas such as creating a clear vision for BIM adoption, establishing a dedicated BIM team, providing training and education programs, developing standardized BIM processes, promoting collaboration, and supporting the acquisition of BIM software and hardware. Additionally, Collaborative efforts among government, industry leaders, and educational institutions are crucial. Government support can be facilitated through a single window system for BIM implementation, quality assurance/control measures, and capacity building programs. Pilot projects can demonstrate the benefits of BIM, while life cycle analysis and performance metrics can quantify its return on investment. Additionally, recognizing and rewarding early adopters and offering tax breaks can incentivize BIM use.

4.2 Specific Actions for adoption of BIM in Pakistan:

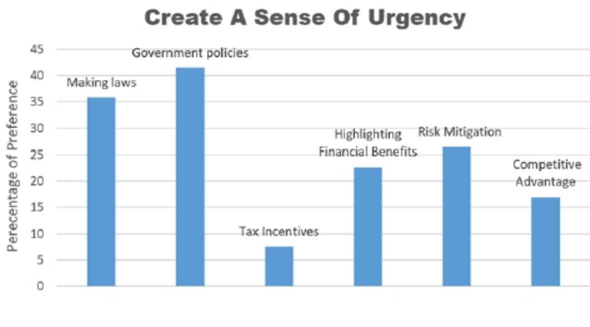


Fig 5(a)

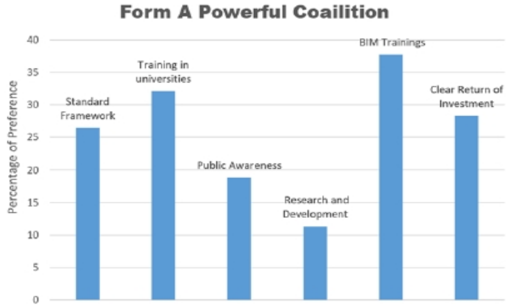


Fig 5(b)

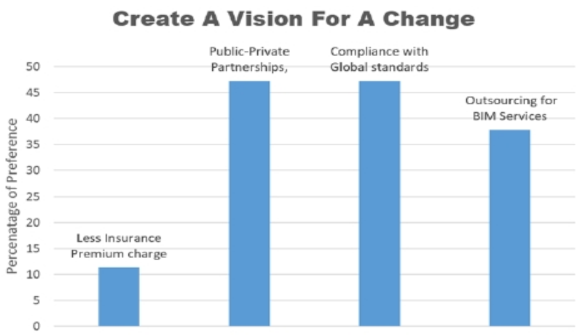


Fig 5(c)

Fig 5(d)

Fig 5(e)

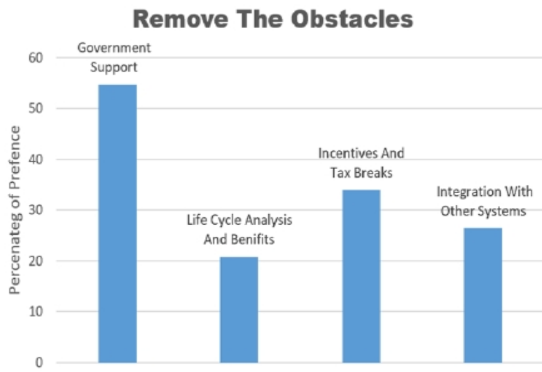
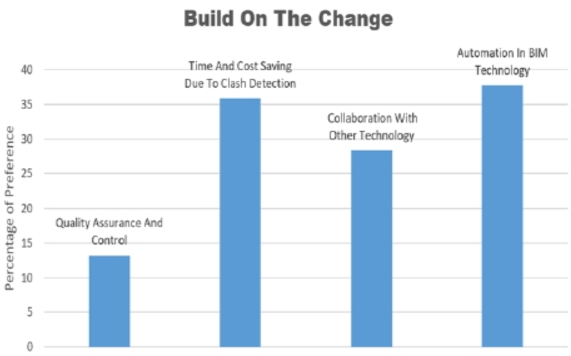


Fig 5(f)



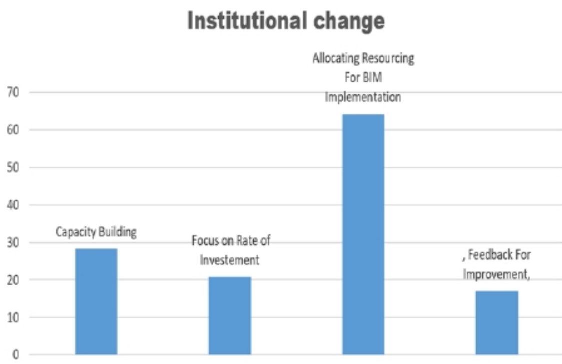


Figure 13: Actions for Kotter's 8 steps, determined through survey

The survey results, analyzed using John Kotter's eight-step change model, provide detailed strategies to facilitate BIM implementation in Pakistan as indicated in the Figure-14. Creating a sense of urgency emerged as a crucial step, with respondents emphasizing the importance of government policies such as making laws, providing tax incentives, and highlighting financial benefits and competitive advantages. Forming powerful coalitions through training in universities, public awareness campaigns, and research and development initiatives was also deemed essential.

Creating a vision for change is another vital step, with strong support for public-private partnerships, compliance with global standards, and outsourcing BIM services. Communicating this vision effectively requires leadership from larger organizations, pilot projects, and departmental collaboration. Achieving short-term wins through performance metrics, clear goal-setting, and showcasing early adopter success stories is essential to maintain momentum and demonstrate the benefits of BIM.

Removing obstacles is paramount, with overwhelming support for government intervention, including life cycle analysis, incentives, tax breaks, and system integration. Building on changes through time and cost savings from clash detection, collaboration with other technologies, and automation in BIM technology is crucial for sustained progress. Finally, institutionalizing changes requires capacity building, resource allocation for BIM implementation, and a focus on continuous improvement. These strategic steps offer a comprehensive approach to overcoming the barriers to adoption of BIM in Pakistan’s construction industry.

Furthermore, clear goals and milestones should be established to guide implementation. Integrating BIM with existing technologies and encouraging cross-departmental collaboration can further enhance its effectiveness. Showcasing success stories and promoting automation in BIM technology can also inspire wider adoption. By implementing these actions, Pakistan’s construction industry can overcome the barriers to BIM adoption and achieve greater efficiency, innovation, and success.

4.3 Framework of Actions for the adoption of BIM in Pakistan

Table 2: Specific Actions determined after survey

Kotter 8 steps	Specific actions to reinforce the step
1. Create a sense of urgency	i. Government policies and regulations ii. Making laws iii. Showcasing Risk Mitigation iv. Highlighting Immediate Financial Benefits
2. Building a guiding Coalition	i. BIM Training in universities ii. Education and training iii. Demonstrate clear ROI (Rate of Investment) iv. Making a standard framework
3. Form a strategic Vision	i. Compliance with global standards ii. Private-Public Partnership iii. Outsourcing for BIM Services
4. Enlist a volunteer Army	i. Encouragement of cross departmental collaboration ii. Pilot projects iii. Larger organization taking the lead
5. Enable Actions by removing barriers	i. Government support ii. Incentives and Tax breaks
6. Generate Short Term Wins	i. Key performance indicators (KPIs) ii. Metric and monitoring iii. Set clear goals and milestones iv. Single window system
7. Sustained Acceleration	i. Automation in BIM technology ii. Time and cost saving due to clash detection
8. Institute change	i. Allocating resourcing for BIM Implementation ii. Capacity Building

Further findings indicate that most of the professionals consider the BIM sustainability step as the most crucial step. The analysis of the open-ended questions reveals that the professionals believe that implementation of BIM might be achieved by various means but the real problem lies in sustaining the implementation of BIM as indicated in Figure-15. One way of doing this is by using the credibility gained from the previous projects performed on BIM to further encourage the usage of BIM in future projects. Using Key Performance Indicators (KPIs) to use effectiveness of BIM can also be helpful in sustainability of BIM. Other steps which carry more importance are forming a strategic vision and creating institutional changes. A vague vision might result in loss of opportunities and limited buy-in for BIM initiatives. Institutional changes usually require a culture change within an organization which motivates the users to adapt to these changes. Achieving this is possible through a coalition of large organizations, resulting in a broader audience to adopt BIM.

4.4 Most Significant action for the adoption of BIM in Pakistan

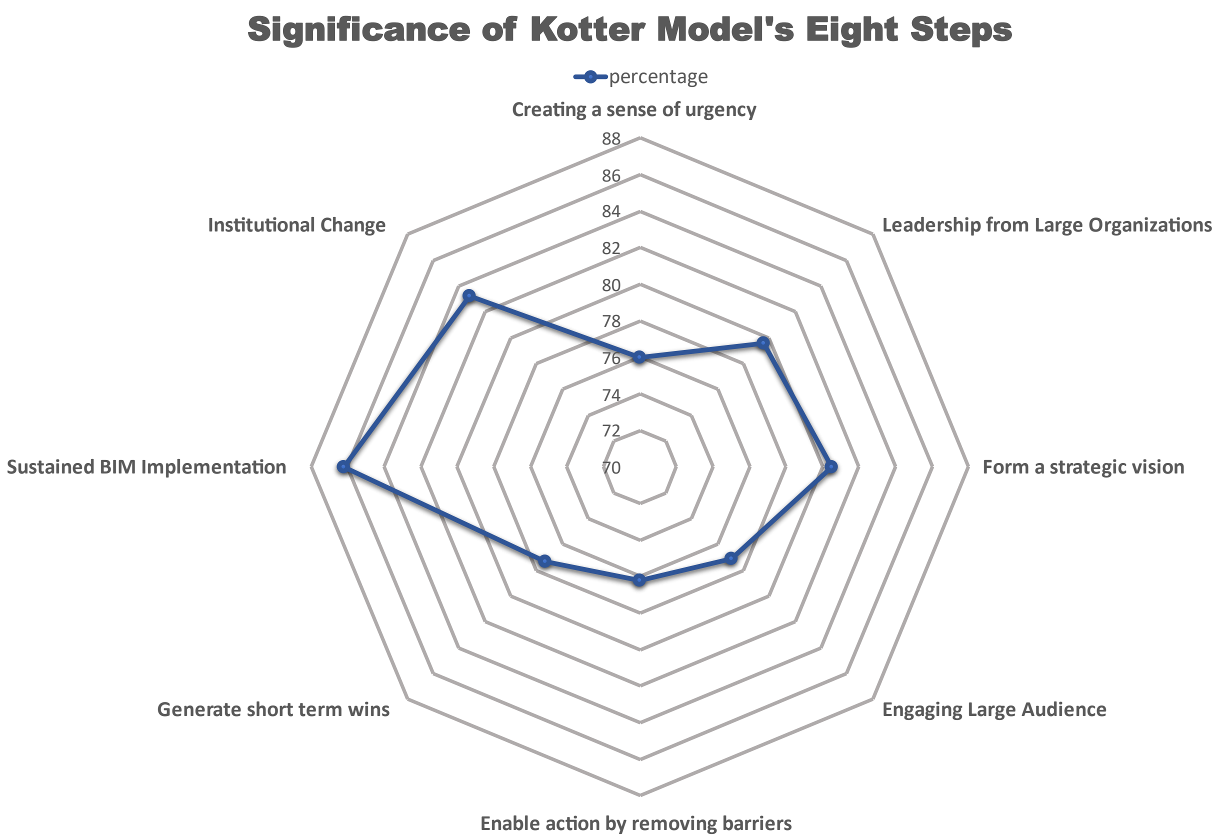


Figure 14: Significance of Kotter Model's Eight Steps

The radar chart illustrates the significance of every Kotter's eight steps in the context of BIM implementation, based on survey data. It visually represents how respondents rated the importance of each step for achieving successful and sustained BIM integration. This detailed analysis highlights the key areas where stakeholders believe efforts should be concentrated to overcome barriers and promote BIM adoption.

Creating a sense of urgency is rated highly, indicating that respondents believe it is crucial to emphasize the immediate need for BIM adoption. This can be achieved through government policies, financial incentives, and showcasing competitive advantages. Establishing this urgency is seen as a fundamental step to kickstart the BIM implementation process and motivate stakeholders to take necessary actions promptly.

Leadership from large organizations also receives a high rating, underscoring the importance of strong and visible leadership to champion the BIM initiative. Leaders from prominent organizations can play a pivotal role in driving industry-wide adoption by setting examples and providing the necessary support and resources. Their involvement is critical in creating momentum and securing buy-in from other stakeholders.

Forming a strategic vision is another highly rated step, reflecting the need for a clear and compelling vision for BIM implementation. This vision should be supported by public-private partnerships and alignment with global standards. A well-defined vision helps in guiding the efforts of all stakeholders, ensuring that everyone is working towards common goals and understanding the long-term benefits of BIM adoption.

Engaging a large audience is seen as moderately important. While broad communication and awareness are necessary to support the adoption process, they might be considered secondary to more direct actions like creating urgency and strong leadership. Effective engagement strategies can ensure that all stakeholders are informed and on board, but they must be integrated with other strategic efforts to be truly effective.

The steps related to enabling action by generating short-term wins, removing barriers, and achieving institutional change are rated lower but still considered significant. Removing obstacles is essential, yet respondents might see it as part of a broader strategy rather than a standalone priority. Generating short-term wins can help maintain momentum and demonstrate the benefits of BIM, but it is not as critical as establishing a strategic vision or sense of urgency. Institutional change, including capacity building and resource allocation, is vital for long-term sustainability, ensuring that BIM practices become deeply embedded within the industry's operations. Overall, the radar chart suggests that creating urgency, strong leadership, and strategic vision are the most critical steps for successful and sustained BIM implementation in Pakistan.

4.1 SPSS Analysis

Exploratory Factor Analysis
Survey 1:

1. Correlation Matrix

2. **Correlation Matrix[a,b]**

		REGR factor score 1 for analysis 1	REGR factor score 2 for analysis 1	REGR factor score 3 for analysis 1	VAR00025
Correlation	VAR00017	-.400	.829	-.632	.994
	VAR00018	-.348	.882	-.628	.987
	VAR00019	-.448	.763	-.687	.953
	VAR00020	-.238	.945	-.559	.956
	VAR00021	.834	-.061	.660	-.515
	VAR00022	.385	.603	-.053	.223
	VAR00023	-.413	.810	-.679	.962
	VAR00024	-.453	.735	-.609	.978
	REGR factor score 1 for analysis 1	1.000	.090	.893	-.368
	REGR factor score 2 for analysis 1	.090	1.000	-.282	.849
	REGR factor score 3 for analysis 1	.893	-.282	1.000	-.593
	VAR00025	-.368	.849	-.593	1.000

a. Determinant = .000

b. This matrix is not positive definite.

The correlation matrix shows the correlations between each pair of variables. High correlations (close to 1 or -1) indicate that the variables are likely measuring the same underlying construct. For example:

VAR00017 and VAR00018 have a very high correlation (.991), suggesting they may measure similar constructs.

Some variables, like VAR00021, have weaker correlations with others, indicating they may represent different factors.

3. Communalities

4. **Communalities**

	Initial	Extraction
VAR00017	1.000	.986
VAR00018	1.000	.999
VAR00019	1.000	.956
VAR00020	1.000	.960
VAR00021	1.000	.924
VAR00022	1.000	.758
VAR00023	1.000	.978
VAR00024	1.000	.936
REGR factor score 1 for analysis 1	1.000	.890
REGR factor score 2 for analysis 1	1.000	.940
REGR factor score 3 for analysis 1	1.000	.735
VAR00025	1.000	.971

Extraction Method: Principal Component Analysis.

Communalities indicate the proportion of each variable's variance that can be explained by the extracted components:

- High communalities (close to 1) suggest that a large proportion of the variance in the variable is explained by the factors. For example, VAR00018 has a communality of .999.
- Lower communalities suggest less variance is explained by the factors. For example,

VAR00022 has a communality of .758.

1. Total Variance Explained

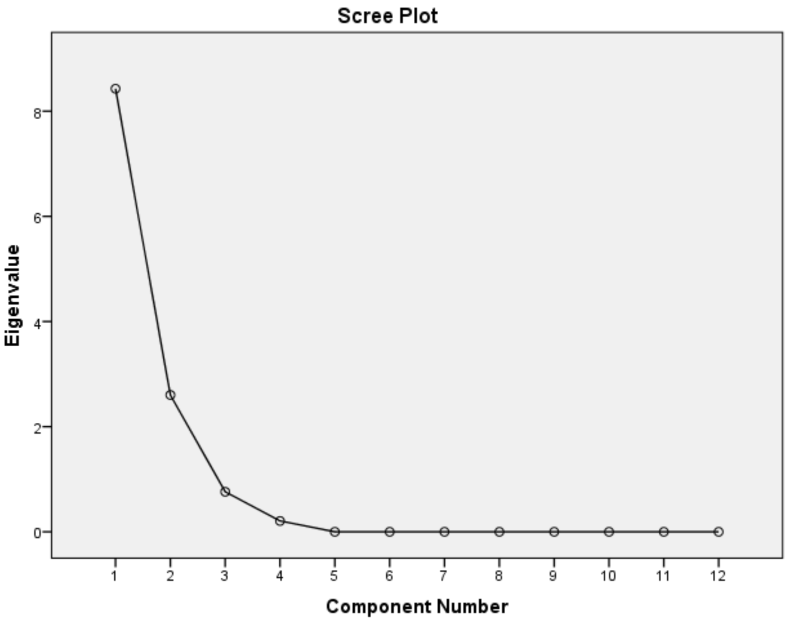
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.429	70.238	70.238	8.429	70.238	70.238
2	2.603	21.693	91.931	2.603	21.693	91.931
3	.762	6.347	98.278			
4	.207	1.722	100.000			
5	6.583E-16	5.486E-15	100.000			
6	4.298E-16	3.581E-15	100.000			
7	1.689E-16	1.408E-15	100.000			
8	6.141E-17	5.117E-16	100.000			
9	2.127E-17	1.772E-16	100.000			
10	-9.269E-17	-7.724E-16	100.000			
11	-6.186E-16	-5.155E-15	100.000			
12	-1.210E-15	-1.009E-14	100.000			

This table shows how much variance in the data is explained by each component:

- Component 1 explains 70.238% of the variance.

- Component 2 explains 21.693% of the variance.



Together, these two components explain 91.931% of the total variance, indicating a good model fit since over 90% of the variance is captured by the two components.

2. Component Matrices

Component Matrix[a]

	Component	
	1	2
VAR00017	.992	
VAR00018	.990	.133
VAR00023	.985	
VAR00025	.984	
VAR00019	.977	

VAR00024	.964	
VAR00020	.950	.240
REGR factor score 2 for analysis 1	.812	.529
REGR factor score 3 for analysis 1	-.713	.475
VAR00022	.271	.827
REGR factor score 1 for analysis 1	-.472	.817
VAR00021	-.523	.807

Extraction Method: Principal Component Analysis.[a]

2 components extracted.

Pattern Matrix[a]

	Component	
	1	2
VAR00018	.997	
VAR00020	.989	
VAR00023	.978	
VAR00017	.972	-.105
VAR00025	.966	
VAR00019	.955	-.113
REGR factor score 2 for analysis 1	.942	.407
VAR00024	.908	-.225
REGR factor score 1 for analysis 1	-.216	.888
VAR00021	-.268	.885
VAR00022	.506	.786
REGR factor score 3 for analysis 1	-.550	.582

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 6 iterations.

Component Matrix and **Pattern Matrix** show the factor loadings before and after rotation, respectively:

Component Matrix: Shows initial loadings. For example, VAR00017 loads heavily on Component 1 (.992).

Pattern Matrix: After rotation, it becomes clearer which variables load significantly on which components. For instance, VAR00018 (.997) and VAR00020 (.989) load strongly on Component 1, while REGR factor score 1 (.888) and VAR00021 (.885) load on Component 2.

Structure Matrix: Shows the correlation between variables and the components:

Structure Matrix

	Component	
	1	2
VAR00018	.999	-.161
VAR00017	.988	-.247
VAR00023	.987	-.204
VAR00025	.980	-.240
VAR00020	.975	
VAR00019	.971	-.252
VAR00024	.941	-.358
REGR factor score 2 for analysis 1	.882	.270
VAR00021	-.397	.924
REGR factor score 1 for analysis 1	-.346	.919
VAR00022	.391	.712
REGR factor score 3 for analysis 1	-.635	.662

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

- Variables like VAR00018 (.999) and VAR00017 (.988) have high correlations with Component 1.
- VAR00021 (.924) and REGR factor score 1 (.919) correlate highly with Component 2.

5. Component Correlation Matrix

This matrix shows the correlation between the components:

Component Correlation Matrix

Component	1	2
1	1.000	-.146
2	-.146	1.000

The correlation between Component 1 and Component 2 is -.146, indicating a slight negative correlation. This suggests that while the components are somewhat independent, there is a small inverse relationship between them.

Interpretation Summary:

- **Two main components** were extracted, which together explain about 91.931% of the variance.
- **Component 1** seems to be heavily loaded by variables VAR00017, VAR00018, VAR00019, VAR00020, VAR00023, VAR00024, and VAR00025, indicating these variables measure a similar underlying construct.
- **Component 2** is mainly loaded by VAR00021, REGR factor score 1, and REGR factor score 3.
- The **variables VAR00018, VAR00023, VAR00025**, etc., are primarily associated with Component 1, while **REGR factor score 1 and VAR00021** are associated with Component 2.
- The components are relatively independent with a slight negative correlation, indicating

they represent distinct but slightly inversely related constructs.

Survey 2:

1. Initial Assessment

- **Correlation Matrix**:

Correlation Matrix[a]

		VAR00023	VAR00024
Correlation	VAR00017	-.095	-.162
	VAR00018	.007	.311
	VAR00019	.517	.333
	VAR00020	.557	.384
	VAR00021	.446	.283
	VAR00022	.119	.057
	VAR00023	1.000	.568
	VAR00024	.568	1.000

a. Determinant = .037

Shows the pairwise correlations between your variables (VAR00017 to VAR00024). This matrix helps understand the relationships among the variables before factor extraction.

- **KMO (Kaiser-Meyer-Olkin) Measure and Bartlett's Test of Sphericity**:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.661
Bartlett's Test of Sphericity	Approx. Chi-Square	156.976
	df	28
	Sig.	.000

Indicates the adequacy of the data for factor analysis. A KMO value of 0.661 suggests that the data are moderately suitable for this technique. With a significant p-value (p <

.001), indicates that correlations between variables are sufficiently large for factor analysis to be meaningful.

- **Communalities**:

- **Communalities**

	Initial	Extraction
VAR00017	1.000	.753
VAR00018	1.000	.891
VAR00019	1.000	.729
VAR00020	1.000	.590
VAR00021	1.000	.822
VAR00022	1.000	.702
VAR00023	1.000	.778
VAR00024	1.000	.700

Extraction Method: Principal Component Analysis.

These values (ranging from 0.590 to 0.891) indicate the proportion of variance in each variable that can be explained by the extracted factors. They are high, suggesting that the factors are likely capturing substantial variance in each variable.

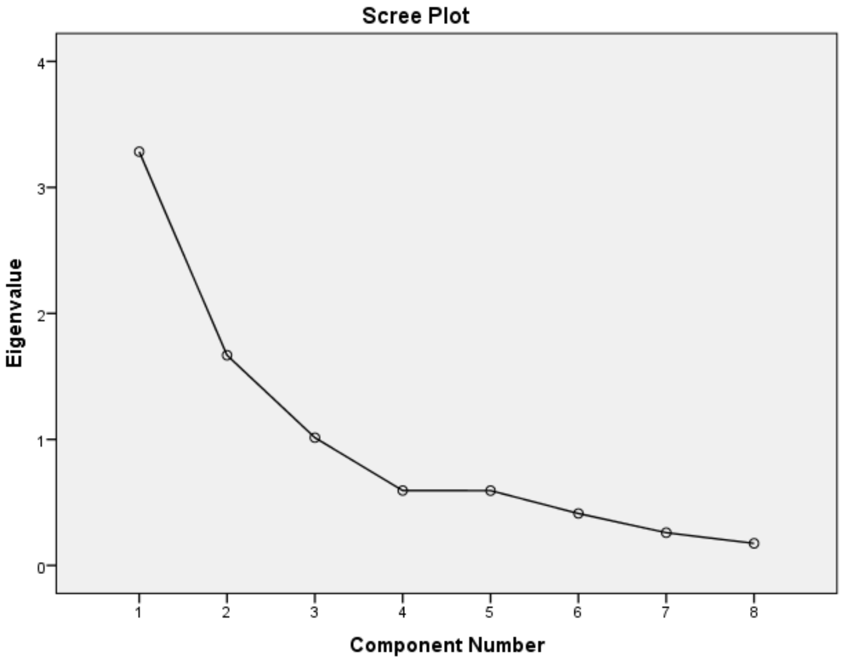
2. Factor Extraction and Variance Explained

- **Eigenvalues and Extraction Sums of Squared Loadings:**

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.284	41.044	41.044	3.284	41.044	41.044
2	1.668	20.849	61.892	1.668	20.849	61.892
3	1.014	12.674	74.567	1.014	12.674	74.567
4	.594	7.428	81.995			
5	.593	7.416	89.411			
6	.412	5.153	94.564			
7	.260	3.248	97.812			
8	.175	2.188	100.000			

These values represent the amount of variance each extracted component explains. The first three components have eigenvalues greater than 1, explaining a cumulative total of 74.57% of the variance. Confirm that the three extracted components account for 74.57% of the total variance in the data.



3. Component Matrix

Component Matrix[a]

	Component		
	1	2	3
VAR00021	.833	.183	-.309
VAR00019	.824		-.223
VAR00020	.722	-.262	
VAR00023	.688	-.508	-.217
VAR00024	.578	-.494	.348
VAR00017	.249	.771	-.309
VAR00022	.531	.613	.208
VAR00018	.487	.304	.749

Component Loadings: These coefficients show how each variable contributes to each component. Key loadings:

- **Component 1**: Influenced strongly by VAR00021, VAR00019, and VAR00020.
- **Component 2**: Influenced strongly by VAR00023, VAR00024, and VAR00018.
- **Component 3**: Influenced strongly by VAR00017, VAR00022, and VAR00018.

5. Pattern Matrix

6. **Pattern Matrix[a]**

	Component		
	1	2	3
VAR00023	.889	-.213	-.181
VAR00019	.800	.246	
VAR00021	.778	.441	
VAR00020	.721	-.109	.112
VAR00017		.854	
VAR00024	.519	-.519	.326
VAR00018			.971
VAR00022	.102	.486	.584

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser
Normalization.[a]
a. Rotation converged in 8 iterations.

Pattern Loadings: Similar to component loadings but after rotation, providing insight into the structure of each component in terms of the original variables.

3. Structure Matrix

4. **Structure Matrix**

	Component		
	1	2	3
VAR00023	.832	-.232	
VAR00019	.815	.256	.323
VAR00021	.790	.449	.328
VAR00020	.755		.319
VAR00024	.616	-.472	.416
VAR00017		.863	.195
VAR00018	.227		.939
VAR00022	.285	.566	.681

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Structure Coefficients: Reflect the correlations between each variable and each component after rotation, offering a clear interpretation of which variables are most strongly associated with each component.

6. Component Correlation Matrix

Component Correlation Matrix

Component	1	2	3
1	1.000	.006	.308
2	.006	1.000	.135
3	.308	.135	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Inter-component Correlations: Shows correlations between the extracted components. These correlations help understand how distinct or related the factors are to each other.

Interpretation Summary

Component 1: Appears to reflect a factor related to variables possibly related to a specific domain or construct defined by VAR00021, VAR00019, and VAR00020.

Component 2: Represents another distinct factor captured by VAR00023, VAR00024, and VAR00018, suggesting a different underlying dimension.

Component 3: Indicates yet another factor related to VAR00017, VAR00022, and VAR00018, potentially reflecting a separate aspect of the data.

Reliability Analysis (Cronbach Alpha Test)

Survey 1:

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1369.567	4	342.3917	6.753186	0.00025	2.583667
Columns	4.55E-12	11	4.13E-13	8.15E-15	1	2.014046
Error	2230.833	44	50.70076			
Total	3600.4	59				

The value of cronbach's alpha is 0.851922
Interpretation of Results:

The p-value (0.00025) in rows is less than the significance level 0.05, indicating that there is a statistically significant difference between the means of the groups in the "Rows" factor. Therefore, we reject the null hypothesis and conclude that there is a significant difference in at least one pair of means among the groups. The p-value (1) in columns is much greater than the significance level 0.05, indicating that there is no statistically significant difference between the means of the groups in the "Columns" factor. Therefore, we fail to reject the null hypothesis, suggesting that there is no significant difference among the groups in this factor. The error 2230.833 within the group variation represents the variability within each group that is not accounted for by the factors being studied. Additionally, the value of Cronbach's alpha 0.851922 suggests good internal consistency reliability among the items in your measurement instrument or scale. A Cronbach's alpha value above 0.7 is generally considered acceptable.

Overall, these results indicate a significant difference between the groups in the "Rows" factor, while there is no significant difference among the groups in the "Columns" factor.

Survey2:

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	654.3149	51	12.8297	4.505463	1.02E-17	1.383089
Columns	48.78606	7	6.969437	2.447488	0.018386	2.035252
Error	1016.589	357	2.847588			
Total	1719.69	415				

The value of cronbach's Alpha is 0.778047

Interpretation of Results:

The p-value 1.02E-17 in rows is much smaller than the significance level 0.05, indicating that there is a statistically significant difference between the means of the groups in the "Rows" factor. Therefore, we reject the null hypothesis and conclude that there is a significant difference in at least one pair of means among the groups. The p-value 0.018386 in columns is less than the significance level usually 0.05, indicating that there is a statistically significant difference between the means of the groups in the "Columns" factor. Therefore, we reject the null hypothesis and conclude that there is a significant difference in at least one pair of means among the groups. The error 1016.589 in both columns and rows represents the variability within each group that is not accounted for by the factors being studied. The value of Cronbach's alpha (0.778047) suggests acceptable internal consistency reliability among the items in your measurement instrument or scale.

Overall, these **results** indicate significant differences between the groups in both the "Rows" and "Columns" factors, suggesting that both factors have an impact on the dependent variable being measured.

Pearson Correlation Analysis

Survey 1:

	Does BIM	Does BIM	Does BIM	Does BIM	Is more di	Does BIM	Do you th	Do you th	Governme	Is there la	BIM mode	Fimilar wi
Does BIM minimize the problems faced during the executions of the project	1											
Does BIM reduce errors and omissions?	0.99091	1										
Does BIM improves communication among the team?	0.97926	0.96765	1									
Does BIM improves project documentations?	0.9449	0.97698	0.89387	1								
Is more difficult to use than other software?	-0.49406	-0.41989	-0.43868	-0.34498	1							
Does BIM cost more than other software?	0.25512	0.36297	0.30889	0.44141	0.62736	1						
Do you think BIM reduce time and delays?	0.98443	0.98351	0.99615	0.92743	-0.4099	0.36196	1					
Do you think BIM improves quantity and cost estimation	0.98231	0.94845	0.96018	0.8756	-0.58876	0.08873	0.95146	1				
Government initiative supporting implementaion of BIM in Pakistan	-0.39999	-0.34782	-0.44849	-0.23803	0.83385	0.38526	-0.41286	-0.45305	1			
Is there lack of BIM usage from client?	0.82854	0.88233	0.76274	0.94525	-0.06053	0.60281	0.81049	0.73476	0.09045	1		
BIM modelling can be implemented in Pakistan?	-0.63186	-0.62792	-0.68656	-0.55864	0.65977	-0.05285	-0.67866	-0.60901	0.89303	-0.28235	1	
Fimilar with modelling	0.99445	0.98681	0.9525	0.95598	-0.51477	0.22303	0.96227	0.97777	-0.36827	0.84919	-0.59313	1

Interpretation of Results:

- BIM minimizing execution problems is highly correlated with reducing errors and omissions, improving team communication, project documentation, reducing time and delays, improving quantity and cost estimation, and familiarity with modeling. It is negatively correlated with the perceived difficulty of use, government initiatives, and the feasibility of implementation in Pakistan.

- Reducing errors and omissions with BIM is highly correlated with improving team communication, project documentation, reducing time and delays, improving quantity and cost estimation, and familiarity with modeling. It is negatively correlated with the perceived difficulty of use, government initiatives, and the feasibility of implementation in Pakistan.

- Improving team communication with BIM is highly correlated with improving project documentation, reducing time and delays, improving quantity and cost estimation, and familiarity with modeling. It is negatively correlated with the perceived difficulty of use, government initiatives, and the feasibility of implementation in Pakistan.

- Improving project documentation with BIM is highly correlated with reducing time and delays, improving quantity and cost estimation, and familiarity with modeling. It is negatively correlated with the perceived difficulty of use, government initiatives, and the feasibility of implementation in Pakistan.

- The perceived difficulty of using BIM is negatively correlated with its effectiveness in minimizing problems, reducing errors and omissions, improving communication, and improving documentation. It is positively correlated with the lack of BIM usage from clients and the cost of BIM.

- The cost of BIM is positively correlated with the perceived difficulty of use and lack of client usage. It is weakly correlated with other factors such as reducing time and delays and improving quantity and cost estimation.

- The cost of BIM is positively correlated with the perceived difficulty of use and lack of client usage. It is weakly correlated with other factors such as reducing time and delays and improving quantity and cost estimation.

- Improving quantity and cost estimation with BIM is highly correlated with reducing time and delays and familiarity with modeling. It is negatively correlated with government initiatives and the feasibility of implementation in Pakistan.

- Government initiatives are negatively correlated with most factors, including minimizing problems, reducing errors, improving communication, reducing time and delays, and improving quantity and cost estimation.

- The lack of BIM usage from clients is positively correlated with the perceived difficulty of use and the cost of BIM. It is negatively correlated with the feasibility of implementation in Pakistan and other effectiveness factors such as improving documentation, communication, and reducing errors.

- The feasibility of implementing BIM in Pakistan is negatively correlated with most factors, indicating challenges in implementation if BIM is perceived as difficult, costly, or lacking government support.

- Familiarity with modeling is highly correlated with positive perceptions of BIM's effectiveness in reducing problems, errors, improving communication, documentation, reducing time and delays, and improving quantity and cost estimation.

Survey 2:

	1) Creating a Sense of Urgency	*2) Big organizations taking the lead*	*3) Form a strategic vision*	*4) Engaging Large Audience*	*5) Enable action by removing barriers*	*6) Generate short term wins*	*7) Sustain BIM Implementation*	*8) Institutional Change*
1) Creating a Sense of Urgency	1							
2) Big organizations taking the lead	0.120041539	1						
3) Form a strategic vision	0.181622138	0.31024651	1					
4) Engaging Large Audience	-0.0289644	0.24592569	0.470353726	1				
5) Enable action by removing barriers	0.36223916	0.26545355	0.770898238	0.495341169	1			
6) Generate short term wins	0.449073616	0.45853153	0.293556692	0.246044283	0.411799	1		
7) Sustain BIM Implementation	-0.094883593	0.0073411	0.517237997	0.556694246	0.446024	0.119459	1	
8) Institutional Change	-0.161938073	0.31067028	0.333415465	0.384087761	0.282821	0.057263	0.567582	1

Interpretation of Results:

- • There's a slight tendency for a higher sense of urgency to be associated with a stronger focus on strategic vision, enabling action by removing barriers, and generating short-term wins. However, it appears less related to engaging a large audience, sustaining BIM implementation, or institutional change.

- Big organizations leading tends to be associated with a stronger focus on strategic vision, engaging a large audience, enabling action, generating short-term wins, and institutional change.

- A clear strategic vision is strongly associated with engaging a large audience, enabling action by removing barriers, sustaining BIM implementation, and driving institutional change.

- Engaging a large audience is positively associated with strategic vision, enabling action, sustaining BIM implementation, and institutional change.

- Enabling action by removing barriers is strongly associated with having a clear strategic vision and moderately associated with engaging a large audience and sustaining BIM implementation.

- Generating short-term wins is slightly associated with a sense of urgency, big organizations taking the lead, and enabling action, but less so with other factors like strategic vision or institutional change.

- Sustaining BIM implementation is positively associated with having a clear strategic vision, engaging a large audience, enabling action, and institutional change.

- Institutional change is moderately associated with engaging a large audience and sustaining BIM implementation. It has weaker associations with other factors such as big organizations taking the lead or forming a strategic vision.

As we conducted the interviews, the results indicate that the implementation of BIM and its adoption in Pakistan is not a simple process but rather a multifaceted process.. While there is a general recognition of the advantages of BIM, which include improved collaboration, reduced errors, and increased efficiency, there are also significant barriers to adoption, including lack of awareness, high initial costs, and resistance to change. The survey respondents highlighted the importance of government support and incentives, as well as the need for education and training to overcome the skills gap in BIM technology.

4.2 Interviews

As we conducted the interviews, the results indicate that the implementation of BIM and its adoption in Pakistan is not a simple process but rather a multifaceted process.. While there is a general recognition of the advantages of BIM, which include improved collaboration, reduced errors, and increased efficiency, there are also significant barriers to adoption, including lack of awareness, high initial costs, and resistance to change. The survey respondents highlighted the importance of government support and incentives, as well as the need for education and training to overcome the skills gap in BIM technology.

The survey results also suggest that the construction industry in Pakistan is hesitant to adopt new technologies, and that there is a need for a cultural shift towards embracing BIM as a standard practice. The respondents emphasized the importance of BIM in enhancing project success, reducing costs, and improving quality, and many expressed a willingness to invest in BIM technology in the future.

However, the survey also revealed that there are significant challenges to overcome, including the lack of qualified HR and integration with existing technology, as well as the need for a clear vision and strategy for implementation of BIM. The respondents also highlighted the significance of government policies and regulations to support the adoption of BIM, and the need for a capital change in the way construction projects are regulated. The recommendation was to implement BIM in three phases: firstly, by conducting training sessions and raising awareness; secondly, by executing multiple BIM projects on a larger scale; and finally, by mandating BIM through government regulations.

The interview results suggest that while there is a strong desire to adopt BIM in Pakistan's construction industry, there are significant barriers to overcome, including lack of awareness, high initial costs, and resistance to change. However, with the right support and incentives, including government policies and education and training, the adoption of BIM can be accelerated, leading to improved project outcomes and sustainable development.

4.3 Limitations

Our research paper on Building Information Modeling (BIM) and its adoption in Pakistan using Kotter's 8-Step Change Model, while comprehensive, faces several limitations that warrant further discussion. Firstly, the linear and prescriptive features that define Kotter's model may not fully capture the complex and iterative nature of change processes in real-world BIM implementations. Kotter's model assumes a sequential progression through each of the eight steps, which may not align with the dynamic realities of BIM projects where multiple steps could be revisited or undertaken concurrently. This rigidity can be problematic in fast-paced environments where adaptability and flexibility are crucial. Consequently, our reliance on this model might have led to oversimplification of the change process, potentially overlooking the need for iterative feedback loops and continuous improvement cycles.

Additionally, the scope of our research is largely informed by existing literature and theoretical frameworks, which may not fully encompass the latest technological advancements or emerging best practices in BIM. Given the rapid evolution of BIM technologies, it is possible that our recommendations could quickly become outdated as new tools and methodologies are developed. Moreover, the literature we reviewed may not have adequately represented the diverse range of experiences across different types of organizations and geographical regions. Our case studies, while illustrative, may have been biased towards larger, more resourced firms that are more likely to document and publish their successes, thus not fully representing the challenges faced by smaller firms or those in developing regions where BIM adoption is still in its infancy.

Another significant limitation is the potential bias in our analysis due to the selection of case studies. We may have inadvertently chosen examples that showcase successful BIM implementations, which could skew the overall perspective of our paper towards positive outcomes. This selection bias can result in an overly optimistic view of the effectiveness of Kotter's model in facilitating BIM adoption. In reality, many organizations struggle with BIM implementation, facing significant obstacles that may not have been adequately represented in our paper. This could lead to an imbalance in our findings, underreporting the instances where BIM projects did not meet their objectives or encountered substantial resistance.

Moreover, our paper may not have sufficiently addressed the cultural and contextual differences that can significantly impact BIM implementation. The adoption and integration of BIM are heavily influenced by organizational culture, local industry practices, and regulatory environments. By generalizing our findings, we may have overlooked these critical contextual variables, thereby limiting the applicability of our recommendations in diverse settings. For instance, the strategies that work well in a large multinational firm in a developed country may not be directly transferable to a small, locally-focused firm in a developing region. Future research should aim to incorporate a deeper understanding of these cultural and contextual factors to provide more tailored and effective implementation strategies.

Finally, while we discussed potential actions to overcome barriers to BIM implementation, the paper may lack sufficient detail on the practical aspects of executing these actions. Our recommendations, though theoretically sound, might not provide detailed, actionable steps that organizations can directly apply. There is also an inherent limitation in predicting the long-term impact of BIM adoption based on short-term implementation studies. The sustainability of the changes implemented and their long-term benefits require longitudinal studies that track BIM projects over extended periods. This would offer a more thorough comprehension of the long-term effects and the development of BIM techniques over time.

4.4 Future Directions

To address the limitations identified in our research, future studies should consider adopting a more iterative and flexible approach to examining BIM implementation using Kotter's model. One potential avenue is the development of hybrid models that integrate Kotter's structured approach with more adaptive project management techniques such as Agile. Agile methodologies emphasize iterative progress, constant feedback, and flexibility, which can complement Kotter's steps by allowing for continuous adjustments and improvements throughout the BIM implementation process. This hybrid approach could better accommodate the complexities and uncertainties inherent in large-scale BIM projects, providing a more resilient framework for managing change.

Further research should also prioritize empirical studies that gather primary data from a diverse range of organizations. While our paper relies heavily on secondary data and literature reviews, conducting surveys, interviews, and case studies across different sectors, organizational sizes, and geographic regions would provide a richer and more representative understanding of BIM implementation challenges and successes. Empirical evidence from a broad spectrum of organizations can validate and refine the theoretical models proposed in our initial research, ensuring that our recommendations are grounded in real-world experiences and practical realities.

Another promising direction for future research is to explore the purpose of cutting-edge technologies, such as artificial intelligence (AI), machine learning (ML), and cloud computing, in enhancing BIM implementation. These technologies have the potential to address several barriers identified in our paper, such as data interoperability, accuracy, and collaboration. For instance, AI and ML can automate data validation processes, reducing the risk of errors and ensuring higher data quality. Cloud computing can promote real-time cooperation and data sharing among project stakeholders, overcoming geographical and organizational boundaries. Investigating how these technologies can be integrated with BIM to enhance its capabilities and streamline implementation processes would provide valuable insights for the construction industry.

Additionally, future studies should examine the influence of contextual and cultural aspects on BIM implementation in greater depth. Conducting comparative studies across different cultural and regulatory environments can help identify best practices and strategies that are context-specific. Understanding how local industry practices, organizational cultures, and regulatory frameworks influence BIM adoption can lead to more tailored recommendations that consider these variables. For example, exploring BIM implementation in countries with stringent building regulations versus those with more flexible regulatory environments can highlight different challenges and strategies for compliance and optimization.

Finally, longitudinal research is pivotal to evaluate the long-term outcomes and sustainability of BIM implementation initiatives. Short-term studies, while valuable, do not capture the full lifecycle of BIM projects and the ongoing challenges and benefits that may arise. Longitudinal studies that track BIM projects over longer periods of time can provide insights into how sustainability of the changes can be implemented, the evolution of BIM practices, and the long-term impact on project outcomes and organizational performance. Such research can reveal whether the initial benefits of BIM adoption are maintained over time and identify any emerging issues that need to be addressed to ensure the continued success of BIM initiatives.

In conclusion, while our research paper on BIM and its implementation using Kotter's 8-Step

Change Model offers valuable insights and recommendations, it is necessary to recognise its limitations and shortcomings and consider future developments for further study. The linear and prescriptive nature of Kotter's model may not fully capture the complexities of real-world BIM projects, and our reliance on existing literature may not encompass the latest technological advancements or diverse organizational experiences. Selection bias in case studies, cultural and contextual differences, and the need for more practical, detailed recommendations are additional limitations that should be addressed in future research.

To enhance the robustness and applicability of our findings, future research should adopt more iterative and flexible approaches, gather primary data from a diverse range of organizations, and explore the integration of advanced technologies with BIM. Examining cultural and contextual factors in greater depth and conducting longitudinal studies to evaluate long-term outcomes will provide us with a detailed complete understanding of BIM implementation and its sustained impact. By addressing these future directions, researchers can contribute to a more dynamic and nuanced understanding of BIM, ultimately facilitating more successful and widespread acceptance of this transformative technology in the construction industry.

Through these efforts, the construction industry can better navigate the challenges connected with BIM implementation, leveraging its full potential to improve project outcomes, enhance collaboration, and drive innovation. As BIM continues to develop further, ongoing research and adaptation will be crucial in ensuring that organizations can effectively harness its capabilities to meet the demands of increasingly complex and sophisticated construction projects.

CHAPTER 5

CONCLUSION

5.1 Conclusion

In conclusion, this research highlights the need for a multi-pronged approach to triumph over the barriers hindering BIM acceptance and adoption in Pakistan's construction industry. By applying Kotter's 8-Step Change Model, the industry can create a sense of urgency, build a guiding coalition, form a strategic vision, enlist a volunteer army, enable actions by removing barriers, generate short-term wins, sustain acceleration, and institute change. The model provides a structured framework and the most impactful actions for addressing the identified barriers, including financial constraints, lack of skilled professionals, cultural resistance to change, and unclear contractual terms. The study's findings suggest that the most crucial step is sustaining the implementation of BIM, which can be achieved by using credibility gained from previous projects, implementing KPIs to measure effectiveness, and forming a strategic vision. The interviews and survey results emphasize the importance of government support, education and training, and a cultural shift towards embracing BIM as a standard practice. By implementing these actions, Pakistan's construction industry can overcome the barriers to BIM adoption and achieve greater efficiency, innovation, and success.

Section b

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