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Overcoming Barriers to Implementing Building Information Modelling in Kuwait's Ministry of Public Works: A Framework for Sustainable Construction

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Abstract: Construction projects in Kuwait's Ministry of Public Works (MPW) involve numerous resources and stakeholders, necessitating effective communication and data sharing to avoid errors, conflicts, and resource wastage. Integrating Building Information Modelling (BIM) into the traditional procurement management approach has the potential to revolutionise the construction industry, enabling remote access to information and waste prevention, particularly for megaprojects. Despite its benefits, BIM adoption has been slow in MPW projects. This study investigates the reasons behind this reluctance and proposes a framework to integrate BIM into MPW projects. A qualitative research method of narrative analysis on semi-structured open interviews with key stakeholders in MPW was conducted to identify the benefits and barriers of BIM implementation. The study found that while tangible barriers were absent, challenges included a lack of senior management support, an inadequate BIM-skilled workforce, adherence to traditional processes, and limited awareness of BIM's importance in circularity and sustainability. Nevertheless, a pilot project demonstrated improvements in collaboration, visualisation, budget estimation, and information sharing through BIM. This study proposes a framework for incorporating BIM into the MPW tendering process to address these issues, validated through interviews with tender managers. This framework aligns with Kuwait's Vision 2035 for sustainable buildings and the Sustainable Development Goals (SDGs) of the United Nations by encouraging the implementation of BIM. Since BIM has the potential to be an effective instrument in reaching these global goals, Kuwait's construction industry should embrace and deploy BIM.

Keywords: BIM; MPW; framework; Sustainable Development Goals SDGs; stakeholders

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1. Introduction

Kuwait's commitment to achieving a sustainable built environment aligns with its 2035 vision. However, the construction sector faces significant challenges, including resource wastage, project delays, and cost overruns. These issues are often attributed to insufficient collaboration and communication [1]. Following the economic catastrophe caused by the Souq Al-Manakh stock market crash, the Kuwait National Development Plan 2025 has shifted its focus towards the reconstruction and diversification of Kuwait's economy. A central theme of this plan is stimulating economic growth, with a strong emphasis on construction and developmental initiatives [2]. In recent years, these initiatives have led to substantial investments in infrastructure and construction, with a projected annual expenditure exceeding USD 120 billion [3]. As of 2022, Kuwait's construction industry has grown to a market worth USD 17.2 billion, and it is expected to further expand by over 3% between 2024 and 2027 [4]. The Ministry of Public Works (MPW) in Kuwait plays a pivotal role in executing a majority of government projects through collaborations with private entities and subcontractors. Currently, public sector entities dominate 70% of the economic landscape. To boost economic advancement, Kuwait's government aims to increase private sector involvement through public–private partnerships (PPP) [2]. The conventional tendering process followed by the MPW suffers from shortcomings that result in inadequate data transfer and misinterpretation. These issues can lead to waste generation, miscalculations, and inconsistencies in stakeholder documents. Even more critical are the challenges associated with awarding contracts to the lowest bidder, vague or absent requirements, deficient contract documentation, and poor cost-estimating procedures. These issues are emblematic of the traditional public contract procurement process [3]. According to Mohemad et al. [5], evaluating bidders without clear information presents significant risks and challenges. In traditional tendering, subcontractor selection often hinges on the lowest quoted price, as contractors aim to maximize their profit margins. However, this approach can lead to client dissatisfaction and eventual profit loss [6]. Embracing state-of-the-art technologies like lean construction and Building Information Modelling (BIM) shows promise for enhancing performance efficiency and overcoming the aforementioned issues [1].

The application of BIM emerges as a solution for mitigating waste generation linked to process-based errors and lapses in communication. BIM, by honing the flow of information, aids in averting such pitfalls [7]. Furthermore, BIM facilitates the realization of a Circular Economy (CE) by enabling functions like waste management reporting, automatic clash detection, reduction in errors within the design phase, fostering stakeholder collaboration, simulating waste generation scenarios, and providing visual representations of information [8]. BIM's adoption is pervasive in many developed countries and has evolved into a foundational requirement within the procurement process for public projects [9]. For Kuwait, BIM possesses the potential to revolutionize the traditional procurement management approach employed by the MPW. However, Kuwait encounters hurdles in BIM adoption, underscoring the pressing need for a framework to seamlessly integrate it into construction projects. To overcome the challenges in BIM implementation, various frameworks have been proposed to guide its integration into construction projects. These frameworks offer a structured approach to ensure the successful implementation and seamless integration of BIM. One such framework, developed by Olanrewaju and Babarinde [10], comprises six stages: awareness, planning, implementation, execution, evaluation, and improvement. This systematic framework guides the implementation process, commencing with creating awareness about the benefits of BIM and culminating in its effectiveness evaluation. Another proposed framework by Arayici et al. [11] encompasses five stages: initiation, awareness, adoption, adaptation, and deployment. This comprehensive approach initiates with assessing an organization's readiness for BIM adoption during the initiation stage and concludes with the effective implementation of BIM on a project during the deployment stage.

This research fills a gap in the literature by conducting direct interviews with decision-makers in public authorities, exploring the realities and challenges of integrating BIM. The study introduces a practical and easily implementable framework for incorporating technology into the public tendering process, adding novelty to the existing knowledge base.

This research aims to establish a BIM framework to enhance the performance of construction projects within Kuwait's Ministry of Public Works (MPW). This research pursues its objective through a multifaceted approach, which includes identifying challenges, formulating solutions, and subsequently developing and validating the envisioned framework. At its core, the proposed framework aims to serve as a guideline for the integration of BIM into Kuwait's MPW Design-Bid-Build (DBB) procurement process. Promoting collaboration across various disciplines and integrating BIM with green assessment criteria and renewable energy, contributes to sustainable development [12]. In the realm of sustainable design and construction, BIM enhances energy efficiency, daylighting, orientation, and natural ventilation [13]. This aligns with Sustainable Development Goal (SDG) 9 by promoting innovation and fostering the establishment of resilient infrastructure. Furthermore, it resonates with SDG 11, which focuses on enhancing inclusivity, safety, resilience, and sustainability in urban landscapes and human settlements. Beyond the realm of global goals, this framework is also in line with Kuwait's Vision 2035, a transformative roadmap and a vision of refining project delivery mechanisms, fostering collaboration, and catalysing innovation within Kuwait's construction sector. The ultimate goal is to enhance the awareness and understanding of BIM's impact on project performance and to provide recommendations for future research and implications for practice.

2. Benefits of BIM for the Construction Industry and Waste Management

BIM is a digital representation of the physical and functional characteristics of a facility, which supports decision-making throughout its life cycle during design, construction, and operation. An integral component of BIM is the digital twin, an immersive virtual representation of physical structures. The unique feature of BIM is its dynamic interconnectivity, automatically updating associated viewpoints, schedules, and cross-sections when any part of the model is altered, encompassing both quantitative and qualitative aspects [14]. The fundamental value of BIM lies in its ability to provide comprehensive insights into building elements, including material characteristics, dimensions, volume, attributes, and precise location. It extends beyond surface-level data, incorporating layers of additional information, including end-of-life scenarios like deconstruction guidelines and environmental impact. This multifaceted approach positions BIM as a powerful tool for deconstruction planning, waste reduction, and waste quantification, especially when combined with digital twinning [14]. Additionally, BIM can contribute to achieving LEED (Leadership in Energy and Environmental Design) certification, a globally recognized green construction rating system [15].

BIM significantly influences construction waste minimization by preventing waste through effective design communication and coordination. Design-related causes of waste generation can be mitigated with BIM [16]. It supports sustainable construction by encouraging green procurement, efficient bidding, and the simulation of construction processes for environmental performance [17]. Integrating BIM with IoT enables real-time assessment of building performance, and 4D BIM aids waste reduction through planning and monitoring [18]. BIM enhances early stage decision-making for sustainable choices and improves the ability to influence building performance [19]. Integrating BIM with Material Passport promotes resource recovery and recycling [20]. Overall, BIM has proven to be cost-effective, increasing life cycle cost savings in building projects.

Waste generation is a pressing concern in Kuwait, with up to 97% of generated waste categorized as non-domestic waste, out of which 53% is construction and demolition waste (CDW). This substantial presence of CDW emerges as a critical issue, yielding resource wastage and environmental concerns [21–23]. BIM plays a vital role in identifying waste factors [24] by enhancing decision-making precision and efficiency. The "WE-BIM" software plugin offers a solution for the precise quantification of construction waste based on building elements and waste categories from the European List of Waste (European Commission). This quantification informs design choices, potentially increasing recycling rates by 49% at a building's end of life [25]. Despite BIM's waste control potential, the construction sector continues to experience an increase in waste generation [26]. Furthermore, a BIM-based waste estimation and planning system, utilizing an application programming interface (API), provides volume data for component categories and materials. It calculates demolition and renovation waste quantities, estimates landfilling charges, and determines the number of pickup trucks required [27].

Challenges for BIM Implementation in Kuwait

Numerous studies have highlighted the challenges associated with adopting Building Information Modelling (BIM) in construction projects. These challenges span various critical areas. One such challenge is a lack of awareness and knowledge about BIM, which can hinder its effective adoption. Additionally, the significant expenses related to software and training, coupled with resistance to depart from traditional methods, can act as barriers to embracing new technology. Moreover, there is often a lack of incentives to motivate the construction industry to adopt BIM. Successful BIM implementation hinges on effective collaboration and coordination among project stakeholders [11,28–32]. The literature still lacks sufficient information to fully understand how BIM affects the growth of collaboration in a project setting. In-depth qualitative methods are required to investigate the intricacy of collaborating in BIM projects [33]. Furthermore, the absence of standardized approaches to BIM implementation is another significant barrier [34].

The architecture, engineering, and construction (AEC) project involves multiple stakeholders, each focusing on their benefits and transferring risks down the supply chain, leading to decision-making confusion [35]. Understanding diverse stakeholders dynamically improves project outcomes [36]. In traditional tendering, a focus on low-cost bids leads to cost overruns and conflicts, especially when subcontractors are selected based solely on low prices [6]. BIM's absence in traditional tendering contributes to waste, misinterpretation, and delays [37,38]. BIM in tendering ensures clear requirements, the qualification of bidders, and alignment with client needs [39]. BIM's benefits in public projects include increased economic value, efficiency, and informed decision-making through digital representation [17]. Despite its proven impact on performance, public departments are hesitant to adopt BIM in Integrated Project Delivery. Integrating BIM in Integrated Project Delivery facilitates the exploration of alternative approaches and reduces error [40]. It has been proved that BIM can improve PPPs performance by 28.9% [17]. However, public departments are not willing to adopt BIM and commit resources to integrate BIM with IPD [40].

In Kuwait, where building codes and regulations are becoming increasingly complex and variable, there is a growing need to automate the permitting procedure and streamline the code compliance auditing process [41]. To create design and visual models effectively using BIM, specialists must be proficient in utilizing the tool to ensure resource-efficient project delivery [42]. However, the implementation of BIM in the Kuwaiti AEC industry faces various challenges and barriers. These challenges include a lack of information and research on the impact of BIM barriers on construction projects in developing countries [43].

3. Research Methodology

A qualitative research methodology was employed to gain an understanding of the construction project procurement process within Kuwait's MPW. The aim was to explore both the barriers and benefits of implementing BIM within the MPW. Drawing from the study's findings, a framework for integrating BIM into the MPW's contract procurement process was developed. Figure 1 outlines the research methodology followed in this study.

Firstly, a literature review was conducted to assess the current status of BIM implementation in the construction industry and to understand the associated benefits and challenges. A total of 272 articles were obtained for the literature review by searching Science Direct using the keywords "Framework", "BIM", "Public", and "Tender" within the time frame of 2000 to 2023. After a thorough examination of their relevance to the topic and objectives of the study, 10 articles were chosen and reviewed. Similarly, 17 additional articles from Google Scholar and Web of Science, which are very relevant to this study, were chosen. This was followed by the second stage where semi-structured interviews were conducted with key stakeholders in Kuwait's construction industry, including client engineers, tender managers, contractors, and consultants.

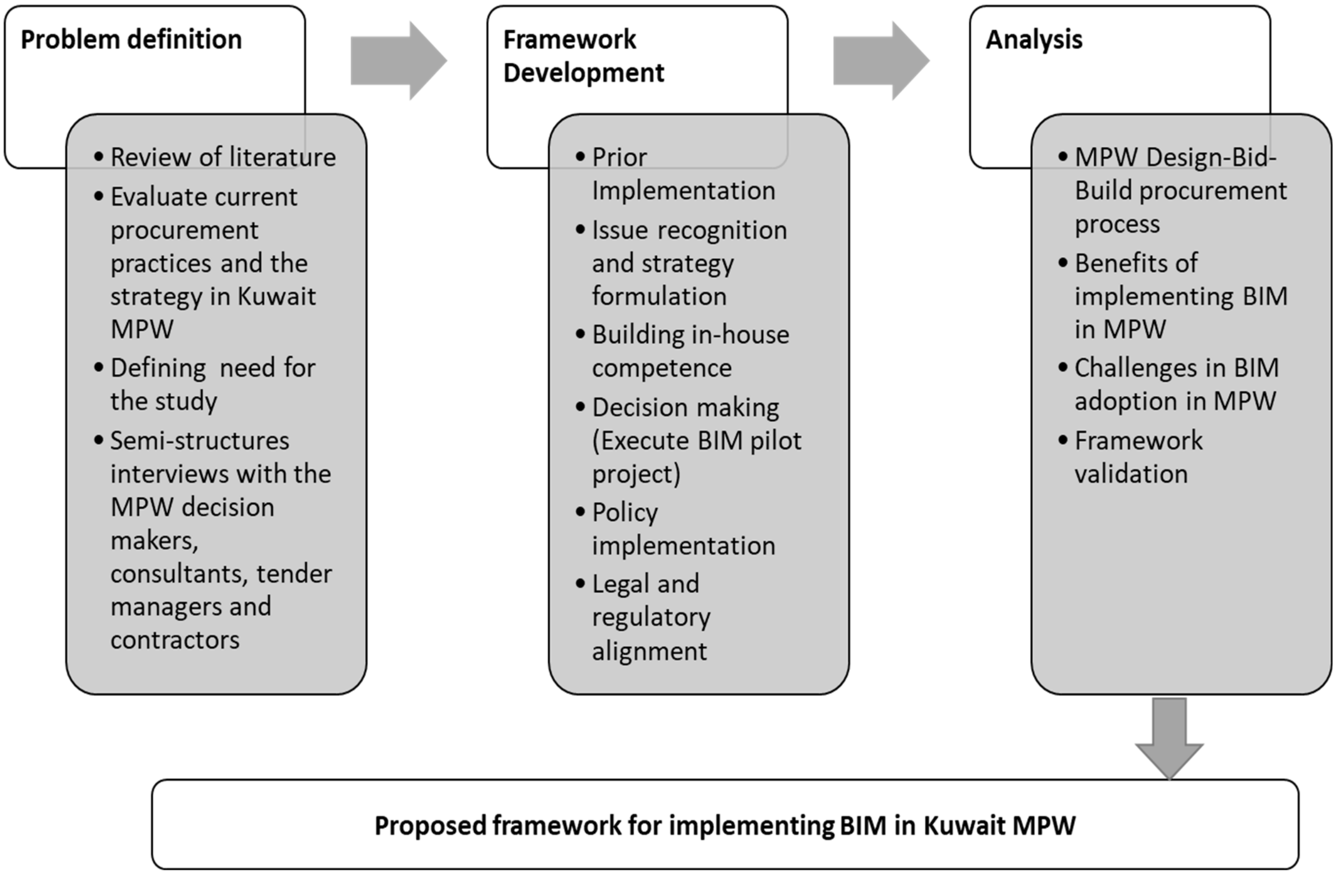

Figure 1. Research methodology.

Four individuals were chosen from the ministry, considering their expertise and experience in the field. The interview process concluded after obtaining four responses due to data saturation, as suggested by Mason [44]. A structured interview would affect the liberty of sharing experiences and would be biased [45]. In research, open-ended questions prove valuable when delving into intricate issues lacking a predetermined or finite set of responses [46]. To ensure a comprehensive understanding of the ground reality, an open and semi-structured interview format was adopted, recognizing that a structured interview might limit insight. Narrative analysis, as advocated by [47], was employed to interpret textual responses in the context of respondents' industrial experiences. The goal was to evaluate BIM adoption in Kuwait's MPW and to gain insights into challenges and opportunities within the MPW's DBB procurement process. The third stage includes the development of a proposed BIM framework based on the literature review findings and stakeholder interview insights. This framework included guidelines, procedures, stakeholder roles, BIM requirements, standards, and execution plans for the DBB procurement process. Finally, the proposed framework was evaluated using the MPW project as a case study to assess its impact on project delivery, collaboration, and innovation in the Kuwait construction industry. The interviews were conducted with four different stakeholders in the ministry to have a comprehensive understanding of the construction project process. Participants were given a plain language statement authorized by Brunel University's ethics committee. Conducted face-to-face, detailed interviews with the consultant and the contractor lasted between 20 to 40 min, while interviews with the tender manager and client involved in the implementation of BIM lasted 60 min. The aim was to gain insight into the perspectives of these individuals on BIM as a waste reduction tool, identifying benefits, challenges, and potential for future improvement based on their experience. Table 1 shows the backgrounds of the participants, and Table 2 outlines the interview questions.

Table 1. Interviewees' positions and experiences.

Professional	Years of Experience	Position
Director Engineer/Owner/Client	+30	Director of the design department in MPW
BIM Consultant/Specialists	+30	Managing director of virtual projects
Construction Managers/Contractors	+28	Manager of construction projects
Tender manager	+20	Organizing tender reviews and deadlines in accordance with the customer's frameworks

Table 2. Key questions for interviews (semi-structured interview questions).

Number	Key Questions for Interviews
1	How acquainted are you with BIM and its application in construction projects?
2	Could you describe your experience with the DBB procurement process?
3	How would you ensure that all stakeholders engaged in the DBB procurement process receive sufficient training and support in utilizing BIM software and comprehending the BIM workflow?
4	How would you approach the development of BIM guidelines and standards for the DBB procurement process within the Kuwait MPW?
5	Do you consider the MPW to have a substantial role in promoting the implementation of BIM in the industry?
6	Could you evaluate the effectiveness of BIM implementation in the DBB procurement process and outline the metrics you would employ to gauge its success?
7	What do you believe are the benefits of incorporating BIM into the DBB procurement process?
8	How do you perceive the impact of implementing BIM on (a) the environment and (b) claims analysis and dispute resolution?
9	Do you have confidence in the ability of BIM implementation to effectively tackle construction challenges within the Kuwait MPW?
10	In your view, what are the primary challenges that may arise during the implementation of BIM in the DBB procurement process, and how would you suggest addressing them?

4. Results and Analysis

The findings presented in this section predominantly reflect the viewpoints of the respondents regarding the implementation of BIM in the MPW tender procurement process for government construction projects, addressing the associated challenges.

4.1. Participant Responses

All stakeholders (Participant A, Participant B, Participant C, Participant D) involved in the study unanimously agreed on the substantial benefits of implementing BIM in the MPW procurement processes. They provided comprehensive feedback on how this implementation would enhance construction projects. When asked about their familiarity with BIM and its impact on construction projects, all stakeholders expressed a high level of knowledge and experience regarding its advantages. These individuals are well-versed in BIM, having encountered successful implementations in other projects and directly witnessed the benefits. They have actively engaged with various BIM software platforms, such as Autodesk Revit and Navisworks, and have first-hand experience with the positive outcomes these tools can deliver to projects. The subsequent results are presented systematically, addressing the benefits and challenges of implementing BIM in MPW. The final section provides a comprehensive overview of the six procedural steps that make up the detailed framework for BIM implementation.

4.2. Design-Bid-Build Procurement Process

BIM offers a promising solution to enhance the shortcomings of the tendering process by providing precise and comprehensive information to all stakeholders involved [48]. BIM ensures that the entire design aligns with the client's needs and facilitates the efficient evaluation of contractor design details against project requirements [49].

The experience of working with the DBB procurement process is examined through the various viewpoints of a client, contractor, consultant, and tender manager. The various perspectives include:

1. The client emphasized the process's dependability while acknowledging the risk of low work quality.
2. Contractors acknowledged the advantages of a competitive bidding environment but revealed challenges in accurately estimating costs while upholding quality standards.
3. Consultants underscored the potential for disputes arising from design changes and the inclusion of extra work not initially outlined in the contract.
4. Tender managers highlighted the substantial effort required to develop comprehensive requirements and specifications, along with the task of evaluating multiple bids. However, they also emphasized the benefits of securing competitive bids and selecting a contractor based on specific criteria.

This comprehensive exploration of perspectives sheds light on the strengths and challenges associated with the DBB procurement process. In Kuwait, the lengthy process of obtaining governmental approvals during the design phase is a major cause of delays. Designers are expected to secure approvals from various governmental entities, including the municipality, fire brigade, and Minister of Electricity. This process typically involves obtaining between 2 and 22 approvals, which is currently carried out manually. Each entity and reviewer assess the requests, provides comments, and grants approvals manually. To address this, efforts are underway to persuade government entities to collaborate and create a unified 3D model using BIM, significantly saving time. To ensure stakeholders receive sufficient training and support in utilizing BIM, comprehensive strategies include needs assessment, tailored training programs, adept trainers, diverse learning modalities, ongoing support, on-site assistance, collaborative platforms, and regular evaluation. Regarding the development of BIM guidelines and standards for the Kuwait MPW DBB procurement process, the contractor emphasized the importance of stakeholder collaboration, clear BIM deliverables, information exchange protocols, software compatibility, and periodic revisions. The contractor also expressed a strong belief in the MPW's pivotal role in promoting BIM adoption in the construction sector. The MPW can endorse BIM integration through specifications, guidelines, and procurement protocols while supporting industry-driven initiatives and collaborating with stakeholders. To evaluate the effectiveness of BIM implementation in the DBB procurement process, a variety of measurable metrics can be employed, including coordination and clash detection, communication and collaboration, time and cost savings, project visualization and client satisfaction, benchmarked deliverables, and construction error reduction. Consistent monitoring and evaluation throughout the project lifecycle are essential for gauging the success and efficacy of BIM integration.

4.3. Benefits and Challenges of BIM Implementation in Kuwait's Construction Projects

Stakeholder interviews were conducted to explore the advantages of integrating BIM into the DBB procurement process within the Kuwait MPW. The client emphasized the significance of BIM based on experiences from the world's largest children's hospital project, which successfully reduced design iterations and conflicts, leading to time and cost savings during construction. With a vast construction portfolio comprising 43 megaprojects and a budget exceeding USD 3.8 billion, BIM adoption assumes a crucial role for MPW. Integrating BIM into DBB procurement offers benefits such as conflict mitigation, improved collaboration, precise budget estimates, enhanced project understanding, and efficient decision-making. These advantages align with research objectives, demonstrating positive impacts on MPW's construction projects and operational efficiency. Regarding environmental and claims analysis aspects, BIM fosters sustainable practices, energy analysis, waste reduction, safety planning, and efficient claim resolution. BIM's comprehensive project documentation enhances transparency and efficiency in the construction industry. When asked about confidence in BIM's ability to address construction challenges within MPW, the client acknowledged its potential. However, successful implementation requires strategic planning and collaboration among all stakeholders involved in the construction process.

In interviews regarding the introduction of BIM in the MPW's DBB procurement process, challenges were identified. A technical director from a contractor company noted that BIM usage is often limited to contractual obligations due to employee reluctance, limited understanding of BIM concepts, and a lack of client and top management support. Additionally, late contractor involvement hinders collaboration.

To address these challenges, a managing director of a consulting company specializing in BIM emphasized the need for a mindset shift in the construction sector. This includes updating contract templates and recognizing the value of contractors' work. BIM implementation requires dedication and investment.

It was also acknowledged that BIM adoption through DBB has advantages but faces limitations like delayed contractor engagement and the need for comprehensive education and training. Primarily, the efficacy of the BIM process is compromised by the delayed engagement of contractors in the post-design phase, particularly impacting collaboration and integration among project participants [37]. Secondly, comprehensive education and training are prerequisites to fully harness stakeholders' BIM capabilities. During the initial stages of BIM integration, locating proficient BIM specialists among clients, consultants, and contractors can prove challenging. Consequently, the BIM model might necessitate supplementary data, potentially influencing diverse factors, including pricing reliability [50]. Effective BIM implementation requires environmental preparation and the revaluation of how contractors' contributions are assessed. The construction sector's mind-set and specific measures like environmental preparation and reimagining contractor assessment, along with education and training, are essential for successful BIM integration in MPW's context [37,50]. For example: as per the consultant's insights, effective BIM implementation mandates environmental preparation, encompassing requisites such as retaining hard copies for inquiries and adhering to a 21-day response window for straightforward inquiries, based on contract templates conceived three decades ago, before the Internet era. Moreover, segregating design requirements from construction needs is paramount. The consultant additionally highlighted the urgency to re-evaluate the assessment of contractors' work, currently anchored in material consumption. This approach contradicts the objective of incentivizing contractors to engage in value engineering to mitigate their fees. Overcoming the challenges inherent in BIM adoption within MPW entails concerted endeavours to reshape the construction sector's mind-set, complemented by specific measures like environmental priming and reimagining the appraisal of contractors' contributions. These measures, coupled with robust education and training initiatives, lay the groundwork for a successful BIM integration, thereby unlocking its substantial benefits within the context of MPW.

4.4. Proposed Framework for Implementing BIM in Kuwait

The proposed BIM framework for the Kuwait MPW constitutes a theoretical set-up that simplifies the intricate features of the BIM domain by indicating meaningful concepts and their interconnectedness [51]. To enhance the tender process, MPW could adopt this integrated BIM framework within the conventional DBB delivery method, employing the lowest bid procurement process (Figure 2). This shift can enhance efficiency. For this transformation, a well-defined scope for BIM integration is crucial, specifying necessary information, timing, and recipients. MPW should set acceptance criteria for contractor-supplied information. Value-based criteria for BIM integration, human and IT resources, and budget allocation details should be in the tender documentation. The six steps can fit into procurement contracts for various project types, with slight modifications needed for different procurement methodologies. For example, the selection process for pilot projects in step 4 may vary between DBB, design-build, or construction management projects. Additionally, the emphasis on BIM implementation may differ in conventional procurement contracts due to the separation of design and construction phases [51]. In the following sections, we will detail all of the steps to thoroughly analyse the framework.

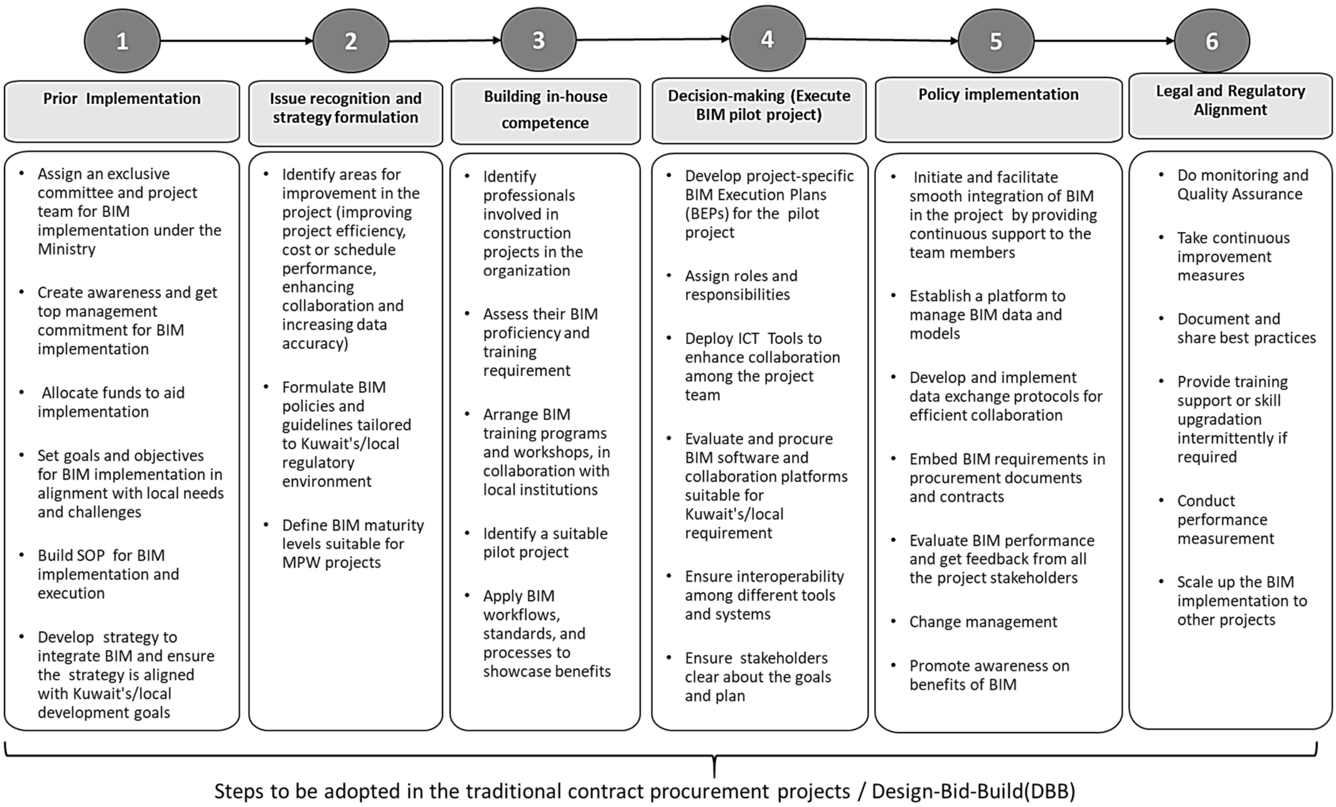

Figure 2. The developed integrated BIM Framework in Kuwait Ministry of Public Works (author's original work, based on the literature and research findings).

4.4.1. Prior Implementation

The initial step in implementing BIM under the Ministry of Kuwait involves forming a dedicated committee and project team, comprising professionals from various disciplines such as architecture, engineering, and construction management. It is essential to appoint a leader to oversee the process and ensure its successful execution. Creating awareness about the significance of BIM and securing top-level management support are crucial steps.

Allocating dedicated funds for BIM implementation is essential to provide the necessary resources for tools, training, and infrastructure. Setting goals and objectives aligned with local requirements is vital for a clear direction. Developing standard operating procedures (SOP) tailored for BIM implementation ensures a systematic approach.

In the final step, a comprehensive strategy is needed to integrate BIM into the existing landscape, aligning with local development goals and organizational objectives. To ensure seamless BIM integration without conflicts, early collaboration among stakeholders, training on material handling and waste management, and the inclusion of a dedicated waste management clause in contracts would be advantageous [52]. Additionally, the implementation of BIM assists project participants in enhancing technologies and procedures from planning to the end-of-life phase to manage construction and demolition waste effectively [53]. This strategy must not only harmonize with Kuwait's local development goals but also align with the broader organizational objectives. Such alignment ensures that BIM serves as an enabler of the overall development vision while contributing to the growth of the construction sector.

4.4.2. Issue Recognition and Strategy Formulation

The second step involves evaluating the requirements and challenges faced by Kuwait's construction sector. This evaluation aims to identify the underlying causes of these issues and areas ripe for improvement. Factors such as infrastructure development objectives, project intricacies, and current operational procedures must be considered. It is also essential to retrieve historical data to gain insight into past performance and establish benchmarks for future enhancements. During this phase, it is prudent to avoid projects with high risks, political complications, or financing challenges that could arise in the event of project failure. For instance, the inaugural BIM project should be chosen carefully, as any mishaps could potentially be attributed to BIM itself.

The subsequent step involves crafting a comprehensive strategy for BIM implementation that harmonizes with Kuwait's broader objectives. These objectives might include elevating project efficiency, reducing construction waste, and fostering enhanced collaboration among the various stakeholders. Furthermore, it is crucial to establish BIM policies and guidelines that seamlessly align with Kuwait's unique construction methodologies and regulatory framework. A vital aspect of this alignment is designing BIM maturity levels that correspond precisely to the specific needs and capacities of projects within Kuwait. These policies play a role in setting the prerequisites for BIM, outlining distinct roles and responsibilities, establishing data standards, and delineating the step-by-step procedures to be adhered to throughout the entirety of each project's lifecycle.

4.4.3. Building in-House Competence

In the phase of building in-house competence for implementing the BIM framework, the initial step is to identify professionals involved in construction projects, such as architects, engineers, project managers, and contractors. Their current proficiency in BIM practices is assessed to identify knowledge gaps. To bridge these gaps, tailored BIM training programs and workshops are designed, potentially involving collaboration with local educational institutions or BIM experts.

After enhancing the workforce's BIM proficiency through training, the next step is to select a suitable pilot project that mirrors the organization's typical construction endeavours in terms of scope and complexity. This pilot project functions as a demonstration of BIM implementation, integrating BIM workflows, standards, and processes. It showcases benefits like improved collaboration, precision, and project management while accumulating real-world insights. This demonstration helps garner stakeholder support and provides experiential knowledge for refining and enhancing BIM practices in future projects.

The following competencies are expected from construction professionals in the field of BIM:

(a) The capability to minimize design alterations;
(b) Proficiency in extracting construction waste information from the model;
(c) Familiarity with materials and the use of recycled materials in projects;
(d) The ability to effectively visualize models to prevent change orders;
(e) Knowledge of modular construction techniques.

4.4.4. Execute BIM Pilot Project

In the framework implementation process, a crucial step involves developing project-specific BIM execution plans (BEPs) tailored for the designated pilot project. These plans clearly define roles and responsibilities for team members, specifying their unique contributions to the project's BIM implementation. Furthermore, to foster collaboration within the project team, information and communication technology (ICT) tools are strategically deployed. These tools serve as enablers, facilitating seamless communication, data sharing, and synchronization among team members, ultimately enhancing project efficiency. To ensure the seamless integration of technology, a comprehensive assessment is conducted to evaluate and acquire BIM software and collaboration platforms. The selection of these tools is performed meticulously to align with Kuwait's specific requirements and local considerations. Ensuring the interoperability of these tools is critical, enabling smooth data exchange and cohesive workflows across different systems. Essential to success is ensuring that all stakeholders have a clear understanding of the project's objectives and the devised plan. This transparency not only promotes alignment among stakeholders but also ensures that the project progresses with a unified vision. By maintaining open communication and clarity regarding objectives, potential misunderstandings are mitigated, facilitating a harmonious execution. To safeguard data integrity and prevent unauthorized modifications in BIM-derived information, it is imperative to restrict access to relevant data and implement a secure data access licensing system. Collaborating with government entities and BIM experts can lead to the establishment of protocols for integrating BIM into construction projects, further enhancing the tool's reliability [54,55].

4.4.5. Policy Implementation

In the implementation of a framework, it is crucial to seamlessly integrate BIM into the project, while providing ongoing team support to foster the effective utilization of BIM. To achieve this, a dedicated platform is essential for the organized management of BIM data and models. This platform serves as a centralized hub for storage, access, and collaboration. Furthermore, the use of data exchange protocols can enhance collaboration efficiency. Notable examples of BIM platforms include Autodesk BIM 360, Trimble Connect, Procore, Aconex, and Bentley ProjectWise. Strategically embedding BIM requirements into procurement documents and contracts is pivotal to ensure that specific BIM deliverables, roles, and responsibilities are seamlessly integrated. This approach helps maintain BIM standards throughout the project lifecycle. Additionally, evaluating BIM performance gathers insights from stakeholders' aids in the refinement of BIM practices. Effective change management strategies are vital for successfully navigating the transition to BIM practices, including adjustments in both processes and mindsets. Lastly, promoting the awareness of the benefits of BIM among stakeholders and within the industry fosters enthusiasm and support for ongoing BIM integration [54,55].

4.4.6. Legal and Regulatory Alignment

In the framework implementation process, the 'Monitoring and Quality Assurance' phase is essential, involving the consistent oversight of BIM integration while maintaining high-quality standards. To facilitate ongoing improvement, 'Evaluation and Continuous Improvement Measures' are initiated, with regular assessments identifying areas for refining BIM practices. The knowledge gained from these assessments is systematically 'Documented and Shared as Best Practices', creating a valuable resource accessible to the team for current and future projects. To support ongoing growth, the organization offers 'Training Support or Skill Enhancement' as needed, addressing skill or knowledge gaps with intermittent training programs. Performance measurement is crucial to assess BIM integration efficiency, using predefined key performance indicators (KPIs) to evaluate project impact, efficiency gains, and communication improvements. As the success of BIM practices becomes evident, 'Scaling up BIM Implementation' to encompass more projects is considered, guided by lessons learned from initial implementations. This fosters a culture of continuous improvement and a strategic approach to widespread BIM adoption.

In the AEC industry, disputes among parties often arise, and BIM features can significantly aid in addressing legal issues and mitigating disputes. However, caution is necessary, as the integration of BIM itself may give rise to legal disputes related to intellectual property rights, contractual arrangements, design responsibilities, dispute resolution authority, and the lack of standardization. Fortunately, these concerns can be alleviated through the adoption of contract agreements that establish standardized procedures, along with the creation of a dedicated BIM execution plan (BEP) and a common data environment. A BEP, developed early in the project's lifecycle, serves to enhance project success by providing a roadmap that clarifies the roles of all parties in implementing BIM for the project. The choice of the most suitable BEP standard should be determined by each institution or business based on its unique needs [56]. Typically, it encompasses the entire implementation process, including data, design and management, collaboration and information exchange, BIM deliverables, and project closeout [57]. To pre-empt disputes associated with BIM adoption, it is advisable to implement collaborative procurement strategies while formulating protocols for the smooth exchange of information among all involved parties. Ensuring that all stakeholders comprehend the contractual agreement will further mitigate conflicts.

4.5. Validation

In this phase, semi-structured interviews were conducted with tender managers to gather insights and feedback on various aspects of the BIM framework, including BIM guidelines, BIM execution plans (BEPs), project execution plans (PEPs), BIM model management plans, training methods, and performance evaluation mechanisms. These interviews delved into stakeholders' perspectives on proposed BIM strategies, their alignment with organizational objectives, and practicality. The collected data underwent qualitative analysis, identifying themes, patterns, and shared insights from stakeholders' responses. This analysis validated and refined the components of the BIM framework to ensure alignment with the practical intricacies of MPW's construction projects. Insights from the validation step contributed to enhancing the BIM framework, making it more contextually relevant and operationally feasible within the MPW's context. This iterative process, guided by stakeholder input, ensures the final BIM framework effectively meets the organization's requirements, objectives, and operational realities, improving the prospects of successful implementation and positive project outcomes.

4.6. Discussions

In the pursuit of enhancing the tender process at Kuwait's MPW, this study introduces a BIM integration framework. Validated through interviews with tender managers, the framework seeks to enhance BIM understanding among experienced engineers and higher authorities, ultimately enhancing the performance of MPW construction projects. The study also delves into the reasons behind the limited BIM adoption in MPW projects, drawing insights from qualitative interviews with key stakeholders, as summarized in Table 3.

The introduction of BIM into Kuwait's MPW faces considerable challenges. One major obstacle is the limited awareness and understanding among construction industry stakeholders, especially experienced engineers, who are accustomed to traditional tender approaches dating back to 1982. This hesitancy, backed by the existing literature, hampers the adoption of new technologies. In Kuwait, BIM awareness remains limited, with only 26% of surveyed participants recognizing its role in construction [58]. The construction industry in Kuwait is slower in adopting technology compared to other sectors [31]. Despite the global momentum towards BIM adoption in construction, Kuwait's construction industry restricts its usage, with only a few projects having embraced it so far [31,59]. Insights from consultants highlight that effective BIM implementation requires meticulous environmental preparation. The consultants emphasize the necessity of separating design requirements from construction needs and urgently reassessing the evaluation of contractors' work, especially when the current approach conflicts with the intended goal of incentivizing value engineering for fee mitigation.

Despite numerous studies on BIM integration in construction projects [60–62], a gap exists in understanding its integration into the MPW tendering process. MPW's reliance on the DBB method and a lack of research on reasons for MPW's hesitation toward BIM integration highlight the need for a framework to seamlessly integrate BIM into the MPW tendering process. To overcome inherent challenges in BIM adoption within the MPW, concerted efforts are needed to reshape the construction sector's mind-set. Specific measures, such as environmental priming and reimagining the appraisal of contractors' contributions, along with robust education and training initiatives, lay the groundwork for successful BIM integration, unlocking its substantial benefits within the context of the MPW.

Table 3. BIM adoption benefits and barriers from the MPW stakeholders' perspectives.

Stakeholder's Perspective Interviewed in This Study?	Benefits	Challenges
Client/ Owner	1. Improves resource efficiency and asset management accuracy. 2. Maintenance information facilities management can be accessed easily. 3. Fast and accurate cost estimation budget by the end of the design phase. 4. Reduce design iteration (request for information) and variation orders. 5. Reduce the overall cost of the delivery of the facility and clash detection. 6. Improve collaboration and coordination between departments and with the ministry. 7. Adopt more informed decision making by depending on BIM model for design visualisation. 8. Expedite getting approvals from other government entities during the design phase. 9. Environmentally friendly by reducing waste and paper-based processes.	1. Longer initial integration time of BIM in the project. 2. Lack of awareness about benefits of integration. 3. Initial cost of acquiring the software and integrating is high. 4. Lack of BIM capacitance among workforce which also leads to additional training cost. 5. Lack of standard tools and protocols. 6. Resistance toward BIM implementation.
Consultants	1. Improved energy efficiency. 2. Conceptual and feasibility improvements in the pre-construction phase. 3. Documentation of information with high accuracy.	1. Lack of client awareness. 2. Lack of responsibilities of BIM-related decisions.
Contractors	1. Improved safety and occupational health by reducing site congestion. 2. Improved site utilization. 3. Effective project management and efficient resource management by minimizing waste.	1. Lack of human resource with BIM expertise. 2. Not desired or demanded by subcontractor. 3. Resistance to change on integrating BIM. 4. Legal issues related to BIM such as data security. 5. Lack of support from top management. 6. The complexity of a BIM model.

The DBB procurement process, deeply ingrained in the Kuwaiti construction sector, poses challenges by often leading to communication breakdowns and project delays. The literature review shows that current strategies frequently modify traditional methods, with the DBB approach commonly employed for BIM delivery [63]. Modern contracts can accentuate competition over collaboration in construction projects. The role of market direction and government support is crucial, as industry entities may require expertise and capabilities to meet their requirements. The potential benefits of BIM are emphasized, along with the significance of innovative strategies and government endorsement for effective BIM integration into construction projects. Interviews with consultants highlight the influence of modern contracts on collaboration and competition within construction projects. Consultants argue that such contracts tend to accentuate competition over collaboration, substantiating their claim with instances of errors by both designers and the contracts themselves.

They assert that the adoption of BIM as a collaborative platform under such circumstances is infeasible due to the prevailing competitive climate. In contrast, the contractor emphasizes the pivotal role of reducing site congestion in promoting safety and health enhancements. This discussion underscores the intricacies of modern contracts and their impact on project dynamics, stressing the need for a multifaceted approach to ensure successful project outcomes. A deeper understanding of the collaborative process may result in improved BIM implementation as an effective and efficient breakthrough technology [33]. The role of market direction and government support in facilitating widespread BIM adoption is underscored, as industry entities may necessitate expertise and capabilities to meet their requisites. The discussion accentuates the potential merits of BIM while underscoring the significance of innovative strategies and government endorsement for its effective integration into construction projects.

5. Conclusions

In summary, the AEC projects face complexity with stakeholders pursuing individual benefits and transferring risks, leading to decision-making challenges. Understanding diverse stakeholders enhances project outcomes. Traditional tendering's focus on low-cost bids results in conflicts and cost overruns. The absence of BIM in traditional tendering contributes to waste and delays. BIM in tendering ensures clear requirements and aligns with client needs, offering benefits like increased economic value and informed decision-making. Despite proven performance improvements, public departments hesitate to adopt BIM in Integrated Project Delivery, which can facilitate alternative approaches and error reduction, potentially improving PPPs performance. However, challenges persist in public departments' willingness to adopt BIM and allocate resources for integration with Integrated Project Delivery.

The Collaborative BIM Decision Framework strives to ease the adoption of BIM in the AEC industry. It addresses both technical and non-technical challenges, overcomes legal, procurement, and cultural barriers, and offers guidance on initiating the process and utilizing available tools.

This study presents solutions for the integration of BIM into Kuwait's construction projects to improve communication, data sharing, and project efficiency. BIM has the potential to transform traditional procurement management for large projects by enabling remote access to information and reducing waste. Despite its benefits, BIM adoption in Kuwait has been slow, attributed to factors like a lack of senior management support, a shortage of skilled BIM workers, adherence to conventional processes, and a limited understanding of BIM's circularity benefits. The study highlights positive outcomes from a pilot project, demonstrating BIM's enhancements in collaboration, visualisation, budget estimation, and information sharing. These findings lead to a comprehensive framework to seamlessly integrate BIM into the Ministry of Public Works tender process. Validation through interviews with tender managers underscores its practicality and potential to reshape project management. While tailored for Kuwait's Ministry of Public Works, the findings and proposed framework have broader implications for BIM implementation challenges and strategies in construction practices globally, contributing to a wider discourse on enhancing construction practices through BIM integration. The proposed framework is not confined to Kuwait, as the challenges and benefits it addresses are universal. Any administrative body can adopt and leverage this framework for its advantages.

The primary aim of this research was to provide a framework for enhancing efficiency in Kuwait's construction industry through BIM integration. There are, however, some limitations and recommendations, which include:

1. The careful consideration of the timeframe for implementing legislation or mandates, considering the organisation's employee count.
2. Testing the framework's viability in other countries in the region to assess similarities and disparities.
3. Employing quantitative methods for analysing the impact of BIM on project performance.
4. Evaluating the practical applicability of the proposed framework in real-world projects.
5. Forging partnerships with educational institutions to provide staff training and developmental opportunities.

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