technologies

Article

The Role of BIM 6D and 7D in Enhancing Sustainable Construction Practices: A Qualitative Study

Hanan Al-Raqeb [1] and Seyed Hamidreza Ghaffar [2,3,*]

[1] Department of Civil and Environmental Engineering, Brunel University London, Uxbridge UB8 3PH, UK; hanan.alazemi@brunel.ac.uk
[2] Civil Engineering, University of Birmingham, Dubai International Academic City, Dubai P.O. Box 341799, United Arab Emirates
[3] Applied Science Research Center, Applied Science Private University, Amman 11937, Jordan
* Correspondence: s.h.ghaffar@bham.ac.uk

Abstract: The construction industry in Kuwait is experiencing a transformative shift with the adoption of Building Information Modeling (BIM) technologies, particularly BIM 6D for sustainability analysis and 7D for facility management. This study investigates the integration of these dimensions to address sustainability challenges in Kuwait's construction sector, aligning practices with the United Nations' Sustainable Development Goals (SDGs). Through qualitative interviews with 15 stakeholders—including architects, engineers, and contractors—and analysis of industry reports, policies, and case studies, the research identifies both opportunities for and barriers to BIM adoption. While BIM offers significant potential for lifecycle analysis, waste reduction, and energy efficiency, its adoption remains limited, with only 27% of construction waste recycled. Challenges include high initial costs, a shortage of skilled personnel, and resistance to change. The study highlights actionable strategies, including enhanced regulatory frameworks, university curriculum integration, and professional training programs led by the Kuwait Society of Engineers, to address these barriers. It also emphasizes the critical role of collaboration among government bodies, industry leaders, and institutions like the Kuwait Institute for Scientific Research. Drawing from successful international BIM projects, the findings offer a practical framework for improving sustainability in arid regions, positioning Kuwait's experience as a model for other Middle Eastern and North African countries. This research underscores the transformative role of BIM technologies in advancing global sustainable construction practices and achieving a more efficient and eco-friendly future.

Keywords: sustainable transformation; Kuwaiti construction; facility management; BIM 6D; BIM 7D; construction waste

check for updates

Academic Editor: Luis Fernando Alarcón

Received: 12 December 2024
Revised: 22 January 2025
Accepted: 28 January 2025
Published: 3 February 2025

Citation: Al-Raqeb, H.; Ghaffar, S.H. The Role of BIM 6D and 7D in Enhancing Sustainable Construction Practices: A Qualitative Study. *Technologies* **2025**, *13*, 65. https://doi.org/10.3390/technologies13020065

1. Introduction

The construction industry is a key driver of global environmental impact, accounting for up to 42% of energy consumption and 35% of greenhouse gas emissions, particularly in regions like North America, over the last decade [1]. These figures highlight the urgency of adopting innovative technologies to address the sector's sustainability challenges. While integral to the industry, traditional Computer-Aided Design (CAD) approaches have proven insufficient in meeting contemporary sustainability demands [2,3]. A comparative analysis of construction methods reveals that integrating low-carbon materials significantly reduces emissions compared with conventional practices [4]. This underscores the potential of advanced digital tools to support sustainability in construction. Moreover, research from

Norway [5] demonstrates that digital governance platforms are vital in meeting the United Nations' Sustainable Development Goals (SDGs), fostering the development of smart, sustainable cities. Globally, many nations, including Kuwait, are aligning their construction industries with the UN's 2030 SDGs. Since its endorsement in 2015, Kuwait has sought to harmonize these goals with its Vision 2035 and the Kuwait National Development Plan (KNDP) [6–8]. Kuwait's Vision 2035 emphasizes the development of innovative and sustainable infrastructure, directly aligning with BIM's 6D and 7D dimensions, which focus on sustainability and facility management. By incorporating these advanced technologies, the construction sector can meet the vision's goals of resource optimization and reduced environmental impacts [9].

However, despite these ambitions, the Kuwaiti construction sector continues to encounter obstacles in achieving these sustainability objectives. A key solution lies in adopting advanced technologies such as Building Information Modeling (BIM), particularly its 6D and 7D dimensions, which offer a pathway to reducing the environmental footprint of construction and advancing sustainability in Kuwait. BIM has evolved from a tool that offers 3D visualizations of architectural assets into a comprehensive digital framework that integrates multiple dimensions of information. These dimensions extend from the traditional 3D geometric representations to 4D (time), 5D (cost), 6D (sustainability), and 7D (facility management) models [10,11]. This evolution has transformed how the architecture, engineering, and construction (AEC) industry plans, builds, and maintains assets, incorporating data from the entire lifecycle of a project [12,13]. Each BIM dimension enhances decision-making, from the design phase to construction, and through to facility management, offering a more holistic approach to sustainability [14,15].

These dimensions are defined by the level of information they provide and the project stage in which they are applied [16]. BIM 6D focuses on integrating sustainability into construction projects, enabling energy-efficient designs, waste reduction, and the adoption of sustainable materials throughout a building's lifecycle. BIM 7D enhances the management of facilities, promoting efficient resource use and energy conservation, and optimized maintenance strategies. By leveraging these dimensions, Kuwait's construction sector could significantly improve its environmental performance and operational efficiency [17,18]. Kuwait presents a compelling case study due to its ongoing urban expansion and challenges in waste management and resource efficiency. Despite its alignment with the UN SDGs and Vision 2035, the country faces barriers to adopting advanced digital tools like BIM, making this study both timely and necessary for driving sustainable construction practices. For instance, the harsh environmental conditions, including high temperatures and arid climates, demand resilient and energy-efficient infrastructure. BIM's ability to enable lifecycle analysis, waste reduction, and resource optimization positions it as a vital tool for addressing these challenges and aligning Kuwait's construction practices with its national and global sustainability goals

However, the Kuwaiti industry faces significant barriers to fully realizing the benefits of BIM, particularly in areas like data standardization, cybersecurity concerns, and inconsistent data management practices. Overcoming these challenges is critical for advancing BIM's role in fostering sustainable development [19]. Global studies indicate that, while awareness of BIM is growing, a significant gap remains between awareness and adoption. For instance, although 94% of UK construction professionals are familiar with BIM, only 39% report active implementation [20]. This highlights the need for strategic frameworks that support BIM's integration into construction workflows [21].

This study aims to contribute to the broader discourse on sustainable construction by exploring the role of the implementation of BIM 6D and 7D within the Kuwaiti context. The study aligns BIM practices with UN SDG 12 (responsible consumption and production) and

SDG 9 (industry, innovation, and infrastructure). BIM's alignment with SDG 9 is evident in its potential to drive innovation and improve construction workflows, while SDG 12 is supported through BIM's emphasis on waste reduction and resource efficiency.

Through qualitative research, including interviews with 15 key stakeholders from government officials, policymakers, construction company executives, architects, engineers, and facility managers, and government document analysis, this research seeks to provide actionable insights for enhancing sustainability in Kuwait's construction sector. Although the subjective nature of qualitative interviews may introduce bias, these expert perspectives offer crucial industry insights.

While this research underscores the promise of BIM 6D and 7D in addressing sustainability goals, it acknowledges the limitations of existing studies in fully examining their applicability. Specifically, prior research lacks comprehensive investigations into how these dimensions can be practically implemented and integrated with Kuwait's construction workflows. Moreover, there is limited quantifiable evidence demonstrating the environmental and economic benefits of BIM 6D and 7D in real-world projects. Future work should prioritize addressing these gaps by focusing on practical implementation strategies, quantifying environmental benefits, and developing stakeholder-specific frameworks to overcome adoption barriers.

Integrating BIM Dimensions in Construction Practices

BIM dimensions offer a collaborative framework that significantly enhances communication, coordination, and operational efficiency across the entire project lifecycle. By enabling stakeholders to work within a unified digital environment, BIM supports real-time data sharing and decision-making [22]. BIM integrates multiple dimensions ranging from 3D to 10D that facilitate the holistic management of construction projects, from design through to operations [23]. Each dimension contributes uniquely to improving sustainability and efficiency in construction:

3D BIM: enables clash detection, reduces rework, minimizes waste, lowers initial costs, and supports prefabrication efforts, enhancing overall construction efficiency.

4D BIM: aids in construction planning and management, promotes early stakeholder involvement, shortens schedules, saves costs, and encourages the use of sustainable materials.

5D BIM: focuses on whole-life costing and lifecycle cost (LCC) analysis, ensuring better financial management over the asset's lifetime.

6D BIM: facilitates early-stage energy analysis, reduces LCC, offers sustainable design alternatives, conducts lifecycle analyses, and minimizes waste, water, and material usage [16].

7D BIM: improves space and maintenance management, ensures energy-efficient operations, supports economical renovations, and enhances lifecycle management of assets [17].

8D BIM: emphasizes health and safety management, ensuring compliance with safety standards and minimizing risks during construction and operation phases.

9D BIM: focuses on lean construction principles, optimizing resource use and reducing waste in construction processes.

10D BIM: centers on industrialized construction, promoting automation, prefabrication, and modular construction techniques for greater efficiency and sustainability.

The adoption of BIM software, particularly in the context of 6D for dynamic energy analysis and simulation, offers notable advantages, including rapid assessment of design alternatives, and detailed financial and operational insights across the project lifecycle. The integration of 7D BIM further enhances facility management by providing comprehensive data on building components, specifications, maintenance, and warranties, supporting efficient asset management [17]. In addition to modern applications, BIM's potential extends to preserving cultural heritage. For instance, Historic Building Information Modeling (HBIM) has been instrumental in documenting, restoring, and managing historic transportation infrastructures, ensuring that modernization efforts align with the conservation of these critical assets [9].

One study [23] identifies the practical benefits of big BIM data in the AEC sector, particularly emphasizing advancements in post-construction phases due to mature technologies like sensor networks and IoT devices. BIM has demonstrated significant economic benefits, including a substantial return on investment (ROI) [24]. Research consistently shows that BIM helps prevent scheduling delays and reduces rework, contributing to cost savings. For instance, a case study of a USD 35 million academic building at Emory University, Atlanta, Georgia, revealed that BIM's clash detection capabilities reduced design errors, resulting in approximately USD 259,000 in savings [25,26] This study emphasizes the critical role of integrating lean construction (LC), BIM, and sustainability in addressing key challenges in construction projects, such as collaboration, productivity, and quality, while highlighting the importance of prioritizing human development alongside processes and technology.

A review of the literature from 2015 to mid-2021 identified two primary themes in the intersection of BIM and sustainability: green buildings and rating systems. Integrating facilities management information enables a holistic and sustainable approach to asset management, extending BIM's benefits beyond the construction phase and into the operational lifespan of buildings [25–29]. The development of a multi-dimensional BIM framework serves as both a research tool and a practical guide for industry stakeholders. This framework seeks to standardize BIM terminology, processes, and practices, facilitating clearer communication and effective implementation across the construction industry [30] Integrating BIM 6D and 7D during the design phase can streamline construction operations and maintenance, presenting opportunities for enhanced energy efficiency and resource optimization [31]. Addressing information gaps in the transition from construction to operations and maintenance through integrated knowledge-sharing models further emphasizes the importance of generating comprehensive information within BIM models [32]. This comprehensive approach, which leverages BIM's various dimensions, optimizes construction processes and facility management, thereby contributing to a more sustainable built environment [33]. Additionally, a proposed BIM framework aligned with national sustainability agendas highlights the strategic integration of BIM 6D and 7D dimensions within broader sustainability initiatives. This framework is consistent with Kuwait's Vision 2035 for sustainable buildings and the United Nations' Sustainable Development Goals (SDGs), underscoring the global importance of BIM in driving sustainable development [34].

2. Methodology

This study employed a qualitative approach to investigate the integration of BIM 6D (sustainability) and 7D (facilities management) into the Kuwaiti construction sector, with a focus on sustainable waste management and lifecycle optimization. Expert insights were gathered through a series of in-depth interviews with document analysis. The methodological steps are outlined in Figure 1.

2.1. Literature Review

An extensive literature review was conducted to establish a theoretical foundation on BIM 6D, 7D, sustainability in construction, and their integration. This review identified key knowledge gaps and areas requiring further investigation, which informed the study's direction. An extensive literature review was conducted to establish a theoretical foundation and identify research gaps. The literature review was conducted using a systematic approach to ensure the comprehensiveness and reliability of the research.

Key databases, including Scopus, Web of Science, and Google Scholar, were consulted to identify peer-reviewed articles, government reports, and industry guidelines related to BIM 6D and 7D implementation. The search strategy involved using Boolean operators and specific keywords such as "BIM 6D", "BIM 7D", "construction sustainability", and "waste management in Kuwait". Inclusion criteria focused on studies published in the last 15 years, written in English, and directly relevant to BIM in sustainability and construction. Exclusion criteria included duplicate studies, non-peer-reviewed sources, and articles without sufficient relevance to Kuwait's construction context. The review also incorporated cross-references from selected studies to expand the dataset. This systematic approach ensured a robust foundation for understanding BIM's role in sustainable construction.

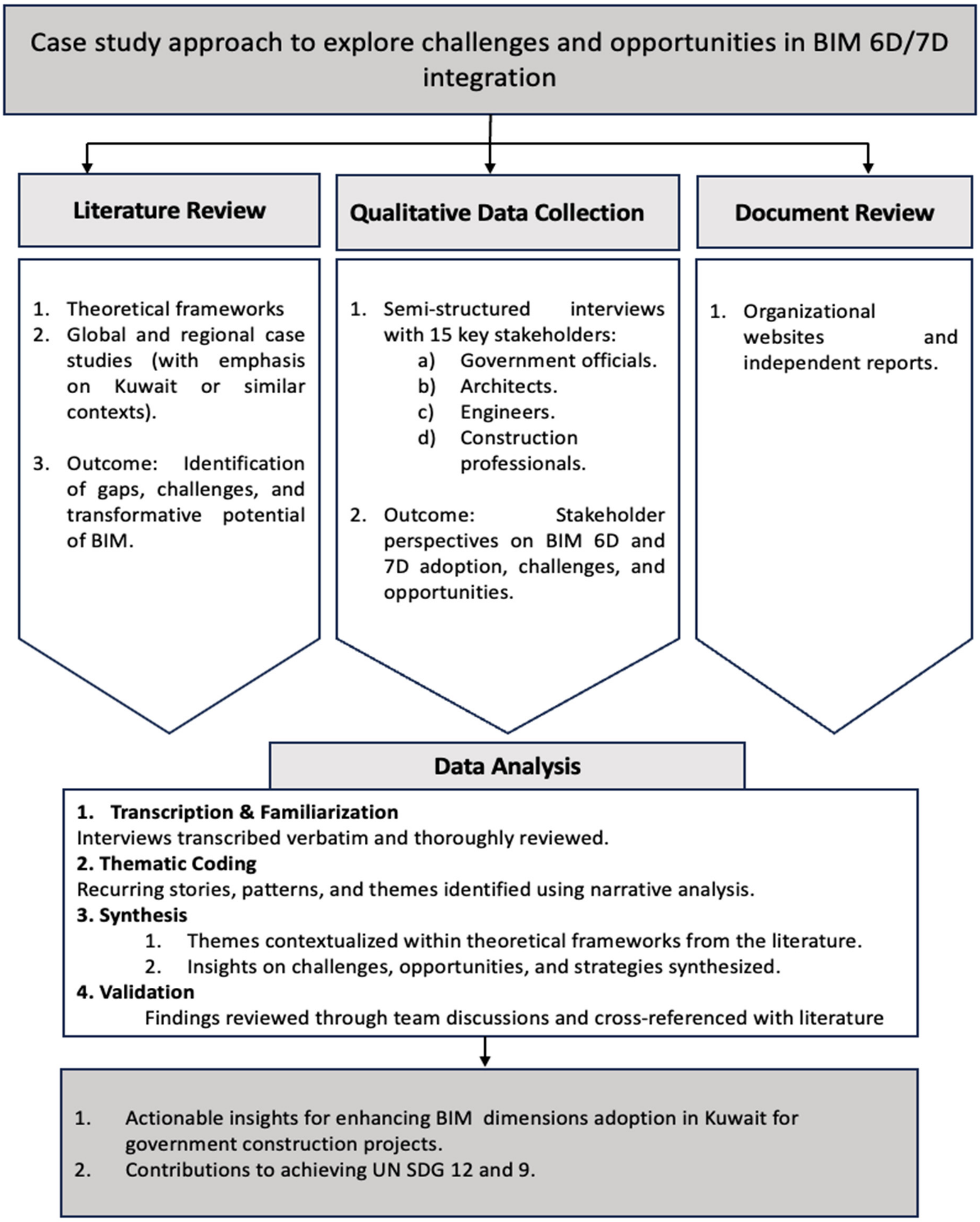

Figure 1. Research methodology.

BIM 6D and 7D frameworks and global applications.

Studies addressing sustainability challenges in Kuwait and comparable regional contexts.

The review highlighted critical gaps, particularly regarding the integration of BIM for sustainability and waste management, and informed the development of the interview protocol.

2.2. Document Analysis

To complement the qualitative data from interviews, a systematic document analysis was conducted. This method involved reviewing policy documents, government reports, project case studies, and industry guidelines related to BIM 6D and 7D implementation in Kuwait's construction sector. The selection of policy documents, government reports, project case studies, and industry guidelines was guided by specific inclusion criteria to ensure a comprehensive and unbiased analysis. Documents were chosen based on their relevance to BIM 6D and 7D applications, publication recency (within the last 10 years), and their focus on Kuwait's construction sector or comparable contexts. Sources from credible institutions, including government agencies, academic research, and industry leaders, were prioritized to maintain validity. To further reduce bias, documents were cross-referenced across multiple sources, and contrasting perspectives were considered when available

National and regional policies on construction waste management and sustainability.

BIM-related frameworks and technical documentation from industry stakeholders.

Document analysis provided contextual data to corroborate and enrich interview findings, offering insights into existing practices, regulatory challenges, and the institutional landscape.

Key documents were identified based on their relevance to the research aims. These documents were analyzed systematically to extract themes and align findings with the theoretical framework established through the literature review.

2.3. Interview Protocol Development

A semi-structured interview protocol was developed, tailored to extract expert insights on the integration of BIM 6D and 7D in the context of sustainability challenges and opportunities in Kuwait's construction sector. The protocol ensured consistency across interviews and focused on three key areas:

1. The contribution of BIM 6D to sustainability and waste reduction in construction projects.
2. The role of BIM 7D in facilities management for lifecycle sustainability.
3. The challenges and transformative potential of integrating BIM for sustainable construction.

The interview protocol was developed based on insights gained from the literature review and document analysis, focusing on sustainability, waste management, and collaboration among industry stakeholders. All participants were provided with an informed consent form and a plain language statement, both of which were approved by Brunel University's ethics committee.

2.4. Participant Selection

A purposive sampling technique was utilized to select 15 industry professionals, ensuring a diverse range of perspectives. The participants included BIM consultants, sustainability experts, architects, construction managers, and facilities management professionals, representing key stakeholders in Kuwait's construction sector. This diversity enriched the data by capturing a wide variety of insights and providing a holistic perspective on the research topic. The sample size of 15 participants is sufficient, given the qualitative nature of this study, as it ensures depth of inquiry while maintaining manageable data analysis. Furthermore, the diverse professional backgrounds of the participants enhance the reliability and validity of the findings, aligning with the research goals of understanding multifaceted challenges and opportunities within the sector. Table 1 outlines the participants' professional backgrounds.

Table 1. Participant positions and experience.

Professional	Years of Experience	Position
(A) The Municipality Director Engineer (Government)	30+	Director of the design department in government ministries.
(B) BIM Consultant/Specialist	22+	Managing director of virtual projects.
(C) Construction Manager/Contractor	32+	Manager of construction projects.
(D) Architect	20+	Sustainability manager.

2.5. Data Collection

In-depth, semi-structured interviews were conducted with selected experts. The conversational interviews allowed participants to elaborate on their experiences and provide nuanced insights. Probing questions were used to explore specific topics further.

Additionally, insights from the document analysis were cross-referenced during interviews to explore how participants' views aligned with or differed from documented policies and practices. The semi-structured interview questions (outlined in Table 2) were designed to elicit detailed responses on the integration of BIM 6D and 7D, sustainability challenges, and potential transformations in Kuwait's construction industry. These questions facilitated focused discussions, ensuring the collection of rich, actionable insights.

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

Number	Key Questions for Interviews
1	What are the prevailing challenges and gaps related to sustainability and waste management in the Kuwaiti construction industry?
2	How does the integration of BIM 6D enhance sustainability and reduce construction waste in the Kuwaiti construction process?
3	What role does BIM 7D play in facilities management, and how does it contribute to maintaining sustainability throughout the lifecycle of constructed assets?
4	To what extent can the integration of BIM 6D and 7D transform traditional construction practices in Kuwait, enhancing efficiency and reducing environmental impacts, including waste reduction?
5	What challenges are encountered during the integration of BIM 6D and 7D in Kuwaiti construction, particularly in relation to waste management, and what recommendations can be proposed to overcome these challenges?
6	How can BIM 6D and 7D be leveraged to optimize resource utilization and minimize material wastage during the construction phase in Kuwait?
7	What are the potential benefits and drawbacks of implementing BIM 6D and 7D specifically for waste management practices in Kuwaiti construction projects?
8	How can industry stakeholders, including government agencies and private sector companies, collaborate to promote the use of BIM 6D and 7D to reduce construction waste?

2.6. Data Analysis

Narrative analysis, as recommended by [35], was used to interpret the textual responses in the context of the respondents' industrial experiences. Figure 1 illustrates the research methodology. The narrative data obtained from the interviews, along with the findings from the document analysis, were analyzed using thematic analysis. This approach allowed for the identification of patterns, themes, and key insights across both datasets.

- Familiarization with data: the transcripts from interviews and findings from document analysis were thoroughly reviewed to develop a deep understanding of the data.
- Thematic coding: data were coded and categorized into themes, integrating insights from interviews and document analysis. Key phrases and ideas were systematically coded and categorized. This process involved grouping related codes into categories to capture recurring patterns and concepts.
- Analytical rigor was maintained through constant comparison and validation of findings.
- Synthesis: themes from the interviews were contextualized with data from document analysis, ensuring a comprehensive understanding of BIM integration in Kuwait.
- Validation: to ensure analytical rigor, findings were reviewed through iterative discussions among the research team and cross-referenced with existing literature.
- Justification: thematic analysis was selected due to its flexibility and effectiveness in managing qualitative data. Compared with alternative methods, it allowed for a nuanced interpretation of the narratives and document findings while aligning with the study's focus on exploring stakeholder perspectives and contextual challenges in BIM adoption.

3. Results and Discussion

The insights gathered from participating professionals reflect a diverse range of expertise in BIM implementation and sustainability management, offering a comprehensive examination of the transformative potential of integrating BIM dimensions 6D and 7D. Experts highlighted how these advanced functionalities can drive sustainable practices throughout the construction lifecycle by optimizing resource utilization and enhancing operational efficiency. However, they also pointed out significant challenges hindering widespread adoption, including technological barriers, organizational resistance, and cultural inertia.

Stakeholders, including Participants (A, B, C, and D), identified the limited availability and awareness of sustainable construction materials as a major issue, which was raised by approximately 70% of interviewees. Participant A emphasized the importance of effective construction waste management, noting that the sector generates around 60% of total waste in Kuwait, yet only 27% of this waste is currently recycled. This situation exacerbates environmental pollution and undermines efforts to promote sustainable practices in the industry.

3.1. Analyzing Policy and Industry Documents on BIM and Waste Management

To provide a foundational understanding of the current state of waste management and BIM adoption in Kuwait, a detailed document analysis was conducted. This analysis focused on policy documents, project reports, and industry publications to identify trends, gaps, and opportunities in integrating BIM 6D/7D technologies for sustainable construction.

3.1.1. Waste Management Policies and Practices

The document analysis revealed significant gaps in Kuwait's CDW management framework. While national policies acknowledge the importance of sustainability, there is limited enforcement of waste segregation and recycling practices. For instance, a report by the Kuwait Municipality (2019) indicates that only 27% of construction waste is recycled, compared with rates exceeding 70% in developed countries [36]. This disparity highlights a lack of infrastructure and regulatory enforcement for effective waste diversion. Additionally, key government documents such as *Environmental Protection* [37] emphasize sustainable development but fail to provide detailed guidelines for the construction industry. This regulatory gap hinders the effective implementation of sustainable practices, including the integration of BIM for waste management.

Table 3 presents data on construction waste quantities and recycling rates in Kuwait from 2021 to 2023, as reported from municipality documents. The table highlights incremental improvements in waste recycling, while also underscoring the persistent challenges in reducing landfill waste. Despite gradual increases in recycling rates, a significant proportion of construction waste still ends up in landfills. This situation calls for more effective waste management strategies and stricter regulations. For instance, mandating the use of recycled materials in new construction projects, implementing stricter penalties for non-compliance with waste management standards, and providing incentives for companies that significantly reduce their landfill contributions are potential solutions. One major contributing factor is the absence of on-site recycling machinery in construction projects, particularly in large-scale developments, which exacerbates the waste management issue.

Table 3. Municipal statistics data document on construction waste in Kuwait [37] (2021–2023).

Year	Environment Preservation Industrial Company (EPIC)		Arab International Industrial Project (AIIP)		Waste Sent to Landfills (%)
	Total Construction Waste (tons)	Waste Recycled (%)	Total Construction Waste (tons)	Waste Recycled (%)	
2021	884,248.5	27%	901,942	22%	16%
2022	656,429	27%	635,592	23%	12%
2023	60,310	26%	45,277	27%	21%

Additionally, the regulatory frameworks and the industry-wide adoption of sustainable practices remain in their nascent stages. Only around 30% of stakeholders expressed confidence in existing regulations. Earlier research indicated that awareness of BIM's role in the construction sector is limited, with only 26% of surveyed participants recognizing its potential. Furthermore, 80% of stakeholders stressed the need for more comprehensive and robust regulations to effectively guide sustainable practices in construction projects [38].

3.1.2. BIM Adoption and Technological Readiness

Analysis of industry publications suggests that BIM awareness in Kuwait is growing but remains limited to large-scale infrastructure projects. Notably, projects like the Sheikh Jaber Al-Ahmad Cultural Centre and the new Kuwait International Airport have successfully adopted BIM 6D and 7D for sustainability and lifecycle management. However, smaller construction firms lack access to the technical expertise and financial resources needed for BIM adoption. A survey conducted by the Kuwait Environment Public Authority (2019) reported that only 22% of local construction firms actively use BIM technologies, and, among these, integration of sustainability-focused dimensions (6D and 7D) is minimal. This low adoption rate underscores the need for targeted training programs and government incentives to bridge the technological readiness gap [39].

3.1.3. Alignment with Global Best Practices

Comparing Kuwait's policies and practices with global leaders such as the UK and Finland reveals a stark contrast. For instance, both of the latter countries have national BIM mandates and standardized protocols that streamline the integration of sustainability in construction projects [40]. In Kuwait, the absence of such frameworks has created fragmentation in how BIM is understood and implemented [8].

3.2. Challenges in BIM 6D/7D Integration

The construction industry in Kuwait is encountering critical challenges in adopting sustainable practices and effectively managing waste. Addressing these challenges is essential for enhancing the sustainability of construction operations and aligning with global trends. Stakeholder interviews have revealed several pressing issues hindering progress in this area.

3.2.1. Lack of Awareness and Understanding

A recurring theme from stakeholder interviews was the limited awareness of sustainable practices among contractors and developers. As Participant D noted, "Many contractors prioritize cost over sustainability, leading to excessive waste. Additionally, there is a significant gap in the availability of sustainable materials locally". This lack of awareness is compounded by a limited understanding of how BIM 6D and 7D can drive sustainability. These challenges are not unique to Kuwait, as similar issues have been noted in other developing construction markets, where short-term cost savings often take precedence over long-term sustainability goals [41]. Despite the growing global awareness of BIM, particularly in countries like the UK, Canada, Finland, and New Zealand, there remains a substantial gap between awareness and implementation [20]. Another key barrier identified is the inadequacy of regulatory frameworks. Participant C, a project manager, highlighted the lack of stringent enforcement of waste management regulations: "Regulatory frameworks are not stringent enough to enforce waste management practices effectively. There is also a lack of standardized processes for waste segregation and recycling, which exacerbates the problem". This finding is consistent with the global literature on the role of regulation in driving sustainability in construction [42]. Effective regulations, coupled with clear guidelines, are essential for promoting the adoption of BIM as a tool for sustainability in Kuwait.

3.2.2. Resistance and Initial Investment Costs

Resistance to change emerged as a critical challenge. As Participant A stated, "Resistance to change from traditional construction practices is a significant barrier. The initial investment required for sustainable materials and technologies is another hurdle". The financial burden of adopting BIM 6D and 7D, particularly for smaller firms, is significant. The literature supports the notion that high upfront costs can deter adoption, despite long-term benefits [43]. This resistance is further exacerbated by limited access to training programs focused on sustainability.

3.3. Proposed Solutions to Overcome Challenges

To address the challenges identified in BIM integration, several strategic solutions are proposed.

- Cost–benefit analysis for BIM integration: a key strategy to overcome resistance is the use of comprehensive cost–benefit analyses. These analyses can demonstrate the long-term financial and operational benefits of BIM integration, showcasing potential cost savings over the lifecycle of a project. Advocacy for the incorporation of such analyses at the project inception stage is crucial. By highlighting reduced waste, optimized resource use, and improved project efficiency, stakeholders can be more readily convinced of the return on investment (ROI) [44]. Tailored workshops and training sessions, emphasizing successful case studies and quantifiable metrics like energy savings and lifecycle cost efficiency, can further support stakeholder engagement. Visual tools such as BIM-based simulations and dashboards, along with pilot projects, can effectively showcase the comparative benefits of traditional versus BIM-enabled approaches.

Additionally, according to Participant D, BIM 6D and 7D models can address resource constraints such as water scarcity and energy consumption, which are crucial in Kuwait's context. Integrating BIM in infrastructure projects also mitigates environmental and economic burdens by enabling better fund allocation and sustainability strategies [45]. By promoting cost–benefit analyses supported by government incentives, Kuwait can enhance its commitment to sustainable construction while aligning with global best practices.

- Specialized training and upskilling: the need for specialized skills to operate BIM technologies was a significant concern for most participants. Upskilling staff or hiring new professionals is often seen as resource intensive [46]. To address this, collaboration with BIM consultancy services, such as those offered by Autodesk, could support the development of tailored training programs. Additionally, continuous professional development through certification programs can help build the necessary expertise within the workforce, reducing reliance on external specialists [47].
- Change management and awareness initiatives: resistance to change is a common challenge in adopting new technologies. Effective change management strategies are essential, including clear communication about the benefits of BIM integration, engagement with all stakeholders, and the gradual introduction of new processes [48]. Industry conferences, such as the Gulf BIM & Digital Construction Conference, can play a pivotal role in raising awareness and building momentum for change. As the literature suggests, involving employees in the decision-making process and addressing their concerns early can foster a more accepting environment for digital transformation [49].
- Standardization of processes and guidelines: a significant barrier to BIM integration is the lack of standardized processes across the industry. Standardization is critical for ensuring consistency in project execution and sustainability outcomes [46]. Collaboration with industry stakeholders and regulatory bodies is essential to develop industry-wide guidelines that facilitate seamless BIM integration. Research indicates that countries with well-established BIM guidelines tend to have higher rates of BIM adoption and more successful project outcomes [50].
- Governmental support and policy incentives: governmental support is a key enabler of BIM adoption. Policies that incentivize the use of BIM, such as tax incentives for green building projects or subsidies for training programs, can significantly reduce barriers to entry. Participant E emphasized the need for active government involvement: "Supportive policies and incentives would encourage the wider adoption of BIM technologies". This finding aligns with global research that highlights the role of government intervention in accelerating the adoption of sustainable practices [51].
- Continuous assessment and feedback loops: continuous assessment and feedback loops are essential for the successful integration of BIM [34]. Without ongoing evaluation, there is a risk of stagnation and missed opportunities for improvement. Establishing mechanisms for regular reviews of the integration process can help identify areas for improvement and implement refinements that enhance project efficiency and

sustainability outcomes [52]. This study proposes solutions that include cost–benefit analysis, specialized training, regulatory reform, and change management strategies. For instance, a review board could be established to ensure the continuous updating of regulations and standards, aligning them with technological advancements and material science [53]. By addressing these challenges, Kuwait can leverage BIM to significantly enhance its sustainability outcomes, aligning with both global construction trends SDGs and the country's Vision 2035 goals. The Kuwaiti construction industry faces significant challenges in adopting BIM 6D and 7D for sustainability and waste management, which align with issues highlighted in the existing literature. The integration of BIM in construction introduces a range of obstacles that hinder its widespread adoption. These challenges are deeply rooted in the industry's technical limitations, organizational structures, and financial constraints [54]. Despite these barriers, they can be addressed through strategic planning, stakeholder collaboration, and government support. This study proposes solutions such as cost–benefit analysis, specialized training programs, regulatory reforms, and change management strategies. By tackling these issues, Kuwait can harness BIM's potential to significantly improve sustainability outcomes, aligning with global construction trends, the Sustainable Development Goals (SDGs), and the country's Vision 2035 objective.

3.4. Opportunities for Sustainable Construction

Industry experts in Kuwait recognize the substantial potential for advancing sustainable construction practices through the integration of BIM technologies, particularly 6D and 7D. Participant A highlighted that the rapid growth of Kuwait's construction industry presents a unique opportunity to embed sustainability into projects from their inception. With urbanization and infrastructure development accelerating, adopting BIM technologies can improve efficiency and minimize environmental impact, aligning with Kuwait's Vision 2035 and the New Kuwait Development Plan. However, despite this potential, awareness of sustainable construction methods remains limited. Government initiatives are essential to effectively promote green practices and drive their adoption. Furthermore, ongoing research is critical to ensure the safe, efficient, and large-scale implementation of these technologies, maximizing their impact on Kuwait's construction sector [55]. Participant B emphasized Kuwait's critical challenge of limited resources, particularly water scarcity and high energy consumption. The integration of BIM 6D and 7D offers a potential solution by optimizing resource utilization, reducing waste, and improving energy efficiency in construction projects. Leveraging these technologies strategically can help Kuwait mitigate its environmental impact and align with global sustainable development standards. Over the past few decades, increasing environmental awareness has also driven significant scientific interest in renewable energy sources [56].

3.4.1. Exploring the Role of BIM 6D Integration in Kuwait's Construction Industry

Participant D emphasized that integrating BIM 6D signifies a paradigm shift in the construction industry's sustainability approach. This advanced dimension enriches the geometric model with essential sustainability information, providing a comprehensive and dynamic view of the entire project lifecycle. A key benefit of BIM 6D is its profound impact on minimizing construction waste, extending property lifecycles, and reducing maintenance costs. Supporting this view, recent research [57] underscores how BIM 6D integrates environmental and sustainability data into building design and construction processes, leading to significant reductions in waste generation and operational costs over the lifecycle of a building. Further studies have demonstrated the potential of BIM 6D to enhance resource utilization and energy efficiency through lifecycle cost analysis, operations and maintenance optimization, and efficient energy use [58]. Participant C noted that the Kuwait Green Building Council (KGBC), a nonprofit NGO, plays a pivotal role in promoting sustainable building practices in Kuwait through advocacy, education, and collaboration. By leveraging BIM 6D, resource optimization and energy efficiency can be enhanced at every stage of the construction process. This technology empowers informed decision-making that aligns with global environmental standards. Sustainability is no longer viewed as a standalone consideration but as an integral part of the design and construction philosophy. The integration of BIM 6D enables a proactive approach to sustainability, allowing for early identification and mitigation of potential environmental impacts throughout the project lifecycle. A notable example of this application is the Sheikh Jaber Al-Ahmad Cultural Centre in Kuwait. The project team employed 6D BIM to conduct a comprehensive lifecycle analysis, evaluating the long-term environmental implications of design choices, materials, and operational strategies, ensuring the building's sustainability throughout its lifespan. Similarly, the implementation of 6D BIM in the construction of the new airport in Kuwait extends beyond the construction phase, offering a holistic solution for efficient facility management and long-term sustainability. Research [59] further emphasizes that BIM capabilities—such as lifecycle cost analysis, operations and maintenance optimization, energy efficiency, daylight analysis, thermal design, and cost transparency—significantly contribute to sustainability in construction. Essentially, the integration of BIM 6D is not just a technological upgrade; it is a transformative force that aligns construction projects with the principles of sustainable development. At the University of Kuwait, the adoption of BIM 6D has the potential to play a pivotal role in advancing sustainability goals for construction projects. This not only improves current project outcomes but also positions the institution as a leader in environmentally conscious and resilient construction practices.

3.4.2. The Role of BIM 7D in Maintaining Sustainability

BIM 7D extends the capabilities of traditional BIM by integrating advanced aspects such as facility management and asset performance. This expanded dimensionality holds significant promise for maintaining sustainability throughout the entire lifecycle of construction projects. Participant A emphasized the importance of BIM 7D in government ministries' design departments, particularly for facilities management, stating, "BIM 7D represents a vital advancement for us, offering a new level of sophistication in how we oversee and sustain our assets throughout their entire lifecycle". A study conducted in Islamabad, Pakistan, demonstrated that using BIM in conjunction with life-cycle assessment (LCA) and geographic information systems (GIS) can substantially reduce greenhouse gas emissions. Specifically, the materialization stage saw a 29.35% reduction, the operational stage a 16.04% reduction, and the end-of-life phase a 21.14% reduction in GHG emission. Recent studies [60,61] underscore the transformative potential of BIM 7D in enhancing sustainability practices within the construction industry. By incorporating facility management data and performance analytics into the BIM model, stakeholders gain valuable insights into building operations and maintenance, enabling proactive decision-making to optimize resource utilization and minimize environmental impact. One key area where BIM 7D contributes to sustainability is reducing construction waste. Research highlights that BIM-based approaches, particularly those incorporating 7D dimensions, facilitate the identification and mitigation of waste throughout the construction process. By providing real-time data on material usage, resource allocation, and project progress, BIM 7D empowers stakeholders to implement lean construction principles and minimize waste generation [62]. Moreover, integrating predictive maintenance and lifecycle analysis capabilities in BIM 7D models allows stakeholders to identify opportunities for extending the lifespan of built assets and optimizing their performance over time. This proactive approach enhances sustainability, reduces long-term operational costs, and strengthens the resilience of infrastructure against environmental challenges. Participant D, involved in the Kuwait Oil Company (KOC) project, highlighted the enhanced design capabilities offered by BIM 7D. He noted, "BIM 7D has revolutionized our approach to design by integrating detailed sustainability data. This allows us to make more informed decisions early in the design phase, ultimately reducing construction waste and improving energy efficiency". Participant D also reported significant improvements in lifecycle management and maintenance planning, further stating, "With BIM 7D, we have a comprehensive view of the building's lifecycle, enabling proactive maintenance and reducing long-term operational costs. This level of detail was not possible with traditional 3D or 4D models. By integrating BIM 7D, the KOC project has achieved substantial improvements in both sustainability and operational efficiency, setting a new standard for future construction projects". Research [11,60] confirms that BIM 7D is an essential lifecycle management technology that significantly impacts the lifespan and sustainability of building projects.

3.5. Stakeholder Strategies and Recommendations

To effectively enhance stakeholder engagement in sustainable construction practices, exploring the potential of integrating advanced technologies such as BIM 6D and 7D is crucial. This integration fosters efficiency and aligns with sustainability objectives, providing a framework for informed decision-making among stakeholders.

The Integration Potential of BIM 6D and 7D

Participant B underscored the pivotal role of strategically integrating BIM 6D and 7D, signaling a significant evolution in construction methodology. He noted that he perceives this integration as transformative, transcending traditional boundaries and heralding a comprehensive redefinition of our industry approach. BIM 7D, with its pronounced emphasis on sustainability, introduces a critical dimension to the construction process, extending beyond conventional design and construction phases to encompass the entire project lifecycle. This integration seamlessly integrates sustainability considerations into decision-making, from initial design to ongoing maintenance, reflecting a paradigm shift rather than just a technological upgrade. Ref. [63] highlights the transformative potential of BIM 7D, emphasizing its ability to integrate sustainability principles into every phase of a construction project. Furthermore, [64] demonstrates how incorporating BIM technologies like 6D and 7D leads to improved project efficiency and reduced environmental impact. An experienced architect emphasizes that BIM 6D and 7D redefine the construction approach beyond mere efficiency. Beyond mere efficiency gains, the combined utilization of BIM 6D and 7D offers a unified and holistic perspective of projects, treating them as interconnected systems rather than discrete stages. This holistic view ensures that sustainability is not an addendum but an integral aspect throughout every phase, from inception to maintenance. A notable example of this integration's efficacy can be observed in the construction of the new airport in Kuwait. By employing BIM 6D and 7D methodologies, the project aimed to enhance operational efficiency and significantly reduce construction waste. The project achieved remarkable success in minimizing waste generation and optimizing resource utilization through real-time tracking of resources and material utilization, coupled with predictive maintenance insights. Another example from the private sector, Silicon Engineering Consultants Pvt. Ltd., has used BIM 6D and 7D in many projects in Kuwait. The "Al-Faisal Tower" project is one significant example, where the sustainability and energy efficiency of the structure were evaluated using BIM 6D. The facility management data were tracked using BIM 7D, ensuring the building's technical specifications and maintenance schedules were accurately recorded to minimize the generation of waste and optimize the consumption of energy. The transformative potential of this integration lies in its alignment with sustainability objectives, facilitating efficiency enhancements across the entire project lifecycle. It empowers stakeholders to make informed decisions aligned with environmental stewardship, inherently reducing the environmental impact and contributing to a more sustainable construction industry.

3.6. Future Recommendations from the Participants' Perspective

The strategic integration of BIM 6D and 7D represents a paradigm shift in construction methodology, underscoring a mindset that acknowledges the interconnectedness of project phases This shift towards sustainability-driven decision-making fosters improved efficiency and reduced environmental footprints, shaping the trajectory of sustainable construction practices beyond individual projects. The possibility of attracting investments in green technologies and sustainable infrastructure was also noted by participants. With sustainability becoming a global priority, Kuwait has the chance to showcase its commitment to innovative, environmentally responsible construction practices. The adoption of BIM 6D and 7D could position the country as a regional hub for sustainable development. Education was another recurring theme in the discussions. Several participants emphasized the importance of preparing future professionals with the necessary skills to implement BIM technology and promote sustainable construction practices. Investment in educational programs can foster a sustainability-driven culture within the industry and ensure its long-term success and resilience. Furthermore, participants stressed the need for international collaboration to accelerate the adoption of BIM 6D and 7D. By working with global experts and organizations, Kuwait can gain access to cutting-edge technologies and foster knowledge exchange. This approach could help solidify Kuwait's role as a leader in sustainable development at the regional and international levels. Table 4 outlines future recommendations from participants to enhance the adoption of BIM technologies and sustainable practices in Kuwait.

Table 4. Future recommendations from the participants' perspective.

Recommendations	Description
Policy Recommendations	• Establish robust regulatory frameworks mandating BIM technology. • Task the Kuwait Institute for Scientific Research (KISR) with developing BIM standards and guidelines. • Provide incentives (e.g., tax subsidies) for sustainable practices. • Increase government support for research and development in BIM for sustainability
Professional Development	• Invest in training programs to enhance proficiency in BIM technologies among professionals. • Support the Kuwait Society of Engineers (KSE) in offering BIM training to construction professionals. • Prioritize workforce upskilling to better leverage BIM tools. • Promote knowledge sharing and collaboration across the industry
Education Integration	• Integrate BIM and sustainability principles into educational curricula. • Encourage universities to offer BIM-related courses and degree programs. • Equip students with the skills to drive sustainable transformations within the industry. • Foster partnerships between educational institutions and industry stakeholders.
Collaboration and Knowledge Exchange	• Create platforms for ongoing dialogue and collaboration between stakeholders. • Facilitate the exchange of ideas and best practices to address shared challenges. • Promote public–private partnerships to accelerate BIM adoption.

4. Conclusions

This study investigated the integration of BIM 6D (sustainability analysis) and 7D (facility management) dimensions to address sustainability challenges within Kuwait's construction industry, a critical yet underexplored area in the regional context. The research highlights how these advanced BIM dimensions optimize resource utilization, minimize material waste, and support data-driven decision-making, aligning construction practices with international environmental standards. By embedding sustainability principles across the lifecycle phases of design, construction, and maintenance, the findings demonstrate a significant paradigm shift toward more sustainable and efficient practices in Kuwait's construction sector. The proposed framework offers actionable strategies to overcome barriers such as high initial investment costs, a shortage of specialized personnel, and resistance to technological change. These include targeted training programs, awareness campaigns, government incentives, and enhanced regulatory measures. Furthermore, the study underscores the alignment of BIM adoption with the United Nations' Sustainable Development Goals, particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production), emphasizing the potential for BIM to contribute to global sustainability objectives. Collaboration among government entities, industry stakeholders, and academic institutions is identified as critical for maximizing the impact of BIM technologies. While this study provides a foundational framework for advancing sustainable construction practices in Kuwait, future research should investigate the economic implications of BIM adoption and its long-term cost–benefit dynamics to support widespread implementation. This work contributes to the global discourse on sustainable development by offering insights that can be adapted to regions with similar environmental and industrial challenges.

Author Contributions: Conceptualization, H.A.-R. and S.H.G.; methodology, H.A.-R. and S.H.G.; formal analysis, H.A.-R. and S.H.G.; investigation, H.A.-R.; resources, H.A.-R. and S.H.G.; data curation, H.A.-R.; writing—original draft preparation, H.A.-R.; writing—review and editing, S.H.G.; visualization, H.A.-R. and S.H.G.; supervision, S.H.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the ethical considerations, and approved by the Ethics Committee of Brunel University of London (47286-LR-Feb/2024- 49791-1).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Vairagade, M.S.; Kumar, N.; Singh, R.P. View of Automated Construction of Structures using 3D Printing: A Review. In Proceedings of the 12th Structural Engineering Convention-An International Event (SEC 2022), Jaipur, India, 19–22 December 2022.
2. Shooshtarian, S.; Caldera, S.; Maqsood, T.; Ryley, T. Using Recycled Construction and Demolition Waste Products: A Review of Stakeholders' Perceptions, Decisions, and Motivations. *Recycling* **2020**, *5*, 31. [CrossRef]
3. Azhar, S.; Brown, J. BIM for sustainability analyses. *Int. J. Constr. Educ. Res.* **2009**, *5*, 276–292. [CrossRef]
4. Arenas, N.F.; Shafique, M. Reducing embodied carbon emissions of buildings—A key consideration to meet the net zero target. *Sustain. Future* **2024**, *7*, 100166. [CrossRef]
5. Ibrahim, A.M. A mapping towards a unified municipal platform: An investigative case study from a Norwegian municipality. *Sustain. Future* **2022**, *4*, 100063. [CrossRef]
6. Mohamed, M.A.T.; Shahda, M.M.; Eltarabily, S.; Megahed, N. Taking the SDGs into Account: A BIM-Based Strategy for Integrating Smart Materials in Building Components. *Port-Said Eng. Res. J.* **2023**, *28*, 56–72. [CrossRef]

7. United Nations. *General Secretariat of the Supreme Council for Planning and Development*; United Nations: New York, NY, USA, 2015.
8. Kuwait National Development Plan, 2020–2025. 2020. Available online: https://media.gov.kw/assets/img/Ommah22_Awareness/PDF/NewKuwait/Revised%20KNDP%20-%20EN.pdf (accessed on 2 May 2024).
9. Salah, R.; Szép, J.; Károlyfi, K.A.; Géczy, N. An Investigation of Historic Transportation Infrastructure Preservation and Improvement through Historic Building Information Modeling. *Infrastructures* **2024**, *9*, 114. [CrossRef]
10. Bukunova, O.; Bukunov, A. Building Information Modeling for Sustainable Construction. *IOP Conf. Ser. Mater. Sci. Eng.* **2021**, *1079*, 032080. [CrossRef]
11. Kaewunruen, S.; AbdelHadi, M.; Kongpuang, M.; Pansuk, W.; Remennikov, A.M. Digital Twins for Managing Railway Bridge Maintenance, Resilience, and Climate Change Adaptation. *Sensors* **2023**, *23*, 252. [CrossRef] [PubMed]
12. Kaewunruen, S.; Lian, Q. Digital Twin aided Sustainability-based Lifecycle Management for Railway Turnout Systems. *J. Clean. Prod.* **2019**, *228*, 1537–1551. [CrossRef]
13. Yalcinkaya, M.; Arditi, D. Building information modeling (BIM) and the construction management body of knowledge. *IFIP Adv. Inf. Commun. Technol.* **2013**, *409*, 619–629. [CrossRef]
14. Chong, H.Y.; Lee, C.Y.; Wang, X. A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. *J. Clean. Prod.* **2017**, *142*, 4114–4126. [CrossRef]
15. Ellis, G. The Evolution of BIM Dimensions: 3D, 4D, 5D & Beyond. Available online: https://www.autodesk.com/blogs/construction/bim-dimensions/ (accessed on 2 May 2024).
16. Chapter 2—Literature Review | Lifecycle BIM for Infrastructure. In *Lifecycle BIM for Infrastructure*; The National Academic Press: Washington, DC, USA, 2023.
17. The 7 Dimensions of BIM. Available online: https://biblus.accasoftware.com/en/wp-content/uploads/sites/2/2021/07/The-7-dimensions-of-BIM.pdf (accessed on 2 May 2024).
18. Barnes, P.; Davies, N. *BIM in Principle and in Practice*; ICE Publishing: London, UK, 2014.
19. Team, E. 6D BIM and Construction Sustainability. Available online: https://biblus.accasoftware.com/en/6d-bim-and-construction-sustainability/ (accessed on 2 May 2024).
20. Akanbi, L.A.; Oyedele, L.O.; Omoteso, K.; Bilal, M.; Akinade, O.O.; Ajayi, A.O.; Davila Delgado, J.M.; Owolabi, H.A. Disassembly and deconstruction analytics system (D-DAS) for construction in a circular economy. *J. Clean. Prod.* **2019**, *223*, 386–396. [CrossRef]
21. Ismael, D.; Shealy, T. Sustainable construction risk perceptions in the Kuwaiti construction industry. *Sustainability* **2018**, *10*, 1854. [CrossRef]
22. Farhadi, F. What Are BIM Dimensions? 3D, 4D, 5D, 6D, 7D, 8D, 9D BIM. Available online: https://neuroject.com/bim-dimensions/ (accessed on 2 May 2024).
23. Sompolgrunk, A.; Banihashemi, S.; Golzad, H.; Le Nguyen, K. Strategic alignment of BIM and big data through systematic analysis and model development. *Autom. Constr.* **2024**, *168*, 105801. [CrossRef]
24. Lee, G.; Park, H.K.; Won, J. D3 City project—Economic impact of BIM-assisted design validation. *Autom. Constr.* **2012**, *22*, 577–586. [CrossRef]
25. Azhar, S.; Khalfan, M.; Maqsood, T. Building information modeling (BIM): Now and beyond. *Australas. J. Constr. Econ. Build.* **2012**, *12*, 15–28. [CrossRef]
26. Moradi, S.; Sormunen, P. Integrating lean construction with BIM and sustainability: A comparative study of challenges, enablers, techniques, and benefits. *Constr. Innov.* **2023**, *24*, 188–203. [CrossRef]
27. Ferdosi, H.; Abbasianjahromi, H.; Banihashemi, S.; Ravanshadnia, M. BIM applications in sustainable construction: Scientometric and state-of-the-art review. *Int. J. Constr. Manag.* **2023**, *23*, 1969–1981. [CrossRef]
28. Fokaides, P.A.; Apanaviciene, R.; Černeckiene, J.; Jurelionis, A.; Klumbyte, E.; Kriauciunaite-Neklejonoviene, V.; Pupeikis, D.; Rekus, D.; Sadauskiene, J.; Seduikyte, L.; et al. Research challenges and advancements in the field of sustainable energy technologies in the built environment. *Sustainability* **2020**, *12*, 8417. [CrossRef]
29. IndiaCADworks: BIM Implementation—Progressing from BIM 3D to 7D. Available online: https://www.indiacadworks.com/blog/bim-implementation-progressing-from-bim-3d-to-7d/ (accessed on 2 May 2024).
30. Succar, B. Building information modelling framework: A research and delivery foundation for industry stakeholders. *Autom. Constr.* **2009**, *18*, 357–375. [CrossRef]
31. Michaud, M.; Meyer, J.; Forgues, D.; Ouellet-Plamondon, C. A taxonomy of sources of waste in bim information flows. *Buildings* **2021**, *11*, 291. [CrossRef]
32. Tan, A.Z.T.; Zaman, A.; Sutrisna, M. Enabling an effective knowledge and information flow between the phases of building construction and facilities management. *Facilities* **2018**, *36*, 151–170. [CrossRef]
33. Alwan, Z.; Nawarathna, A.; Ayman, R.; Zhu, M.; ElGhazi, Y. Framework for parametric assessment of operational and embodied energy impacts utilising BIM. *J. Build. Eng.* **2021**, *42*, 102768. [CrossRef]
34. Al-Raqeb, H.; Ghaffar, S.H.; Haitherali, H.; Gopakumar, A. Overcoming Barriers to Implementing Building Information Modelling in Kuwait's Ministry of Public Works: A Framework for Sustainable Construction. *Buildings* **2024**, *14*, 130. [CrossRef]

35. Picado Argüello, B.; González-Prida, V. Integrating Change Management with a Knowledge Management Framework: A Methodological Proposal. *Information* **2024**, *15*, 406. [CrossRef]
36. Alatoom, M. *Policy Paper for the Environment Pillar*; Kuwait Public Policy Center: Kuwait City, Kuwait, 2019.
37. Generation, W.; Recycling, W.; Collection, W.; Strategy, W.M. *Waste Management Atlas of Kuwait*; Kuwait Environment Public Authority: Kuwait City, Kuwait, 2022.
38. Director, M. Municipality Statistics. 2023. Available online: https://www.e.gov.kw/sites/KGOArabic/Pages/HomePage.aspx (accessed on 4 April 2024).
39. Al-Raqeb, H.; Ghaffar, S.H.; Al-Kheetan, M.J.; Chougan, M. Understanding the challenges of construction demolition waste management towards circular construction: Kuwait Stakeholder's perspective. *Clean. Waste Syst.* **2023**, *4*, 100075. [CrossRef]
40. Kuwait Environment Public Authority (KEPA). 87/2019. Available online: https://epa.gov.kw/en-us/home (accessed on 2 May 2024).
41. *Nbim. 180*; National Building Information Modeling Standard. NIMBS Committe, 2007. Available online: https://buildinginformationmanagement.wordpress.com/wp-content/uploads/2011/06/nbimsv1_p1.pdf (accessed on 2 May 2024).
42. Enobie, B.K.; Okwandu, A.C.; Abdulwaheed, S.A.; Iwuanyanwu, O. Effective waste management in construction: Techniques and implementation. *Int. J. Appl. Res. Soc. Sci.* **2024**, *6*, 1642–1652. [CrossRef]
43. Alhawamdeh, M.; Ferriz-Papi, J.A.; Lee, A. Examining the Drivers to Support Improved Construction and Demolition Waste Management for a Circular Economy: A Comprehensive Review Using a Systematic Approach. *Sustainability* **2024**, *16*, 6014. [CrossRef]
44. Vikram, A.S.; Vidhya Lakshmi, S. Advancements in Environmental Management Strategies and Sustainable Practices for Construction Industry: A Comprehensive Review. *SSRG Int. J. Civil Eng.* **2023**, *10*, 10–22.
45. Gharaibeh, L.; Eriksson, K.; Lantz, B. Quantifying BIM investment value: A systematic review. *J. Eng. Des. Technol.* **2024**. [CrossRef]
46. Mohamed, A.S.; Xiao, F.; Hettiarachchi, C. Project Level Management Decisions in Construction and Rehabilitation of Flexible Pavements. *Autom. Constr.* **2022**, *133*, 104035. [CrossRef]
47. Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. *BIM Handbook: A Guide to Building Information Modelling for Own-Ers, Managers, Designers, Engineers, and Contractors*, 2nd ed.; John Wiley & Sons: Hoboken, NJ, USA, 2011.
48. Zilberova, I.Y.; Novoselova, I.V.; Mailyan, V.D.; Petrov, K.S.; Shvets, A.E. Prospects for the Use of BIM Technologies at All Stages of the Life Cycle of an Investment and Construction Project. *Mod. Trends Constr. Urban Territ. Plan.* **2023**, *2*, 44–53. [CrossRef]
49. Shawky, K.A.; Abdelalim, A.M. Standardization of BIM Execution Plans (BEP's) for Mega Construction Projects; A Comparative and Scientometric Study. *Trans. Mach. Learn. Artif. Intell.* **2024**, *12*, 103–129. [CrossRef]
50. Kumar, R.; Singh, R.; Goel, R.; Singh, T.; Priyadarshi, N.; Twala, B. Incentivizing green building technology: A financial perspective on sustainable development in India. *F1000Research* **2024**, *13*, 924. [CrossRef] [PubMed]
51. Verma, A.K.; Adams, S.G.; Lin, C.Y.; Escobales, N.; Flory, I.L. Institutionalizing continuous improvement plan in an engineering technology department—Closing the loop. In Proceedings of the 2017 ASEE Annual Conference and Exposition, Columbus, OH, USA, 25–28 June 2017.
52. Al-Raqeb, H.; Ghaffar, S.H. 3D Concrete Printing in Kuwait: Stakeholder Insights for Sustainable Waste Management Solutions. *Sustainability* **2025**, *17*, 200. [CrossRef]
53. Handayani, T.N.; Putri, K.N.R.; Istiqomah, N.A.; Likhitruangsilp, V. The Building Information Modeling (BIM)-Based System Framework to Implement Circular Economy in Construction Waste Management. *J. Civ. Eng. Forum* **2021**, *8*, 31–44. [CrossRef]
54. Romero-Arismendi, N.O.; Olivares-Galvan, J.C.; Escarela-Perez, R.; Hernandez-Avila, J.L.; Jimenez-Mondragon, V.M.; Gonzalez-Montañez, F. Multidisciplinary Review of Induction Stove Technology: Technological Advances, Societal Impacts, and Challenges for Its Widespread Use. *Technologies* **2024**, *12*, 206. [CrossRef]
55. Polymeropoulos, I.; Bezyrgiannidis, S.; Vrochidou, E.; Papakostas, G.A. Enhancing Solar Plant Efficiency: A Review of Vision-Based Monitoring and Fault Detection Techniques. *Technologies* **2024**, *12*, 175. [CrossRef]
56. Sampaio, A.Z. BIM as a Computer-Aided Design Methodology in Civil Engineering. *J. Softw. Eng. Appl.* **2017**, *10*, 194–210. [CrossRef]
57. Koutamanis, A. Dimensionality in BIM: Why BIM cannot have more than four dimensions? *Autom. Constr.* **2020**, *114*, 103153. [CrossRef]
58. Malik, Q.; Nasir, A.R.; Muhammad, R.; Thaheem, M.J.; Ullah, F.; Khan, K.I.A.; Hassan, M.U. Bimp-chart—A global decision support system for measuring bim implementation level in construction organizations. *Sustainability* **2021**, *13*, 9270. [CrossRef]
59. Andreani, M.; Bertagni, S.; Biagini, C.; Mallo, F. 7D BIM for sustainability assessment in design processes: A case study of design of alternatives in severe climate and heavy use conditions. *Archit. Eng.* **2019**, *4*, 3–12. [CrossRef]
60. Ismail, N.A.A.; Rooshdi, R.R.R.M.; Sahamir, S.R.; Marhani, M.A. A Systematic Literature Review on BIM-based Facilities Management towards Sustainable Construction. *Chem. Eng. Trans.* **2023**, *106*, 385–390. [CrossRef]

61. Azhar, S.; Nadeem, A.; Mok, J.Y.N.; Leung, B.H.Y. Building Information Modeling (BIM): A New Paradigm for Visual Interactive Modeling and Simulation for Construction Projects. In Proceedings of the First International Conference on Construction in Developing Countries (ICCIDC-I), Karachi, Pakistan, 4–5 August 2008; Volume 1, pp. 435–446.
62. Yan, H.; Damian, P. Benefits and barriers of building information modelling. In Proceedings of the 12th International Conference on Computing in Building Engineering, Beijing, China, 16–18 October 2008; pp. 1–5.
63. Sood, R.; Laishram, B. A Review on Unexploited Features of N-Dimensional Bim: An Indian Construction Scenario. In Proceedings of the World Construction Symposium, Colombo, Sri Lanka, 24–26 June 2022; pp. 39–49. [CrossRef]
64. Widanage, C.; Kim, K.P. Integrating Design for Manufacture and Assembly (DfMA) with BIM for infrastructure. *Autom. Constr.* **2024**, *167*, 105705. [CrossRef]