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Development of a BIM Implementation Roadmap: The Case of Iran

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Abstract: High expectations from employers and complex communication between stakeholders in the construction industry, resulted in fundamental changes during the design and construction process. Excellence in communication and coordination is required between stakeholders and automated interdisciplinary change management to meet needs and expectations in the construction industry. Building Information Modeling (BIM) offers numerous benefits, including reducing construction time, cost, and risk while improving project quality, communication, and coordination. However, there are still significant barriers to BIM implementation. Since Iran is in the early stages of BIM implementation, a roadmap for adopting BIM in Iran's construction industry is designed for the first time to exploit BIM benefits in this paper. Face-to-face interviews were conducted with professionals to structure the roadmap. In addition, online interviews were carried out with 16 experts. Furthermore, a Delphi-based approach was employed to reach consensus. The roadmap consists of six main pillars with 53 activities designed to create a matured BIM plan based on local culture and needs. And the roadmap begins with assigning a strong leadership to lead the process. The industry is expected to be motivated to adopt BIM as it learns the benefits associated with BIM. Then, it continues with developing related best practices, rules and regulations. In the third stage, the roadmap encourages the industry to provide the required education and training. In the next pillar, the roadmap follows the establishment and development by defining a contractual platform. In the fifth pillar, the quality of BIM and its results will be measured and compared with expectations and pre-defined goals. Eventually, the government will provide a continuous BIM implementation.

The study is expected to facilitate BIM implementation in the Iran construction industry which will improve the quality of Project Management Body of Knowledge (PMBOK) practices. It will help to culminate tangible and intangible project deliverable by reducing time, cost, risks and improving overall quality. Therefore, all stakeholders satisfy the final outcome beside resolving conflicts and interferences.

Keywords: Automation; BIM; Construction; Implementation; Roadmap

1. Introduction

Numerous studies indicate the advantages of Building Information Modeling (BIM) implementation in the construction industry for the whole life cycle of a building, including planning, designing and engineering, construction, and facility management [1-10]. In the early engineering stage, BIM can improve programming by providing a preliminary cost and time estimation, informing the feasibility, reducing possible issues, and documenting the early-stage situation [1-7]. Employing BIM will accelerate and facilitate designing, redesigning, and design review by walking through a 3D model, and detecting conflicts such as clashes before construction [1-4,8]. This process and technology could sequence construction tasks and help to manage resources such as humans, equipment, and materials [2-5,7]. Also, the 3D model could explore an accurate quantity survey and cost estimation [2–4,7]. During the construction phase, communication is facilitated by leveraging BIM. The construction team controls traffic flows and sites' entrances and exits, so the team closely monitors the material flow. The site usage is efficient, and cash flow is tracked in real time. Performing the as-built construction reduces waste and material loss, so it avoids rework cost and effort duplication. It also helps to notify workers facing hazards to reduce HSE (Health, Safety, and Environment) risks [2–5,7–9]. In the post-construction phase, efficient asset management can be achieved by leveraging access to information related to the construction phase. Simultaneously, the building system will be analyzed to optimize energy consumption. Also, any component's life cycle is integrated into BIM; therefore, if the operational warehouse connects to the BIM, any shortages in spare parts will be alarmed and produced, so a continuous operation is expected [2–4,10]. Crucially, requirements should be predicted and satisfied through a comprehensive logistic plan that could bring step-by-step actions to exploit all benefits of using BIM.

In Iran, the government strives to minimize the related cost and enhance the opportunity for more construction projects inception with a limited budget allocated to the construction sector. According to the law approved in 2018, only 4% of the total government's budget had been allocated to the construction sector. In 2020, this share has surprisingly decreased to 3.5% of the total budget, while it increased by 5%. Again, in 2021, the government assigned 4% of the total budget to the construction sector [11–13]. There is a significant need to use BIM to produce the best results with the limited budget.

In the engineering phase, BIM enables a Life Cycle Cost Analysis (LCCA) [14,15]. Also, BIM provides a robust feasibility study and conceptual design. Resource conflicts could be realized, and project teams detect clashes before project initiation and make predictive decisions to avoid rework. In the meantime, energy consumption could be optimized using BIM [15]. Time and knowledge are effectively managed, and project understanding is enhanced [16]. Then, the project will be planned effectively, resource management will be enhanced, fabrication will be safe and fast, and the site will be planned efficiently [15]. Also, conflicts between workforces will be reduced through workspace optimization [17]. In addition, BIM aims to reduce material waste [18]. Communication between stakeholders helps to improve physical resource management. BIM helps produce as-built drawing. Furthermore, HSE issues will be controlled. Within the maintenance, facilities, and assets will be managed efficiently. The operation team can anticipate building components' life cycle to inform the operation's warehouse to replace broken elements. The crisis could be managed with fewer injuries and damages [19].

A study showed the positive effect of BIM on project management knowledge areas (PMKAs), in which BIM can improve various aspects of project

management, including risk, communication, cost, and schedule [20]. Another study also demonstrated an impressive enhancement in PMKAs and the quality of project management by contributing BIM to the project management activities and deliverables [21]. Iran's construction industry has several significant barriers that hinder companies from applying BIM in their projects. These barriers include a lack of BIM experts, limited awareness around BIM applications, absence of required rules and regulations, inadequate knowledge about BIM usage, lack of support from decision-makers, and high initial cost of providing related software and hardware. Additionally, the rate of investment return is ambiguous to the industry, making it uncertain to use BIM [22]. A BIM implementation roadmap has been proposed for the first time for Iran's construction industry in this paper to address these impediments. The BIM implementation roadmap is based on the current local culture and is designed to satisfy the current needs of the Iranian construction industry. A Delphi-based approach was used to collect experts' opinions through a questionnaire, resulting in a comprehensive roadmap based on six pillars, including 50 tasks within a 5-year anticipated implementation period. The roadmap is expected to guide industry players to actively participate in the process to achieve the pre-defined goals promptly. BIM implementation and continuous improvement are also expected to reach the highest positive potential of BIM in the industry.

2. Literature review

This paper discusses, on the one hand, advancements in BIM implementation road mapping. On the other hand, it provides a useful roadmap to adopt BIM in Iran's construction industry. For this purpose, the countries that have an approved or proposed roadmap are discussed in the following with a summary of BIM implementation roadmap pillars in **Table 1**:

In the 1970s, Finland introduced a new approach to digitizing construction [23], and in 2001 started pilot projects [24]. In 2007, BIM became mandated in construction projects [24]. The 5-pillar Finish BIM implementation roadmap relies on five pillars approved in 2014 [25], which resulted in 99% of BIM adoption in 2016 [26].

The Canadian BIM Council was established in 2008 and required BIM to be used in public sector projects [27]. In 2014, BuildingSMART (2014) published the Canadian BIM implementation roadmap with six main pillars [28], which concluded a 67% expansion in the use of BIM in the industry in 2018 [29].

Singapore accepted the BIM adoption roadmap before requiring BIM in projects. In this regard, two different versions of the roadmap were published in 2010 [30] and 2014 [31]. Efforts engendered in 65% BIM implementation in 2014 [32]. BIM is currently required in projects with a value of more than 50 million US dollars [33].

In 2017, France approved the BIM implementation roadmap and, at the same time, made BIM mandatory as of this year [34]. In 2015, the BIM usage percentage touched 71%, which revealed a 32% improvement within two years [35].

In the 2000s, South Korea was interested in BIM applications in the construction industry [27]. In 2016, the Ministry of Land, Infrastructure, and Transport (MOLIT) published the Korea BIM implementation roadmap. Since 2016, BIM has been mandated in all public and construction projects valued at more than 50 million US Dollars required by the Public Procurement Service [24].

Spain approved the BIM implementation roadmap in 2015 and subsequently mandated BIM in all public projects with a value of more than 2 million euros [34].

In 2011, Britain legislated to implement BIM level 2 in all public infrastructure projects cost more than 5 million pounds [19, 28, 29]. The BIM implementation roadmap published by Cambridge University in 2018 consists of 5 pillars [36].

In 2017, Indonesia's industry was motivated to employ BIM [37], and in 2018, the Indonesian BIM implementation roadmap was approved [38]. As a result, 70% of the Indonesian industry adopted BIM level 1 in 2020 [39]. Since 2018, BIM become compulsory in all public projects with more than two stories and more than 2000 square meters [40].

Apart from approved roadmaps in pioneer countries, researchers proposed roadmaps in other countries that have not yet been approved. In **Table 1**, the approved and proposed roadmaps are presented.

Table 1. Proposed and approved BIM implementation roadmaps.

Country	Pillars									Ref
Finland	Standards and guidelines for the whole life-cycle	Comprehensive information management know-how	Collaborative model-based processes	Services created through open data	Enabling technology					[25]
Canada	Engage	Develop	Education	Deploy	Evaluate	Sustain				[28]
Singapore	Drive BIM collaboration throughout Virtual Design and construction	BIM for Design for Manufacturing & Assembly	New Training programmes at all levels	BIM for Facility Management & Smart City	Research & Development					[31]
Britain	Approach	Governance	Commons	Enablers	Change					[36]
Hong Kong	Collaboration	Incentive and Proven Benefits	Standard and Common Practice	Legal and Insurance	Information Sharing and Handover	Promotion and Education	Sufficient Digital Capability and Vendor Support	Risk Management	Global Competitiveness	[41]
Mongolia	Developing the Program	Preparation	The Implementation of the Program							[42]
Germany	Preparatory Phase	Extended Pilot Phase (Level 1)	BIM Performance Level 1 for New Projects							[43]
Portugal	Removing Impediments	Building BIM Capability and Capacity	Incentivizing BIM Adaptors							[27]
Malaysia	Standard and Accreditation	Collaboration and Incentives	Education and Awareness	National BIM Library	BIM Guideline and Legal Issues	Special Interest Group	Research and Development			[44]
Ireland	Leadership	Standards	Education &Training	Procurement						[45]
Saudi Arabia	Develop BIM Task Group	Set Foundation for BIM Adoption and Implementation	Cultural Change	Education	Investment by Government and Construction Companies	Implementation of BIM	Performance Measurement	Identify and Address Challenges	Review of National Strategy	[46]
Brazil	Governance	Infrastructure Technology and Innovation	Legal Framework	Technical Regulation	Investments	Capacity	Induction by the Federal Government	Communication		[47]
Pakistan	Private and Government Based Organizations	Policies Making								[48]
		Cooperation with International Organizations	Guidelines and Regulations for BIM Implementation							
		Awareness Toward Sustainability via BIM	Solutions for Environmental and Energy Crises							
		Impact of BIM on XL And L Scale Projects	Impact of BIM on XL, L, M, S Scale Projects							
Nepal	Establishment of Task Group and Develop Policy Documents	Engagement with Stakeholders	Development of Roadmap	Education and Training	Development of Pilot Projects/ Case Studies	Investment in Software and Hardware Infrastructure	Development of Collaborative Working Culture and Assurance of Long-Term Commitment			[49]
Ethiopia	Collaboration	Incentive and Proven Benefits	Standards and Common Practices	Legal and Insurance	Information Sharing and Handover	Promotion and Education	Sufficient Digital Capability and Vendor Support	Risk Management	Regional Competitiveness	[50]
Algeria	Technology	Policy 1	Process	Policy 2						[51]
Costa Rica	Technology	Politics	Process							[52]
Egypt	Government Engagement	Prepare BIM Guidelines	Training & Education	Collaborative Worldwide Projects	Measurement & Evaluation	Adaption & Promotion				[53]

Some similar tasks could be identified when considering roadmaps' tasks shown in **Table 1**. Conceptually, similar tasks are as follows:

- Motivating the industry to join the program could be establishing a leader, a task group, or a government. The task aims to put a robust leader in overall activities to implement policies and keep the process on track.

- Another critical task is to adopt the necessary laws and regulations to prevent deviations from the goals. The other expectation is to create continuous communication with the international community to maintain best practices. The importance is to clarify the requirement over a dynamic platform that will experience change based on international and national developments.

- Since one of the significant obstacles to BIM implementation is the lack of knowledge and awareness [22], it is vital to offer education courses in universities or training courses in non-academic institutes.

- It is also crucial to measure whether the quality of BIM implementation meets the pre-defined goals or the approved standards. Therefore, assessment tools are required to validate the implementation and detect any variations.

- Eventually, stakeholders should ensure that BIM will be used continuously in all construction projects. The roadmap and its steps provide a reliable platform to implement BIM sustainably.

On the other hand, various tasks are included in the roadmaps based on the local needs to compensate for shortages and remove obstacles in each country. Therefore, the Iran BIM implementation roadmap needs a deep understanding of local problem recognition and gathering information specifically for Iran. Thus, the authors conducted a comprehensive literature review below.

Iran is still in the infancy of BIM implementation [54]; meanwhile, Iranian companies are not interested in and generally have limited knowledge about BIM [55]. Only 28% of companies express BIM usage in their projects [56]. Several investigations explored BIM adoption impediments in the Iran construction industry, such as limited knowledge and absence of trained personnel, strict rules, economic issues such as incentives, and software and hardware preparation costs. On the other hand, only 2D drawings are acceptable legally; meanwhile, engineering lead time is more than the traditional method [21, 56, 57].

Despite research indicating that BIM could accelerate activities in Oil, Gas, and Petrochemical (OGP) projects, its usage is still rare in Iran [58]. According to a survey, 44.2% of Iranian consultants strongly believe in the positive effects of BIM on safety. In addition, through a survey, 33.3% of contractors and 30.2% of clients announced that BIM reduces HSE risks at construction sites [59]. Fakhimi *et al*. (2017) claimed that 54% of non-building construction projects use BIM to enhance project understanding through a 3D model [60]. Furthermore, 48% of non-building construction projects utilize BIM for design purposes, while 20% use it for clash detection. Additionally, 20% apply BIM for planning, 33% to explore quantity, and 34% to assess constructability. Marefat *et al*. (2019) found that Iranian consultants have more knowledge than contractors and clients, attributed to a lack of commitment and interest in BIM among client bodies [59]. Zakeri *et al*. (1996) revealed that despite the allocated budget for the construction industry in Iran, 51% of working hours and 24-46% of productivity are lost at construction sites. Implementing remote construction techniques enables firms to achieve the highest level of efficiency [61].

Fazeli *et al*. (2020) developed an effective model that links cost estimation items to quantities based on the Cost Estimation Standard of Iran in a case study. The developed model provides an acceptable level of accuracy and accelerates the cost estimation while significantly reducing the required resources [62]. Ashtab and Farzad (2018) conducted a study to explore the use of BIM in providing tender cost estimation based on the Iran National Bill of Quantities. They claimed that BIM is a feasible and reliable tool for this purpose [63]. Hadavi and Tavakolan (2018) developed a model that links project changes to project cost estimation, demonstrating a dedicated platform for decision-making [64]. A study conducted in 2021 proposed a BIM implementation roadmap for petrochemical building projects, focusing on three crucial challenges: process, people, and tools [65]. A platform is also represented by relying on the personnel's required capabilities and the possible strategies to prepare the organization to assist top managers and professionals in facilitating organizational BIM implementation [66]. Rohani and Banihashemi (2022) investigated the steps necessary for a successful BIM implementation and concluded that a comprehensive and sequential series of activities is essential. The initial step in achieving a successful BIM implementation is introducing BIM as a newly emerging technological innovation and raising awareness about its potential benefits. Subsequently, it is crucial to establish required standards and regulations about BIM, including developing a standardized contract form specific to BIM projects. These actions help create a solid foundation for effective BIM implementation throughout the industry. Organizations are expected to be attracted to BIM at this stage. In the final step, known as the inter-organizational stage, organizations should strive to overcome and eliminate obstacles that hinder the implementation of BIM [67].

Although BIM is an academic course in 'construction and engineering management' in Iran the course

material is outdated, representing knowledge from ten years ago [54]. Several studies have identified obstacles to BIM implementation in Iran's construction industry, intending to motivate the government to remove these barriers. However, despite these efforts, BIM is still in its preliminary stages, and there is no clear indication of a serious commitment to expanding its use in the industry. While BIM offers many benefits to project stakeholders, its implementation in Iran has experienced very little progress [54]. Not only in Iranian public projects but also in Iranian private projects, BIM implementation encounters many challenges; as Athari Nikooravan and Golabchi (2023) concluded, barriers include lack of support from decision-makers, teams showing resistance to change methods, experts reluctant to share data, inefficient workflow to produce and circulate information, lack of a standard contractual framework, absence of a dispute resolution mechanism, interoperable software which faces technical limitations, lack of parametric objects library, and time and expenditure for model development [68]. Toward a widespread BIM adoption in the Iranian industry, Taheripour *et al*. (2022) performed research to identify the barriers and suggest some strategies to resolve them [69]. The authors stated that allocating incentives, involving risk-takers, automating organization structure, and creating a collaborative atmosphere through sufficient and efficient training would improve BIM adoption in the industry.

Studies have shown a lack of contract templates that provide an efficient platform for BIM implementation [70]. In this regard, Mahdian *et al*. (2023) proposed a contract template that aims to resolve BIM barriers based on a case study on Design-Build (DB) and Design-Bid-Build (DBB) projects in Iran [71]. Research conducted in 2020 showed that barriers to BIM adoption in Iran's construction industry are the lack of time to implement BIM, the costs of purchasing software, and the lack of knowledge about the benefits of BIM [57].

This research aims to produce an implementation roadmap based on the current needs and environment of the local construction industry to overcome obstacles.

3. Research Methodology

3.1. Research Preparation

A comprehensive literature review is employed to identify local needs and barriers and then to review previous studies with BIM implementation roadmaps. Among all reviewed roadmaps, Canada's [28] and Ireland's [45] BIM implementation Roadmap revealed a close relation to the current environment, considering explored local needs.

The barriers to BIM implementation include: BIM professionals are rare, awareness is insufficient among stakeholders, rules, and regulations are not approved yet, knowledge about BIM is lacking, decision-makers are not demanding, and initial funding to prepare software and hardware is high. In addition, the return of investment (ROI) is ambiguous, making it risky to use BIM. Based on the conducted literature review and the insights obtained from the other countries' roadmaps, the Iran BIM Implementation Roadmap has been drafted. This roadmap highlights the strategies and approaches for resolving the obstacles encountered during BIM implementation.

The drafted roadmap has been discussed through face-to-face interviews with high-level managers. Gathered comments resulted in principal changes in the body of the roadmap. As a result, some tasks have been added to, changed, or removed from the roadmap. Since the interviewees had a substantial experience with an influential role in the industry, and was expected to provide practical and reliable information, which reflected the reality of the construction environment.

3.2. Data Collection

The key to success in this research is to gather professional information through a reliable platform. The gathered data will facilitate BIM implementation roadmap requirements determination and aim to prepare a comprehensive judgment. The Delphi-based approach accumulates professionals' perceptions to measure consensus and generate a reliable outcome.

Various types of research relied on the Delphi-based method, resulting in accurate outcomes as shown in **Table 2**:

Table 2. Recent studies based on the Delphi approach.

Row	Year	Title	Ref.
1	2023	Building Information Modelling, Integrated Project Delivery, and Lean Construction Maturity Attributes: A Delphi Study	[72]

Table 2. Recent studies based on the Delphi approach. Continuation Table:

Row	Year	Title	Ref.
2	2023	Justifying the Effective Use of Building Information Modelling (BIM) with Business Intelligence	[73]
3	2023	Liability Factors and Conceptual Framework for Contracts to Manage Design for Digital Fabrication in Construction Projects	[74]
4	2023	Verification and validation of a framework for collaborative BIM implementation, measurement and management (CIMM)	[75]
5	2022	A theoretical BIM-based framework for quantity take-off to facilitate progress payments: the case of high-rise building projects in Vietnam	[76]
6	2021	A relational framework for smart information delivery manual (IDM) specifications	[77]
7	2021	Building Operation and Maintenance: A Framework for Simplified Building Information Modeling (BIM) Digital Mobile Application	[78]
8	2021	Building information modeling based building sustainability assessment framework for Kazakhstan	[79]

In the Delphi approach, applied analyses are utilized due to their ability to employ theories, regulations, fundamentals, and techniques developed through investigations to answer actual issues. Applied research identifies practical needs and boosts living quality [80]. Regarding its essence, this kind of investigation descriptively and realistically explains real-world situations and facilitate information gathering about the current state toward ease of making decisions [81]. Eventually, considering the nature of this research, which collects information from the field, this research is categorized as "descriptive, exploratory."

The advantages and disadvantages of adopting BIM were initially studied with a deep and extensive literature review, and the essential obstacles were explored, specifically in Iran.

In the next step, a preliminary roadmap is drafted and discussed with professionals to culminate through in-person interviews with experienced experts. The stage resulted in task modification, a roadmap scheme, and a schedule. This step aims to answer the following questions:

1-How can we speed up and energize the construction industry to adopt BIM?

2-What is the current state of BIM implementation in the construction industry?

3-What are the crucial impediments to adopting BIM?

4-How much time roughly does the sector need to apply BIM?

5-What are the expected achievements relying on BIM?

The interviews resulted in fundamental changes in the pre-defined tasks of the roadmap. A semi-structured questionnaire was designed, with 53 questions in 6 sections, as represented in the appendix, each indicating a pillar, and distributed between 18 professionals to assess the consensus among experts. The questionnaire was designed in 5-point Likert scale and asked participants to add any comment to improve the questionnaire or clarify the ideas. 16 out of 18 experts participated in the investigation. A plurality of the respondents worked at employer organizations (44%), and a quarter worked as consultants. The contractor has the lowest share (12%), almost half of the consultants. Researchers had next to one-fifth of the respondents with 19%. The contribution of each of the mentioned groups is shown in **Figure 1**.

Table 3 illustrates the education level of participants. As revealed, most participants (68.75%) were master of science graduates. In contrast, only one of the responders was a Ph.D. graduate, and 25% of participants had a bachelor of science degree.

Table 3. Participants' education.

Education	Frequency	Percent of Frequency
PhD	1	6.25%
MSc	11	68.75%
BSc	4	25%
Total	16	100%

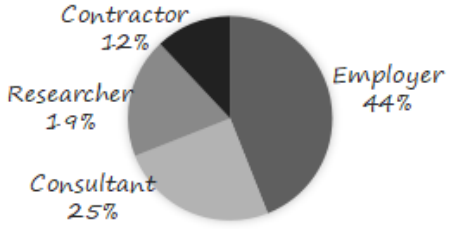

Figure 1. Research participants.

According to **Figure 2**, the research indicates that the most significant proportion of participants (37.5%) had less than five years of work experience. In the following, about one-third of respondents have between 10 and 15 years of experience. A quarter of collaborators have 5 to 10 years of experience in the industry, and only about 6% have 15 or more years of background in the construction industry.

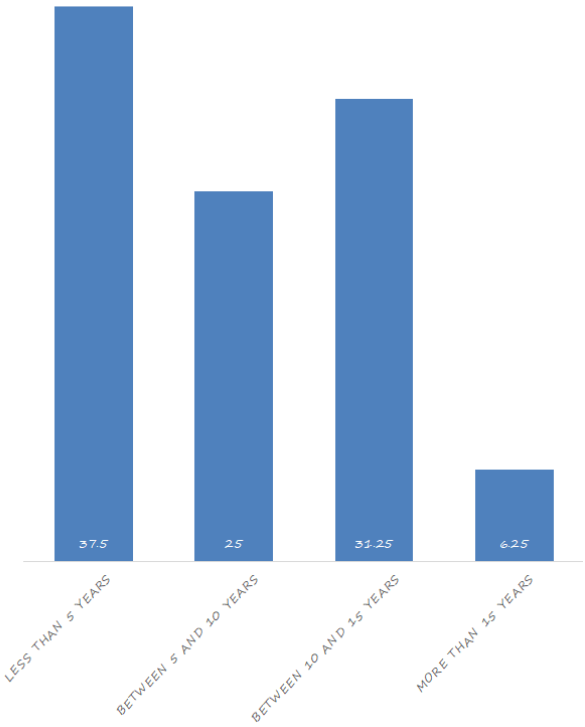

Figure 2. Participants working experience.

3.3. Data Analysis

The proposed road map was verified using a Delphi-based method, in which participants' inputs significantly influence the outcome, but there was no established criterion for selecting the participants and measuring their qualifications [82]. Generally, decision-makers, experts with particular expertise, and individuals with strong backgrounds in judgment were invited to fill out the questionnaire. On the other hand, the specific number of respondents has not been defined. Studies suggested a range of collaboration between ten to more than 2000 participants. If the participants are homogeneous, a consensus can be achieved with 10 to 20 respondents, while 15 to 30 respondents are needed to achieve consensus in the case of heterogeneity [83]. In the Delphi method, the consensus is typically reached when at least 80% agreement is obtained for 7-point criteria and 70% agreement for 5-point criteria [82]. However, other studies have defined consensus as 50% or more of the votes being the same, or at least a 70% agreement in the second or third rounds. In the process, questions can be removed if convergence of the answers is observed, helping to streamline the questionnaire in subsequent rounds. Conversely, increasing the gap between results indicate a deviation from consensus [84]. Consensus is measured using the interquartile range, which should be equal to or less than one [85, 86]. Four statistical parameters are decisive in evaluating the Delphi-based results: mode, median, mean, and dispersion indexes (including interquartile range and standard deviation) [87]. In addition to achieving agreement through voting, additional criteria are considered to measure consensus. These criteria include ensuring that the standard deviation is equal to or less than 1.64 and the mean is equal to or above 3.25. These criteria serve as additional quantitative measures to evaluate the level of agreement among participants in the Delphi-based method, thereby enhancing the assessment process [77]. Before distributing the questionnaires among anonymous experts, the questionnaire was discussed with three highly qualified professionals and modified to ensure alignment with the subject matter and avoid deviations. The expert opinion-gathering process is presented in **Figure 3**.

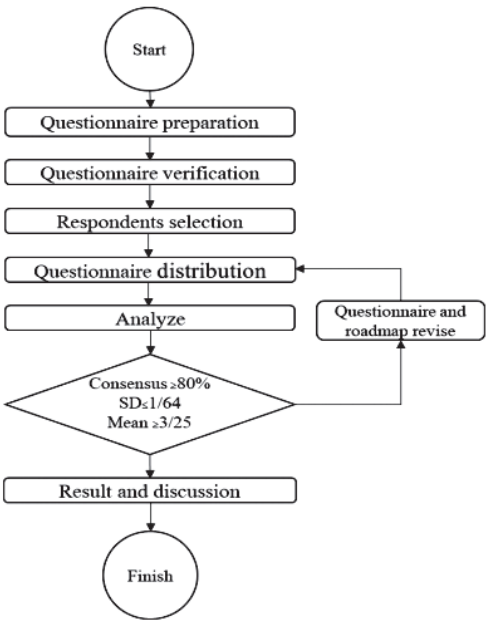

Figure 3. Validation through Delphi approach.

4. Results

4.1. Survey outcome

The process presented in **Figure 3** was iterated for three rounds. In the first round, the opinions received were analyzed using key indicators such as percentage of agreement, standard deviation (SD), and mean. Based on the comments received, certain modifications were made to the roadmap tasks, resulting in changes to the questionnaire. The process was repeated for two additional rounds to attain an agreement of over 80% for the specified outlined in the proposed roadmap. By the third round, a consensus was reached on each question using a 5-point Likert scale. The survey outcome is represented in **Table 4**.

Table 4. Analysis results.

Question	Round 1				Round 2				Round 3			
	SD	Mean	Consented	Consensus	SD	Mean	Consented	Consensus	SD	Mean	Consented	Consensus
Q1	1.46	3.50	Yes	63.75%	1.49	3.73	Yes	75.00%	0.79	4.31	Yes	86.25%
Q2	1.33	3.81	Yes	71.25%	1.33	3.81	Yes	76.25%	0.91	4.19	Yes	83.75%
Q3	1.02	4.13	Yes	82.50%	1.02	4.13	Yes	82.50%	0.83	4.19	Yes	83.75%
Q4	1.41	3.50	Yes	70.00%	1.31	3.88	Yes	77.50%	0.89	4.13	Yes	82.50%
Q5	1.29	3.75	Yes	75.00%	1.12	4.06	Yes	81.25%	0.81	4.13	Yes	82.50%
Q6	1.03	4.00	Yes	80.00%	0.93	4.06	Yes	81.25%	0.81	4.38	Yes	87.50%
Q7	0.79	4.31	Yes	86.25%	0.79	4.31	Yes	86.25%	0.60	4.31	Yes	86.25%
Q8	0.60	4.31	Yes	86.25%	0.60	4.31	Yes	86.25%	0.79	4.31	Yes	86.25%
Q9	1.26	3.56	Yes	71.25%	1.26	4.00	Yes	80.00%	0.68	4.25	Yes	85.00%
Q10	1.02	4.13	Yes	82.50%	1.02	4.13	Yes	82.50%	0.62	4.38	Yes	87.50%
Q11	0.62	4.38	Yes	87.50%	0.62	4.38	Yes	87.50%	0.50	4.38	Yes	87.50%
Q12	1.05	3.81	Yes	76.25%	1.09	3.88	Yes	77.50%	0.82	4.00	Yes	80.00%
Q13	1.15	3.88	Yes	77.50%	1.15	4.00	Yes	80.00%	1.00	4.06	Yes	81.25%
Q14	1.06	4.06	Yes	81.25%	1.31	3.63	No	81.25%	0.89	4.13	Yes	82.50%
Q15	1.33	3.81	Yes	71.25%	1.33	3.81	Yes	71.25%	0.93	4.06	Yes	81.25%
Q16	1.33	3.81	Yes	71.25%	1.33	3.81	Yes	71.25%	0.93	4.06	Yes	81.25%
Q17	1.33	3.81	Yes	71.25%	1.33	3.81	Yes	71.25%	0.93	4.06	Yes	81.25%
Q18	1.45	3.69	Yes	73.75%	1.42	3.81	Yes	72.50%	1.20	4.13	Yes	81.25%
Q19	0.50	4.38	Yes	82.50%	0.50	4.38	Yes	82.50%	0.50	4.38	Yes	87.50%
Q20	0.68	4.25	Yes	85.00%	0.70	4.31	Yes	76.25%	0.89	4.00	Yes	80.00%
Q21	1.17	3.81	Yes	87.50%	1.17	3.81	Yes	87.50%	0.96	4.13	Yes	82.50%
Q22	1.15	3.56	Yes	71.25%	1.24	3.75	Yes	86.25%	0.70	4.31	Yes	86.25%
Q23	1.20	3.63	Yes	72.50%	1.24	3.75	Yes	76.25%	0.77	4.06	Yes	81.25%
Q24	1.18	4.06	Yes	75.00%	1.18	4.06	Yes	75.00%	0.85	4.06	Yes	81.25%
Q25	1.17	3.81	Yes	75.00%	1.17	3.81	Yes	75.00%	0.72	4.13	Yes	82.50%
Q26	1.11	3.81	Yes	81.25%	1.11	3.81	Yes	81.25%	0.63	4.44	Yes	88.75%
Q27	1.20	3.63	Yes	72.50%	1.15	3.88	Yes	76.25%	0.77	4.06	Yes	81.25%
Q28	1.00	4.06	Yes	81.25%	1.00	4.06	Yes	76.25%	0.62	4.13	Yes	82.50%
Q29	1.28	4.19	Yes	83.75%	1.25	4.31	Yes	77.50%	0.66	4.19	Yes	83.75%
Q30	0.73	4.44	Yes	88.75%	0.63	4.56	Yes	81.25%	0.60	4.31	Yes	86.25%
Q31	0.77	4.06	Yes	86.25%	0.77	4.06	Yes	86.25%	1.25	4.31	Yes	86.25%
Q32	0.48	4.69	Yes	91.25%	0.48	4.69	Yes	91.25%	0.63	4.56	Yes	91.25%
Q33	0.85	4.06	Yes	81.25%	0.85	4.06	Yes	81.25%	0.77	4.06	Yes	81.25%
Q34	0.68	4.25	Yes	93.75%	0.68	4.25	Yes	93.75%	0.62	4.63	Yes	92.50%
Q35	1.15	3.63	Yes	72.50%	0.98	3.81	Yes	81.25%	0.85	4.06	Yes	81.25%

Table 4. Analysis results. Continuation Table:

Question	Round 1				Round 2				Round 3			
	SD	Mean	Consented	Consensus	SD	Mean	Consented	Consensus	SD	Mean	Consented	Consensus
Q36	1.18	3.94	Yes	85.00%	1.18	3.94	Yes	85.00%	0.68	4.25	Yes	85.00%
Q37	1.36	3.88	Yes	76.25%	1.36	3.88	Yes	76.25%	0.68	4.06	Yes	81.25%
Q38	1.10	4.00	Yes	80.00%	1.10	4.00	Yes	78.75%	0.68	4.25	Yes	85.00%
Q39	1.31	3.56	Yes	71.25%	1.35	3.69	Yes	80.00%	0.75	4.19	Yes	83.75%
Q40	0.81	3.88	Yes	77.50%	0.82	4.00	Yes	80.00%	0.82	4.00	Yes	80.00%
Q41	0.51	4.56	Yes	91.25%	0.51	4.56	Yes	91.25%	0.51	4.56	Yes	91.25%
Q42	1.22	3.81	Yes	76.25%	1.24	3.94	Yes	78.75%	0.83	4.19	Yes	83.75%
Q43	0.89	3.88	Yes	77.50%	0.73	4.00	Yes	80.00%	0.73	4.00	Yes	80.00%
Q44	0.52	4.50	Yes	90.00%	0.52	4.50	Yes	90.00%	0.52	4.50	Yes	90.00%
Q45	0.75	4.19	Yes	83.75%	0.75	4.19	Yes	83.75%	0.75	4.19	Yes	83.75%
Q46	0.77	4.25	Yes	85.00%	0.50	4.38	Yes	87.50%	0.50	4.38	Yes	87.50%
Q47	1.00	3.94	Yes	78.75%	0.85	4.06	Yes	81.25%	0.85	4.06	Yes	81.25%
Q48	0.68	4.25	Yes	85.00%	0.60	4.31	Yes	86.25%	0.60	4.31	Yes	86.25%
Q49	0.48	4.69	Yes	93.75%	0.48	4.69	Yes	93.75%	0.48	4.69	Yes	93.75%
Q50	0.51	4.44	Yes	88.75%	0.51	4.44	Yes	88.75%	0.51	4.44	Yes	88.75%
Q51	1.32	4.00	Yes	80.00%	1.34	4.06	Yes	81.25%	0.89	4.38	Yes	87.50%
Q52	0.72	4.38	Yes	87.50%	0.73	4.44	Yes	88.75%	0.73	4.44	Yes	88.75%
Q53	0.48	4.69	Yes	93.75%	0.48	4.69	Yes	93.75%	0.48	4.69	Yes	93.75%

4.2. Proposed road map

Next, the six pillars of the proposed road map will be discussed. Three colors have separated each party's responsibilities: blue indicates government duties, yellow represents academia, and green shows industry such as contractors, consultants, subcontractors, manufacturers, and vendors. Five years have been anticipated to implement the roadmap perfectly, while it requires monitoring the progression regularly.

4.2.1. Leadership

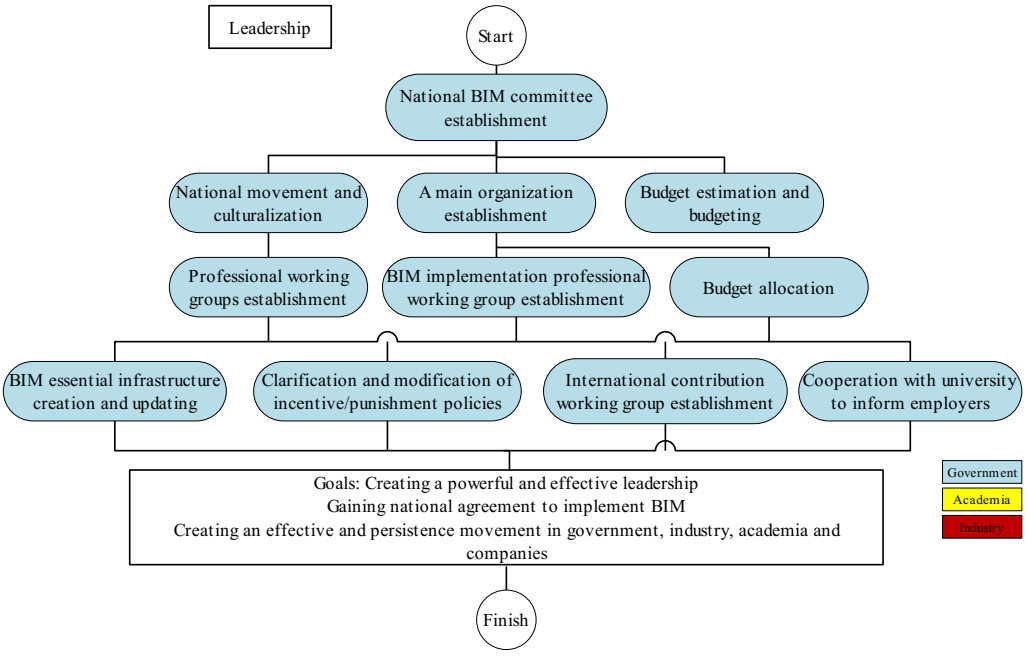

Figure 4. Leadership Pillar.

As illustrated in **Figure 4**, this pillar is compelling government bodies, industry, and academia toward an effective movement to implement BIM in the building industry under a robust leader, emitted between highly qualified and experienced managers. The leadership should have a clear vision of defining long-term goals and expectations. Leadership should align all BIM implementation participants and unite them toward the goal. Incentives will energize firms to adopt BIM and accelerate the movement creation. Therefore, required budget or policies could be allocated, such as a tax exemption or extra tender technical evaluation. One of the main concerns is the persistence of using conventional methods. Therefore, the leadership must encourage the parties to accept and implement fundamental changes. An effective leader should convince industry and academia to contribute to adopting BIM and establish professional working groups to collaborate with international teams to exchange state-of-the-art experiences and advancements to enhance national movement. Initially, four goals are expected to achieve the robust and effective leadership required to create a comprehensive movement and integrate academia, private and public sectors. The leader should maintain novel and continuously communicate with pioneer and proactive professional groups.

4.2.2. Standardization

This process deals with the legislation of legal and technical rules and regulations, recommendations, and other related materials. The legal and technical package should intellectually align with Iran's construction industry needs. The process should facilitate pursuing, discovering, and employing new international advancements and best practices. In this regard, the National BIM Standard Committee should first be formed to recommend and prepare legal and technical material, follow them up for approval or modification and notification, and identify implementations and report deviations in Iran. The committee should define fundamental strategy and national goals. Then, the committee should identify any potential risks and impediments against new processes and procedures. Then, the committee should obtain confirmation of rules, regulations, recommendations, codes, and standards approval. It is also vital for the committee to communicate with active international groups, which helps find new developments. So that all the legal and technical material should be updated continuously. Since some companies employ BIM, a framework is required to evaluate qualification and rank companies during a project team or award selection. It assists employers in analyzing bidders' ability to implement BIM in their projects and could influence the technical qualification result. An online monitoring system is defined to monitor BIM implementation quality with the expected one. The pillar's structure is presented in **Figure 5**.

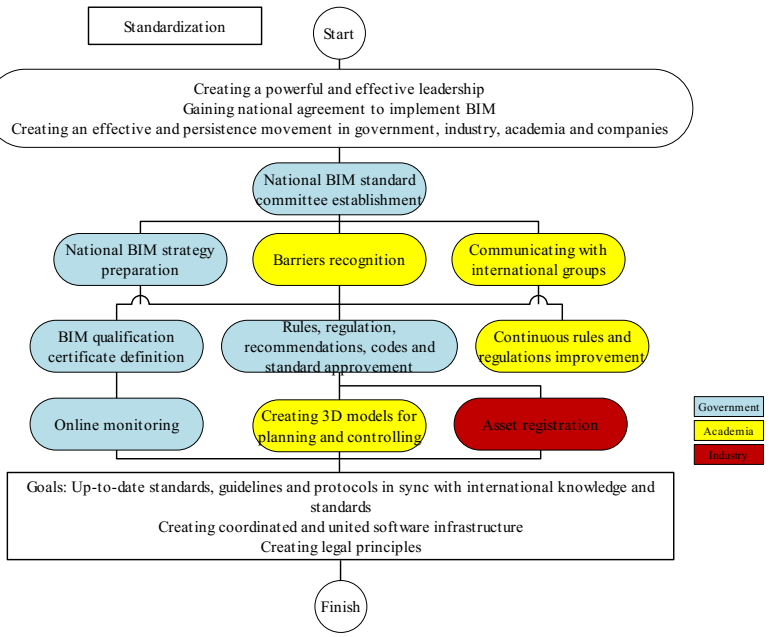

Figure 5. Standardization Pillar.

4.2.3. Education

This pillar points required activities to share knowledge and train individuals and organizations to implement BIM. Before any action, an executive board should be formed. An online assessment platform can identify individual and organizational deficiencies and weaknesses. In addition, the board should provide an education framework to compensate for training requirements. The process should be directed by academia or training professionals, who can identify needs and deliver effective training. Also, a shortlist should be drawn to issue the names of eligible training institutes. In addition, equally for each trainee, the training platform should provide a standard, reliable, and practical level of expertise. The academia is typically in charge of conducting analytical research and finding out what is hindering BIM implementation nationally. The other aspect of education to fulfill the market need to employ recent graduates is to define BIM courses in the university. Therefore, students have an acceptable knowledge of BIM immediately after graduation. A successful education process demands workforce development, moving in parallel with international advancements. So, the board should communicate with international groups to update education contents.

Figure 6 shows the education pillar and subtasks.

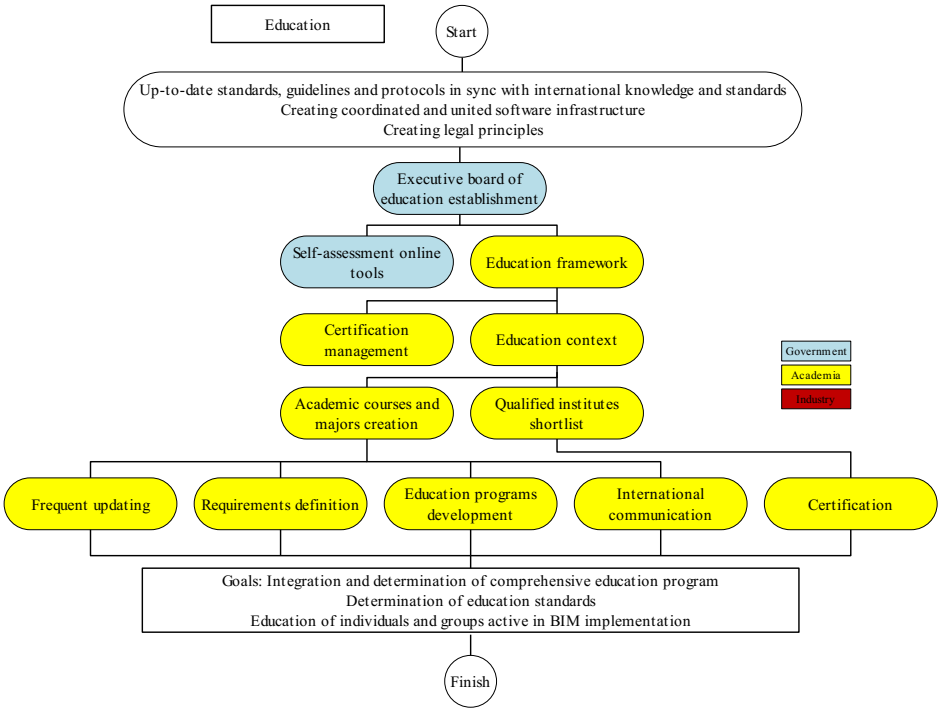

Figure 6. Education Pillar.

4.2.4. Development

The development pillar (**Figure 7**) follows the framework development of a contractual platform and aims to approve a contract draft that satisfies employers' needs to implement BIM in their projects. Therefore, it is essential to legislate a technical and legal platform, and a standard language of contract should be defined to issue the standard contract draft relying on the framework. Various drafts must be approved to comply with different project delivery methods. The most crucial step that should be taken in this pillar is planning to mandate BIM in projects. As BIM is not expected to be implemented in all projects, it is necessary to consider the circumstances under which BIM is required.

4.2.5. Assessment

This process (**Figure 8**) aims to establish the criteria to measure the BIM maturity and the level of BIM implementation in construction projects. The pillar follows to attract employers' attention and support the continuous assessment of the current BIM adoption state. Initially, the key performance indexes (KPIs)

should be defined and developed continuously. Then, an online dashboard needs to be created to measure maturity level based on KPIs, and the outcomes should be kept in a database. It helps to trace improvement in BIM implementation and measure current and expected achievements to take corrective decisions. The results should be incorporated into contract templates to address any identified deficiencies. Furthermore, amendments can be made to the contract drafts to reflect the recommendations and insights derived from the Delphi-based method. Integrating these results into the contract templates and making necessary modifications ensures that the contract adequately accounts for the identified areas of improvement.

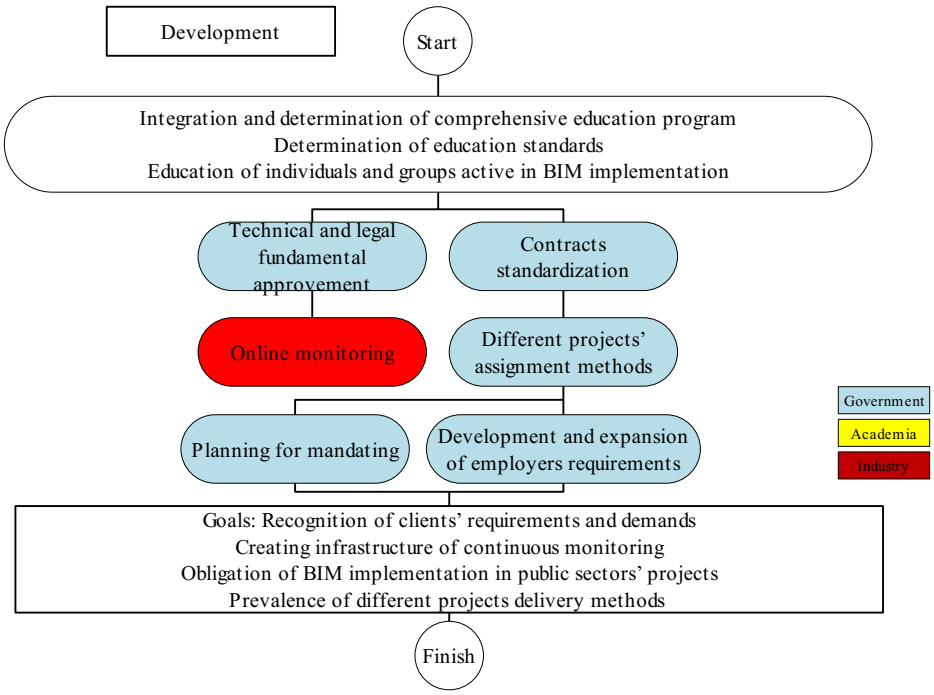

Figure 7. Development Pillar.

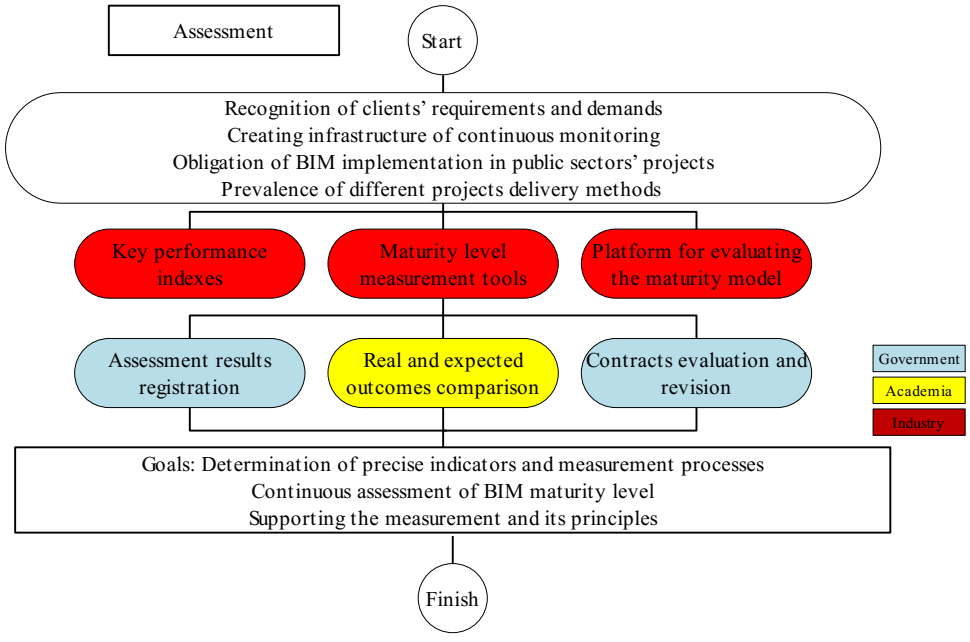

Figure 8. Assessment Pillar.

4.2.6. Reliability

This pillar guarantees persistent BIM implementation regardless of whether the project is public or private and the size of the project. The pillar aims for BIM adoption development in the construction industry. Also, it persuades rules and regulations to be reviewed due to international advancements. Therefore, the latest revision of laws, regulations, protocols, and industry standards should be applied. On the other hand, by documenting achievements, the whole industry will be motivated to exploit BIM. Meantime, industry and academia should cooperate through BIM implementation. So, a close relationship with international groups is required to use prosperous experiences. Maintaining these experiences will result in BIM implementation improvement (**Figure 9**).

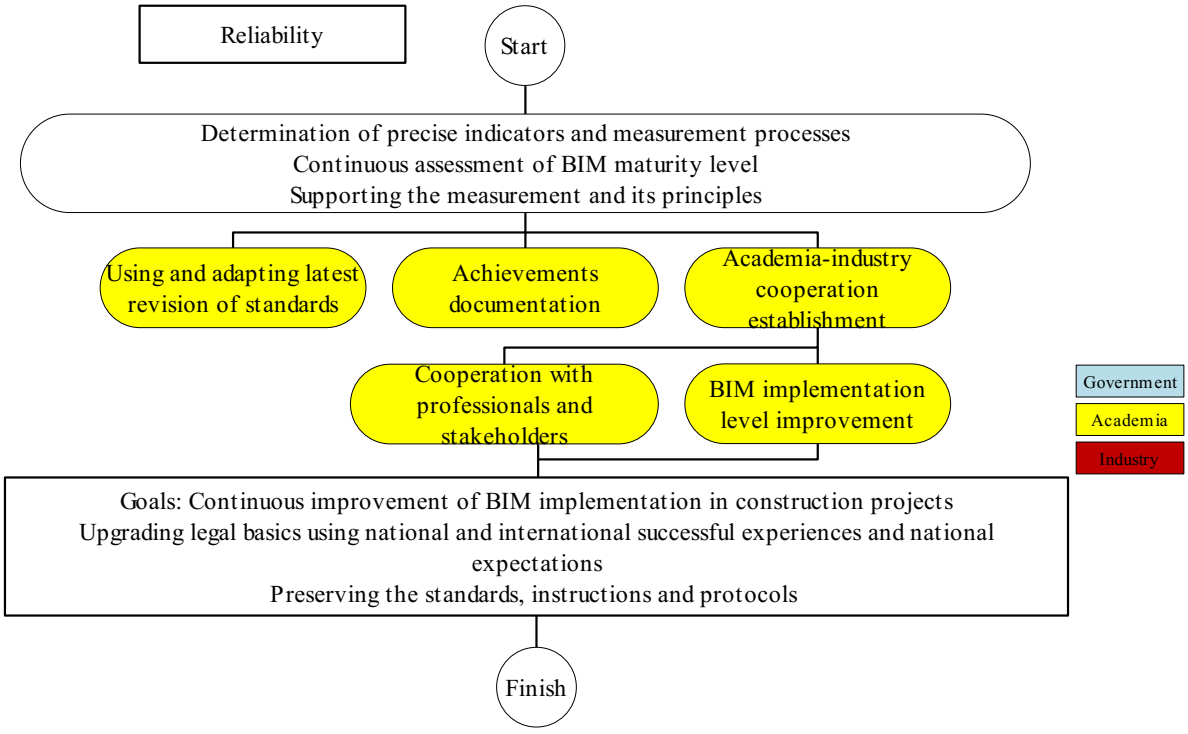

Figure 9. Reliability Pillar.

5. Discussion

This study proposed a roadmap toward BIM implementation in the Iranian construction industry through a comprehensive survey. First, removing the barriers to BIM adoption is necessary to achieve the intended goals. BIM adoption impediments are lack of knowledge, absence of experts, strict rules, economic issues such as incentives, and initial funding to prepare suitable software and hardware. Meanwhile, the accepted drawing format is 2D; the engineering phase also requires more time than the traditional approach due to lack of training and experience. Moreover, decision-makers are busy with resolving daily problems and do not have additional capacity to develop BIM implementation in projects. Also, lack of training causes limited awareness about BIM advantages and its positive effect on the final deliverables. Additionally, it is essential to establish a regulatory system that can approve and implement practical rules specifically tailored to the construction industry environment in Iran. This regulatory framework should aim to address local issues and provide incentives to the industry. So, it can effectively contribute to solving industry-specific challenges and foster growth and development within the construction sector. In the same vein, since Iranian firms face financial issues, they require motivation to solve them; for instance, the employer could allocate incentives or exemptions. Furthermore, for widespread use of BIM, the government should earn industry trust, and it is feasible through performing pilot projects to illustrate how BIM could serve stakeholders and immune return of investment (ROI) in the short term.

Meantime, while the highest turnover happens in the construction phase, the private sector prefers to spend less time in the engineering phase; however, engineering is generally more time-consuming with BIM [21, 55-57, 59].

The proposed road map has been shaped by the needs and impediments recognition through a comprehensive literature review. Then, the primitive roadmap structure was discussed with professionals, and the roadmap structure was deeply affected. Next, a structured questionnaire has been designed with 53 questions in 6 main sections. The questionnaires were distributed among 16 experts, and their opinions were collected in three rounds. Eventually, the roadmap has been modified based on the results. In the end, a roadmap has been proposed adapted to Iran's needs and impediments. Nevertheless, research experienced difficulties as follows:

• Professionals who contributed to the face-to-face interview to modify the primitive structure are not accessible.

• Highly qualified experts were not interested in cooperating with the research. In the meantime, finding experts with reliable opinions and sufficient knowledge proved a significant challenge.

• To obtain a comprehensive result, the participation of all stakeholders in the research was essential. In industry, employers and contractors particularly had limited knowledge about BIM.

6. Conclusion

Since BIM provides many benefits to the construction industry, a roadmap for implementing BIM for Iran's construction industry is proposed in this research. The roadmap stands on local culture and built environment to fulfill needs. A 6-pillar roadmap, based on comprehensive literature and global achievements, has been prepared, consisting of 53 tasks. This roadmap incorporates insights and best practices from various sources to provide a well-rounded and comprehensive approach. The BIM implementation is expected to contribute to the construction industry through overall improvement of PMBOK and to the society as:

• Provides easy-access information during the life-cycle from inception to decommissioning

• Assists project managers to control time, cost, and progress in real-time

• Provides real-time quality control to improve the overall quality of deliverables

• Reduces risks and aims to make predictive and corrective decisions while measuring their effects

• Reducing HSE and environmental impacts

• Reduces time and cost of the project

• Eliminates clashes, interferences, and reworks

• Facilitating help during a crisis

• Implementing circular economy

For this purpose, initially, a primitive roadmap structure was designed. Then, to measure its reliability and practicability, the draft has been discussed with three professionals with invaluable experience in the industry and enough knowledge about public and private sector issues. Face-to-face interviews resulted in fundamental changes in the roadmap tasks to transform them into realistic and practical activities. Subsequently, the opinions of 16 experts were gathered using a Delphi-based approach. Experts have been selected from industry and academia with different working experiences. Interviews led to modifying some tasks based on current local industry needs. The consensus has been achieved through three rounds of interviews, and the roadmap has been stable. The roadmap provides a progressive sequence from the current infancy estate to a mature expected estate over five years. It is crucial to appoint a powerful and charismatic leader to create a movement in the industry to ensure continuous and persistent BIM adoption. Also, periodic monitoring aims to measure the achievements compared with expectations and detect any deviation to take corrective actions. BIM implementation project participants are expected to experience more satisfaction in tangible and intangible achievements, such as cost and time-saving, quality improvement, and reputation rectification. The roadmap pillars are as follows:

• The first pillar follows to make an efficient movement in the industry by employing a decisive leader who stands out with a realistic view of the current state and perspective on the industry's future needs.

• The second pillar pinpoints adapting the rules, regulations, and technical instructions to fill gaps.

• The objective of the third pillar is to address the shortage of experts in the industry by focusing on education and training initiatives. This pillar aims

to provide the necessary knowledge and skills to compensate for the lack of expertise. Additionally, it seeks to promote general awareness and understanding of the application of Building Information Modeling (BIM) and highlight the benefits associated with its implementation. By doing so, this pillar aims to enhance the overall knowledge and capabilities within the industry.

• It is also expected that through this pillar, BIM courses and disciplines will be created in the university.

• The fourth pillar points out defining a contractual language to employ a uniform contract template that could satisfy employers' needs.

• The fifth pillar provides trustworthy evaluations to correct deviations and compare achievements with expectations.

• The sixth pillar aims to implement BIM continuously and persistently.

Impediments in the way of this research were difficulties in setting appointments with professionals for a face-to-face interview. On the other hand, qualified experts were less interested in participating in the study due to their busy and intensive work schedules. Meanwhile, employers and contractors have a lower knowledge level about BIM than researchers and consultants.

7. Limitation and Future Research

This research is limited to proposing a BIM implementation roadmap for the Iran construction industry. Although the proposed roadmap could provide a potential benefit for other countries, it needs an in-depth investigation to explore each specific or local needs. The future area of research could be worked on developing tasks in detail, such as focusing on one of the most critical pillars, education, proposing a practical procedure based on best practices, or drafting the required rules and regulations based on successful regional or international practices.

Conflicts of Interest

The authors declare no conflict of interest.

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Appendix

Section 1: Respondent's information

Education	Diploma ◯	Associate degree ◯	Bachelor ◯	Master ◯	PhD ◯
Experience in construction	Less than 5 years ◯	Between 5 and 10 years ◯	Between 10 and 15 years ◯	More than 15 years ◯	

Section 2: Details of respondents' workplace

Name of the company					
Activity	Client ◯	Consultant ◯	Contractor ◯	Researcher ◯	Other ◯

Section 3: Contact information

Email address

Section 4: Defined activities in the roadmap

- Please select only one answer for each question
- Whether selecting disagree or totally disagree please provide your reason and, or your corrective comment(s)

Please provide your idea about considering the following tasks in the **Leadership pillar**

Stage	Question	Reason	Corrective comment
1-1	Creating a national movement through the government and legislative authorities (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-2	National BIM committee establishment through the government and legislative authorities consists of representatives from the government, construction industry societies, and universities with the leadership of the government representative (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-3	Forming a reference and central organization to lead stakeholders and activists of the construction industry (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-4	Cost estimation, budgeting planning, and providing required funds to support BIM implementation (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-5	Notifying public sector, construction industry, universities, and other stakeholders about BIM benefits through advertisements (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-6	Formation of specialized working groups such as planning, financial, standardization, and legal working groups (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-7	Creating and updating the necessary infrastructure to implement BIM by the national BIM committee (Such as network infrastructure, software, hardware, etc.) (Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-8	Allocating, planning, and budgeting (Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-9	Establishing specialized BIM implementation working group and defining high-level strategies (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-10	Approving and modifying incentive/punishment policies to implement BIM in projects (Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
1-11	Creating a working group to exploit international contributions to produce, verify, compare, and develop the information for continuous improvement (Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Please provide your idea about considering the following tasks in the **Standardization pillar**

Stage	Question	Reason	Corrective comment
2-1	The National BIM Standardization Committee establishment consists of representatives from the legislator side, the Ministry of Roads and Urban Development, the Municipality, Professors, and professional advisors to produce and approve required rules and regulations aimed to accept international BIM standards (Required time: 2 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Continuation Table:

Stage	Question	Reason	Corrective comment
2-2	Preparing National BIM strategy as the strategic document to set the goals of BIM implementation (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-3	Recognition and assessment of the level of commitment, tendency, resistance, and obstacles to implementing known international BIM standards in active groups in the construction industry by the National BIM Standardization Committee (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-4,5,6	Preparation, compilation, and regulation of national BIM guides and recommendations, instructions, rules and regulations, and standards (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-7	Defining the BIM qualification certificate in different levels and disciplines of the construction industry by Road, Housing & Urban Development Research Center as the responsible organization with the contribution and support of various divisions of government, industry, and educational institutes (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-8	Communication with International Groups to develop and update standards and instructions considering international events and advancements (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-9	Development of required infrastructure to provide quick and online access to BIM implementation conditions to monitor and assess BIM adoption in projects and facilitate the national and international activities adaptation (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-10	Continuous monitoring, revising, and development of national BIM standards, instructions, rules and regulations, and guidelines according to national (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-11	Supervising all construction processes to reconcile with recommendations, standards, rules, and regulations, and approved client requirements (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-12	Creating trial 3D models and samples of buildings for planning and controlling different disciplines of geotechnical investigations, engineering, manufacturing, installation, and operation per technical and legal approvals and standards aims to create a primary sample and enhance BIM implementation understanding (Required time: 4 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
2-13	Defining Asset Registry standards based on national and international standards to data transfer in BMS and performance control in the operation phase (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Please provide your idea about considering the following tasks in the **Education pillar**

Stage	Question	Reason	Corrective comment
3-1	Establishing an executive committee consisting of ministry and academia representatives for high-level educational planning, course determination, and producing educational content along with obtaining advice from construction experts (Required time: 2 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-2	Creation of online BIM self-assessment tools based on client requirements and legal and technical approvals to assist companies in exploring educational needs and level of knowledge determination (Required time: 2 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-3	Presentation of a comprehensive reference platform and identifying educational goals, including all disciplines and different expertise according to national BIM strategic goals (Required time: 2 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Continuation Table:

Stage	Question	Reason	Corrective comment
3-4	Identification and creation of educational courses and production of practical content related to national BIM strategy (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-5	Management and launch of the BIM certificate issuance program in different industry sectors by the Ministry of Roads and Urban Development and Road, Housing & Urban Development Research Center (Required time: 5 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-6	Recognition and establishment of qualified institutes approved by the Ministry of Science Research and Technology, and Road, Housing & Urban Development Research Center, and issuing licenses to institutions for holding educational courses (Required time: 5 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-7	Defining and creating majors related to BIM in universities and defining courses in other majors related to the construction industry (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-8	Certifying BIM to companies, groups, and individuals in different disciplines (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-9	Establishment a committee including academia and industry representatives, and a representative from the National BIM educational committee with the aim of academia and industry interaction to remove academic, technical, and professional needs (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-10	Continuous update of educational program and content according to BIM global knowledge and industry needs (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-11	Companies' ability and gained knowledge assessment to explore technical qualification during tender and help clients (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
3-12	Holding workshops and seminars for experts and managers for knowledge improvement, and according to BIM scientific developments and industry needs (Required time: Continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Please provide your idea about considering the following tasks in the **Development pillar**

Stage	Question	Reason	Corrective comment
4-1	Determining the necessary technical and legal issues to reflect the requirements of contracts with the help of legal associations for the BIM development (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
4-2	Modifying the general conditions of consulting and construction contracts and adding the general needs of clients in the BIM implementation in projects (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
4-3	Determining and approving the minimum requirements for contracts for BIM implementation to guarantee clients' benefits (Required time: 6 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
4-4	Creating continuous monitoring tools for BIM implementation for clients to receive information, review, manage, and evaluate BIM implementation in projects (Required time: 8 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
4-5	Development and standardization of contract templates to implement BIM (Required time: 2 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
4-6	Definition of different project delivery methods such as PC, EPC, EPCF, DB, BOT, ... which, based on the project conditions, creates and improves the collaborative environment between the project parties in the BIM implementation (Required time: 2 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Continuation Table:

Stage	Question	Reason	Corrective comment
4-7	Development and updating client requirements and standard framework in BIM implementation along with experience in national and international projects and modern knowledge (Required time: continuously) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
4-8	Creating a perspective to require BIM in projects based on characteristics (such as area, cost, etc.) and passing general laws to require BIM implementation (Required time: 4 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Please provide your idea about considering the following tasks in the **Assessment pillar**

Stage	Question	Reason	Corrective comment
5-1	Development and updating criteria and key indicators of performance with the aim of performance and ability continuous assessment in different project phases (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
5-2	Developing a model and method for measuring the maturity level and capability of BIM in projects according to technical and legal basis (Required time: 6 years) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
5-3	Creating a suitable platform for evaluating the maturity model and BIM capability in improving the efficiency of construction projects (Required time: 6 years) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
5-4	Recording the results of performance evaluation in a data bank to provide the possibility of studying the process of improving the maturity and ability of BIM over time (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
5-5	Comparing the BIM performance and maturity level in projects with expected and similar international results to evaluate the success level of BIM implementation and help to make corrective decisions (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
5-6	Reviewing the principle and content of construction contracts based on current conditions to achieve more successful outcomes (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		

Please provide your idea about considering the following tasks in the **Reliability pillar**

Stage	Question	Reason	Corrective comment
6-1	Adaptation of the latest revision of national BIM standards to international innovations and transformation to approved legal and technical bases to maintain the reliability of BIM implementation (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
6-2	Documenting and promoting the successes achieved through national case studies and presenting in BIM and construction professional seminars and magazines and presenting corrective decisions based on lessons learned (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
6-3	Consolidation of partnerships between industry and academia to encourage production and innovation and improve the level of maturity and reliability of BIM (Required time: 3 months) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
6-4	Maintaining collaboration with professional associations and stakeholders by the National BIM Committee to maintain reliability (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		
6-5	Improving the level of BIM implementation and technical and executive ability in individuals and companies through continuous communication with international successful experiences to maintain reliability (Required time: Continuous) Totally agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Totally disagree ◯		