



Revamping established project procurement approaches to support BIM implementation

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Purpose

Previous studies have established to a great extent that regulatory frameworks and, in particular, procurement approaches – that are common in a particular context – have a major impact on the success of BIM implementation in construction projects. Despite the close links between these two concepts, research on the effect of procurement approaches on BIM implementation is scarce. To address this gap, this paper aims to investigate the barriers that affect BIM implementation through the lens of procurement approaches.

Design/methodology/approach

A mixed method approach was adopted using a questionnaire survey (n=116) and interviews with key stakeholders (n=12) in Jordan. The outcomes of the quantitative parts were augmented with findings from interviews.

Findings

It was revealed the deployment of unfavourable construction procurement approaches represents a major hurdle toward BIM implementation. Though essential for enhancing BIM implementation, it is revealed that a fundamental change from the common Design bid build (DBB) to more collaborative procurement approaches remains infeasible given the realities that govern the construction industry.

Originality/value

As the first of its kind, a set of recommendations for establishing a supportive workable procurement which does not deviate significantly from common procedures and practices is presented. Rather than advocating a shift to procurement approaches that are aligned with BIM, findings offer novel insight into the necessity of developing a

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3 framework within the boundaries of the current and widely adopted procurement
4 approaches, to address the identified construction procurement issues and facilitate BIM
5 implementation.
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12 **Keywords:** BIM diffusion, Construction procurement, Change management, Transition,
13 Digitalisation, Sustainability
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17 18 19 **Introduction**

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21 Building Information Modelling (BIM) is identified as one of the most promising
22 approaches in terms of improving construction procedures, to meet the growing global
23 demand for constructed facilities and buildings ([Al Hattab, 2021](#)). This is due to its
24 ability to support the supply chain through the management and the integration of
25 essential information across the lifecycle of projects ([Olanrewaju et al., 2021a](#)). Both
26 researchers and practitioners have established to a great extent that through
27 implementing BIM superior outcomes can be achieved in project delivery, compared to
28 non-BIM approaches ([Zhen Liu et al., 2021](#); [Pavón et al., 2021](#)). Indeed, future
29 construction processes should rely on BIM-based procedures to achieve the level of
30 efficacy and productivity, expected from delivering projects ([Amin Ranjbar et al.,](#)
31 [2021](#)).
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47 Many studies have indicated that regulatory frameworks and, in particular,
48 procurement approaches have a major impact on the success of BIM implementation in
49 projects ([Abanda et al., 2017](#); [Chen et al., 2019](#); [Pavón et al., 2021](#); [Svalestuen et al.,](#)
50 [2017](#)). This is because BIM is a collaborative platform; thus, deriving the maximum
51 benefit from its implementation requires a collaborative ecosystem ([Oraee et al., 2019](#)).
52 Clients are, therefore, likely to change the way that they procure projects in
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3 implementing BIM, to ensure a more integrated and collaborative working process is in
4 place ([Dalui et al., 2021](#); [Tao et al., 2021](#)). Different procurement approaches can
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6 achieve different collaboration levels by establishing the relationships among the
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8 involved parties and the tasks at hand across the project lifecycle ([Kuiper, 2021](#); [Malla
9 et al., 2022](#)). In acknowledging the practical implications of selecting procurement
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11 approaches, governments around the world – e.g. the UK and Australia – have
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13 emphasised the deployment of collaborative procurement approaches ([Dalui et al.,
14 2021](#); [Elghaish et al., 2020](#)), or the development of a new procurement approach for
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16 BIM implementation ([Elghaish, Abrishami, et al., 2021](#)). Indeed, a lack of
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18 understanding and the subsequent lack of interest in using favourable procurement
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20 approaches that support BIM implementation can negatively suppress any envisaged
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22 advantage in implementing BIM in projects ([Durdyev et al., 2019](#)).
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31 The crucial role of the public sector and the procurement approaches taken by
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33 the public sector in BIM implementation have been widely recognised in past research
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35 ([Abuezhayeh et al., 2021](#); [Albaali et al., 2021](#); [Btoush & Haron, 2017](#); [Durdyev et al.,
36 2019](#)). Existing studies, however, have been focused on one form of procurement in
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38 specific contexts, mostly through the lens of exploring the barriers that thwart a wider
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40 adoption of certain procurement approaches ([Durdyev et al., 2019](#)). A review run on the
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42 related literature reveals a conspicuous absence of research on the regularity
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44 frameworks (procurement approaches) and their effect on BIM implementation from a
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46 broad perspective. Further research is needed to bring to light the theoretical and
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48 practical relationships and recognise the constructive and destructive interactions
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50 between project procurement and BIM implementation in project delivery ([Fan et al.,
51 2018](#); [Jamil & Fathi, 2018, 2020](#)).
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3 This paper, therefore, is an attempt to address the gap in the literature, and to
4 bring awareness and clarity to the constellation of factors associated with procurement
5 approaches that affect BIM implementation. Objectives are formulated to identify the
6 barriers to BIM implementation associated with procurement approaches adopted in the
7 public sector, and the challenges of the adopted procurement approaches pertinent to
8 BIM implementation.
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10 11 12 13 14 15 16 17 **Contextual Background**

18 19 20 **The need for BIM implementation**

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22 Building Information Modelling (BIM) has been widely praised as a new paradigm and
23 the next digital transformation in the Architecture, Engineering and Construction (AEC)
24 sector, towards one that is more productive and agile ([Akintola et al., 2021](#); [Hosseini et
25 al., 2021](#); [Zomer et al., 2021](#)). The literature reveals two main areas in which BIM can
26 support construction projects: whole lifecycle performance; and building assessment
27 and evaluation ([Al Hattab, 2021](#); [Olanrewaju et al., 2021a](#)).
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37 BIM can support lifecycle performance over the lifecycle of projects in three ways.

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39 Firstly, increased visualisation through the ability to provide visual information that
40 relates to products and process performance, including 3D models and walkthrough
41 features ([Akinlolu & Haupt, 2021](#)). Secondly, the ability to exchange data embedded in
42 BIM among multi-disciplinary users with different sustainability analysis tools and the
43 automation of the design evaluation processes ([Al Hattab, 2021](#)). Finally, BIM adds
44 value by improving collaboration and communication among various stakeholders
45 during the design, construction, operations and maintenance of constructed facilities
46 ([Elghaish, Abrishami, et al., 2021](#)). A shared vision for all the stakeholders working on
47 the same project is offered by BIM, as an integrated platform ([Khanna et al., 2021](#);
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3 [Orace et al., 2019](#)). The second area where BIM offers added value is related to the
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5 assessment and evaluation. This refers to various types of evaluation and assessment
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7 methods for determining the performance of a building; these analyses include internal
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9 processes such as structural and HVAC systems optimisation and contextual analyses,
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11 such as in site orientation, building massing and daylighting ([Alwan; Nguyen &](#)
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13 [Sharmak, 2021](#)). The fragmented information exchange practices, as in traditional
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15 delivery approaches, cause the discontinuity of these analysis systems ([Pavón et al.,](#)
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17 [2021](#)). BIM contributes through the use of technology such as a database for data
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19 exchange and integration ([Elghaish, Hosseini, et al., 2021](#); [Zahid et al., 2021](#)).
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21 Specifically, throughout the design process, BIM creates the opportunity by allowing
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23 multi-disciplinary information to be superimposed on one model ([Carvalho et al., 2021](#)),
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25 thus BIM can be used to analyse the buildings as fully integrated dynamic systems and
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27 adjust construction processes to enhance the performance of constructed facilities
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29 ([Ziwen Liu et al., 2021](#)).
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36 With the above in mind, there is a growing interest in implementing BIM, as reported in
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38 various studies ([Hong et al., 2019](#)) along with an abundance of recommendations and
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40 policy positions for promoting BIM as a panacea for woes in the construction industry
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42 ([Hosseini et al., 2021](#)). Nonetheless, past research has acknowledged that neither
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44 widespread BIM implementation, nor the envisaged systematic transition within the
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46 AEC sector has occurred ([Zomer et al., 2021](#)), due to some unfavourable contextual
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48 factors, as discussed next.
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54 **Barriers to BIM implementation**

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57 BIM implementation barriers were classified by [Saka and Chan \(2020\)](#) into three main
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59 categories: Human/organisational, technical and business barriers. Business barriers
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were investigated further by [Evans and Farrell \(2020\)](#) and expanded to become the business and legal barriers. Table 1 represents the BIM barriers identified in the literature under each of these categories, from noteworthy, most recent publications. Applicable contractual context, potential legal risks and commercial considerations fall within and can be defined under the overall umbrella of procurement approaches and practices, as argued by [Kuiper and Holzer \(2013\)](#) and [Fan et al. \(2018\)](#). It stands to reason then that a wide range of barriers stems from a lack of supportive procurement procedures and approaches ([Dao et al., 2021](#); [Fan et al., 2018](#); [Kuiper & Holzer, 2013](#)), as discussed next.

Table 1: Barriers to BIM implementation

Category	Description	References
	Additional resources and expenses (high economic investment software)	(Eadie et al., 2014; Ullah et al., 2019)
	Fragmented procurement approaches	(El Hajj et al., 2021; Gurevich & Sacks, 2020)
Business and legal problems	Increased risk and liability	(Dao & Chen, 2021; Khoshfetrat et al., 2020; Ragab & Marzouk, 2021)
	Lack of a comprehensive framework or implementation plan	(Dao & Chen, 2021; Olanrewaju et al., 2021b; Wang & Lu, 2021)
	Lack of a legal framework (model ownership and legal contract)	(Dao et al., 2021; Gad et al., 2020; Malla et al., 2022; Nguyen, 2021)
	Lack of standards	(Hadi, 2020; Tran-Hoang-Minh et al., 2021; Wu et al., 2021)
Technical problems	Lack of interoperability	(Bouhmoud & Loudyi, 2021; El Hajj et al., 2021; Olugboyega & Windapo, 2021)
	Attitude and awareness (resistance to change from 2D drafting practices)	(Durdyev et al., 2021; Evans & Farrell, 2020; Hamma-adama et al., 2020)
Human/ organisational problems	Complexity (long hours to develop a BIM model)	(Alemayehu et al., 2021; Belay et al., 2021; Saka & Chan, 2020)

Cultural change	(Durdyev et al., 2021 ; Faisal Shehzad et al., 2020 ; Olugboyega & Windapo, 2021)
Employees lack BIM skills, education and training (design, engineers and subcontractors)	(Pokusaev et al., 2021) (Hosseini et al., 2021)
Organisational challenges among construction professionals	(Ademci & Gundes, 2021 ; Farooq et al., 2020 ; Karampour et al., 2021)

Construction Procurement: A precursor to BIM implementation

Construction procurement is understood by several researchers and practitioners in the construction industry under different terms, such as the procurement approach, procurement systems, procurement methods, procurement delivery methods or project delivery methods ([Bolpagni, 2013](#)). The procurement approach is considered a crucial parameter that contributes to the success of construction projects and clients' satisfaction ([Dalui et al., 2021](#); [Elghaish et al., 2020](#); [Khanna et al., 2021](#)). In principle, a procurement approach determines the overall framework for allocating the authorities and responsibilities of project stakeholders in a construction project ([Popov et al., 2021](#); [Rahman & Sainati, 2021](#)). According to [Montalbán-Domingo et al. \(2019\)](#); [Sayyed et al. \(2021\)](#); [Wang et al. \(2020\)](#) the most common and preferable procurement approaches in the public sector are traditional design bid build (DBB) and design and build (DB), whilst the construction management (CM) method is the least favoured one compared to the other two approaches.

Implementing BIM relies on establishing a collaborative delivery approach that enables all parties to involve from the early design stage ([Durdyev et al., 2019](#); [Elghaish & Abrishami, 2020](#)), share risk/reward ([Elhendawi et al., 2019](#); [Jobidon et al., 2021](#); [Rahimian et al., 2021](#)), and work collaboratively through the Common Data Environment ([Oraee et al., 2019](#); [Ozkan & Seyis, 2021](#); [Stransky, 2020](#)). Therefore, the main driver to foster the implementation of BIM is to explore the current state of

procurement approaches, as well as the legal system characteristics in terms of supporting collaboration among project parties ([Alhusban, 2021](#); [Fan et al., 2018](#); [Kuiper & Holzer, 2013](#)).

Implementing BIM faces challenges when using a traditional delivery approach such as design-bid-build, where contractors are not involved in the design stage ([Durdyev et al., 2019](#); [Alhusban, 2018](#)). This reduces the efficiency of developing reliable and realistic designs ([Abrishami & Martín-Durán, 2021](#); [Salim & Mahjoob, 2020](#)). Though BIM works efficiently with the traditional design and builds approach – regarding design development – there is still a lack of collaboration during the entire project lifecycle ([Dalui et al., 2021](#); [Khanna et al., 2021](#); [Oraee et al., 2019](#); [Alhusban, 2017](#)). As such, coupling BIM and Integrated Project Delivery (IPD) is highly recommended to enable involving parties early from the conceptual stage, sharing risk/reward according to performance and creating sustainable relationships in the construction societies ([Brahmi et al., 2021](#); [Durdyev et al., 2019](#); [Elghaish et al., 2020](#)).

Research Gap and Motivation

[Btoush and Haron \(2017\)](#) developed a study to explore the awareness of BIM in the Jordanian construction society, however, the study did not consider a wide range of views such as clients, contractors and governmental agencies. Moreover, [Matarneh and Hamed \(2017\)](#) investigated barriers to implementing BIM, however, collected data through a questionnaire with practitioners with very low experience (2 to 5) years, therefore, the study could not explore all barriers deeply. Later, [A KA Al-Btoush and Al Btoosh \(2019\)](#) studied many projects that were implemented in Jordan using the BIM process, tools and techniques, results indicated that there is still a significant lack of understanding BIM implementation process among Jordanian companies.

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3 With all above in the mind, there is a need for a study that considers all
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5 construction society views regarding barriers of implementing BIM in their
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7 organisations including governmental agencies, contractors and private clients. The
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9 needed study should consider mixed research methods to cover a wide range of BIM
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11 barriers through the entire stages of construction projects.
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14 **Research Methods**

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18 This research is exploratory. Both qualitative and quantitative methods were needed for
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20 the nature of this research. Mixed methods sequential procedures were adopted in this
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22 research which allow “a more complete and synergistic utilisation of data than doing
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24 separate quantitative and qualitative data collection and analysis” ([Wisdom et al., 2012](#)).
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28 BIM and the impact of procurement approaches on BIM implementation are not
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30 currently explored in the public construction sector in Jordan. Therefore, the study
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32 started by applying a quantitative approach (Phase one: A questionnaire survey) with a
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34 larger sample from the major stakeholders in the public construction sector to
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36 investigate the feasibility of BIM in the public sector in Jordan. Moreover, it also aimed
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38 to identify the key issues in BIM implementation. Then, the qualitative methods (Phase
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40 two: Interviews) were adhered to by implementing a detailed exploration of the BIM
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42 practitioners regarding certain issues raised from the questionnaire study and literature
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44 review. Equal priority was given to both the quantitative and qualitative data regarding
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46 the data collection and analysis. Data integration was considered with a combination of
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48 the collected, analysed and interpreted data.
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54 Concurrent validity was used to validate the results as for example, the questionnaire
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56 findings showed that public procurement approaches are one of the main barriers to
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58 implementing BIM in the public construction sector in Jordan whereas the interviews
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3 were used to find out how and why public procurement approaches affect BIM
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9 **Phase one (Questionnaire)**

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12 Questionnaires were used because large amounts of information can be collected from a
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14 large number of participants over a short time span. Moreover, the data collected
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16 through the questionnaires can be easily quantified, thus measuring changes by
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18 comparing and contrasting the results with other research outcomes ([Fellows & Liu,](#)
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20 [2021](#)).
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24 Choosing an appropriate and suitable sampling method is a crucial step in
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26 questionnaire surveys. [Desu \(2012\)](#), explained that “a sample size calculation justifies
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28 the proposed study and in doing so demonstrates that the study can support the
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30 statistical analysis required to answer the research question”. To collect and reach a
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32 variety of viewpoints from construction professionals in the Jordanian public sector,
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34 three groups were targeted: public clients, public consultants and public contractors.
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36 The public client is represented by the Ministry of Public Work and Housing (MPWH)
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38 and the Government Tender Department (GTD). MPWH and GTD consist of 20
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40 departments such as the Planning and Project Management Unit, the Support Operations
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42 Management and the Management of Buildings Technical Studies. Each of these
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44 departments is responsible for a particular aspect of the delivery of public buildings in
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46 Jordan. Therefore, the total population sampling method was chosen for the public
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48 client group including 20 Heads of Department (HOD).
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54 **The consultants and contractors accounted for the highest number of BIM users**
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56 **in the Middle East (Gerges et al., 2017);** therefore, the public contractors and
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58 consultants were reached through the database available on the MPWH and GTD
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websites. Due to the high numbers in the sampling population, stratified random sampling was used for the public consultants and contractors, which combines stratified sampling with random sampling. Stratified random sampling is a method of sampling that consists of dividing a population into groups known as strata. The strata are formed based on the members' shared characteristics and attributes. This research has adopted the Jordanian Government classification for public contractors and consultants which was based on the financial, technical and administrative qualifications, equipment and experience in the execution of works as stated in the Government works by-law No. 71 for the year 1986, Section 8, Article 23. The same article in point E, stated that these "construction contractors' classification tables, which should be issued by the Minister, shall be adopted for the execution of all governmental works in the Kingdom" (The Hashemite Kingdom of Jordan, 1986, p. 24). This provides the necessary validity for using this classification when targeting the public sector in Jordan and for generalising the research findings.

Therefore, the public contractors were classified into grades 1-6 and public consultants were classified into first-grade class A, first-grade class B, second-grade and third-grade. Table 2 represents the questionnaire strata, total population and sample size. The sample size calculation was based on a confidence level of 95% that the real value is within $\pm 5\%$ of the measured/surveyed value.

Table2: Questionnaire data

Research Strata	MPWH& GTD	Contractor			Consultants			
	HOD	1 st	2 nd	3 rd	1 st A	1 st B	2 nd	3 rd
Population	20	80	68	136	18	11	3	0

Total number of population	20	284	32
Sample Size	20	164	30

Based on the sample size calculation, 164 questionnaires were sent out to contractors and 80 valid questionnaires were received. For governmental agencies such as MPWH; GTD; and HoD: Head of Department, 20 questionnaires were sent out and all 19 valid responses were received. Regarding consultants, 30 questionnaires were sent, and 17 valid responses were received. As such, all received valid questionnaires are 116.

The questions of the questionnaire were structured into five main sections namely; ‘profile of respondents’ to ensure that they were appropriate for the survey; ‘awareness and current status of BIM’ to understand how BIM is currently used in the public sector in Jordan and for which building type and project; ‘barriers to BIM use for public projects’ to identify the barriers to BIM implementation for delivering public building projects in Jordan; ‘feasibility of BIM adoption for the public sector’ to reveal how the participants consider BIM at present and ‘procurement approaches used in BIM public projects’ to identify what type of procurement approaches are used in delivering public buildings in Jordan.

Phase two (Interviews)

Interviews are a suitable approach for collecting in-depth primary data, which a study can analyse ([Gill et al., 2008](#)). The interviews aimed to investigate the current practices and common issues regarding BIM implementation in the construction public sector through the lens of the procurement approach adopted. The questions of the interviews were structured into five main sections; ‘BIM delivery issues in the Jordanian public

projects’, ‘the current construction procurement approaches implemented in the Jordanian public sector including the tender processes and stakeholders’, ‘the main challenges in the adopted construction procurement approaches that affect the implementation of BIM and ‘How to overcome BIM procurement issues’.

A total of 12 interviews were conducted with interviewees with a high level of managerial expertise in the public sector. The adequacy of the sample size is justifiable, given that as argued by Bazeley (2013) data saturation can occur once more than six participants have been interviewed. In this research, data collection reached a saturation point after the eighth interview as no additional data were being found whereby the researchers noted similar instances over and over again.

The ‘purposive sampling’ approach was used to identify and select individuals who are especially knowledgeable about and experienced with BIM. Purposive sampling is used because it enables researchers to fulfil the research objectives in terms of access to knowledge and experience, as well as ensuring that experts are available and willing to participate. The interviewees were therefore selected depending on their previous experience of BIM processes and procurement delivery approaches. The Phase 1 data collection (from the BIM feasibility study) assisted in identifying the possible interviewees who have the necessary and relevant experience. Table 3 represents the interviewees’ profiles.

Table 3: Interview participants

Organisation size	Participants	Department/ Company	Position	No. of years of experience in BIM implementation	Size of the projects
Medium	P1	Public client/ design department	Project manager	7	Hundreds of million JD
Medium	P2	Public client	Project manager	5	1-50 million JD

Small	P3	Public client/ GTD	Tender manager	7	1-50 million JD
Small	P4	Public client	Project manager	6	1-20 million JD
Medium	P5	Consultant	BIM manager	10	20-100 million JD
Small	P6	Consultant	Contract manager	7	1-629 million JD
Medium	P7	Consultant	Project manager	8	1-260 million JD
Small	P8	Construction management	Construction manager	7	5-200 million JD
Small	P9	Construction management	Project manager and construction manager	7	Several billion JD
Medium	P10	Contractor	Contract manager	10	1-20 million JD
Medium	P11	Contractor	Project manager	8	1-80 million JD
Small	P12	Contractor	BIM regional manager	9	20m-4.5 billion JD

Semi-structured interviews were adopted to collect in-depth information about BIM phenomena and procurement approaches. Open-ended questions and questions oriented toward BIM implementation and procurement approaches were posed by the researcher. The interviews were conducted Face-to-face and recorded. This has resulted in 70 pages in English and Arabic.

Once the interviews were recorded and transcribed, it was essential to develop a general strategy for analysis. The content analysis technique was used as a basis for the interview analysis as it is suitable for conducting exploratory research in an area where not much is known to enable the common issues from the data to be reported. Analysing the data using content analysis has reported three main themes namely; BIM barriers, procurement approaches and how procurement approaches affect BIM implementation.

From Data to Findings

BIM barriers

The weighted averages for BIM barriers were calculated by estimating the mean value of all respondents' responses corresponding to each barrier (Wang & Wu, 2012) for each group (the public clients, consultants and contractors), and then the barriers were ranked from 1 to 11 for each group (see Table 4). The main five barriers to BIM implementation, as stated by the respondents and agreed by different groups, are perceived as the need for 'additional resources and expenses', 'procurement strategies', 'lack of BIM skills, education and training', 'complexity (long hours to develop a BIM model)' and 'lack of a comprehensive framework or implementation plan'.

Table 4: BIM implementation barriers to the public sector

BIM Barriers	Rank					
	Public Clients		Public Consultants		Public Contractors	
	19 Respondents		17 Respondents		80 Respondents	
	Ranking	Weighted average	Ranking	Weighted average	Ranking	Weighted average
Additional resources/ expenses	1	4.00	2	3.65	1	4.60
Procurement approach	2	4.00	3	3.65	2	4.26
Lack of BIM skills, education and training	3	3.95	4	3.41	3	4.11
Complexity (long hours to develop a BIM model)	4	3.95	1	3.71	5	4.08
Lack of a comprehensive framework or implementation plan	5	3.84	5	3.41	4	4.11
Culture change	6	3.79	7	3.27	9	4.00
Attitude and awareness (resistance to change from 2D drafting practices)	7	3.79	8	3.27	7	4.03

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Organisational challenges among construction professionals	8	3.76	6	3.40	8	4.01
Lack of a legal framework (model ownership and legal contract)	9	3.72	9	3.24	6	4.08
Lack of interoperability	10	3.68	11	3.06	10	3.99
Lack of standards	11	3.58	10	3.18	11	3.86
Increased risk and liability	12	3.58	12	2.82	12	2.76

Analysis of the interviews further assisted and complemented the information gained from the survey in clarifying the nature of the main barriers associated with procurement. In integrating the outcome of the survey with interview transcripts, three main overall barriers were identified: business and legal, technical and organisational, as discussed next as shown in Figure 1.

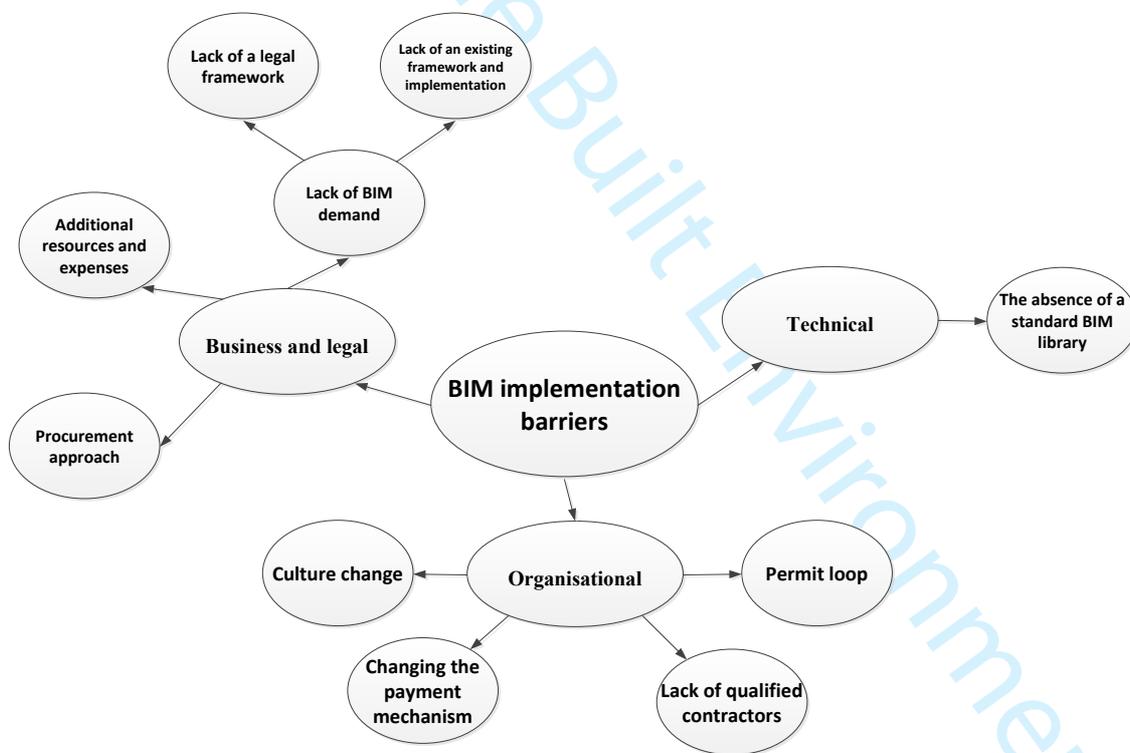


Figure 1. BIM implementation barriers in Jordan

Business and Legal

Three main business and legal barriers to BIM implementation were reported by the participants:

- The procurement approach: A majority of the 12 participants reported that the procurement approach is one of the main barriers and is considered to be one of the major business and legal issues to implementing BIM. Most of the participants indicated that the chosen procurement approach does have a direct impact on the success of BIM implementation. Moreover, they agreed that to fully implement and realise the benefits of BIM, a procurement approach that enhances collaboration among stakeholders is needed. P8 reported that the “*type of procurement affects the implementation of BIM, of course*”. P11 added that “*the selected procurement approach will affect the usage of BIM considering the supply chain, the mentality and culture of procurement, how we are going to procure and when we going to procure*”. He continued by saying that “*there is a gap between implementing BIM and understanding BIM and procurement in Jordan*”. P5 expressed that “*to maximise the utilisation of BIM, we need a procurement approach that facilitate collaboration between the project stakeholders*”.
- Additional resources and expenses: A majority of the 12 participants reported that the initial investment cost is one of the main barriers. P5 stated that: “*The problem with BIM implementation – in Jordan – is that they consider it to be an increase in investment*”

P6 has explained the reason for considering BIM as an increasing cost and additional expense is due to the traditional way of working which depends on the lowest cost in Jordan.

- Lack of Public client awareness and demand: Participants have stated that the lack of governmental awareness and demand for BIM is among the main barriers to BIM implementation. Moreover, this has led to the absence of a legal framework i.e. form of contract and copyright and ownership of the models. P7 highlighted the importance of having amended forms of contract as he explained that:

“As there is a lack of BIM demand from the government, other stakeholders will not be bothered to create any form of contract for BIM implementation”.

Copyright and ownership of BIM models are also among the main legal barriers to implementing BIM in Jordan, and they should be included in the main contract, as expressed by P7 and P12.

Furthermore, *the* lack of governmental awareness and demand for BIM has led to the absence of a lack of existing framework and implementation plan for BIM. P9 expressed that:

“A lack of public client awareness and demand for BIM has led to the absence of a standardised approach, framework or plan to implement BIM”.

Technical

The absence of a standard BIM library is among the major technical problems for implementing BIM in the public sector in Jordan, The interview participants reported that there is a lack of a standardised BIM library. Therefore, P6 claimed that two methods are used for collecting material information to import into a BIM model.

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3 Firstly, suppliers are asked about the specification of certain items, then the information
4 is imported and saved in the BIM library. The second way is to browse the internet for
5 BIM components for this certain item. He added that:
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11 *“This is easier, but we browse and import to the BIM model without consulting the*
12 *contractor or their sub-contractors as they are not on board yet”.*
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15 16 17 **Organisational**

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20 As shown in the Figure 1 above, the four main organisational barriers to BIM
21 implementation are culture change, payment mechanism, buildings' permit loop and
22 lack of qualified contractors:
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- 26
27 • Culture change: The interview participants expressed that resistance to change is
28 one of the main organisational BIM barriers in Jordan. P3 stated that:

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30
31 *“It starts with the culture, for example, many engineers in Jordan still use hand*
32 *drawings for small projects”. These people need to be educated about the new*
33 *tools. He added that “the problem is to make BIM a culture and style”.*
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37 • Changing the payment mechanism was considered to be a barrier for the
38 government in implementing BIM. P12 suggested that:

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41
42 *“BIM implementation will hold the project back; more time and money will be*
43 *spent on the design and preparation stages to make the construction stage*
44 *shorter in time compared to the conventional approach by reducing the rework*
45 *and having more accurate drawings”.*
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55 P11 (a contractor) described changing the payment mechanism as a
56 barrier to BIM implementation:
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3 *“It’s considered a barrier to BIM implementation to spend more time and money*
4 *on the design as it’s not the way that the sector is used to work”.*
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8 He added that:
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11 *“The flow of the money then, of course, will be completely different between*
12 *BIM and the conventional approaches. So, if this issue is not well understood by*
13 *both sides, the public client and his supply chain, major conflicts will occur in*
14 *the payment mechanism, planning and scheduling of the project”.*
15
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- 20
21 • The buildings’ permit loop, as expressed by P5 and P6. The permit loop in a
22 Jordanian construction project includes the Jordanian Engineering Association
23 (JEA), Jordanian Construction Contractor Association (JCCA), MPWH, and the
24 Greater Amman Municipality (GAM). These parties cannot audit BIM models,
25 as the interview participants claimed; therefore, each time the consultants or
26 contractors need to obtain a permit, they need to print a design out in 2D
27 drawings. This will consume more time, cost and effort. Thus, the full benefits
28 of BIM will not be realised by project stakeholders; therefore, to implement
29 BIM, there is a need to change the way JEA, JCCA, MPWH, and GAM review
30 and audit the design. Moreover, these audit units need to be trained, so they can
31 audit the design through a BIM model.
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- 46 • Lack of qualified contractors. There is a shortage of qualified contractor
47 companies compared to consultant companies. This issue has been outlined by
48 the interview participants. P5 (a consultant) reported that:
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52 *“I know many big consulting firms in Jordan have started to utilise BIM, but I*
53 *don’t know so far about the contractors who can use BIM”.*
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P7 (a consultant) also added that “*there is a lack of Jordanian contractors experienced in BIM implementation and pricing*”.

How procurement approaches affect BIM implementation

The combination of findings reveals the major areas in which procurement approaches affect BIM implementation, a description of which follows.

Common approaches of procurement

A majority of the public buildings projects – in Jordan – were awarded a DBB contract procurement approach as 77% of questionnaire respondents stated that they had been using DBB to deliver their projects (see Figure 2), and interview participants stated that 76% of the public buildings projects in Jordan were delivered using DBB approach (see Figure 2).

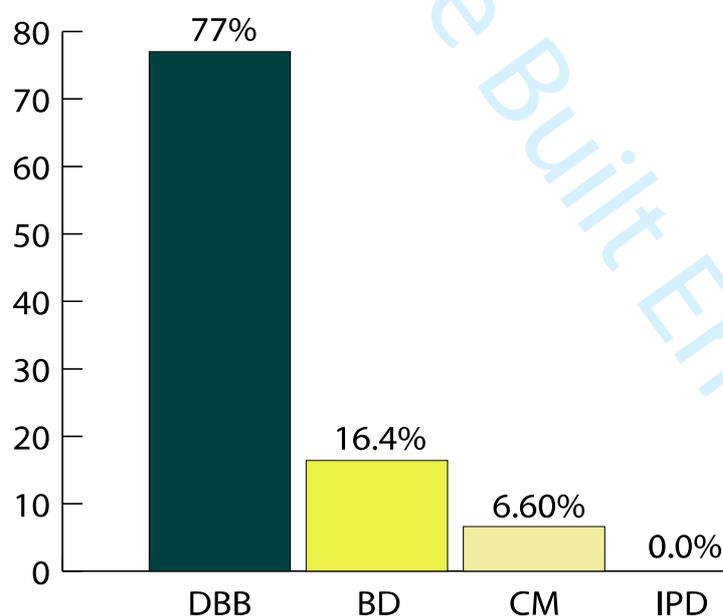


Figure 2. Procurement approaches adopted for delivering public buildings in Jordan

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3 That said, the change of the procurement approach was not deemed a viable
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5 solution, as the interviews cited many reasons for adopting DBB to deliver public
6
7 building projects:
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- 10
11 • The culture of the construction industry. P7 (a consultant) claimed that:
12
13 *“The government is used to doing business in a certain way, and they will be*
14
15 *resistant to change to new tools or ways of working because they don't know the*
16
17 *benefits, how to implement it or why to choose one approach and not another”.*
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- 20
21 • The existing rigid system in the governmental tendering procedures, explained
22
23 by interview participants as relating to the need for the public sector to be
24
25 accountable to the public, and thus have an open competitive bidding process
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27 where the awarding criteria is based on price only.
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30 • The lack of experience and knowledge on how to apply other procurement
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32 approaches as the majority of the public projects are offered on DBB approach.
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- 34
35 • The lack of construction companies whose having in-house design teams to
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37 deliver the DB procurement approach.
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40 • There is no real definition of a CM firm due to the rigidity of tendering system
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42 that deals with only the public consultants and contractors as the contract form
43
44 itself, which is based on the International Federation of Consulting Engineers
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46 (FIDIC) contract, deals with the main contractor, the engineer (the designer and
47
48 supervisor) and the owner (the government).
49

50
51 Interview participants expressed that BIM was only implemented under DBB to
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53 deliver public building projects in Jordan. They reported that this is because BIM has
54
55 only been recently introduced, and so it has not yet been explored with other
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57 procurement approaches. Although BIM implementation through the DBB procurement
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3 approach can improve the overall process, it cannot deliver all the potential BIM
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5 benefits due to the structure of this approach. This, therefore, could hinder project
6
7 stakeholders from implementing BIM in a collaborative environment to obtain the full
8
9 benefits. Indeed, the contractors' late involvement is not ideal because of their limited
10
11 contribution to the design process.
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14 The use of the DBB approach as the one prevailing procurement arrangement
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16 has generated two main fragmented BIM processes as reported by the interview
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18 participants, as summarised as follows:
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22 **Process one:** Most projects delivered utilising BIM follow these stages:
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- 26 1. The consultants build the BIM model in the design stages.
- 27 2. They export the designed BIM model into 2D drawings.
- 28 3. The contractor then bids based on these 2D drawings, and the construction work is
29 carried out based on these 2D drawings.
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36 **Process two:** The other BIM-based process:
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- 40 1. The consultants build the BIM model.
- 41 2. They export the designed BIM model into 2D drawings.
- 42 3. The contractor bids based on these 2D drawings.
- 43 4. The contractor builds his own BIM model based on the drawings to calculate the
44 quantities and detect any clashes.
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52 The interview participants provided six main issues associated with the adopted
53 procurement approach causing the adoption of the two fragmented BIM processes, as
54 follows.
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Lack of a structured procurement process for BIM implementation

The interview participants stated that because there is a lack of existing BIM standards, regulations and guidelines specific to the construction industry in Jordan, a structured procurement process for BIM implementation is missing. Moreover, the absence of rigid governmental actions, such as policies, strategies and plans for BIM implementation has negatively impact the BIM adoption by the consultants and contractors firms.

P2 reported that:

“The absence of structure and a standardised procurement process has affected the ‘know-how’ to implement BIM throughout the procurement process”.

P8 added that:

“The first step to implementing BIM is by having a standardised procurement process not only to follow but also to educate the public stakeholders on how BIM should be implemented”.

Unclear roles and responsibilities

BIM implementation has caused a change in customary project roles and positions. Moreover, BIM implementation has resulted in new roles and responsibilities. The interview participants identified that there are unclear roles and responsibilities for project stakeholders for BIM-based building projects; this is one of the key issues in the current procurement process because there is an absence of BIM standards in Jordan. The interview participants stated that the reason for such issues is that BIM has only been recently adopted to deliver public buildings. Therefore, BIM implementation is not yet at the stage of having set standards.

Lack of contractors' involvement from early design stages

BIM was mainly implemented under DBB. Therefore, the lack of contractor and sub-contractor involvement in the design phase is one of the major barriers to effective implementation of BIM, as stated by the interview participants. P6 said that “no one here understands or accepts bringing the contractor into the design phase without the tendering process, which is usually after stage 4”. This confirms the outcome of the questionnaire analysis in which the culture change is among the main barriers to implement BIM in the public construction industry in Jordan. Moreover, P2 (a public client) commented that late contractor involvement in the project lifecycle was reflected in the fragmented nature of BIM processes in Jordan; this led the contractors to build and use BIM models from scratch.

Rigidity of the tender process

Tendering is a significantly important step in a procurement approach. The interview participants stated that the tender process adopted by the public client is rigid, and it is necessary to adhere to it. P8 reported that:

“There is a rigid system of tendering in the governmental tendering procedures”.

This due to the procurement regime is governed primarily by the Government Works Regulation No. (71) of 1986, issued pursuant to Articles 114 and 120 of the Constitution, and by the ‘National Procurement Legislation’. In these regulation and legislation, the technical services (consultants) and works’ tenders (the contractors) are mentioned as separate stages. Therefore, these laws lean towards two separate agreements between the government-consultants and the government-contractors. This was reflected in the fragmented nature of BIM processes in Jordan.

Limited pre-qualification list

P2 and P4 stated that MPWH qualifies consultants and contractors based on their speciality that is their experience in buildings and civil engineering projects, such as with roads, bridges and water. However, the interview participants criticised the limited nature of the pre-qualification list for consultants and contractors for BIM-based building projects. P1 added BIM model is not yet enforced in the tender stage, therefore, consultants and contractors are not appointed on their ability to deliver construction projects using BIM.

Unclear guidance on the required BIM level of development (LOD) over the project lifecycle

Due to the lack of BIM standards in Jordan, an interesting issue that has been highlighted is the necessary level of development (LOD) throughout the procurement process. P1 commented that:

“Now, BIM is not part of the tender stage. However, if BIM becomes an essential part of the public procurement process, guidance is necessary on the LOD required for procuring the delivery team”.

P12 also expressed that: *“the major challenge we face in implementing BIM in our projects is how much information and what developments we need at each stage of the project”.*

Discussion of findings

BIM Implementation: The Complex Puzzle

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3 This study has identified many human/organisational, technical business and legal
4
5 barriers to BIM implementation. A lack of deployment of a construction procurement
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7 approach that supports BIM implementation in this context represents a major concern.
8
9 Changing the procurement approach for an increased level of collaboration between the
10
11 stakeholders is a critical step toward implementing BIM. However, the clear message
12
13 from the world of practice indicates that a fundamental change to a more collaborative
14
15 procurement approach is not currently possible due to technical, cultural and economic
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17 issues. This has confirmed the view that profound changes and transforming the
18
19 construction industry radically to a BIM-enabled collaborative project environment is a
20
21 challenging task ([Howard & Björk, 2008](#)).

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27 In fact, from the literature, it was highlighted that the public sector has a primary role in
28
29 BIM adoption ([Belay et al., 2021](#); [Bolpagni, 2013](#)). Many countries around the globe
30
31 have realised the vital role of public authorities in promoting BIM, such as the United
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33 States (US), Australia and the United Kingdom (UK) ([Olanrewaju et al., 2021a, 2021b](#)).
34
35 [Belay et al. \(2021\)](#) argued that the public sector should not only initiate and drive BIM
36
37 implementation but should also act as a regulator. Therefore, governments in the US
38
39 ([Koort, 2021](#)), Australia ([Hosseini et al., 2021](#)) and the UK ([Dalui et al., 2021](#)) have
40
41 mandated certain implementation strategies for the use of BIM in public construction
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43 projects. This contradicts the recondition by many researchers on the need to change the
44
45 entire construction practices at once to adopt BIM practices. Instead, identifying work
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47 processes to develop a framework for BIM implementation that synchronises with the
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49 common procurement processes in a specific context is needed, as previously argued by
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51 [Porwal and Hewage \(2013\)](#).

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57 ***Procurement to Unfold Complexities of BIM Implementation***
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3 Reviewing the literature revealed two main viewpoints in dealing with the effect of
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5 the selected procurement approach on the successful of BIM implementation: A
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7 profound procurement change is necessary for BIM implementation ([Elghaish et al.,](#)
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9 [2020](#)) particularly to deliver the necessary collaborative platform that brings together
10
11 multiple stakeholders over the project lifecycle ([Durdyev et al., 2019](#)). Therefore, it has
12
13 been stated that clients are likely to change the way that they procure buildings when
14
15 implementing BIM to ensure a more integrated and collaborative working process
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17 ([Foulkes, 2012](#)). IPD was hailed as the ideal procurement approach that allows the
18
19 project stakeholders to achieve ‘full BIM collaboration’ ([Brahmi et al., 2021](#); [Durdyev](#)
20
21 [et al., 2019](#); [Elghaish et al., 2020](#)) and efficient BIM-based processes.

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24 Others have argued that profound changes and transforming the construction
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26 industry radically to a BIM-enabled collaborative project environment is a challenging
27
28 task ([Howard and Bjork, 2008](#)). Therefore, a common misconception has been
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30 identified by many researchers on the need to change the entire construction practices at
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32 once to adopt BIM practices ([Kim, 2015](#)). Instead, researchers recommend identifying
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34 work processes to develop a framework for BIM implementation that synchronises with
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36 the currently adopted procurement process in a specific context ([Porwal and Hewage,](#)
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38 [2013](#); [London et al., 2008](#)).

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40 In this research, the Jordanian public sector agrees with the latter argument due to
41
42 the explored issues associated with changing the entire procurement approach.
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44 Moreover, this study has revealed that the DBB is the main procurement approach for
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46 delivering public buildings in Jordan. Moreover, apart from corroborating the
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48 recommendation of previous studies in a new context, this study goes one step ahead,
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50 by identifying the requirements of a feasible procurement approach that supports BIM
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52 implementation, while is deemed viable within the boundaries of the current
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possibilities of real-life projects. As mentioned in the literature, there is a growing interest in implementing BIM ([Hong et al., 2019](#)) ([Hosseini et al., 2021](#)) in the construction industry. According to Kassem and Succar (2017), it was indicated that BIM Implementation is a three-phased approach combining an organisation's readiness to adopt, capability to perform and performance maturity. The study assessed implementation within 21 countries where it was found that BIM implementation is mostly passive where in principle; this indicates that implementation is associated with awareness, encouragement and observation. Although this provided an informed positioning of BIM Implementation, it did not holistically shed the light into how BIM implementation can be informatively enforced. This study therefore provided an additional lens into the role of procurement ([Popov et al., 2021](#); [Rahman & Sainati, 2021](#)), and how it can act as a precursor to BIM implementation.

The basic principles of ISO 19650-2:2018 do not reflect the specific conditions of each country, so it is appropriate to examine the possibility of providing guidance in individual national annexes that reflects the peculiarities of national procurement ([Popov et al., 2021](#)). Therefore, this research has revealed the main issues facing the current adopting procurement approach in the public sector in Jordan and Lack of a structured procurement process for BIM implementation, unclear roles and responsibilities, lack of contractors' involvement from early design stages, rigidity of the tender process, limited pre-qualification list, unclear guidance on the required BIM level of development (LOD) over the project lifecycle. Thus, Figure 3 shows the requirements of the adapted procurement approach, divided into two main categories: those that address a lack of existing practices, and those needed to establish the new system. The proposed framework in Figure 3 is considered as a point of departure that can inform developing BIM protocols and strategies to use ISO 19650 BIM standards.

Based on each of the procurement requirements presented in Figure 3, an appropriate mapping with different ISO 19650 documentation can be done, which supports a more structured set of workflows across the project lifecycle. More importantly, the proposed framework can also support mitigating many of the Human/organisational, technical and business barriers ([Evans and Farrell \(2020\)](#)) that can be presented in a BIM-based construction project.

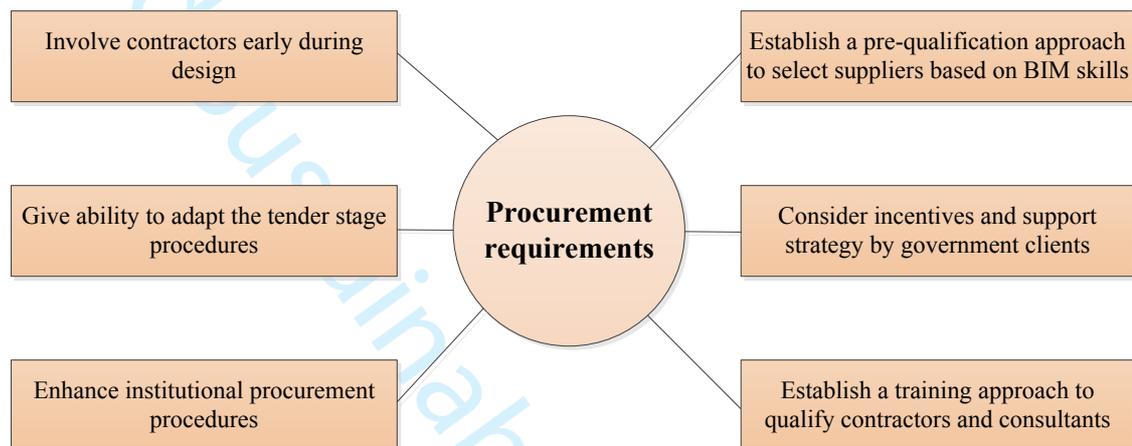


Figure 3. Framework for implementing/fostering BIM in Jordan

Management related challenges are typical for developing countries when it comes to BIM implementation including procurement approaches (Bui et.al, 2016). For instance, Qatar and UAE were planning to initiate a new regulation for public procurement for BIM based projects (Gerges et.al, 2017). Moreover, it is recommended for all governmental bodies in developing countries to release a plan to develop collaborative procurement methods on all publicly funded projects (El Hajj et al., 2021). Therefore, the framework in Figure 3 can be used by other similar governmental bodies in developing countries when implementing BIM.

Conclusion

As an exploratory research study in Jordan, the purpose of this study is to investigate three aspects of implementing BIM in the public sector: (i) barriers to BIM

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3 implementation associated with procurement; (ii) common procurement approaches in
4 the public sector; (iii) procurement approaches issues that affect BIM implementation.

7 The results illustrate that there are still many BIM barriers that need to be addressed.

9 These barriers are classified under three categories; human/organisational, technical and
10 business and legal barriers. Procurement approaches under business and legal barriers
11 are among the major barriers that need to be addressed. This is through the deployment
12 of a construction procurement approach that supports BIM implementation in this
13 context. DBB has been found to be the most adopted approach for delivering public
14 buildings. This approach has been criticised by BIM practitioners due to many reasons
15 such as the total separation of the design and construction phases where which led to the
16 adoption of two fragmented BIM processes. Consequently, this research shows the main
17 issues associated with the DBB approach that hinders the implementation of BIM.

19 As this research identified many technical, cultural and economic issues that
20 hinder the total change of the procurement approach to a more collaborative-based one
21 for the BIM-based building projects, a procurement framework for BIM implementation
22 that synchronises with the currently adopted procurement process in this context should
23 be developed. The details of such a procurement approach are discussed to inform
24 researchers as well as the world of practice.

26 This study is the first about BIM and procurement in the public sector in Jordan.
27 Findings raise awareness and offer a reference point for public clients, public
28 consultants and public contractors dealing with procurement and BIM implementation
29 issues. The knowledge acquired and developed will support policy makers and decision
30 makers in designing strategies and plans for BIM adoption and implementation in
31 Jordan. In particular, government can consider the following measures to overcome the
32 revealed procurement barriers for BIM based projects: (1) Establishing national BIM

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3 hub including public consultants, public contactors, professional associations (JEA and
4 JCCA) and research community in Jordan such as developed in the UK to increase the
5 awareness on the benefits of BIM implementation and collaborative procurement
6 approaches in Jordan. (2) The government with collaboration with the professional
7 associations (JEA and JCCA) and universities should develop guidelines based on a
8 pilot projects to facilitate BIM implementation, in compatible with current procurement
9 approach through mapping with different ISO 19650 documentation. (3) The
10 government should amend the tender stage conditions to award the public projects to the
11 suppliers who uses BIM compared to other non-users suppliers with similar conditions.
12 (4) The early involvement of contractor is essential. This research recommends the
13 government to use of a pre-construction services agreement (PCSA) basis. Therefore,
14 the contractor is hired through the means of a two-stage tender process under a
15 traditional procurement approach to enhance team integration. (5) The prequalification
16 procedure in Jordan has been criticised due to its limiting list, which has a direct effect
17 on the effective implementation of BIM. Therefore, this research proposes establishing
18 a pre-qualification list to appoint BIM qualified consultants and contractors which
19 includes BIM and IT assessment forms.

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This research should also be of interest to researchers in the field as it provides a basis for future research and fills a knowledge gap in the area of BIM implementation and procurement issues to facilitate BIM implementation by providing solid knowledge about BIM adoption and implementation in this context. Furthermore, this research enables insight into the subjective perception of professionals (that is the project managers, BIM managers, tender managers and construction managers) in regard to the relationship between the procurement approaches and effective BIM implementation.

Despite the contributions of the study, several limitations should be acknowledged. As the proposed framework has not been implemented on any organisation, the researcher recommends future research on applying the proposed framework to a case study to measure the actual impact of the framework and to suggest modifications if any are needed based on a longitudinal study. Moreover, the study was based on data collection from a single case (the Jordanian public sector). Despite the consideration of Jordan as a typical developing country, the researcher recommends future studies on other developing countries to verify the results of this study. MPWH and GTD are representatives of the public client due to their significant role in procuring public buildings. Nevertheless, the researcher acknowledges that conducting the study with a larger sample will enable broader generalisations of the research outcomes. Collecting data from other governmental ministries such as the Ministry of Municipal Affairs, the Ministry of Higher Education and the Ministry of Health would be appropriate. These limitations provide fertile grounds for research.

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Reviewers Comments to Author	Authors Response to Reviewers Comments
Reviewer: 1	
The authors should check the results on pages 16-17 for this paragraph "The procurement approach:...is needed." There is no information regarding which interviewee(s) mentioned that barrier.	Thank you for your valuable comment. The paragraph has been amended to include the interviewees who highlighted the barrier
Figure 3 needs to be checked. Some words are unreadable because of the black shadow.	Thank you for your valuable comment. The figure has been amended.
Reviewer: 2	
While the regional focus is a strong aspect of your work, I encourage you to delve deeper into how your findings contribute uniquely to the broader field of BIM research. Are there insights or patterns observed in your study that challenge, extend, or refine existing theories or practices in a novel way?	Thank you for your valuable comment. Discussion of the findings section has been modified including how the insights of this study challenge and extend the current theories.
Further detailing, particularly around the rationale for the chosen sample size and the structure of your research instruments, would strengthen the credibility of your approach.	Thank you for your valuable comment. More details on the rationale for the chosen sample size and the structure of the research instrument have been added.
Your results section is well-articulated, but the analysis could be deepened. Consider exploring the why and how behind the patterns observed.	Thank you for your valuable comment. The results section has been amended to deepen the analysis including the why and how behind the patterns observed.
Also, more explicitly draw out the implications of your findings for practice, policy, and future research. How can these insights practically influence BIM implementation strategies?	Thank you for your valuable comment. Conclusion section has been modified to include how the research insights and the proposed framework can influence strategies for the Jordanian government and the industry to increase BIM implementation.
Nonetheless, continue to refine the sentence structure for simplicity and clarity. This will make your paper more accessible to a wider audience, including those who may not be specialists in your specific research area.	Thank you for your valuable comment. Sentences have been revised to simplify the language.
Broadening the Scope: Reflect on how your study can add value not just within the Jordanian context but in similar environments or even contribute to global	Thank you for your valuable comment. Discussion of the findings section has been modified to include why and how this research contribute to similar

discussions on BIM implementation.	environments.
The study provides insights specific to Jordan's public sector, which is valuable. However, it primarily relies on established BIM literature and methodologies, and the uniqueness of its contribution appears limited to the regional context. It still lacks groundbreaking insights or novel perspectives that would significantly contribute to the broader field of BIM research.	Thank you for your valuable comment. Analysis section has been modified including how the insights of this study extend the current theories.
The paper demonstrates an understanding of relevant literature and cites a range of sources. However, it does not seem to offer new theoretical insights or extend existing frameworks in a significant manner. Even after the revisions, it's more of a regional application of known concepts rather than a novel contribution to BIM literature.	Thank you for your valuable comment. This study is the first about BIM and procurement in the public sector in Jordan. Findings raise awareness and offer a reference point for public clients, public consultants and public contractors dealing with procurement and BIM implementation issues. So it is appropriate to examine the possibility of providing guidance in individual national context that reflects the peculiarities of national procurement. Conclusion section has been modified to include concrete strategies to overcome current explored procurement barriers and to enhance BIM implementation.
The mixed-method approach, combining quantitative and qualitative data, is appropriate. However, the justification for the sample size and the detailed structure of questionnaires and interviews could still be better articulated to strengthen the research design's robustness.	Thank you for your valuable comment. More details on the rationale for the chosen sample size and the structure of the research instrument have been added.
The paper identifies implications for practice in Jordan's public sector and suggests potential impacts on policy and strategy design. However, the link between theory and practice is not strongly established, and implications are more speculative than empirically supported. Future research suggestions are noted, but the paper could benefit from more concrete strategies for overcoming identified barriers.	Thank you for your valuable comment. The conclusion section has been modified to include strategies for the Jordanian government and the industry to overcome the identified procurement barriers.

Table1. Barriers to BIM implementation

Category	Description	References
Business and legal problems	Additional resources and expenses (high economic investment software)	(Eadie et al., 2014 ; Ullah et al., 2019)
	Fragmented procurement approaches	(El Hajj et al., 2021 ; Gurevich & Sacks, 2020)
	Increased risk and liability	(Dao & Chen, 2021 ; Khoshfetrat et al., 2020 ; Ragab & Marzouk, 2021)
	Lack of a comprehensive framework or implementation plan	(Dao & Chen, 2021 ; Olanrewaju et al., 2021b ; Wang & Lu, 2021)
Technical problems	Lack of a legal framework (model ownership and legal contract)	(Dao et al., 2021 ; Gad et al., 2020 ; Malla et al., 2022 ; Nguyen, 2021)
	Lack of standards	(Hadi, 2020 ; Tran-Hoang-Minh et al., 2021 ; Wu et al., 2021)
	Lack of interoperability	(Bouhmoud & Loudyi, 2021 ; El Hajj et al., 2021 ; Olugboyega & Windapo, 2021)
	Attitude and awareness (resistance to change from 2D drafting practices)	(Durdyev et al., 2021 ; Evans & Farrell, 2020 ; Hamma-adama et al., 2020)
	Complexity (long hours to develop a BIM model)	(Alemayehu et al., 2021 ; Belay et al., 2021 ; Saka & Chan, 2020)
Human/ organisational problems	Cultural change	(Durdyev et al., 2021 ; Faisal Shehzad et al., 2020 ; Olugboyega & Windapo, 2021)
	Employees lack BIM skills, education and training (design, engineers and subcontractors)	(Pokusaev et al., 2021) (Hosseini et al., 2021)
	Organisational challenges among construction professionals	(Ademci & Gundes, 2021 ; Farooq et al., 2020 ; Karampour et al., 2021)

Table2. Questionnaire data

Research Strata	MPWH& GTD	Contractor			Consultants			
	HOD	1 st	2 nd	3 rd	1 st A	1 st B	2 nd	3 rd
Population	20	80	68	136	18	11	3	0
Total number of population	20	284			32			
Sample Size	20	164			30			

Table3. Interview participants

Organisation size	Participants	Department/ Company	Position	No. of years' experience	Size of the projects
Medium	P1	Public client/ design department	Project manager	18	Hundreds of million JD
Medium	P2	Public client	Project manager	15	1-50 million JD
Small	P3	Public client/ GTD	Tender manager	24	1-50 million JD
Small	P4	Public client	Project manager	10	1-20 million JD
Medium	P5	Consultant	BIM manager	8	20-100 million JD
Small	P6	Consultant	Contract manager	36	1-629 million JD
Medium	P7	Consultant	Project manger	23	1-260 million JD
Small	P8	Construction management	Construction manager	45	5-200 million JD
Small	P9	Construction management	Project manager and construction manager	18	Several billion JD

Medium	P10	Contractor	Contract manager	13	1-20 million JD
Medium	P11	Contractor	Project manager	8	1-80 million JD
Small	P12	Contractor	BIM regional manager	9	20m-4.5 billion JD

Table 4. BIM implementation barriers to the public sector

BIM Barriers	Rank					
	Public Clients		Public Consultants		Public Contractors	
	19 Respondents		17 Respondents		80 Respondents	
	Ranking	Weighted average	Ranking	Weighted average	Ranking	Weighted average
Additional resources/ expenses	1	4.00	2	3.65	1	4.60
Procurement approach	2	4.00	3	3.65	2	4.26
Lack of BIM skills, education and training	3	3.95	4	3.41	3	4.11
Complexity (long hours to develop a BIM model)	4	3.95	1	3.71	5	4.08
Lack of a comprehensive framework or implementation plan	5	3.84	5	3.41	4	4.11
Culture change	6	3.79	7	3.27	9	4.00
Attitude and awareness (resistance to change from 2D drafting practices)	7	3.79	8	3.27	7	4.03
Organisational challenges among construction professionals	8	3.76	6	3.40	8	4.01
Lack of a legal framework (model ownership and legal contract)	9	3.72	9	3.24	6	4.08
Lack of interoperability	10	3.68	11	3.06	10	3.99
Lack of standards	11	3.58	10	3.18	11	3.86
Increased risk and liability	12	3.58	12	2.82	12	2.76

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Smart and Sustainable Built Environment

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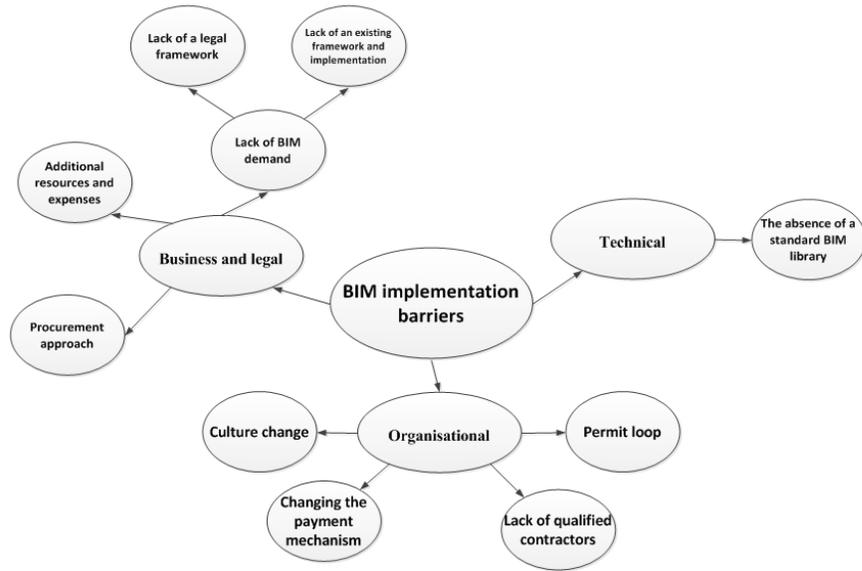


Figure 1. BIM implementation barriers in Jordan

Figure 1. BIM Implementation Barriers in Jordan

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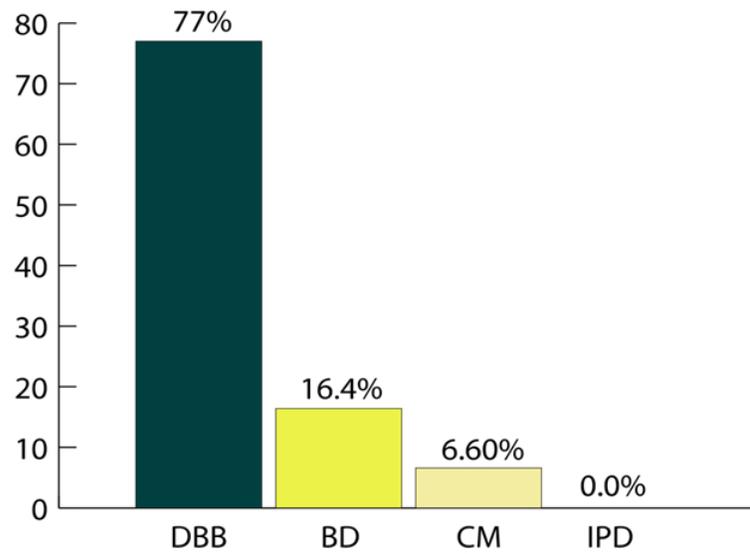


Figure 2. Procurement approaches adopted for delivering public buildings in Jordan

Figure 2. Procurement approaches adopted for delivering public buildings in Jordan

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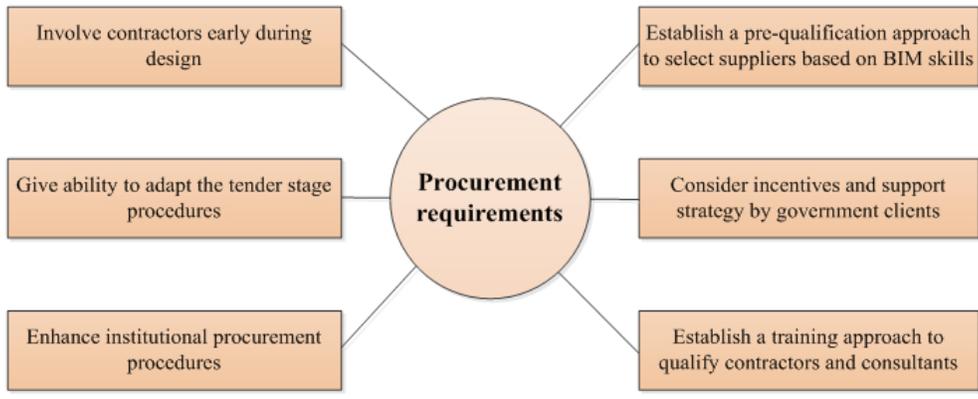


Figure 3. Framework for implementing/fostering BIM in Jordan

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