

# Procurement route and Building Information Modelling (BIM) implementation effect on achieving sustainable buildings in developing countries: a case study of Jordan

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## **Abstract**

*In Jordan and most developing countries, the construction industry faces problems such as chronic resource shortages, general situation of socio-economic stress, institutional weaknesses and a general inability to deal with key issues. There is also evidence that the problems have become greater in extent and severity in recent years. Building Information Modelling (BIM) has emerged as a potential solution to these problems and to improve the performance of the construction industry. Construction procurement routes currently applied in Jordan predate the use of life-cycle BIM for the delivery of construction projects. To date, little has been done to align the various procurement routes used in delivering buildings with the novel opportunities offered via BIM. This paper is a part of an on-going research project to determine whether procurement approaches influence the ability to use BIM approach to deliver sustainable buildings in Jordan.*

## **1. Introduction**

There are 139 middle and low income economies referred to as developing countries according to World Bank (World Bank, 2016). Jordan as a developing country faces a variety of sustainable challenges shared by other developing countries especially in the Middle East such as increasing level of pollution and energy concerns (Ali and Al Nsairat 2009), Jordan is also considered as one of the world's most water-stressed countries (Kisbi, 2011). These issues and other issues pertaining to global warming and carbon emissions make sustainability a priority area of concern (Sheth, 2011) cited in (Mohammad, 2016).

Sustainable development is an ambiguous concept, with a meaning that is complex and contested (Carter, 2007). It has been defined, interpreted, or used in a variety of ways by different groups (planning, academia, business or environmental policy) to suit their own goals (Redclift, 2005). The most frequently quoted definition is from the Brundtland Report (WCED, 1987): "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

'Sustainable built environment' or 'sustainable construction' is a subset of sustainable development that integrates effectively low-energy design materials whilst maintaining ecological diversity (Edwards, 1998). Sustainable construction is defined as "*the creation and management of a healthy built environment based on resource efficient and ecological principles*" (Kibert, 2008).

Jordan suffers from rapid urbanization as approximately 80% of the general population resides in urban areas and 70% of its population lives within 30 km of the capital, Amman (Kisbi 2011). Du Plessis (2007) suggests that an urgency action should be taken to ensure that the high volume of construction that will be undertaken in the developing countries in the process of urbanization is done in ways that are 'socially and ecologically responsible'. However, there are numerous challenges to the introduction of more sustainable technologies and practices in these countries (Ofori, 2007).

Technological innovation plays a key role in both short and long-term economic, societal and environmental sustainability. In recent years, BIM has been considered as one of the most effective technological and organizational innovation in the architecture, engineering and construction (AEC) industry (Succar, 2015) cited in (Soltani, 2016). It can assess design and deliver sustainable building through for example, its ability to virtually construct buildings prior to construction phase which effectively assesses their constructability and resolves any uncertainties during the process that could affect building sustainability (Green Building Development in Jordan, 2013). This can lead to better and more efficient designs that optimize energy usage, limit wasted resources, and promote passive design strategies (Eastman & Liston, 2008).

On the other hand, BIM is considered as a collaborative platform; thus, getting the maximum benefit from its implementation requires a collaborative environment between all disciplines. Different procurement (contractual arrangement) routes can achieve different collaboration levels by establishing the relationships between the involved parties and tasks on buildings' life cycles (Laishram, n.d.).

The issue with the above is that, to date, procurement types were not chosen on their ability to deliver collaborative environments; therefore, BIM has been used in a relatively isolated way, with limited collaboration between designers and other professionals within the projects (Stirton & tree, 2015).

This paper is part of an on-going research project to determine whether procurement approaches influence the ability to use BIM techniques to deliver sustainable buildings in Jordan.

## **2. Literature review**

### **2.1 Sustainable development and Jordanian construction industry**

The Hashemite Kingdom of Jordan, a small, resource-starved, middle-income country with insufficient sources of water, oil, and other natural resources and a growing population (El-Naser, 2014), released its first National MDG report in 2004, which had an important impact on policy-making as the goals, targets and indicators were adapted and aligned with national plans and development priorities. In 2006 two more documents articulated the vision of the country and development planning, namely the “National Agenda” and “We are all Jordan”. Subsequently, this vision was operationalized into a three year National Executive Programme (NEP), specifying policies, programs and projects for government institutions. MDG indicators had been integrated within those plans, related to social welfare, health care, poverty reduction and education (Awad, 2017).

In 2015, “Jordan 2025.A national vision and strategy” was released, through which previous policies, strategies and recommendations were reviewed and a broader process of engagement was set. The strategy includes several Sustainable Development Goals (SDGs), including the eradication of poverty, the improvement of the educational system, the provision of clear water and sanitation, the guarantee of decent work and economic growth and the development of the sustainable communities and cities, but still a lot needs to be done in order for this approach to be effective and enable Jordan’s development to be inclusive and sustainable (Awad, 2017).

The construction sector is critical in delivering sustainable development, as this is important to everyone’s quality of life (Burgan & Sansom, 2006; Morrell, 2010). However, trends driving the demand for building in Jordan include high rate population growth and rapid urbanization, coupled with waves of recurring forced in-migration from neighboring countries over the past 69 years. Urban population exceeds 80% of the total bulk, of which urban poor living in slums rates over 15.7% (UN-Habitat, 2008). However, these trends are making the building sector the fastest growing in the country. In Jordan, the share of the building sector in the final energy consumption accounts more than 33% (UNEP, 2007). Buildings are also responsible for high rate of CO<sub>2</sub> emissions over their lifetime, in addition to significant use of water in a country which is one of the world four poorest in water resources.

For Jordan, this issue arises at a time when the built environment is failing to meet the increasing demands on scarce resources. The construction sector is under increasing pressure to meet a rapidly growing need for housing and commercial space. However, so far the focus with regard to efficiency has been on raising the awareness of households regarding water and energy efficiency. These are minor measures that will not produce large-scale improvements in efficiency, unless they are complemented by sustainable design practices that cover the entire life cycle of buildings (Green Building Development in Jordan, 2013). One of these innovative

practices is the usage of BIM. BIM can be used as a sustainable tool to design construction projects via its seven dimensions: 1D: program data, 2D: design based upon the data, 3D: modeling, 4D: time, 5D: costs, 6D: procurement, and 7D: sustainability. It has been argued that the sustainability dimension (7D) could impact the other six dimensions of the BIM concept (Kapogiannis et al., 2015).

## 2.2 BIM and built environment

### 2.2.1 BIM definition

There is a considerable divergence among those who attempted to define the meaning of building information modeling. Some ambiguity is within the phrase itself. As for example, is the term modeling intended as a noun or verb, does the model refer to instantiated model or the underlying schema. BIM is usually written as Building Information Modeling and generally having two distinct but complementary meanings: either particular engineering software, or a managing process. The latter can be characterized as the adoption of an information-centric view of the whole lifecycle of a building. It is therefore challenging to find a single satisfactory definition of what BIM is. It is proposed that it should be considered and analyzed as a multidimensional, evolving, complex phenomenon.

BIM have been defined by many people depending on their roles in delivering the building. Zuppa (2009) used a survey of 202 AEC professionals to gain an understanding of the prevalent definition of BIM in the industry. The definition most chosen by the respondents identified BIM as a tool for visualizing and coordinating AEC work to avoid errors and omissions. Succar on other hand defined BIM (2009) as a:

*"set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's lifecycle"* (Succar, B., 2009).

BIM can also be defined as a digital representation of a building in the form of an object oriented three-dimensional model, or a repository of project information to facilitate interoperability, automation of processes and exchange of information with related software applications (Miettinen, and Paavola, 2014).

Eastman et al. (2008) states that a building information model contains precise geometry and relevant data needed to support the design, procurement, fabrication, and construction activities required to realize the building. Azhar (2011) builds upon this definition by stating that a building information model characterizes the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories, and project schedule. The building model has been characterized by:

- Data attributes and parametric rules.
- Consistent non-redundant data so changes are propagated to all views and the presentation of all views of the model are coordinated.

- Components that include data that describe how they behave.
- Building components represented by digital objects that know what they are and can be associated with computable graphics (Eastman, 2008).

### **2.2.2 BIM and sustainability**

There is a belief that the adoption of BIM approach can improve the performance of the construction industry (Crotty, 2012). As for example BIM implementation is a means for providing accurate scheduling, diminishing total project costs, yielding quantity take-offs and enhancing project quality (Eastman & Liston, 2008).

Moreover, practitioners believe that BIM can achieve sustainable construction outcomes more effectively than what is currently being achieved in the industry (McGraw Hill, 2010). Over the past decade, many pilots and live projects have been completed and documented in Finland, Sweden, Norway, Germany, France, Singapore and Australia that demonstrate the capability of using BIM in construction for more sustainable products, compared to non-BIM projects (Mihindu and Arayici, 2008).

BIM and sustainability are terms frequently used in construction and academia. BIM is not a new approach within the industry however BIM and its relationship to sustainability is just beginning to realize its potential, as the demand for both BIM and sustainability is increasing (ISSUU, 2015).

BIM has the ability to virtually construct buildings prior to the construction phase, which effectively assesses their constructability and resolves any uncertainties during the process that could affect building sustainability performance. This can lead to better and more efficient designs that optimise energy usage, limit wasted resources, and promote passive design strategies (Eastman & Liston, 2008). BIM for example can evaluate various building skin options and performing daylight (Azhar & Brown, 2009); it can be used to analyze buildings as fully integrated dynamic designs and adjust their construction process to enhance their sustainability (Holness, 2008).

BIM is capable of life cycle cost analysis (LCA) by performing carbon accounting procedures and calculating operational energy use and carbon emissions, which could help improve and sustain buildings' environmental performance (Stadel, 2011). On the other hand, BIM can assess to deliver the required sustainable design via its ability to continuously evaluate buildings' performance over their whole life cycle, which in turn assesses the gap reduction between the design intent and the in-use performance in order to deliver the required whole life performance and to achieve financial savings for the clients when operating their facilities (Kapogiannis, Gaterell, & Oulasoglou, 2015).

### **2.2.3 BIM Implementation**

BIM advancement in the Middle East is on the rise (Gerges, 2017). In 2011 Building Smart reported on the adaptation of BIM in the entire Middle East region (BuildingSmart, 2011). The report surveyed the usage of BIM across the Gulf Cooperation Council (GCC) and Jordan. The report concluded that the penetration was “moderate”, and 25% of participants were “familiar” with BIM processes but only 5% were using it. (Awwad, 2013) explained that the Middle East has the lowest take up of BIM, with the public sector not taking any steps to implement it.

Jordanian government is the first to take the BIM oath in the Middle East. The Kingdom of Jordan's Ministry of Public Works and Housing (MPWH) and the Jordan Engineers Association (JEA) signed an agreement in (2011) with building SMART and BIM Journal to establish the building SMART Forum in Jordan and to start promoting BIM implementation. However, no further actions were taken since then for wider BIM implementation such as road maps, protocols, guidance and standards.

Whereas, in the UK, the government influenced BIM implementation throughout the construction industry (Cabinet Office, 2011), as the use of BIM for public projects (> £5M) was mandatory by 2016. Francis Maude (2012), Minister for the Cabinet Office, stated the following:

‘The government’s four-year strategy for BIM implementation will change the dynamics and behaviors of the construction supply chain, unlocking new, more efficient and collaborative ways of working. This whole sector adoption of BIM will put us at the vanguard of a new digital construction era and position the UK to become the world leaders in BIM’. (Mcgough, Ahmed, & Austin, 2013).

### **2.2.4 BIM and procurement**

Apart from the political drive, BIM is a collaborative platform; thus, getting the maximum benefit from its implementation requires a collaborative environment between all disciplines. Different procurement routes can achieve different collaboration levels by establishing the relationships between the involved parties and tasks on buildings’ life cycles (Laishram, n.d.). Hozler agreed (2011) that regulatory frameworks and in particular contract procurement methods have a major impact on the success of BIM implementation on medium-to-large construction projects.

Building procurement has been defined as “the amalgam of activities undertaken by a client to obtain a building” (Franks, 1984). This clarification is necessary as to distinguish building procurement from the procurement of other goods and services and buying a building from a developer or property agent. Building procurement is a complex process involving the interaction of the client, a team of consultant

designers, constructors, suppliers and various statutory/public interest bodies (The Scottish Government, 2011). The construction industry contrasts most other industries, in that whereas others are mass producers, the construction industry most often produce a one-off prototype (Rijn, 2005). The Scottish Government (2011) describes building procurement as “encompassing the purchase of construction-related services with the ultimate aim of:

- Creating a new building or structure, including all associated site works; and or
- Alteration, refurbishment, maintenance, extension or demolition of an existing building or structure”.

McDermott (1999) also defines building procurement as “the framework within which construction is brought about, acquired or obtained”.

One of the first efforts by industry experts to discuss the relationship between procurement routes and BIM was the NBS BIM Roundtable Legal Discussion in the UK, held in July 2013. The discussion was video-recorded, and the second half was on BIM’s “Technology, Procurement Methods and Processes.” The contributors were specialists in public–private partnership/private finance initiative (PPP/PFI), with a particular focus on the energy and infrastructure sectors; members of the government’s BIM Task Group Core Team; the editor of the Royal Institute of British Architects (RIBA) “Plan of Work 2013”; and the head of contracts and law at RIBA Enterprises. The discussion was about the most appropriate type of procurement to implement BIM where traditional design and build and construction management (CM) routes were failing. These routes were discussed according to the responsibilities and risk distribution between the parties and the timely involvement of the project team, mainly the contractor, which has been argued to increase the potential of BIM as a tool to improve buildings’ performance. Design and build was seen as suitable for BIM implementation; however, the limited client involvement associated with this approach could hinder the levels of collaboration and the pricing of the risk, which would increase the final account (project price). CM was seen as suitable for implementing BIM, but only with expert client involvement. Traditional procurement (lump sum) was criticised on its ability to implement BIM; this is due to the late involvement of the contractor in the delivery process, as design and construction phases are separated by people’s time and involvement. Finally, these routes were not discussed according to specific sector and building types and no consideration was paid to the sustainability issues.

Further research in the Netherlands about the “legal and regulatory aspects of BIM” (Sebastian, 2011) discussed the appropriateness of four procurement types that were applied to BIM-based projects: Design–Bid–Build (DBB), Dutch Building Team, Design and Build (DB), and Integrated Project Delivery (IPD). This research categorized the legal aspects that affect the success of BIM implementation into two types, firstly, the general aspects concerning regulation and law on information and communication, and secondly, the project-specific aspects concerning the

procurement type for a project. This research focused on the effect of BIM usage on the division of tasks, the formal agreements on the parties' roles, and changing the working process between the parties involved. Based on the literature and real practices, the research concluded that BIM can be used in any building type (public and private, small and large, residential and non-residential, and domestic and non-domestic). Moreover, BIM can be used in combination with any procurement type. However, BIM's greatest impact can occur when used in complex projects where stakeholders collaborate in an open and integrated way through the building life cycle. The research recommended further investigation into the most effective procurement for applying BIM for a certain typology of building project (Sebastian, 2011).

Bynum, Issa, and Olbina (2013) aimed to investigate the perception of using BIM to design and construct sustainably among designers and constructors. An online survey was distributed to different types of professionals in the US, and 123 questionnaires were completed. The majority of the respondents believed that IPD and DB are the optimal procurement routes to integrate BIM as a sustainability tool. However, only a quantitative method was used to obtain the data, and the study concentrated on new buildings (Bynum, Issa, & Olbina, 2013).

IPD is defined by the American Institute of Architects (AIA) as:

*'a project delivery approach that integrates people, systems, business structure and practices into a process that collaboratively harnesses the talents and insights of all participants to optimise project results, increase value to the owner, reduce water consumption and maximise efficiency through all phases of design, fabrication and construction.'*

Whereas IPD was initially hailed as the ideal procurement method to allow teams to achieve 'full BIM collaboration' the industry is now viewing the idea of 'full BIM' more cautiously (Cleves & Dal Gallo, 2012). IPD as a delivery method, implemented mainly in the USA; is still the closest fit one could aspire to a contract method in the context of BIM (Holzer, n.d).

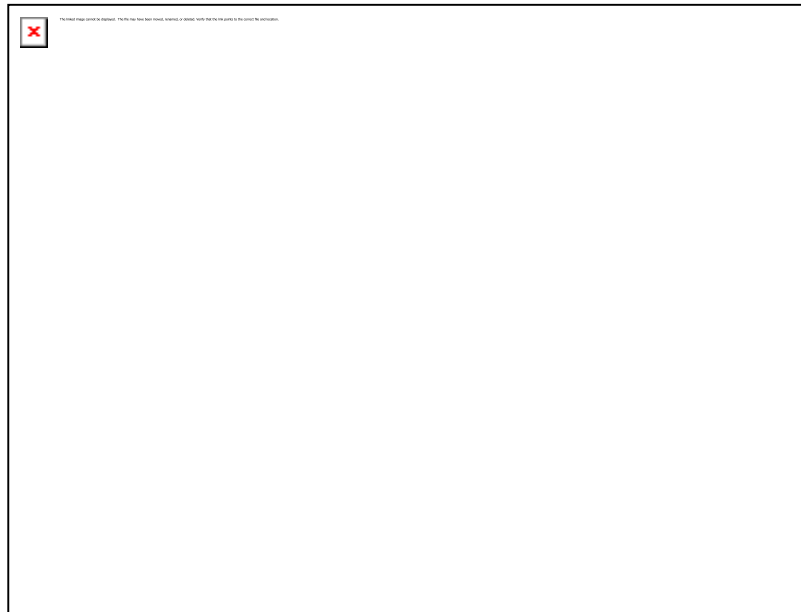
The most widely used delivery method with BIM is the traditional method of DBB (H. Lowe Richard). In Jordan, the most common construction public procurement is two stages DBB (Alkilani, 2012). This type of procurement has been widely criticized for its fragmented approach to project delivery and its failure to form effective teams (Nasrun, 2014). DBB sees a separation between risk and responsibilities by the contracting and consulting sides. This therefore will hinder the team from implementing BIM in a fully collaborative environment in order to get its full benefits.



### 3. Research method

The method applied for the research presented in this paper is as follows: After a brief problem definition, the author draws from literature the following research framework to examine the relationships between the main themes.

This study is a part of a wider PhD-based research program into the Jordanian construction industry; its aim is to investigate the current adopted construction procurement routes and whether such routes are fit for implementing BIM to deliver sustainable buildings.



### 4. Discussions and conclusion:

Current studies show that most project procurement or delivery methods in Jordan are based on the traditional approach. This traditional construction procurement method has been widely criticized for its fragmented approach to project delivery and its failure to form effective teams. Consequently, construction projects experience a number of problems and issues, such as reworks, time delay, rising costs, lack of communication and coordination, and wastages.

BIM is seen as an innovative design process that will help solving issues that may arise in delivering sustainable buildings. Procurement routes or delivery methods are considered in the literature review to be one of the critical actions to fully implement BIM and gain its benefits. However, to date, little has been done to align the various contractual procurement methods in Jordan with the novel opportunities offered via BIM.

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