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ORIGINAL PAPER

Sociocultural sustainability in green building information modeling

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Abstract Building information modeling (BIM) technology used to further processes in the green building industry has received wide coverage in the literature. Some companies have leveraged this natural synergy but many remain on the sidelines, unable to fully exploit the potential offered by BIM in green projects. Moreover, most literature focus on technical aspects of BIM use while ignoring social and cultural aspects of its application. This narrow, tactical focus can undermine the synergy between BIM and green building, and prevent achieving strategic, sustainable goals. The objectives of this article are to: (1) review BIM status in the context of social and cultural sustainability within the building industry; and also, (2) propose criteria for furthering integrative applications that achieve social and cultural sustainability in the green building industry. Five layers of social and cultural sustainability were identified and classified within a framework of BIM applications for purposes of analyzing guidelines and standards. The proposed criteria relates to complexity found in the green building industry and uses BIM integration capability in attempt to achieve social and cultural integration. The criteria proposed serve as a basis for evaluation of BIM performance and therefore, as a solution to mitigate differences in existing guidelines and standards.

Keywords BIM · Corporate social responsibility · Cultural sustainability · Stakeholder theory · Project-based organization · Green building · Social Sustainability

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Abbreviations

BIM	Building information modeling
CSR	Corporate social responsibility
LEED	Leadership in energy and environmental design
BREEAM	Building research establishment environmental assessment method
PBO	Project-based organization
IT	Information technology

Introduction

BIM (building information modeling) technology used to enhance green building industry processes has been widely covered in the professional literature (Krygiel and Nies 2008; McGraw Hill construction 2010). Several companies in building industries have recognized this natural synergy and implemented green projects through BIM technology. This complements trends in other fields such as electric vehicles (Adnan et al. 2017a), and green agricultural practices (Adnan et al. 2017b). We believe broader exploitation of BIM capabilities remain underutilized (Abdirad 2017). Specifically, optimal implementation of information systems can go beyond project-level use and help achieve strategic goals—such as sustainable, green development of buildings. In this instance, implementation is expressed in the unique integration of BIM technology accessible to all project stakeholders. BIM facilitates integration of building information flow and processing (Wu et al. 2017), throughout the supply chain (Papadonikolaki et al. 2015) and can lead to sustainable benefits in green building projects. These benefits include social considerations (Boström 2012), of fairness, awareness, participation and cohesion (Murphy 2012) and broader cultural aspects (Dessein et al. 2015).

Implementation with these considerations adds to existing discourse with diversified expressions of identity, utilized essentially in the connection or connectedness to the building (Wu et al. 2016). Moreover, green building industry demands from unique stakeholders result in technological and procedural challenges (Seyis et al. 2015). Full integration of BIM can lead to social integration and a collaborative culture between all agencies in an otherwise fragmented industry. Further, integration of BIM may lead to decision-making through a system that includes all stakeholders and relates directly to key elements in the building. The result encourages the transition from a continuous linear process to an enhanced process where stakeholders and decision-makers consider building stages holistically (Sebastian 2010). This change could facilitate integration between stakeholders responsible for different project elements.

This article suggests integration between stakeholders—green building corporate communities—be managed with a formal system using Corporate Social Responsibility (CSR) rules as a framework. The integration of BIM to enable collaboration across stages and fields opens a unique organizational and management dimension in the interrelationship between different stakeholders. We believe a possibility exists to create a culture of teamwork, as an independent community, separate from professional and sectoral hierarchical frameworks. Our article proposes this transition: using BIM to facilitate collaborative synergy among all relevant participants required for project decision-making. We believe those within the corporate responsibility framework can achieve informal socialization in their project-based organizations (PBO) utilizing BIM to its fullest potential. This allows green building goals to be achieved in a sustainable manner using sociocultural benefits from within the project.

Only a fraction of firms recognize the potential to integrate information technology (Chen et al. 2014), such as BIM, in green building projects. An even smaller proportion of firms working in this space are able to exploit BIM's full potential (Wu and Issa 2013). Moreover, most literature focus on technical aspects of BIM while ignoring its sociocultural potential. These past studies treat BIM mainly as a technological innovation (Wang and Chong 2015) rather than a social integrator or cultural accelerator. This tactical focus undermines the synergy between the broad applications of BIM and green building, and may affect sustainable social and cultural strategic project goals. Even though aspects of sustainability have been cited in previous articles, to the best of our knowledge, no studies relate BIM technology in the green building industry to social responsibility toward stakeholders with reference to social and cultural sustainability. Therefore, our article objectives are to: (1) review BIM status in the context of social and cultural sustainability within the building industry; and, (2) propose criteria for furthering integrative applications that achieve social and cultural sustainability in the green building industry. By reviewing current use of BIM, through an analysis of published guidelines, our research seeks to prove this industry lacks relevant references to the sociocultural aspects of green building needed for long-term sustainability. Our study offers an effective means, in the form of corporate responsibility rules implemented through BIM, to bridge gaps that exist between stakeholders. The following sections first describe the classification of cultural and social components identified in the integrative implementation of BIM. Then, we compare elements and uses of BIM required in general construction industries (Chen et al. 2016). Finally, we present an integrated social implementation of BIM, in order to propose CSR criteria needed for green construction.

The approach we followed in our review of BIM used a proven and unbiased perspective, where thirty BIM guidelines and standards from different municipalities, cities, and countries were examined. This provided a broad review of exactly how BIM was being applied in general building industries. Our presentation of criteria for implementation of BIM organizes similarities and differences then offers a perspective for achieving sustainable sociocultural benefit using this tool for green building projects. A comparison of BIM review findings can show the importance of defining sustainable sociocultural objectives for BIM application. Our motivation for this study is based on the possibility of extensive integration of this existing technology innovation in green building. Innovation is the application of knowledge for practical purposes (Adnan et al. 2017b) and we believe BIM can help make green building more sustainable. Given the emphasis on sociocultural dimensions in the green building literature (Zuo and Zhao 2014) and environmental perspective given to BIM initiatives (Kannan 2017), our findings strengthen guidelines and standards, and provide important insights for sustainable, sociocultural, green building industry advancements, through fully, integrated BIM implementation.

Review approach

Understanding global regulations enables us to further BIM's use for broader benefit, particularly regarding sustainable sociocultural development of green building practices which require supply chain integration (Berardi 2013). To accomplish this, we reviewed thirty relevant

BIM guidelines and standards. Selected items were based on popularity and references cited in academic publications to ensure they constituted reliable data for examining sociocultural sustainability in practice (Chong et al. 2017). To aid with the examination, we first identified elements of sociocultural sustainability. Our elements included: fairness, which gives equal opportunity to all; awareness, which promotes alternative consumption habits; participation, which included as many groups as possible in the decision-making processes and, cohesion, which promotes community integration (Murphy 2012).

Broadly speaking, sociocultural sustainability is identified with diversified expressions of identity (Wu et al. 2016). BIM facilitates its integration in building information flows and processing throughout the building supply chain (Papadonikolaki et al. 2015). Classification of sociocultural sustainability elements, in the integration between BIM and interrelationships of project participants, reflects relations between communities and stakeholders within the building corporation responsible by virtue of CSR principles. In other words, CSR suggests every corporation has a broad variety of communities with which it must communicate and participate with in relevant decision-making. This approach ensures sustainable development (Asif et al. 2013) through elements important to green building projects like fairness, awareness, participation, cohesion (Murphy 2012) and diversified expressions of identity. Connectedness to the building process (Wu et al. 2016) means CSR adds cultural benefit to different communities in the project, or can support equal, advancing, participative and unifying references to these groups, with emphasis on their connections to green building processes. Classification of social and cultural sustainability elements thus is based on comprehension that all involved in a project integrating BIM are the communities of the corporation charged with the project. This permits better management of all stakeholders, both professionals and tenants, by virtue of CSR concepts, and through integrative BIM application throughout all building stages. Five levels of sociocultural sustainability were identified and classified according to definitions of CSR elements and stakeholder theory (Freeman 2010). This becomes our framework for an integrative BIM application:

1. *Management of stakeholders in the project* An organization's obligation is not only to shareholders, but also to other interest groups (Freeman 2010). Stakeholder management relates to diverse stakeholder positions, including those for every group or individual that influences or is influenced by corporate objectives. Good stakeholder management improves communication and clarifies demands (Yang et al. 2009). BIM application, through formation of a management framework, can help coordinate these different stakeholders, increase cooperation, and achieve integration, while improving information flow and processing (Sebastian 2010). Green building requires integrative planning processes that consider stakeholders and add elements, such as policy details, methods and knowledge of green materials. Additionally, BIM can help form an organizational infrastructure: a requirement that emphasizes the importance of stakeholder management (Qian et al. 2015). Incorporation of stakeholder management in organizational change, with definition of the management framework in the organization and evaluation of its performances, allows BIM applications to facilitate a sustainable competitive advantage (Love et al. 2014).
2. *Stakeholder participation in the project* This classification suggests furthering social sustainability through application of fairness, awareness, participation and cohesion for project participants (Murphy 2012), with an attempt to arrive at cultural sustainability through emphasizing connectedness (Wu et al. 2016). An obstacle to furthering sustainable green building is conflict of interest between stakeholders. For example, contractors may have a low incentive to invest in energy-saving technologies (Berardi 2013) since the main benefit would go to end users. Other examples include absence of investment in community expressions of cultural identity or failure to relate to internal rules for the premises, its conditions, and the experience and customs of its residents. This might be important to eventual tenants but would not resonate with other stakeholders. Lack of shared information between stakeholders and resulting effects on information processing in the supply chain may lead to poor decision outcomes in some stakeholders' viewpoints. Through facilitated participation, and enhanced information flow and processing, BIM can lead to sustainable benefits for stakeholders.
3. *Reference to all project stakeholders—communities related to the corporation* Success or failure of a project depends on community perceptions—those influenced by or influencing the building corporation—in relation to the building project. This is a departure from the viewpoint that only technical characteristics of the building (e.g., type, size) are important. Understanding true social performances from the perspective of corporate communities is very important. In order to achieve project success, it is necessary, first, to identify all communities or stakeholders related to the project. Then, it is necessary to integrate their outlooks (Doloi 2012). Integration can be achieved through BIM. Likewise, BIM can help

achieve integration of supply chain components in the unique and fragmented green building industry. Project stakeholders as communities of the corporation derive from the corporate structure formed within the building project. CSR suggests ways to obtain sustainable benefit. For instance, in a green building project, implementation of sustainable elements might come up against obstacles due to insufficient stakeholders access to information (Berardi 2013). Adopting CSR can obligate project stakeholders, as communities within the corporation, to examine and process information. BIM technology makes this easier and helps arrive at sustainable sociocultural benefit in a green building project.

4. *Tenant involvement as a community in the project* The importance of tenants involvement in planning, building and maintenance of a project cannot be overemphasized (Zanni et al. 2013). In a green building project, implementing sustainable elements may be obstructed due to insufficient references to stakeholders, such as tenants, who have great interest in specific outcomes. Consequently, most decisions in relation to the building, in a social and cultural context, are made by stakeholders with low motivation to adopt elements important to tenants. This can be further complicated because tenants generally are not professionals in the building industry and are not trained in BIM operation. However, they are the people who will use the building. Therefore, it is important to make relevant building information accessible, as regards sustainability, and to include them on the project decision-making team. This allows them an equal opportunity to realize social potential, which in a broad sense includes access to the social network of decision-makers, fosters their awareness of decisions made, includes them in the decision-making processes, and thus furthers their cohesion as a harmonious community, with emphasis on their connectedness to the building. As such, BIM application can lead to relevant information flows to corporate communities. Inclusion of all parties, including tenants and their participation in planning parallel to the professionals results in better dialogue on building a complete information model. This can promote cultural identity and may contribute greatly to community integration. Moreover, through its three-dimensional demonstration capability, BIM can contribute to tenant integration in decision-making and their understanding during preliminary project stages (Dave et al. 2013). Through application of CSR concepts and stakeholder theory, tenants can be identified as corporate communities and their interests furthered. Connection of tenants allows green building to adopt social and cultural elements and thus become sustainable for its users.
5. *Stakeholders' involvement at all stages of the building* Sustainable building requires holistic treatment from stakeholders, and sustainable elements require attention from early planning stages throughout building and operation (Wu and Low 2010). In a green building project, where stakeholders might experience conflicts of interest that affect adopting sustainable elements, following an integrative approach throughout all building stages is essential to arrive at sustainable benefit (Berardi 2013). Therefore, integration of information and knowledge from all the stakeholders, including architects, engineers and contractors, throughout all building stages and from different fields of knowledge, is required. BIM application allows cooperation between different stakeholders at all stages (Sebastian 2011). BIM's integrative capacity allows simultaneous and repeated involvement throughout all green building stages. This involvement in decision-making regarding sustainable elements can: reflect fairness toward different stakeholders; nurture their awareness; enhance participation; and, further community cohesion. At the same time, stakeholder connection to the building will be strengthened. Involvement therefore leads to sustainable sociocultural development in a green building project.

Findings

Thirty BIM guidelines and standards were collected from eight countries to review the BIM concepts in the context of sustainable sociocultural development in practice. The findings were organized into five categories, at different levels of sociocultural sustainability, as presented in Table 1.

Most guidelines and standards are from the USA, and were developed principally by universities, government sectors and organizations for the benefit of industry. A total of 87 references to different levels of social and cultural sustainability were found in the BIM guidelines and standards. The 'collaboration and participation' category received the most references at 29. This was followed by 'project stakeholders,' with 20 references, and 'stakeholder management' with 15 references. There were only 12 references to 'residents/users involvement.' It emerged that BIM guidelines and standards barely related to 'stakeholder involvement at all stages of the building' category.

The results present interesting findings regarding BIM technology practice by showing that guidelines rarely focus on sociocultural sustainability. Of those studied, only NATSPEC–the Australian national guide (NATSPEC

Table 1 BIM guidelines/standards and related cultural sustainability categories

#	Country	Guidelines standards	Stakeholders management	Stakeholders participation and teamwork	Reference to all project stakeholders	Residents/users involvement	Stakeholders involvement at all stages of the building
1	Australia	NATSPEC (2016)	x	x	x	x	x
2	USA	GTFM (2016)		x			x
3		IUAO (2015)		x			x
4		USC (2012)		x		x	
5		LACCD (2016)		x	x	x	
6		SDCCD (2012)	x	x	x	x	x
7		CoD (2011)		x	x		x
8		NIBS (2015)		x	x	x	x
9		GSA (2007)		x	x	x	
10		AIA (2013)	x	x			
11		GSFIC (2013)		x	x		
12		AGC (2010)	x	x	x		
13		USACE (2012)	x	x	x		x
14		NYCDDC (2012)		x	x	x	
15		NYCSCA (2014)	x	x	x	x	x
16		OFCC (2011)	x	x	x	x	
17		TFC (2012)		x			
18		DOA/DSF (2012)		x			x
19	Finland	BuildingSMART Finland (2012)	x	x	x	x	
20	Norway	NHBA (2012)	x	x			
21		Statsbygg (2013)		x			
22	Netherlands	MIKR (2012)		x			
23	UK	BSI (2016)		x	x	x	
24		BSI (2010)	x	x	x		
25		AEC (UK) (2011)	x	x	x		
26		AEC (UK) (2015)	x	x	x		x
27		HKCIC (2015)	x		x		
28		SEC (2014)	x	x	x	x	x
29	Singapore	BCA (2013)	x	x	x		
30	Hong Kong	HKCIC (2015)		x			
	Total		15	29	20	12	11

2016), SDCCD; the standard of the community district College of San Diego in the USA (SDCCD 2012); NYCSCA–the guidelines and standards of the NYC School Construction Authority (NYCSCA 2014); and, the guidelines of the Specialist Engineering Contractors' Group (SEC) in collaboration with the BIM Academy at the University of Northumbria; and, the National Specialist Contractors' Council (SEC 2014) related to all levels. These findings differ greatly in comparison with reviews of guidelines and standards that dealt with BIM technology in the context of sustainable development (Chong and Wang 2016). According to these reviews, NIBS, for instance, encompasses all fields of sustainable development for BIM (Chong et al. 2017). The guidelines and standards were developed for industry and the comparison showed established practice, as it related to sustainable development, but did not cover all levels identified with sociocultural sustainability with respect to BIM technology. The comparison emphasized the importance of defining strategic, sustainable objectives for BIM applications. Due to gaps in recommended implementation, and in light of the importance of social and cultural layers for green building projects, much work is needed. The integrative advantage of BIM as a means for achieving this work and the categories presented provide a basis for a different perspective. These categories establish criteria for broad application of BIM technology to achieve a sociocultural objective in a sustainable green project.

From a general viewpoint, the majority of guidelines and standards dealt in a certain way with the sociocultural context of benefits in operation of the technology—in references to BIM management; to participation and teamwork; and, to the different building stages. These references are important as a basis for effective use of the technology in a project and can facilitate management coordination between the different professionals at the different stages of a building project. However, they do not suggest full, integrative application of BIM technology. The references to integration of all stakeholders, including tenants, at all relevant decision-making crossroads were missing. There is not a true cooperative platform, consistent with stakeholder theory, in place to achieve sustainable sociocultural benefit within a project using BIM. These layers must be considered in the formulation of criteria for global, sustainable treatment for green building projects.

Discussion

BIM makes a great contribution in different dimensions of sustainable development in the construction industry. However, its contribution to all dimensions must be reconsidered for obtaining beneficial results in different areas of sociocultural sustainability in green building. A building project can be examined by many evaluation methods, which provide various measures of green success. Nonetheless, these measurements, including popular indexes such as LEED (USBGC 2016), BREEAM (BREEAM 2016), and Green Star (Green Building Council of Australia 2016), do not focus on social aspects of a project. While stakeholders' social interests are treated in the evaluation of a sustainable social dimension or in evaluation of CSR in the literature (Doloi 2012), their inclusion in evaluation methods in the field is extremely limited. Thus, despite their necessity for evaluation of a sustainable project, there is no widespread integration of stakeholders' social interests in green building evaluation methods. Moreover, examination evaluation methods show they do not include significant evaluation of cultural advantages for different stakeholders in a building project. While integration of culture in sustainable development has been discussed widely in academic discourse, there is no broad expression in the green building industry. This gap is manifest in plans approved as green building, in green building standards, and in related evaluation methods (Wu et al. 2016). The different building evaluation methods use BIM technology in relation to environmental criteria such as energy consumption, water and materials, and as a means of measuring performances (Zanni et al. 2013). This was done with almost complete disregard for project stakeholders and without regard to participation of all those involved in a project, including the tenants, in decision-making processes throughout all building stages. Guidelines and other practical tools are required for purposes of relating to corporate responsibility criteria in order to obtain sustainable sociocultural benefit from green building projects. Green building evaluation methods can fulfill their purpose through reference to CSR criteria, allowing full BIM application and operation of the information technology as a social integrative system.

Proposed CSR criteria of a green outlook

Definition of criteria as a standard for application of BIM technology in interrelationships between stakeholders Review of different evaluation and measurement means found that BIM guidelines and standards do not stress social and cultural aspects projects. Moreover, use of BIM technology in different green building evaluation methods mainly refers to technological uses and not to its integrative sociocultural applications. We therefore propose to broaden the perspective BIM uses for sustainable development and relate to possible sociocultural aspects through the full implementation of the technology within the framework of the interrelationship between project participants. These concepts emphasize the BIM as a product service system rather than only an information technology. Therefore, if guidelines and standards principally coordinate between professionals as an information modeling team for each stage in the building process, then the implementation of stakeholder theory emphasizes, as we suggest, modeling as a social system integrated in the interrelationship between all the corporate stakeholders. This includes integration as a management system responsible for the building information (building information management), its flow, and processing. Implementation leads to a different, simultaneous and repeated approach, integrating BIM in an organizational system in which all the building stages can be examined simultaneously and repeatedly, in project decision-making processes, by all involved. With this social comprehension in relation to the BIM applications, we propose to use corporate responsibility criteria as a standard for BIM application for building information management system evaluation. Our proposal suggests sociocultural implications of BIM are very important. Therefore, moving the focus from evaluation of technological uses to evaluation of integrative applications in social information management is necessary.

The objective of information management is to achieve sustainable sociocultural benefit for stakeholders in a green building project. Thus, the criteria, required in light of the gaps in BIM guidelines and standards, and in view of deficiencies found in green building assessment methods, are intended to assist in evaluating the integrative application of BIM as a means of achieving sustainable benefit from the project. The CSR criteria, as a standard for BIM application, were taken from classification categories that identify sociocultural sustainability levels in the integration of the technology with the stakeholders' interrelationship system. These criteria, marked in Fig. 1, include: (1) identification and reference to stakeholders through creation of a management framework (marked 'BIM' in the figure); (2) stakeholders' collaboration in the project through consolidation of the teamwork culture (marked with the connecting circle in the figure); (3) reference to all project stakeholders as corporate-related communities (marked with the five circles in the figure); (4) involvement of tenants as a stakeholder community in the project (marked in the highlighted circle in the figure); and, (5) involvement of stakeholders throughout all building stages through their inclusion in the decision-making processes in the project (marked with process arrows in the figure).

Examination of BIM application standard performance according to formal and informal means in a project-based organization Definition of CSR criteria for BIM application, as part of the green building outlook, focuses on integration of BIM in the interrelationship between different stakeholders, which constitutes a project-based organization (PBO), for furthering sustainable sociocultural benefit. The form of this organization constitutes a temporary coalition of different companies, unlike a single unit controlled by a hierarchical relationship. This mixed form of organization was presented as network governance, containing an inbuilt set of autonomous companies, dealing with creation of products or services, based on binding implied contracts (social, not legal). Although formal contracts can be drawn up between several members of the organization, these do not define the relations between all the parties (Jones et al. 1997). Thus, the architect, the engineer, the contractor and the end-consumer have contracts with the corporation that manages the project but the contracts do not specify the relations between the subcontractors involved in different building stages, or the relations between the professionals and tenants, required for involvement throughout the project. However, the project requires they work together with mutual adaptations and communications. For improvement of cooperation in joint tasks, this form of network governance relies more on social coordination such as occupational socialization or collective sanctions, than on authority and legal means. However, despite the dominance of the mixed form of organization (inter-firm PBO) over the one-unit organization (intra-firm PBO), it cannot be concluded that projects in the construction industry are carried out according to the inter-firm PBO form only.

According to the constellation proposed by this article, BIM should, in part, be based on CSR toward stakeholders involved in a project. This system expresses inter-firm

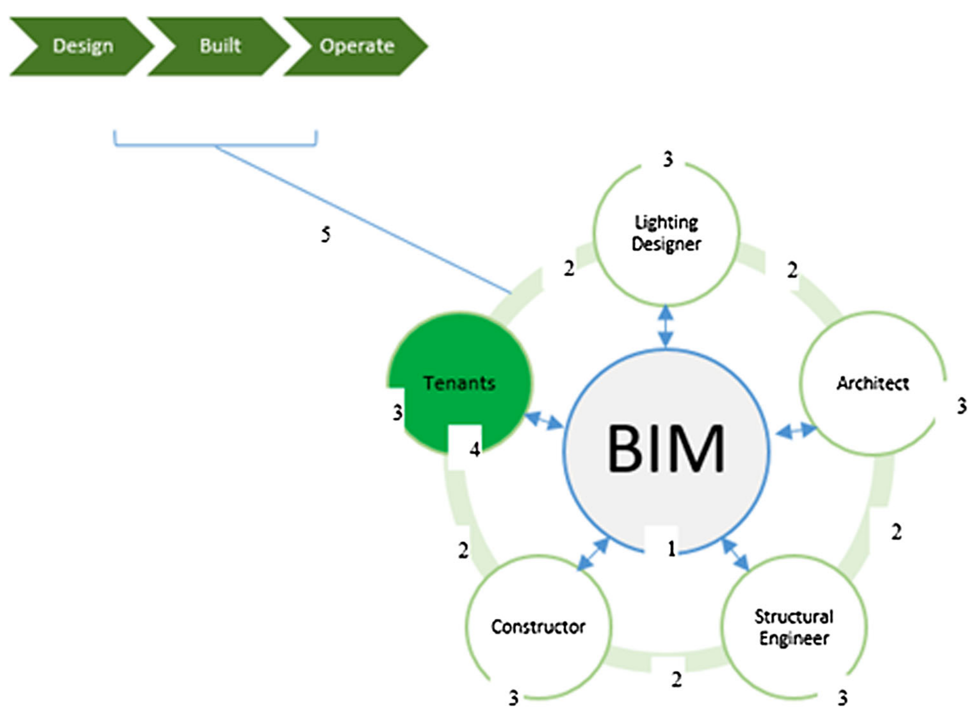

Fig. 1 The CSR criteria of a green outlook.
Source: **1** Stakeholders management in the project: examining management framework. **2** Collaboration with stakeholders in the project: examining teamwork.
3 References to all project stakeholders: examining references to them as corporate-related communities.
4 Involvement of tenants—a corporate-related community as stakeholders in the project: examining tenants participation.
5 Involvement of stakeholders throughout all phases of the building: examination of social reference at all phases

Table 2 CSR criteria as a standard for BIM application

<table>
<tr><td rowspan="8">Parts of Application: Model, Modeling, Management</td><td rowspan="3"></td><td rowspan="3">Building Information Model Context</td><td colspan="3">Stages of Application: Preliminary, Advanced, Parallel</td></tr>
<tr><td>Preliminary Stage</td><td>Advanced Stage</td><td rowspan="7">Identification and reference to the tenants as stakeholders in parallel to the professionals at all building phases</td></tr>
<tr><td>Formal</td><td>Informal</td></tr>
<tr><td rowspan="5">Building Information Management System / Modeling</td><td>Model Management</td><td>Framework contract</td><td>Identifications and references in the network</td></tr>
<tr><td>Stakeholders Participation in Forming a Model</td><td>Contractual obligation to collaborate</td><td>Teamwork</td></tr>
<tr><td>References from all the Professionals To a Model</td><td>Relational Contracting, promoting partnership approach</td><td>Collaborative culture presented between corporate-related communities</td></tr>
<tr><td>Reference from the Tenants to a Model</td><td>Building contracts</td><td>Tenants participation as corporate-related community</td></tr>
<tr><td>Building Phases</td><td>Protocols</td><td>Social reference in the network at all phases</td></tr>
</table>

network governance characterized by informal social systems, based on an intra-firm organizational structure. Characteristics of PBO, the basis for the integration of BIM, emerges from the building information management system. This system, which is examined according to corporate responsibility criteria as a standard for BIM application, is therefore an organizational structure-based social network. Examination of all social systems, formal and informal, can be adopted for achieving integrative benefit within the BIM. This, however, does not necessarily guarantee sustainable benefit for a project. This idea must be integrated into a BIM application standard. Our proposal suggests this criteria be used as a standard for application in BIM technology to ensure recognition of social interrelationships, as corporate responsibility criteria. This will enable shifting focus from evaluating BIM's technological uses to evaluating its integrative potential as an information system to support interrelationships between corporate and other project stakeholders. In this way, three parts of application appear: model, modeling, and management; with the perspective of BIM technology moving from model's uses to its application through integration of the modeling system in social interrelationships. This integration constitutes a more robust building information management system. Our proposal indicates the evaluation of BIM integration within the context of social interrelationships relates to three stages of application: (1) a formal preliminary application stage in the framework of an organizational structure; (2) an informal application stage in the framework of a social network including relevant professionals for decision-making in the project throughout the different building stages; and (3) a parallel application stage given to tenants who are stakeholders relevant to decision-making in all building stages. Formal means include, for instance, management contracts and building agreements. Informal means include, for instance, a collaborative management culture. These implementation parts and stages, examined according to corporate responsibility criteria as a BIM application standard, are presented in Table 2.

Conclusions

This study reviewed the BIM status and outlook in the context of sustainable sociocultural development in the green building industry on the basis of thirty BIM guidelines and standards, providing a clear view of the established practice in relation to this technology. Review of the data included identification of five levels of sociocultural sustainability and their classification in the application of the technology in the social interrelationship between those involved in a building project. Results show the guidelines and standards included specific reference mainly to stakeholder management, participation and teamwork, with indication of all the stakeholders in the project. However, this does not suffice to allow full, integrative application of BIM technology, for achieving sustainable, sociocultural benefit from the project. This article therefore presented corporate social responsibility criteria as a standard for BIM application, with references to all those involved in the project as stakeholders of the building corporation, including end users, throughout all the building stages, in an attempt to achieve of this benefit. Organizational infrastructure implications according to the standard were also examined. Several limitations should be taken into account considering review of the guidelines and standards. These data were selected based on popularity and on the references cited in academic publications relating to the use of BIM technology to achieve sustainable benefit. Therefore, other guidelines and standards were not included, out of a wish to present a well-based and unbiased perspective. Notwithstanding, the review succeeded in offering a discussion framework for examining established practices in industry regarding BIM uses for sustainable development while indicating the sociocultural aspects of its full implementation. The review approach and the corporate social responsibility criteria presented may serve as a basis for evaluate the integration of additional technologies in the interaction between stakeholders involved in green projects.

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