A BIBLIOMETRIC REVIEW OF BUILDING INFORMATION MODELING AND GREEN IN THE CONSTRUCTION INDUSTRY

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Abstract

Nowadays, the Construction Industry has the need to integrate processes, technologies, and people to support strategic goals as well as achieving the sustainability.With this context, Building information modeling (BIM) based technologies are regarded as a potentially useful vehicle for helping project stakeholders to make the best use of the available design data for sustainable design and sustainability rating analysis in the AEC (architecture, engineering and construction) driving for green and sustainable building construction. The purpose of this paper is to critically review the synergisms between BIM and Green to achieve sustainable development in construction industry. The investigation is conducted by the methodology of systematic literature review (SLR) to finding synergisms between concepts, practices and metrics to sustainability. This work examines the compatibility of the green and BIM and its applications. The bibliometric results demonstrated increase publications of BIM and Green in the last 5 years, as well as Automation in Construction is the most frequently journal, US and UK had more papers published and the author Alwan have more publications in this area. The study has two major contributions. First, this paper investigates the integration between green and BIM in new avenue exploration to sustainable construction. Second, it supports and expands current literature, providing both academicians and practitioners a better panorama to understand the present status of proposed framework for achieving sustainability in construction industry.

Keywords: *BIM, sustainable development, construction industry.*

Clasificare JEL : *L74, O14, Q01, Q55*

1. Introduction and context of the study

Over the last decades, sustainable concerns have increasingly gained importance in practice and academic discussions. In this context, building information modeling (BIM) based technologies are regarded as a potentially useful vehicle for helping project stakeholders to make the best use of the available design data for sustainable design and sustainability rating analysis in order to improve energy efficiency and to reduce energy consumption over a building's entire lifecycle, and have prompted efforts to integrate green and sustainable building initiatives into the conventional building design, construction and operation processes [1].

Academics, practitioners and policymakers have extensively cited the benefits of BIM implementation to AEC (architecture, engineering and construction) in parallel to the drive for green and sustainable building construction. Thus, the purpose of this paper is to critically review the synergisms between BIM and Green and highlight its importance to achieve sustainable development in the construction industry. To do this, a systematic literature review (SLR) of the subjects under investigation was conducted. This review explores the following question: How does the interaction between green and BIM can contribute to sustainable development in the construction industry?

2. Background

According to the glossary of the BIM Handbook written by [2], BIM is used as "a verb or adjective phrase to describe tools, processes and technologies that are facilitated by digital, machine-readable documentation about a building, its performance, its planning, its construction and later its operation. Therefore, BIM describes an activity, not an object. To describe the result of the modeling activity, we use the term 'building information model', or simply 'building model' in full". Building Information Model has the potential to be the catalyst for project managers, in order to reengineer their process and to better integrate the various stakeholders of modern construction projects. This reengineering process can be a transition for effective applying Lean principles [3].

The implementation of BIM should have a bottom-up approach, rather than a top-down one, with regard to involve people in its implementation, to ensure the improvement in skills and the understanding of people to implement continuous improvement strategies, and to diminish any potential resistance to changes [4]. According to the author, the seven pillars of a BIM implementation strategy are: to eliminate waste, to increase feedback, to analyze decisions until reaching a consensus, to fasten delivery, to build on integrity, to capacitate the team, and to see the whole.

Due to the iterative and exploratory nature of a construction project, design changes are inevitable. Their structure and content are not static; they can have a continuous change. They can occur even after the beginning of the construction, particularly in fast-track projects. Thus, successful management changes are primordial for an efficient delivery of construction projects. In this context, BIM is expected to play an important role in integrating design, construction, and facilitate management processes through coordinated changes throughout the project life cycle [5].

On the other hand, [2] and [6] propose that for BIM to provide compilation, edition, evaluation and report of information regarding construction projects, the following technologies must be considered:

a) 3D visualization (for aesthetics and functional assessment);
b) Rapid generation of multiple design alternatives;
c) Usage of model data for predictive analysis of the structure (performance, automated cost estimates, and evaluation of customer value conformity);
d) Information maintenance and model integrity (single information source, automated conflict checking);
e) Automatic generation of documents and drawings;
f) Collaboration in the design and construction (multiuser editing of a single discipline model and multiuser visualization of multidisciplinary models, either separated or combined);
g) Rapid assessment and generation of alternative construction plans alternatives (automatic generation of construction tasks, construction process simulation, 4D visualization of construction schedules);
h) Online/electronic object-based communication (visualization of the process status, online communication of product and process information, computer controlled manufacturing process, integration with the database of the project partner-supply chain, context provision for status of data collection onsite/offsite);
i) Automatic transference of information to support computer-controlled manufacturing processes.

In addition, BIM technologies seeks to solve the main problems associated with 2D documents such as the difficulty and the amount of time it takes to access information of such a project, cost estimates, energy efficiency analysis, structural details and others [7].

3. Methodology

In this paper was conducted a systematic literature review in order to locate relevant existing studies based on prior formulated research questions, to evaluate and synthesize their respective contributions. This SLR consists of five consecutive phases: (a) formulation of the question, (b) location of studies, (c) evaluation and selection of studies, (d) analysis and synthesis, and (e) reporting and use of the results [8].

Identifying the keywords is extremely critical to a comprehensive and unbiased review. The search is limited to a set of key words ('BIM', 'Building Information Modeling', 'Environment', 'Sustainable', 'Sustainability', 'green', 'green BIM' and 'Construction'). We searched these keywords in the following databases: Scopus, Emerald, Science Direct and Compendex.The conducted research had combined the search terms into title, abstract or keywords, limited to papers published in peer-reviewed journals up to March 2017, when they were available. Additional papers were identified by reading the papers included in the review. 668 records were identified through databases searching. Then, they were refined by titles/abstracts screening analysis and 563 records were excluded. Following that, 105 articles were analized in depth in an interative process. Based on the full text analysis, a total of 62 articles complied with the selection criteria for bibliometric analisys.

4. Sinergies between BIM and green

Table 1 indicates some of the main synergies between BIM and green:

Table no. 1 Synergies between BIM and green

Ref.	Synergies
[9]	Verified the viability of using information flow processes of a BIM model to speed up environmental assessment in terms of Leadership in Energy and Environmental Design (LEED) certification through a case study of a competition in which participant teams should rapidly evaluate the sustainability of a certain building.
[10]	verify the energy balance of a city and they propose a model, which is integrated with Geographical Information System (GIS) and is developed to support urban planning in terms of solar energy.
[11]	Created a conceptual framework relating the various LEED credits and sustainability analysis conducted within BIM environments.
[12]	Evaluated and optimized a construction project through development of a system based on three criteria collectively: time, cost and environmental impact (CO2 emissions).
[13]	Conducted Life Cycle Analysis (LCA) by exporting Bills of Materials (BOMs) to identify the effects of component selection on indicators and analyzing the cost of using green materials in the design process in a case study.
[14]	Explored a computational model to calculate carbon emissions during the life cycle of a building with the support of functionalities allowed by BIM methodology that aims to fulfill a gap in tools to estimate CO2 during construction phase;
[15]	Created a modeling framework by developing a BIM based plugin to support the decision making process, incorporating Life Cycle Costs (LCC), carbon footprint and ecological footprint (economic and environmental pillars of sustainability) indicators
[16]	Developed an initial ontology required for energetic assessments of edifications, including climate data, construction specification, site details and energy assessment.

5. Bibliometric results

The Figures 1, 2, 3 and 4 indicates the bibliometric results of the synergies between BIM and Green in order to achive sustainable development in construction industry.

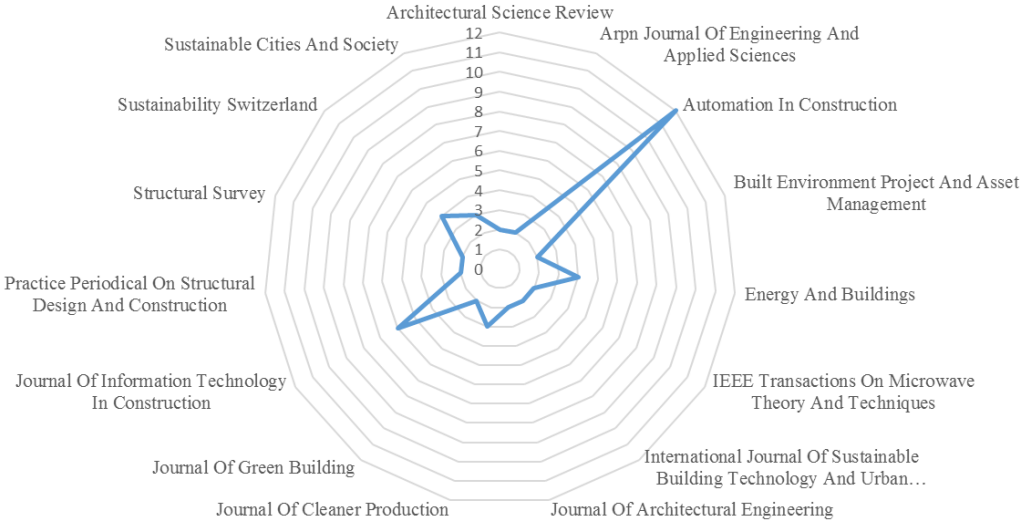

Figure no. 1 BIM-green journals from the literature

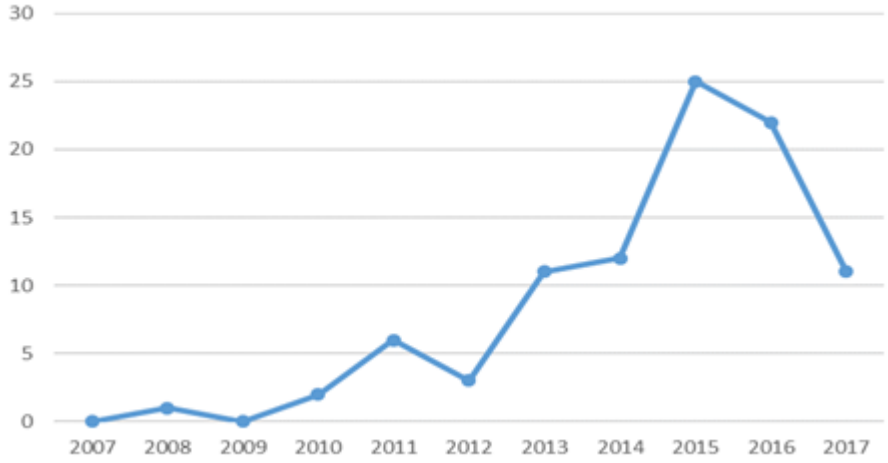

Figure no. 2 BIM-green publications by year from the literature

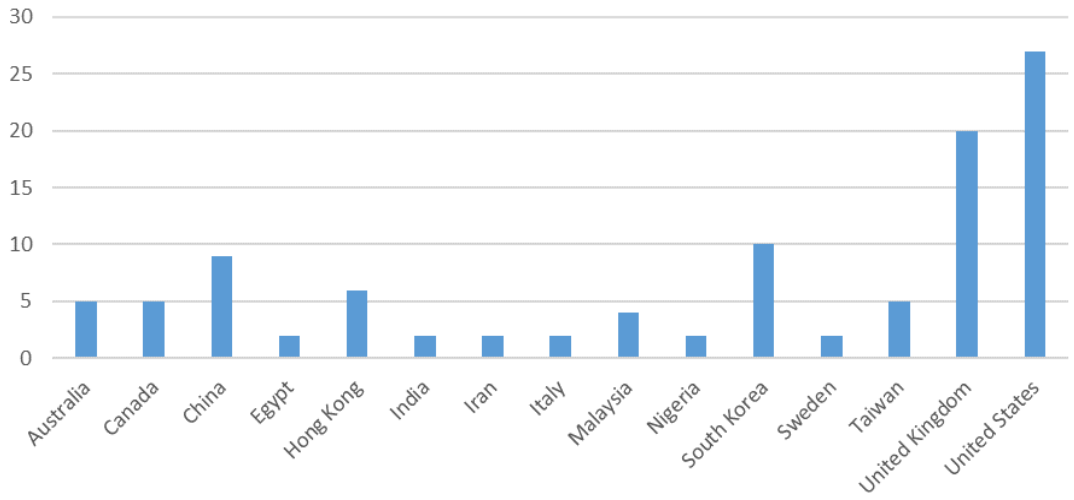

Figure no. 3 BIM-green countries from the literature

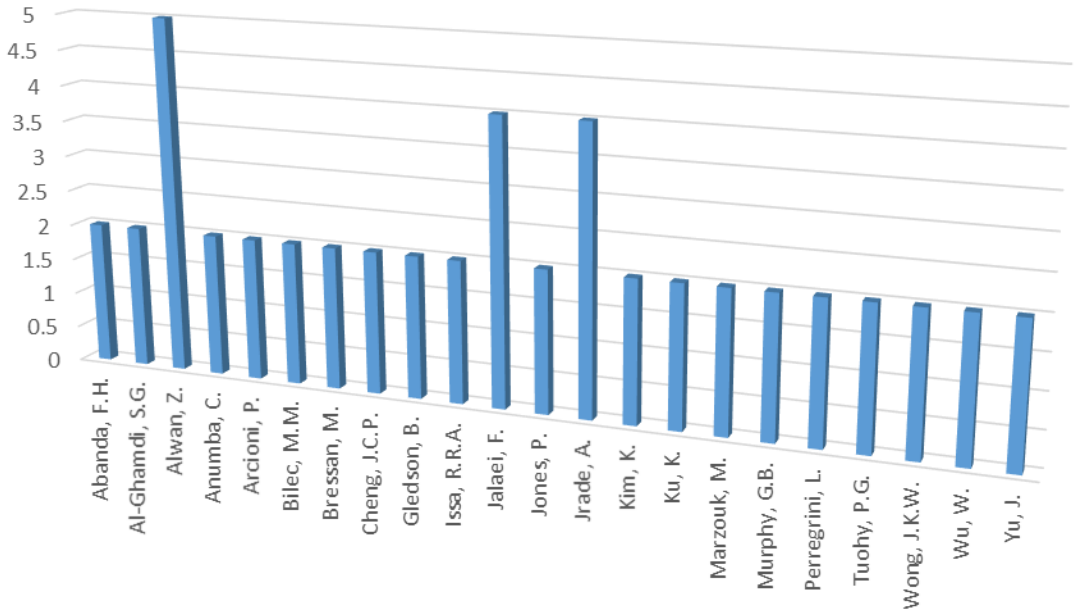

Figure no. 4 BIM-green authors from the literature

The results demonstrated increase publications of BIM and Green in the last 5 years, as well as Automation in Construction is the most frequently journal, US and UK had more papers published and the author Alwan have more publications in this area.

6. Conclusions

Therefore, different aspects of BIM and green paradigms have been studied and sustainability is one of the strategic imperatives for construction projects, which must be aligned to their traditional priorities of profitability and efficiency. This paper offered a systematic review of the existing literature that relates BIM and green, in order to provide guidance on the topic for scholars and to contribute with the definition of clear paths for further research. Besides that, this study also aims at providing industrialists with a general overview of green BIM so they can develop a deeper and richer knowledge on these paradigms, and their practices, to help them formulate more effective strategies for their implementation. This research will also motivate

them, and hence their organizations, to operate sustainably.

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