Journal of Cleaner Production xxx (2017) 1–9

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Drivers for implementing green building technologies: An international survey of experts

Amos Darko [a, *], Albert P.C. Chan [a], De-Graft Owusu-Manu [b], Ernest E. Ameyaw [c]

[a] Department of Building and Real Estate, The Hong Kong Polytechnic University, 11 Yuk Choi Rd, Hung Hom, Kowloon, Hong Kong, China
[b] Department of Building Technology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[c] Department of Construction and Surveying, Kingston University, Kingston upon Thames, Southwest London KT1 2EE, UK

ARTICLE INFO

Article history:
Received 11 July 2016
Received in revised form
20 December 2016
Accepted 9 January 2017
Available online xxx

Keywords:
Green building technologies
Drivers
Construction industry
Sustainability
Sustainable development

ABSTRACT

In recent years, green building technologies (GBTs) have gradually been implemented to minimize negative impacts of the construction industry on the environment, economy, and society. In order to encourage widespread adoption of GBTs, a better and deeper understanding of the drivers for implementing GBTs is necessary. This study aims to identify the major drivers of GBTs implementation. The methodological framework used consists of a comprehensive literature review and a questionnaire survey of international green building (GB) experts, rather than experts in a particular country. The results of statistical analyses of 104 expert responses indicate that the top five drivers for implementing GBTs are energy-efficiency, reduced environmental impact, water-efficiency, occupants' health and comfort and satisfaction, and company image/reputation. Results from *t*-test analysis confirm that out of the 21 drivers examined, 13 are perceived to be significant. The Kendall's concordance test shows that though the experts were from different countries and with diverse backgrounds, a good consensus was reached in their rankings of the drivers. The Mann-Whitney *U* test also verifies the absence of significant differences among the experts in ranking most of the drivers. The findings of this study not only contribute to deepened understanding of the major factors that greatly drive GBTs implementation, but could also encourage the industry practitioners and stakeholders aiming at achieving better construction sustainability to further implement GBTs in the future. From the perspective of international GB experts, this study makes a contribution to the body of knowledge about GBTs implementation drivers, which is important for GBTs promotion.

1. Introduction

The construction industry significantly impacts upon the natural environment, economy, and society. Globally, the construction industry consumes 40% of total energy production, 12–16% of all water available, 32% of nonrenewable and renewable resources, 25% of all timber, 40% of all raw materials, produces 30–40% of all solid wastes, and emits 35–40% of CO_2 (Green Building Council of Australia (GBCA), 2006; Son et al., 2011; Berardi, 2013). Green building technologies (GBTs) can be a solution to these negative impacts; hence, over the past few years, the construction industry has attempted to enhance the sustainability of its activities through the implementation of various GBTs (USGBC, 2003; Zhang et al., 2011a, b). Sustainability or sustainable development is necessary to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987). Ahmad et al. (2016) define GBTs as technologies that are incorporated into building design to make the end product sustainable, such as solar system technology, optimization of building envelope thermal performance, and green roof technology. GBTs aim at enhancing the environmental, social, and economic performance of buildings, which are three dimensions essential to address the need for sustainable development in the construction industry (Love et al., 2012; Zhang, 2015).

Despite the existence of barriers, such as high cost and a lack of information, to applying green building (GB) practices and technologies (Chan et al., 2016), there are many influences that drive the implementation of GB practices and technologies in construction, such as energy and resource conservation and environmental

* Corresponding author.
E-mail address: amos.darko@connect.polyu.hk (A. Darko).

http://dx.doi.org/10.1016/j.jclepro.2017.01.043
0959-6526/

protection (Manoliadis et al., 2006; Ahn et al., 2013). A better and deeper understanding of these drivers is essential to encourage widespread adoption of GB practices and technologies, because such an understanding could significantly impact GB decision-making and help potential adopters to accept GB practices and technologies (Potbhare et al., 2009; Qi et al., 2010). In addition, the willingness of stakeholders to adopt GB practices and technologies could be increased, with a better understanding of the driving factors. Several studies exist on the driving forces behind the implementation of GB practices and technologies (e.g., Manoliadis et al., 2006; Love et al., 2012; Ahn et al., 2013); however, these studies primarily focus on analyzing GB practices and technologies implementation drivers in specific countries. Therefore, conducting an international study or survey is necessary to enrich the body of knowledge for GB. As GBTs implementation has grown to become an international strategic agenda (WorldGBC, 2016), a comprehensive international investigation and survey on GBTs implementation drivers is worthwhile.

There are several issues associated with GBTs implementation in the construction industry. With the objective to investigate and gain a comprehensive understanding of these issues, an international survey was conducted. The survey was conducted to gather and examine the perceptions of GB experts from different countries around the world to establish common set of drivers for, barriers to, and strategies for promoting the adoption of GBTs (Chan et al., 2016). The outcomes on the drivers are reported in this paper. This paper identifies and ranks the major drivers for implementing GBTs and then compares the perceptions of experts with actual GB project experience and those without actual GB project experience regarding the drivers. The findings of this study not only make a significant contribution to the existing research on GB by providing an in-depth explanation and understanding of the major factors that greatly drive the implementation of GBTs, but could also encourage the industry practitioners and stakeholders aiming at achieving better construction sustainability to further implement GBTs in the future. To effectively and efficiently promote and make informed decisions on GBTs implementation, advocates and stakeholders can focus and act based on the driving factors with high mean ranks or values and thus high importance. Furthermore, this research provides an opportunity for organizations and individuals attempting to enter the GBTs market to learn lessons from the perceptions of international GB experts who have had some years of experience in GBTs implementation activities, as to why GBTs must be implemented.

2. Literature review

In this research, the term ‘drivers’ is defined as the reasons why stakeholders decide to use GBTs. Previous studies have addressed various factors that drive the implementation of GB practices and technologies in construction. For example, the study by Love et al. (2012) found the drivers for deciding to use sustainable technologies in Australia to be improve occupant's health and well-being, marketing strategies, reduce the environmental impact of the building, reduction in whole-life cycle costs, marketing and landmark development, and attract premium clients and high rental returns. Low et al. (2014) showed that the important drivers for greening new and existing buildings in Singapore are return on investments, local and overseas competitions, rising energy bills, corporate social responsibility, and marketing/branding motive. In Greece, Manoliadis et al. (2006) identified the following as the most important drivers of change towards sustainable construction: energy conservation, resource conservation, and waste reduction. Several US studies have discussed the drivers of green or sustainable design and construction (Augenbroe et al., 1998; Augenbroe and Pearce, 1999; Vanegas and Pearce, 2000; Ahn et al., 2013; Mulligan et al., 2014). For example, Ahn et al. (2013) presented the major drivers as energy conservation, improving indoor environmental quality, environmental and resource conservation, waste reduction, and water conservation. The highest rank of energy conservation in Ahn et al.'s study reinforced the finding of the earlier study by Augenbroe and Pearce (1999). Zhang et al. (2011a) discovered that building up green reputation and good image, gaining competitive advantage, commitment on corporate social responsibility, reduction in construction costs, developing unique green products, and reduction in operation and maintenance costs are important factors driving the application of green technologies in the Chinese construction industry. Serpell et al. (2013) highlighted the main drivers for sustainable construction in Chile as corporate image, cost reduction, and market differentiation. Edwards (2006) revealed that green offices in the UK increase the productivity of employees by 2–3%, due to the improved workplace environment which in turn lessens employee absenteeism. Several other previous studies have investigated the drivers for implementing GB practices and technologies in different countries, such as in South Africa (Windapo, 2014; Windapo and Goulding, 2015), Turkey (Aktas and Ozorhon, 2015), and India (Arif et al., 2009).

The literature review above summarizes past studies related to the drivers for applying GB practices and technologies. These studies tend to primarily focus on analyzing country-specific drivers, which may limit their application to GBTs implementation in the global construction industry. As a result, the present study aims to examine the major drivers for implementing GBTs in the construction industry, as seen from the perspective of international GB experts and thereby enrich the body of knowledge for GB.

3. Methodological framework

3.1. Identification of GBTs implementation drivers

There are various drivers that influence and shape the implementation of GB practices and technologies in construction, which can be found in the previous studies (e.g., Manoliadis et al., 2006; Zhang et al., 2011a; Love et al., 2012). After a thorough review of previous studies, this study identified 21 potential drivers of GBTs implementation, as summarized in Table 1 with their corresponding literature sources. These factors are well documented in previous research and more applicable. For instance, energy-efficiency, water-efficiency, and reduced environmental impact are widely acknowledged in the literature as crucial factors that drive the GB market. Thus, the identification of this set of drivers focused mainly on factors that have received considerable attention in previous studies conducted in different countries. For a research study, Rowlinson (1988) suggests that well-known factors are more applicable, because respondents would be able to respond easily. As they are more applicable, examining them would be more useful (Cheng and Li, 2002) for gaining a deeper understanding of the factors driving GBTs implementation.

3.2. Data collection

The questionnaire survey is a systematic method for gathering data based on a sample (Tan, 2011) and has been widely used in construction management research (Qin et al., 2016; Annunziata et al., 2016; Huang et al., 2016). For this study, a questionnaire survey was conducted to identify the main drivers for implementing GBTs. Based on a comprehensive literature review, a survey questionnaire was designed. The main questionnaire consisted of the following three sections: the first section communicated the

Please cite this article in press as: Darko, A., et al., Drivers for implementing green building technologies: An international survey of experts, Journal of Cleaner Production (2017), http://dx.doi.org/10.1016/j.jclepro.2017.01.043