ANALYTICAL REVIEW OF GREEN BUILDING DEVELOPMENT STUDIES

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ABSTRACT

Green building is an essential component of sustainable development, but previous studies have offered little in the way of systematic reviews of green building development from the perspective of project management. This research presents the current research trends in this discipline by analyzing the publications in ten major international journals from 2007 to 2016. The analysis was conducted on papers that have reported relevant investigations during that 10-year period. The analyzed research topics were found to group into five themes: green building management in general, the benefits and barriers to green building development, green building performance, stakeholder behavior with regard to green buildings, and green building strategies. Future directions for research relating to green building are suggested for the areas stakeholder management, policies and incentives, communication platform development, and retrofitting of existing buildings. Green building development will continue to be an important research area, and more comprehensive studies on green building management can help to promote further progress in this field.

KEYWORDS:

green building, performance, benefits and barriers, stakeholder, green strategy, future research

INTRODUCTION

Green building, within the larger concept of "sustainable building," is defined specifically as "the implementation of sustainable buildings" (Adler et al. 2011). Green building design and construction is based on adherence to the principle of sustainable development. Notably, the term "green building" seems to be regarded as interchangeable with "sustainable building" or "high-performance building" (Zuo and Zhao 2014). The aim of green building is to incorporate energy-saving features, water conservation, wastes minimization, pollution prevention, resource efficiency, and enhance indoor environmental quality throughout the building's whole life cycle. The principles and methods underlying green building apply at all stages of the building's life,

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including the siting, design, construction, operation, maintenance, renovation, and deconstruction (Horman et al. 2006, Robichaud and Anantatmula 2010).

To assist in the development of green building, a number of rating tools have been formulated. For instance, the Building Research Establishment's Environmental Assessment Method (BREEAM) was launched in 1990, the world's first green building rating system. The Hong Kong Building Environmental Assessment Method (HK-BEAM) was established in 1996. This was the second such system implemented outside Europe. The Leadership in Energy and Environmental Design (LEED) was initiated in 1998 by the U.S. Green Building Council, and this has become a widely appreciated and highly influential green building rating system. China, which is home to the largest construction market in the world, established the Evaluation Standard for Green Building (ESGB) in 2006, which was renamed the Assessment Standard for Green Building (ASGB) in 2014. In addition, there are a series of other leading green building assessment tools, such as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, Green Star in Australia, the BCA Green Mark Scheme in Singapore, the Deutsche Gesellschaft für Nachhaltiges Bauen e.V (DGNB) in Germany, and the Green Building Index in Malaysia. In most of these green building rating systems, the question of whether a building is "green" is assessed in terms of the site; the uses of water, energy, and materials; and the indoor environment quality. A major issue in green building is the appropriate use of land. Site planning and design are key issues in determining a sustainable site (Kibert 2012). Life cycle assessment (LCA) is a quantitative tool for assessing the materials used, energy flows, and the environmental impacts of products. This type of evaluation systematically assesses the impact of each material and process involved (Sharma et al. 2011). During the operation and maintenance stage, a post-occupancy evaluation can be made to measure the indoor air quality and the resource consumption of the green building (Newsham et al. 2013).

Zhao et al. (2015) stated that after several years of development, green building technologies have indeed advanced to a certain degree, but meanwhile, the primary hindrances to green building implementation are non-technological factors. Although there is a prevalent trend in the construction industry toward sustainable development, the practice of the green building management concept remains at an immature stage (Gluch et al. 2014). Therefore, a systematic review of green building development is essential not only to identify current research topics and themes but also the trends in green building development research to highlight future research work needs. In studies so far, researchers have reviewed green building development from the perspectives of energy performance, GHG emissions performance, cost premium, life cycle assessment, and green building incentives (Sharma et al. 2011, Ghaffarian Hoseini et al. 2013, Zuo and Zhao 2014, Dwaikat and Ali 2016, Olubunmi et al. 2016). According to Li et al. (2011), "management" is also an important factor that determines the success or failure of green buildings. But meanwhile, an analytical review is lacking on the management processes necessary for effective green building development. This study aims to identify the latest research findings and future directions from the perspective of green building project management via an analysis of the publications in this area from selected journals between 2007 and 2016.

DEFINITIONS OF GREEN BUILDING

There are various ways to define the term "green." According to the U.S. Green Building Council (one of the earliest organizations to influence the building industry towards green methods), green buildings are described as "buildings that are designed, constructed and operated to

boost environmental, economic, health and productivity performance over that of conventional buildings" (U.S. Green Building Council, 2003). Robichaud and Anantatmula (2010) have also proposed definitions of green building, all of which describe it as a practice that focuses on minimizing a building's total environmental impact. Green building is also a process that enhances environmental, economic, and social efficiency. This approach to building involves a commitment to minimizing disturbances to the environment and the ecosystem by enhancing the efficiency of natural resource usage. Green building stimulates the economic development of society as a whole throughout the building life cycle by increasing the financial returns to developers. Finally, it enhances the well-being and productivity of those who live and work in green buildings by providing them with better indoor air quality. In other words, green building produces "healthy facilities designed and built in a resource-efficient manner, using ecologically based principles" (Kibert 2012). In the various definitions given above, the common elements are environmental concerns, consideration of the entire life cycle, cost efficiency, and improved health.

RESEARCH METHODOLOGY

In this study, the researchers browsed and selected papers published in mainstream journals in order to map the developments in construction project management as they have applied to green buildings over the past 10 years. Ten mainstream journals on green building and sustainable construction management were selected: The *Journal of Construction Engineering and Management* (CEM), *Construction Management and Economics* (CME), the *Journal of Management in Engineering* (ME), the *International Journal of Project Management* (IJPM), *Building Research and Information* (BRI), *Energy and Buildings* (EB), *Building and Environment* (BE), the *Journal of Cleaner Production* (CP), the *Journal of Green Building* (GB), and *Renewable and Sustainable Energy Review* (RSER). In choosing these ten journals, reference was made to Chau (1997), whose study indicated that CME and CEM have been among the top journals relevant to construction and have been highly recognized in the field of construction management. In addition, the ME, IJPM, and BRI are high-quality journals that are well known in the construction field (Lin and Shen 2007). The EB, BE, CP, GB, and RSER were chosen because they publish broadly on topics related to sustainable development and green building. Although many other papers on green building development have been published in other journals, the authors tried to approach the ideal of an unbiased sample. Instead of, impossibly, trying to include every publication related to green building from all publications and inevitably introducing bias among those actually selected. It is believed that the surveying of all relevant papers in the particular 10 journals above is a practical approach to achieving the research aims. Though this review overwhelmingly includes papers in the 10 specific journals above, 3 articles from other journals and 3 books relevant to green building development are cited as an exception because they have a high citation rate in previous green building studies.

The procedures used to review the related literature were as follows.

Papers in the selected journals were scanned issue by issue from 2007 to 2016. After a coarse reading of the research titles, the articles that included keywords such as "green building," "sustainable building," "LEED," "Green Mark," "green roof," "green walls" were downloaded for further consideration.

After a brief review of the selected articles, including their abstracts and conclusions, the number of papers mostly relating to project management in green buildings was reduced. Papers

that included green building management issues to only a small extent were excluded. After this filtering, 226 articles directly related to the green building management process were identified.

Table 1 presents the distribution of these 226 articles among the ten selected journals over the past decade. The *Journal of Green Building*, *Energy and Buildings*, and the *Journal of Cleaner Production* produced the most articles.

TABLE 1. Number of relevant articles in ten selected journals.

JOURNALS	NUM	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
Journal of Construction Engineering and Management	**12**	1	1	4	3	1	1	0	1	0	0
Construction Management and Economics	**15**	0	1	0	1	4	2	2	1	2	2
Journal of Management in Engineering	**14**	2	2	5	3	1	1	0	0	0	0
International Journal of Project Management	**5**	0	1	1	1	0	0	0	1	0	1
Building Research and Information	**19**	2	4	2	4	2	1	1	0	0	3
Energy and Buildings	**51**	15	6	9	7	2	4	3	2	2	1
Building and Environment	**25**	3	9	3	1	1	1	2	3	1	1
Journal of Cleaner Production	**33**	7	11	4	3	3	2	2	1	0	0
Journal of Green Building	**40**	2	10	3	1	0	2	6	5	4	7
Renewable and Sustainable Energy Review	**12**	6	2	3	1	0	0	0	0	0	0

In addition, Table 1 also shows the consistent tendency of the targeted journals to publish green building research papers year by year and that interest in the green building arena has grown steadily over the years. This can be attributed to two main factors. Firstly, as sustainable construction has attracted more in-depth research and development, green building, as one of the key components of sustainable development, has also gained importance. Secondly, as innovation in and the popularization of green building materials and technologies has increased, so too has the proportion of green buildings actually developed and the amount of related research. The study continued by reviewing those papers in Table 1, and mapping the interrelationships over the past decade between the development of green buildings and project management actions and policies.

Research Topic in Green Building Development

Since the first green building standard was established in the United Kingdom in 1990, and since the United Nations Conference on Environment and Development was held in Rio de

Janeiro in 1992, green building has gradually become a prominent direction in architecture and numerous studies on green buildings have been carried out. An analysis of the research topics enables conclusions to be reached on the types of research undertaken and the directions likely to be explored in future research. The identified Table 1 papers were found to fit within one of the following five research categories: green building management in general, the benefits and barriers to green building development, green building performance, stakeholder behavior with regard to green buildings, and green building strategies. The papers are discussed below. There is one section for each of the five categories.

GREEN BUILDING MANAGEMENT IN GENERAL

Dammann and Elle (2006) stated that the formation of a well-functioning common language in green buildings needs shared environmental knowledge and discussed suggestions on how to acquire the green building common language. DuBose et al. (2007) presented a framework illustrating how a green building programme can be evolved in public agencies. This framework contained four major sections, i.e., inspiration, motivation, implementation, and evaluation. Other authors, such as Pearce et al. (2007) and Sentman et al. (2008), argued that to reduce greenhouse gas emissions and regulate climate change, green building policies must be applied from the local to the state level, for both public and private buildings. Aktas and Ozorhon (2015) also stressed that strict environmental policies are the major stimuli behind the conversion of existing buildings into green buildings. These authors found that owner commitment, senior management support, and collaborative work among the involved parties are important to enable green building. To promote sustainable solutions, Ross et al. (2010) indicated that the support and acceptance of users, together with adequate funding, are crucial factors for success. Olubunmi et al. (2016) summarized and criticized external and internal green building incentives based on a comprehensive review. To improve green building incentives, private sectors should be involved, local prevailing conditions should be considered, and long term incentives should also be focused on.

Love et al. (2012) took the first six-star Green Star energy-related commercial office buildings in Australia as examples that revealed the key initiatives needed to achieve such a rating. As to the motivation for using sustainable technologies, the ample financial return prompted clients to invest the additional money, and the most important benefit was a reduction in the requirement for fossil fuel energy. Geng et al. (2013) showed that close collaboration with local government, strong leadership, and a comprehensive plan were the most necessary elements for success. To maintain historic masonry buildings in a 'green way', Forster et al. (2011) proposed a model which evaluated the efficacy of maintenance interventions and the use of materials life cycle data and "cradle to site" techniques to determine embodied CO_2. Historic buildings are mostly characterized by poor energy performance and the need for green retrofitting or renovation. Green retrofitting of such buildings is often economically attractive, as these buildings generally require a specific design approach. Therefore, energy performance contracting can be applied for the retrofitting work (Filippi 2015). According to Wu and Issa (2014) and Inyim et al. (2015), methods for the integration of information technology, such as Building Information Modeling and economic and environmental impact analysis, can help decision-making in design and at the construction stage. Ruparathna and Hewage (2015) also explained that the sustainability of construction projects can be greatly improved by more consideration for sustainability

at the pre-construction stage, i.e., improvements in the project procurement process. Qin et al. (2016) explored risk factors for green building throughout its life cycle in China. The key risk factors include government bureaucracy, inadequate green building maintenance, lack of green design and management experience, and lack of clear green goals. Mohammadi and Birgonul (2016) tried to identify and assess the potential legal risks pertaining to green construction projects and to improve the awareness of professionals on such potential risks. In promoting green building development, green technologies are indeed the basic elements, but just how to conduct the green building management process is also essential.

These studies show the importance of policy making, collaboration and incentives in green building development. A few green retrofit issues also emerged in relation to historic buildings. While the effectiveness of green policies and green incentives has not usually been checked, such checks must be involved in future research. In addition, how to effectively manage 'green retrofitting' of existing buildings also needs further exploration.

BENEFITS AND BARRIERS TO GREEN BUILDING DEVELOPMENT

1) Benefits of green building development

In previous studies, a number of researchers regarded green building as an environmentally friendly practice that also provides social value. Its advantages are thus economic, social, and environmental. Economically, the adoption of green building leads to reductions in lifecycle costs, greater energy savings, tax benefits, and market benefits. Yudelson (2008) pointed out that although the initial cost of a green building is 1% or 2% higher than that of a non-green building, it offers long-term savings and a shorter payback period. Various studies suggest that many green buildings are designed to save energy than traditional buildings, leading to significant energy efficiency improvements. Adler et al. (2011) showed that the energy-saving strategies adopted in green building designs, such as green roof systems, active walls, Low-E glass, efficient HVAC and cooling systems, and light-emitting diodes, not only meet the requirements of users, but also save limited energy resources. Zhang et al. (2011) pointed out that many governments seek to stimulate enthusiasm for green building development by offering tax benefits and incentives in the form of cheaper land prices or other. Yudelson (2008) reported that green buildings that achieve LEED silver certification are eligible for tax abatements in the state of Nevada and that the state government also provides a sales tax rebate for green materials used in LEED silver-certified buildings. Many private and public developers and owners therefore gain marketing benefits from constructing LEED-certified green buildings. Another example of the benefits gained from green building was highlighted by Adler et al. (2011), who showed that green buildings promote product differentiation in the construction market and garner free positive press coverage.

In terms of social benefits, one significant effect lies in improving the health and efficiency of occupants. Adler et al. (2011) explained that green buildings offer a better indoor environment, including better indoor air quality, better thermal comfort, cleaner water, more effective lighting, and more comfortable noise levels, all of which bring health benefits to the occupants. Via post-occupancy evaluations comparing green buildings with conventional buildings, Newsham et al. (2013) found that green buildings do enjoy better indoor environments than conventional buildings as expressed in terms of environmental satisfaction. Because green buildings are designed and constructed in an environmentally friendly manner, a balance

between the building and the ecosystem is sought throughout the building's life cycle. Green strategies such as renewable energy use and waste management can reduce energy use and limit greenhouse gas emissions, thereby protecting the ecosystem.

2) Barriers to green building development

Although green building offers numerous benefits in practice, there are still many obstacles to its implementation, such as higher costs of transport, materials, and design compared to conventional building costs. Kosheleva and Elliott (2006) concluded that the most widely acknowledged impediments include short-sighted decision making, high costs, lack of information, and an inadequate regulatory system. The initial cost of a green building is higher than that of a conventional building because of the stricter green requirements. Green building practices also require more time for implementation, which also increase costs. In meeting the higher initial costs of green buildings, another obstacle is the lack of financial incentives. For example, Häkkinen and Belloni (2011) stated that most regulations or incentives for green buildings are mainly focusing on new buildings instead of existing buildings. Besides, the cooperation among different stakeholders is also required at each stage of green building development. For example, such as in the research conducted by Williams and Dair (2007), they explained that the initial investment required from developers is higher but that the benefits, including a better indoor environment and reduced energy consumption, accrue primarily to the tenants, which results in an unequal distribution of benefits.

In terms of green building performance, there is lack of information on green products and green maintenance systems to inform green building implementation. Also, there has been an insufficient number of case studies to convince developers that green buildings have lower operation costs and greater environmental efficiency. Hence, as Adler et al. (2011) explained, the mainstream market does not yet realize the superior performance that green buildings offer. There is also a lack of public awareness and knowledge of green principles and technologies. Based on a fuzzy impact matrix approach, Shi et al. (2014) evaluated the effectiveness of green building related policies, and the results showed that only half of the policies were considered effective. Although the number of green buildings has grown steadily over the past few years, the field of green building remains relatively new, and green knowledge and technologies are still in the immature stages of development. Insufficient professional expertise in green technologies and methods leads to a weak understanding of the green building concept and a lack of awareness of the green tools and materials available, all of which hinders the implementation of green strategies.

Through these previous studies, the benefits of green buildings have been identified by the researchers from the perspectives of society, the economy, and the environment. Obstacles still exist in green building implementation, the most significant one being initial costs, while studies on how to reduce whole life cycle costs are limited. In addition, the benefits and barriers of green buildings, as affected by different geographical regions, still needs further exploration.

GREEN BUILDING PERFORMANCE STUDIES

1) Resource use efficiency

As Goldberg (2008) explained, green building involves an integration of sustainable products and operating systems. Such integrated systems can reduce a building's overall energy footprint

by saving energy at each part of the system. Sharma et al. (2011) and Mao et al. (2015) showed that Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) are effective tools for the quantitative assessment of materials used, energy flows, and the environmental effects of the products used in green buildings. LCA and LCC can also be applied to green building retrofitting and to identifying the improvement potential of building renovation (Pombo et al. 2016). In addition, as Chalifoux (2006) and Kim et al. (2014) indicated, building energy simulation and linear regression can be used to predict the energy savings from green buildings over the whole life cycle. The Building Energy Efficiency Retrofit (BEER) process is also regarded as effective in improving building energy efficiency, mainly through a project control mechanism. As explained by Xu et al. (2015), the available technology, the organizing capacity of team leaders, the levels of trust, the accuracy of measurement and verification, and the technical skills of team workers are all vital factors in project control.

The application of green building methods makes a substantial contribution to reducing energy consumption, as proven in a number of studies. Pan et al. (2008) used an energy simulation model to evaluate the energy cost savings in green buildings compared to baseline buildings and showed that the energy performance of the green buildings is much better. An 8-year period case study by Issa et al. (2011) indicated that green schools consume less energy and incur lower costs than conventional school buildings. The sustainable energy performance of green buildings was seen to reduce CO_2 emissions in practice and diminish energy consumption (GhaffarianHoseini et al. 2013). Azizi et al. (2015) conducted a questionnaire survey and concluded that the energy saving behavior of green buildings was better than that of conventional buildings. Strategies were suggested to encourage energy-saving behavior, such as raising awareness of energy efficiency through education or having building managers assigned specifically to energy-related matters. Wang et al. (2016) suggested that greenhouse gas emissions performance for the whole life cycle rather than for only the operation stage should be considered in green building evaluation.

2) Cost-benefit analysis

The cost over the entire life cycle is a tool that helps to assess the cost performance of a building. Bartlett and Howard (2000) evaluated the two major tools for such comprehensive costing, namely BREEAM and ENVEST, which enable managers to make more suitable choices and help them to dispel the misconception that "green buildings involve more capital costs." Tatari and Kucukvar (2011) showed how artificial neural networks, multiple regression analyses, and natural neural networks can be applied in cost premium predictions for green buildings. Overall, cost-benefit analysis showed that green building is economically worthwhile. Gabay et al. (2014) showed that when the government is both the entrepreneur and the long-term operator of a facility, green building is economical and can save taxpayers large sums. However, Zhang et al. (2014) demonstrated that as the initial investment is commonly vast, the developers, owners, and end-users are faced with greater uncertainties, which make them less motivated to develop green projects.

When it comes to the cost estimation and financial benefits of green building, researchers and practitioners commonly disagree. A survey by Issa et al. (2010) solicited practitioner opinions on the ranking of potential long-term savings of various kinds. The participants ranked the savings potential for each cost factor in the following order: energy, water, waste, productivity and health, commissioning and maintenance, and last emissions. Rehm and Ade (2013)

conducted a construction costs comparison between conventional and green office buildings and concluded that, on the whole, green buildings are not inherently more expensive just because they provide sustainable materials and systems. Sadatsafavai et al. (2014) compared the financial performance of 14 LEED-certified buildings with those of various non-green facilities and showed that LEED hospitals had higher operating expenses and plant operation expenses. Although the LEED hospitals made higher inpatient revenues, the improvements in income were insufficient to compensate for the higher operating costs. Similarly, Dwaikat and Ali (2016) tried to analyze the green building cost premium based on empirical studies. As limited academic research has been undertaken, they found a significant range in the cost performance of different green buildings.

3) Occupier health and efficiency

After green buildings have been built and used for some time, post-occupancy evaluations are made to assess building performance. Pei et al. (2015) showed how such evaluations allow comparison of the differences between a building's design goals and its actual performance in operation. To achieve and maintain a healthy green building and healthy indoor air quality, Bearg (2009) advised that accurate diagnostic feedback on building performance is essential and that such feedback can help reduce the risks and uncertainties in building operation.

A number of research and case studies have shown that green buildings have positive effects on employee work performance. Ries et al. (2006) indicated that work productivity can be significantly improved by providing an outdoor view, expanding the size of the work area, and improving comfort levels in terms of the temperature and relative humidity. Leaman and Bordass (2007), Gou et al. (2012) and Liang et al. (2014) all compared the occupant comfort and satisfaction in green and non-green buildings. Their studies showed that green buildings have better performance in overall comfort and productivity. Specifically, satisfaction with the air quality, temperature, relative humidity, and individual workspace in green buildings is higher, satisfaction with lighting is similar in both types, and the acoustics scores and privacy in green buildings are lower. For example, Paul and Tylor (2008) compared comfort and satisfaction of occupants in a green building with those of a traditional building and were unable to find sufficient evidence that the green building performed better in terms of aesthetics and serenity. Rajendran et al. (2009) investigated construction worker safety and health in green and conventional projects, and no significant difference was found. To improve the acoustic environment in green buildings, Hodgson (2008) suggested increasing external-internal noise isolation, improving the isolation between workplaces, and using adequate sound absorption methods to control reverberation and noise. Huang et al. (2015) found that passive design features in green buildings improved the indoor thermal environment. These features included sizing and allocating the window positions properly, providing exterior sun shades for window openings, and creating deep corridors. To improve the indoor environment quality effectively, Ravindu et al. (2015) argued that there is a need for designing green buildings which are climate-responsive and locally relevant.

Thus, a large number of green building performance case studies have been performed. The benefits of green building are unclear since the outcomes of these studies seem to be mixed. Therefore, in evaluating the performance of green buildings, longer term analyses should be conducted more often, so as to better evaluate green building efficiency, and these should include all three of the economic, social and environmental aspects.

STAKEHOLDER BEHAVIOR IN GREEN BUILDINGS

1) Stakeholder interrelationship

The term "stakeholder" is defined as "any group or individual who can affect or is affected by the achievement of the firm's objectives." Previous studies related to the stakeholders in green buildings, such as Gluch et al. (2014) have shown that a broader range of stakeholders play influential roles in green buildings.

Stakeholders in a building are commonly concerned with the uncertainty and risk involved in design and management. Therefore, contractors commonly feel that implementing a proactive environmental strategy can place their financial well-being at risk. Son and Kim (2015) showed that prediction models are important to help stakeholders evaluate the potential performance of a green building at the initial stage. Social-network analysis (SNA) is an effective tool for analysis of the relationships between stakeholders. Shen and Yang (2010) used SNA to analyze the effects on projects as influenced by stakeholder relationship networks. Their results led them to promote a stakeholder management framework for construction projects. Yang and Zou (2014) analyzed the risks that exist when internal stakeholders are located in a relatively central position in the project. Yang et al. (2016) modeled the interactive networks of risks that affect different stakeholders and found that the central risks in Chinese green buildings are related to the behavior of the clients, the government, and the end users. Some researchers have focused on the behavior of participants in green buildings. For example, Hojem et al. (2014) found that social learning is essential for stakeholders, as such learning can expand their ambitions and motivate them to pursue energy efficiency goals and broader environmental goals. Some of the past studies that related to core stakeholders and their perspectives are as follows.

2) Developer perspective

A number of third-party standards or labels are used for measuring and appraising the green status of buildings. Developers are seeking to maximize their benefits and may mainly regard green building features as promotional tools for selling buildings to the users or for getting subsidies from governments. Because the initial costs of green buildings are higher than for conventional buildings, some developers are unwilling to invest in green building construction. Sun et al. (2015) discussed the sustainable knowledge of small builders and their attitudes in the UK and found that clients were often a barrier to delivering green buildings because they were unwilling to pay more in the short run for future benefits. Therefore, sets of compulsory and incentive policies need to be stressed if sustainability in construction projects is to be promoted.

3) Contractor perspective

In green building construction, the contractor plays an important role in helping to detail the project, to identify and deliver cost savings, and in communicating with subcontractors (Ladhad and Parrish 2013). A questionnaire survey of contractors by Ahn and Pearce (2007) showed that most expected to obtain green building skills and knowledge and that those who gained professional green building knowledge mainly received it from related conferences and green building trade publications. Qi et al. (2010) explored the drivers for green innovation among contractors and found that the two most important driving forces are managerial concerns and government regulatory pressure. Mokhlesian and Holmén (2012) suggested that construction firms who seek to adapt themselves to green development projects should change their business model elements, such as their value configurations, cost structures, and capabilities.

4) End-user perspective

Green building development is significantly affected by market demand. End user understanding and behavior is crucial to green facility success, which is no less crucial than passive technology application (Vives-Rego et al. 2015). Hewitt et al. (2016) revealed that the consumption behaviors of occupants in green buildings cannot be well predicted by the value-based frameworks. To increase occupant willingness to change behavior, it is necessary to provide them with information, including green building standards relevant knowledge and the effects of energy-saving behavior. Chau et al. (2010) explored end-user behavior in green building development, including the factors of awareness and understanding of green development, willingness to pay for value, and the effects of personal socio-economic backgrounds on their preferences. In some post-occupancy evaluations, such as those by Deuble and Dear (2012), it was found that users in green buildings are more prepared to ignore and tolerate the non-ideal conditions than their counterparts in non-green facilities. In other words, the end users are more tolerant of green buildings, which indicates that user attitudes influence objective measures of building performance and sustainability.

5) Governmental organization perspective

Governmental organizations play major roles in the formulation and implementation of public housing programs. In encouraging green building development, governments often play the roles of catalyst, educator, reformer, regulator, and innovator. For example, Theaker and Cole (2001) showed that in Hong Kong, the role of the government in green building was forceful in the formulation and implementation of public housing programs. Because the comparatively high initial cost of a green building weakens the enthusiasm of many stakeholders, researchers such as Qian et al. (2015) indicated that governments need to offer more incentives and increase the expected utility of green buildings if they hope to achieve market transformation. Some case studies, such as that of Cupido et al. (2010), showed that government policies are important in underlining sustainable building practices and LEED certification. As Ross et al. (2007) indicated, if policy makers want to support green buildings, then municipal policies should be changed to reduce tax rates on green buildings and improve their returns.

In most studies, researchers focused on the different types of stakeholder behavior separately. Only a few studies referred to the interrelationships between stakeholders and the hidden behavioral risks for them. Therefore, for future study, when exploring stakeholder behavior in relation to green buildings, exploration into how to strike a balance between the interests of different stakeholders is important in promoting green building development.

GREEN BUILDING STRATEGIES

The application of green strategies in the construction industry brings increasing economic profits and strong revenue growth. Lu et al. (2013) predicted that the benefits will include economic returns, reduced risk, brand publicity, a broader sense of payback, and advantages from early entry into a new market. Dewlaney and Hallowell (2012) focused on safety management strategies in green building construction and developed a decision support tool to help practitioners enhance construction worker safety. Hwang and Ng (2013) pointed out that to establish a knowledge base for green building management, the critical knowledge areas include schedule

management and planning, stakeholder management, and communication management. The critical skills involve analysis, decision making, teamwork, and problem-solving.

To achieve effective, high-performance green building projects, the early prediction of green building design performance is critical for sound stakeholder decision making (Jaillon and Poon 2008). As Kang et al. (2013) and Son and Kim (2015) indicated, developers should pay more attention to pre-project planning, which can help to reduce the possibility of cost overruns. In addition, studies by Williams (2010) and Gultekin et al. (2013) emphasized that green building features should be considered early in the design process and that contractors should be involved before the design process begins, because such forward thinking can have a major effect in terms of cost savings. Zhang et al. (2014) also suggested that to realize sustainable project management, elements such as mixed-experience design teams, third-party environmental representatives, and effective communication teams should be involved to ensure that each party in the construction project shares the goal of protecting the environment. Besides, other researchers have tried to develop a comprehensive agent-based modeling framework, which can be applied to assess and optimize green building performance comprehensively, for example, reducing energy consumption without compromising occupants' wellbeing and comfort.

Although numerous sustainable development strategies have been developed, Du (2007) pointed out that the effects of these strategies have been limited due to various constraints, such as a lack of integration with mainstream decision-making systems, a narrow base of participation, weak links between policy and on-the-ground reality, or a lack of clear priorities and achievable targets. Zhang et al. (2011) also named the significant barriers in green strategy implementation, including inadequate green appliance design, the high cost of energy-saving materials, the lack of stimulus from customer demand and insufficient efforts behind policy implementation. To solve these social and psychological barriers, Hoffman and Henn (2008) suggested that the most important strategies concern education, structural and incentive change, risk indemnification, tax reform, and improvement in green building standards. To solve the investment uncertainties that developers face and the lack of economic benefit from green technology implementation, Zhang et al. (2014) proposed a framework based on energy performance contracting that could turn "green" investment into "gold" economic benefits. To promote the implementation of building environmental assessment, Wong and Abe (2014) suggested prioritizing education and enhanced public awareness related to sustainable building at the community and national levels, building a stronger business environment for green building, and developing better communications between local building professionals and building owners.

Though researchers have explored the suggestions for delivering green strategies effectively, there remains a lack of empirical studies which confirm that the public is well informed about green buildings and solutions for existing green building development problems need further exploration.

FUTURE RESEARCH DIRECTIONS

According to the identified research themes above, several relevant future research directions are proposed, following analysis of what has been done and what needs to be done in research on green building development. These directions are outlined in Table 2.

TABLE 2. Future research directions in green building development.

Research Topics	Current Status of Research	Future Directions
Green building management in general	1. Green building policies and incentives 2. Retrofitting of existing building	1. Effectiveness of the green building policies and incentives 2. How to promote the conversion of existing buildings into green buildings
Benefits and barriers to green building development	1. Economic, social, and environmental benefits of green buildings 2. Barriers to green building implementation	1. How to reduce the whole life cycle costs in green building development 2. Benefits and barriers to green building development in different regions
Green building performance	1. Resource use efficiency 2. Cost-benefit analysis 3. Occupier health and efficiency	1. Validation of green building performance in the long term 2. Involvement of green elements in the building's whole life cycle
Stakeholder behavior in green buildings	1. Stakeholder interrelationships 2. Behavior of various stakeholders	1. How to deal with conflicts of interest among stakeholders 2. Behavioral risk management among stakeholders
Green building strategies	1. Green building strategies and the application 2. Obstacles to green building strategy implementation	1. How to change public mind-set and behavior 2. How to develop a platform for feedback

Within the topic of "green building management in general," two major directions are worth exploring:

1. *Effectiveness of the green building policies and incentives.* As mentioned before, there are insufficient credible research findings and case studies on the effectiveness of green policies and incentives. Long-term post-occupancy evaluations or whole life cycle assessments should be conducted to analyze the real performance of these green approaches.
2. *How to promote the conversion of existing buildings into green buildings.* There are several incentives for new green building development, but little attention has been given to the incentives for retrofitting existing buildings. Existing buildings are in urgent need of green feature implementation. Finding a way to incentivize developers to turn traditional buildings into green ones remains a challenge. Future research should focus on how to make existing buildings more efficient or on the development of business models for effective upgrades to such buildings.

Under the umbrella of "benefits and barriers to green building development," two issues are likely to be important in future research:

1. *How to reduce the whole life cycle costs in green building development.* As stated by researchers in previous case studies, one significant barrier in green building management is cost. More case studies that can validate the economic performance of green buildings should be made. Researchers should also explore ways to reduce the whole life cycle costs of green building, which can attract developers to pursue real green buildings.
2. *Benefits and barriers to green building development in different regions.* Green building development is dependent on the surrounding environment. For different regions or countries, the factors of climate, geographic setting, and social and economic conditions may vary greatly, and therefore the barriers to green building development in each region need to be explored and compared specifically.

Concerning the topic of "green building performance," two major themes should be further explored:

1. *Validation of green building performance in the long term.* As the performance of green buildings is still partly in doubt, multiple years of data are needed to track changes in the performance of green building through long-term post-occupancy evaluations. The reasons why the performance of green buildings still departs from the anticipated performance need to be further investigated.
2. *The involvement of green elements in the whole life cycle.* Many researchers have surveyed green buildings in terms of their initial stages of construction and occupation. Clearly, involving green elements in the early stages such as design and construction provides more benefits of cost reduction and environmental protection. However, researchers need to expand this focus to investigate the whole life cycle of building construction, from planning to demolition.

Within the topic of "stakeholder behavior in green building," two major questions should be explored in the future:

1. *How to deal with conflicts of interest among stakeholders.* Stakeholders are pursuing their own interests when they implement green building. Therefore, game theory should be applied to better understand where is the point of "game equilibrium" among the stakeholders of green buildings.
2. *Behavioral risk management.* As multiple stakeholders are involved, the uncertainties involved in green building increase. Proper behavioral risk management should be conducted to promote green building development.

As for the appropriate "green building strategies," two major questions should be focused on in the future:

1. *How to change public mind-set and behavior.* Tenant behavior can be changed through education initiatives. Members of the public need to be convinced that green behavior and green building practices are beneficial to their quality of life and for reducing their expenses. Developing the means of implementing such steps requires further research including case studies. However, for those regions where public green buildings are required by the government, this direction can be excluded.
2. *How to develop a platform for feedback.* Development of an effective platform for feedback between end-users and government or industry participants requires effective

communication among those parties. It is very important to build both project-specific platforms and an industry-wide platform. For project-specific feedback, post-occupancy evaluations are essential because they allow the identification and notification of weaknesses. For industry-wide feedback, it is important that green building rating tools be improved to upgrade the assessment system.

CONCLUSIONS

Green building is an effective way of building a sustainable built environment, and this concept has attracted increasing attention worldwide. This study provides an analytical review of the research in the field of green building project management over the past decade by systematically analyzing publications regarding green building development in ten mainstream scholarly journals, CEM, CME, ME, IJPM, BRI, EB, BE, CP, GB, and RSER. This survey of articles identified the major research themes as 1) green building management in general, 2) the benefits and barriers to green building development, 3) green building performance evaluation, 4) stakeholder behavior in green buildings, and 5) green building strategies. In reviewing these themes, it is shown that a number of doubts remain whether the practical performance of green buildings is as expected. Also, incentives encouraging the promotion of green building are lacking and for change in stakeholder behavior. Based on this analysis of the current status of research on green building management, several future research directions are suggested above. The information revealed in this survey of the literature is valuable for researchers because it enables a broader understanding of the key areas and trends of research in the development of green building design and construction.

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