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Green building in China: Identifying and overcoming barriers to sustainable construction

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Abstract. The construction industry in China is a major contributor to the nation's negative environmental impact as it consumes a significant amount of natural resources and generates substantial greenhouse gas emissions and waste. In response, green building, aimed at designing and operating structures in an environmentally responsible way, has been more and more emphasised. Numerous studies have demonstrated the potential benefits of green buildings but green building practices still face several barriers, including high initial investment, lack of knowledge, incomplete regulations and codes and insufficient professional expertise. This research investigates some of the obstacles for green building practices in China, focusing on stakeholders' perceptions. It finds that government barriers are the most dominant, followed by human-related and knowledge and operation-related barriers. Lastly, some recommendations regarding government incentives, public awareness initiatives and collaboration between government and construction professionals are proposed to promote the wider practice of green building. By addressing these challenges, the research aims to contribute to the advancement of sustainable construction in the country.

Keywords: green building, sustainable construction, stakeholder perceptions

1. Introduction

The construction industry is the main contributor to the adverse environmental impact. Sbahieh et al.'s research shows that the construction industry in China generates nearly 50% of greenhouse gas (GHG) emissions, consumes about 40% of natural resources, uses 70% of the nation's electrical power and produces around 55% of the waste in landfills [1]. With the increasing awareness of sustainable development, green building (GB), as an important practice under sustainable construction, has gained more prominence in the construction industry around the world. According to Goubran et al., GB incorporates various practices, from designs to technologies and materials, throughout the whole lifecycle of a building [2]. Numerous studies have proved that GB not only excels in environmental performance - including improved indoor environments, saving on water, electricity and other natural resources and reducing carbon footprints - but also offers benefits, such as enhanced asset value, lower operating costs and improved workplace productivity and health. Today, GB is regulated by a set of standards and certifications in both developed and developing countries.

Despite these benefits, there are various barriers to GB, especially in developing countries like China. These barriers are reflected in different areas, including higher costs, lack of awareness, incomplete legislation and regulation and a lack of expertise, among others. The Chinese government has issued 'The 13th Five-Year Plan for Building Energy Efficiency and Green Building Development' and proposed specific goals and targets in energy saving and reduced GHG missions to support GB but the development of GB has been lower than expected, with the construction of GB being mainly in developed areas like Beijing and Shanghai [3]. Consequently, the aim of this research is to investigate the perceptions of construction stakeholders regarding these barriers in the Chinese construction industry. By addressing these challenges, the research seeks to contribute to the promotion and development of GB practices in China, hence advancing sustainable construction in the country.

2. Defining 'green building'

The US Environmental Protection Agency defines green building (GB), also known as sustainable building, as the practice of designing, constructing and operating structures in environmentally responsible and resource-efficient ways throughout the whole building's lifecycle [4]. The concept of sustainable construction as well as GB has been increasingly emphasised since the 1970s

due to the energy crisis and growing environmental awareness by the public, coupled with technical developments in environmental science. Nowadays, GB practices are regulated by standards and certifications, such as the Leadership in Energy and Environmental Design in the US, the Comprehensive Assessment System for Built Environmental Efficiency (CASBEE) in Japan and the Green Mark in Singapore. The Green Building Council Australia lists three key elements of GB: lower consumption of water, energy and other natural resources; creating healthier environments for people to live and work in; and minimising waste, pollution and other negative environmental impacts [5]. Energy-efficient systems and renewable energy sources reduce energy consumption and GHG emissions. Water-saving fixtures, efficient irrigation, and rainwater harvesting help to recycle water and minimise water use [6]. Green building materials, non-toxic and locally sourced, reduce the environmental impact of construction and deliver healthier indoor environments [7]. Enhancing indoor air quality, natural lighting and thermal comfort improves a room's comfort, reduces operating costs and further positively influences occupancy levels [8]. In summary, GB acts as a significant strategy for achieving sustainable development in the dimensions of environment, economy and society. It can effectively contribute to mitigating climate change, lowering the consumption of natural resources, protecting occupant health and improving employee productivity.

3. Literature review - Barriers to the adoption of GB

Green building (GB) is regarded as a critical concept under sustainable construction. Nevertheless, there are some barriers to their practices, especially in developing countries like China. Previous studies have demonstrated these factors from various aspects. For example, Onifade et al. pointed out higher initial investments and the absence of professional knowledge and expertise are major barriers [9]. Similarly, Darko et al. highlighted the importance of government incentives and financial schemes in promoting the development of GB [10]. These studies provide a basic understanding of the common challenges regarding the development of GBs.

Higher initial investment of GB is considered the foremost barrier, resulting from the extra cost for GB materials, specialised labour and additional maintenance requirements. Additionally, perceived risks and uncertainties associated with new sustainable practices lead to reluctance among developers [11]. Gillott et al. suggested that more comprehensive and localised rating systems and labelling programs, along with inadequate regulatory frameworks, are needed to provide guidance for GB practices [12]. Furthermore, research by Verticchio et al. highlights the requirement for effective government incentives and demonstration projects to promote the development of GB [13]. They also propose that the lack of professional knowledge and expertise is another obstacle. Given that GB is still in its formative stage of development in some areas, relevant technologies and practices are recognised as 'immature' or 'new' and many construction professionals are not adequately trained to apply sustainable practices effectively, resulting in suboptimal utilisation and scepticism about their benefits [14]. Moreover, advanced technologies and practices are sometimes not stable, which requires additional tests and incurs extra cost and schedule. This further leads to the lack of expressed interest and demand from clients as well as less importance given to GB by senior management [15].

While these studies present valuable understandings, there are limited studies specifically concentrating on the barriers to GB practices in the Chinese construction industry. Previous research generally focuses on these issues in broader contexts in developed countries, leaving a gap in studying the unique issues existing in China. The purpose of this research is to fill this gap by analysing how construction stakeholders perceive the barriers to GB practices in the Chinese construction industry. By filling this knowledge gap, this research aims to understand the challenges of GB's development and contribute to its promotion in China, hence advancing green construction practices in this country.

4. Research methodology

A quantitative approach will be used in this research to study the hurdles involved in constructing green buildings in the modern Chinese construction industry. The reasons for using quantitative research are based on its clarity for statistical data collection and analysis, which facilitates numerical analysis and generalised conclusions. Questionnaire surveys serve as the primary data collection method from a large sample (industrial professionals) with different roles in the construction industry.

4.1. Questionnaire development

The construction of the questionnaire was based on a comprehensive literature review related to the barriers preventing GB's practice. The questionnaire was pre-reviewed by several construction experts (who have more than 10 years in GB) to ensure its objectiveness and readability as well as the exact expression of technical terms. Factors which are regarded as critical in terms of preventing the establishment of industrial symbiosis are extracted from the reviewed literature and classified into three groups.

The questionnaire consists of two main parts:

- Development of GB in the Future: Respondents were asked to rate their view on development of GB in the Chinese AEC industry in the future.

- Barriers to the GB's practice: This section covers specific factors that follow the classification and allows respondents to evaluate each one.

A five-point Likert scale was used in which respondents were asked to rate the importance of each barrier (scaled from 1 = not important to 5 = very important). The use of a Likert scale is very common in quantitative research and better contributes to the analysis of the perception of barrier importance by the mean value.

4.2. Data collection and analysis

A snowball sampling non-probability method was used to select participants, with the targeted professionals including builders, architects, researchers, engineers, property owners and investors. The investigation was distributed via email and social media platforms, encouraging participants to forward it to other similar professionals via their networks. This approach helps to reach a valid and effective overall sample size and covers a diverse range of knowledgeable respondents.

The collected data through questionnaire surveys underwent simplistic quantitative analysis, which was coded and input into a spreadsheet for analysis. The quantitative analysis included summarising responses about the future development of GBs and within barrier categories to calculate the mean value and standard deviation of each. Moreover, a qualitative thematic analysis was used to rank the importance of barriers based on the evaluations from the respondents. The higher the mean value of the barrier is given, the more significant the barrier is considered.

5. Data analysis and discussion

The survey results highlight several significant barriers to GB practice in China's construction industry (table 1). These barriers can be grouped into categories including government-related, human-related and knowledge and operation-related. Each category encompasses various factors that collectively hinder the widespread use of GB practice.

Table 1. Key Barriers to Green Building (GB) Adoption in China's Construction Industry

Item	Mean
Government related barriers	3.517
Lack of government incentives	3.842
Lack of localised GB's rating system and labelling programs	3.491
Lack of specific codes and regulations	3.110
Human related barriers	3.257
Lack of expressed interest and demand from clients or investors	3.684
Lack of importance attached to GB by senior management	3.199
Unfamiliarity with GB	2.888
Knowledge and operation related barriers	2.929
Higher initial investment of GB	3.801
Risks and uncertainties associated with new technologies	3.234
Lack of comprehensive databases and information systems of GB	2.544
Lack of awareness of GB and their environmental benefits	2.135

With a mean value of 3.517, government-related barriers are the most significant among these groups. The lack of government incentives, within this group, is the most dominant and has a mean of 3.842. This is consistent with Abdelaal's [16] and Wadu Mesthrige and Kwong's research [11], who highlight the importance of financial incentives and awareness programs in promoting GB practices. Moreover, Shen, Zhang and Long emphasise the need for incentive policies to raise developers' enthusiasm for the adoption of GB [17]. For example, government endorsements can effectively demonstrate the benefits and performance of GB, hence delivering a positive image among public and industry stakeholders [18]. To solve this, Chan et al. proposed that government agencies can establish dedicated promotion strategies and teams or implement effective incentive schemes (such as tax credits and expedited permitting) to raise public awareness and promote GB practices [19].

The lack of localised GB rating systems and labelling programs is also a significant obstacle to the development of GB, with a mean of 3.491. While China issued the Green Building Evaluation Standard (GBES) in 2006 and other countries introduced rating

systems, such as LEED in the US and Green Star in Australia, there is still a need for more standardised and localised rating systems because of China's vast territory, its diverse climate and the varying development conditions of the construction industry in different places. Abdelaal and Guo's research showed that developers in some provinces find it difficult to access reliable and detailed GB standards and guidance [15]. Therefore, developing a more comprehensive and localised GB rating system will provide standardised and authoritative information, contributing to the development of green buildings, as well as sustainable construction.

The lack of specific codes and regulations, although ranked lowest among this group with a mean of 3.11, still poses a significant challenge for GB's development and is considered a major factor compared with those in other groups. Government policies and regulations are effective instruments for GB's promotion, especially in its early stage of development. This is consistent with the research findings of Yu et al., who argue that the promotion of GB is largely dependent upon government policies and regulations [20]. Construction practitioners will implement GB practices if it is a regulatory requirement in the legislation. However, GB is still a relatively new concept, with more relevant legislation, codes and regulations still required. This situation is not exclusive to China but is also the case in other developing countries, such as Malaysia [21] and India [22].

Human-related barriers (total mean value of 3.257) consist of three factors, with the lack of expressed interest and demand from clients or investors (a mean value of 3.684) being the most dominant factor within this group. This factor is the most important for the development of GBs because clients' demands and interests are crucial determinants for GB practices as well as sustainable development. Lam et al.'s research found that Chinese clients have less interest in investing in GBMs as they have no or limited knowledge about the benefits of GB and there is also a lack of market transparency for GB [23]. Shen, Zhang and Long's research also demonstrated that compared with other features, such as price, location and surrounding infrastructure, sustainable features of properties are not qualities that impact the buying decisions of Chinese people [17]. They further suggested that this case would be different in developed countries. The low demand for GB can be attributed to the lack of awareness of the public and clients [19].

The lack of importance attached to GB by senior management (a mean value of 3.199) is another important factor. Chan et al. highlighted that top management's commitment is crucial for successful GB practice considering their significant impact and authority for sustainable strategy [19]. However, many senior managers in China have less environmental consciousness, hindering the adoption of sustainable practices [24, 25]. Construction professionals' unfamiliarity with GB, with a mean of 2.888, ranks second in this group. Compared with conventional building projects, professional knowledge and expertise, as well as an integrated design team, are always required for the success of a GB project, because some sustainable design elements must be considered at its early stage [26]. These will result in additional costs, works and schedules, which is a major consideration for many construction corporations, especially for small companies.

Knowledge and operation-related barriers is another major group and has a mean value of 2.929. Among these factors, higher material orders, operation and maintenance costs of GBs is the foremost factor with a very high mean of 3.801. Higher cost is a crucial consideration for investors, often deterring them from applying GB's practices [27]. According to the Urban Green Council, an extra cost of 4-12% is generally required to achieve LEED certification [28], which includes GB's material costs, specialised labour, advanced technologies and non-traditional procurement methods [29]. Given that China is a developing country and the main goal of construction activities is to meet residential and commercial demands, sustainable goals are not the priority for property investors and the higher cost will significantly hinder GB practices.

The risks and uncertainties associated with new technologies (with a mean value of 3.234) further exacerbate that barrier. As the use of GBs in some less developed areas is a relatively new concept, many developers are often reluctant to apply untested practices due to potential unsuccessful implementation of technologies and a further damaged reputation and additional cost can occur. This issue is also closely associated with the absence of comprehensive databases and information systems of GB (mean value of 2.544). Ge et al. found that some developers find it difficult to access accurate and up-to-date information on the development of green buildings, reducing their interest in investing in GB [30]. The establishment of a comprehensive national database or an information system to provide timely, accurate and updated information requires the participation of relevant construction associations, government authorities and major construction practitioners.

The lack of awareness of GB and its environmental benefits (with a mean value of 2.135) is the last barrier. Despite higher initial investments, GB can contribute to energy savings, increased property values (higher rents and sale values) and low maintenance costs, making them a valuable investment in the long run [31]. However, increased research, publicity and information dissemination can help to improve awareness and promote the development of GB [32].

6. Conclusion and recommendations

In conclusion, this study highlights the main barriers to GB practices in the Chinese construction industry. The findings demonstrate that the government has a vital role in GB's practice as government-related barriers, particularly the lack of government incentives and relevant regulations and localised building codes, are the most dominant barriers. Human-related barriers, including the lack of interest by clients and senior management and unfamiliarity with GB, are also of great importance. Moreover, knowledge and operation barriers, particularly the higher initial investments and the lack of knowledge and understanding about GB, further influence green building practices. To address these, this study recommends the implementation

of effective incentive policies, such as tax credits and subsidies, the establishment of comprehensive and localised GB rating systems and increased public awareness and professional knowledge about the benefits of GB through education and outreach programs. Some successful experiences of these initiatives can be drawn from developed countries.

It is recommended that future research concerning the development of GB should investigate specific barriers and opportunities in different regions of China, particularly comparing GB practices in developed areas and less developed areas. Longitudinal studies can help to understand long-term environmental performance and cost analysis of different GB projects. By addressing these challenges and following appropriate strategies, China can advance its sustainable construction development, making the construction industry more sustainable and environmentally friendly in the future.

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