Will green building development take off? An exploratory study of barriers to green building in Vietnam

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HIGHLIGHTS

- Green building in Vietnam is in its infancy and the number of projects is growing slowly.
- The development of green buildings is challenged by 41 barriers.
- They are represented by social, economic, legislative and technical components.
- Legislative procedures and costs are ranked among the most important barriers.
- The government should regulate the rating systems and enhance public awareness.

ABSTRACT

Green building (GB) is one of the most effective solutions to increase the efficiency of buildings through resource utilisation and recycling, mitigating the negative impact of the construction industry on the environment. As a construction innovation, GB has faced numerous challenges to its penetration into a market crowded with conventional buildings. Studies of GB barriers have been conducted around the world, including the United States, Europe, Australia and Asia, but they are scarce in Vietnam and limited to individual perspectives.

This paper identifies 41 barriers to GB in Vietnam from the literature and validates them by a survey of 215 construction professionals and government officers. Principal Component Analysis in Exploratory Factor Analysis is used to reveal that, while legislative and institutional barriers are widely perceived as the most challenging obstacles, social and cognitive barriers as a whole represent the main hindrances involved. Final remarks include policy recommendations for GB adoption in Vietnam and suggestions for further research.

Keywords: Green building; Vietnam; barriers; factor analysis; exploratory findings

1. Introduction

Vietnam's rapid economic growth has adversely affected its infrastructure and the environment. The increasing demand for buildings, growing population and over-urbanisation, predicted insecurity of energy supply, and environmentally detrimental and negative impacts of climate change are creating the need for a more sustainable built environment (Nguyen & Gray, 2016). Buildings, in general, consume more than 30% of total global final energy use (Berardi, 2017) and a large amount of raw materials, such as 70 % of timber globally (Sev, 2009; Thilakaratne & Lew, 2011). Conventional buildings also add to environment pollution by generating a significant amount of waste during their lifecycle (Chau et al., 2010; Li et al., 2016).

Green building (GB) emerged from the green movement around 1970s-1980s as a solution to meet building demand while reducing the construction industry's energy consumption (Retzlaff, 2010).

Studies have shown that the greening technologies and design applied in GB can increase the efficiency of buildings by up to ten times in terms of resource utilisation (*Green building: project planning & cost estimating*, 2011). Compared to average conventional buildings, certified GBs in Australia and New Zealand emit only 1/3 greenhouse gases, consume 1/3 electricity and ½ potable water, and recycle almost 96% of demolition waste (BCI Economics, 2014). In this study, GBs are defined as 'those embracing the principles of lower environmental impact through greater energy efficiency, lower energy demand, reduced water usage, improved indoor quality and minimising construction waste" (O'Leary, 2008 as cited in Yang & Yang, 2009).

It is argued by a number of construction professionals and GB experts in Vietnam that the adoption of GB in the building market is slow and still in its infancy (Le, 2008; Pham, 2015; Solidiance & VGBC, August 2013). GB adoption faces numerous barriers against its progress to find a niche or be in the mainstream market (as referred in the following section). After the first certified building dating back to 2010, GBs can now be seen in large urban areas throughout Vietnam, mainly in two metropolitan cities – Hanoi and Ho Chi Minh City - as several demonstration projects of large corporations (Solidiance & VGBC, August 2013). In 2013, there were 41 certified and registered GB projects with 7 different rating systems (see Appendix A), among which, the Leadership in Energy and Environmental Design (LEED) Green Building Rating System and LOTUS - a set of market-based green building rating tools developed by the Vietnam Green Building Council (VGBC) - are the two primary GB certification tools (Solidiance & VGBC, August 2013). Updated data obtained from the U.S. Green Building Council (USGBC), VGBC and the International Finance Corporation (IFC)-World bank group shows the existence of 121 GB projects in Vietnam up to 2017, including 84 LEED, 27 LOTUS and 11 IFC EDGE green building certification system projects. Fig. 1 presents the total number of GB projects, mainly 'design as-built'. From 2010 to 2016, there have been only 46 certified projects with rating tools applied (Fig. 2). The statistic demonstrates a stronger trend towards international certification (LEED and EDGE); however, the localised tool (LOTUS) is currently attracting more attention. In comparing LEED and LOTUS, Solidiance and VGBC (August 2013) point out that the former is more recognised while the latter is more applied and costs less.

(Insert Fig. 1 here)

(Insert Fig. 2 here)

2. Literature review

The literature review comprises a review of the barriers to GB in different contexts and government interventions as part of measures to promote GB projects.

2.1 Barriers to GB projects in developed, developing markets and in Vietnam

The small number of GB projects each year and in total are reflected by point A in Appendix B, indicating the slow progress of GB adoption. This graph is also used by Hoffman and Henn (2008) to demonstrate GB adoption in the U.S. in 2008, when there were approximately 1000 LEED certified buildings, comparing to approximately 106,000 current listed LEED projects on the USGBC website. "Diffusion of innovation" theory (Meade & Islam, 2006) and "barrier to entry" theory can explain the slow progress in GB adoption. As GB the concept is still considered an innovation (Potbhare et al., 2009), it will take considerable time and effort to increase the number of initial and early adopters (Appendix C), while barriers to entry are factors that make it "impossible or unprofitable for a company to try to start selling its products in a particular market" (Evans, 2006).

The many barriers and challenges hindering GB adoption have been well documented by numerous studies in the green construction field. A review of related publications - including general GB, sustainable housing (SH), green office and energy efficient building (EEB) - identifies 41 key GB barriers in different markets, as summarised in Appendix D. The existing literature is also clustered into developed, developing markets and Vietnam to identify the similarities and differences between the challenges to adopting GB in different levels of market maturity and economic development[1].

In terms of developed markets, Yang and Yang (2015) classify the barriers to sustainable housing in Australia into technical and design factors, economic factors, socio-cultural factors and institutional factors in reference to Spangenberg's (2002) sustainability prism. The study identifies economic factors as the most significant, followed by institutional factors. This confirms that the housing industry in Australia prioritises economic benefits over other softer values and that there is considerable concern over the inefficient policy-making mechanism involved. Similar barriers are recognised in the U.S. by Mulligan et al. (2014), who state that GB costs are the most frequently reported barrier and that the low awareness of incentive policies is resulting in industry players being less likely to adopt GB. GB projects in Singapore are highly likely to be associated with more risks, including those common to constructions projects and those closely related to green construction, such as the "Use of new construction methods and technology" and "Unclear requirements of clients" (Zhao et al., 2016). Yau (2012a,b), through studies in Hong Kong, stresses the information asymmetry between sellers and buyers around the environmental performance of green housing, where buyers are not fully aware of the operational benefits. Without a clear signal, such as eco-labelling, to reveal the hidden benefits, the consumers will be less likely to pay more for green housing - discouraging green housing developers.

Regarding studies in developing market, Zhang, Liyin, et al. (2011) reveal that financial considerations are the biggest barriers, while lack of motivation, lack of economic incentives and

[1] Developed markets include Australia, New Zealand, United States, Singapore and Hong Kong, while developing markets include India, South East Asia, Malaysia and China.

weak enforcement of legislation are also major obstacles to adopting GB in China (Shen et al., 2017). Isa et al. (2013) also argue that the high economic risks associated with GB investment and inadequate studies of the cost-benefits involved are the main hindrances to GB in Malaysia. Lack of education and limited GB examples also highly influence GB adoption (Isa, et al., 2013).

Comparing the two markets, high initial costs are the most recognised GB barrier. Studies have shown a maximum extra cost of 4% compared to conventional buildings, which is often offset to some extent by savings in operational costs (Braman et al., 2013). Lack of professional training and technical knowledge of market players and legislation issues are mentioned in several studies of developing markets. Overall, research in developing markets has revealed fewer barriers than in developed markets. This may illustrate the maturity of the GB adoption process in developed markets in comparison with developing markets, as the greater adoption rate reveals more hindrances with regards to psychological aspects (Hoffman & Henn, 2008). Although there are differences between the GB barriers perceived by studies with the two backgrounds, the adoption of GB in developed and developing markets generally faces similar barriers.

Studies of the GB barriers in Vietnam are scarce and most related information is from the viewpoints of academia and consultants. The only study with an appropriate methodology is a report by Solidiance and VGBC (August 2013), in which more than 20 industry leaders (suppliers, architects, contractors and project consultants) were interviewed. The report identifies five main barriers to GB growth in Vietnam, comprising low electricity price, lack of government incentives, limited supply of skilled employees with GB awareness, short-term thinking and misaligned incentives between building developers and users, low awareness and price sensitivity discouraging property developers. In addition to the report, we reviewed seven key articles relating directly to GB in Vietnam. These were found by conducting a search with English and Vietnamese terms ‘barriers to GB in Vietnam’ and ‘rào cản đối với công trình xanh’ in Google and filtering out irrelevant results such as news or announcements of GB projects. The articles were obtained from the *Architecture Magazine of Vietnam Association of Architects*, *Asia Life Magazine, Asia Green Building*, the Vietnam Green Building Database and Network, National Energy Efficiency Programme and Ecology global network. However, it is noted that several websites republished one article, demonstrating the lack of a comprehensive study of GB in Vietnam. 24 barriers were found in these key references and are summarised in Appendix D.

2.2 Government interventions to mitigate GB barrier

Government’s involvement is considered as one of the essential and effective ways to promote GB in many recent studies from Asia – such as Malaysia (Chan et al., 2009), Hong Kong (Gou et al., 2013; Qian et al., 2016); Singapore (Hwang et al., 2017); China (Qian & Chan, 2010; Zhang & Wang, 2013); the United States (Mellross & Bud Fraser, 2012; Mulligan, et al., 2014); Australia (Zuo et al., 2012); and Europe (van Bueren, 2009). Shafii and Othman (2006) suggest that governments can stimulate and ensure the development of a sustainable construction industry “both indirectly, through legislation and planning control, and directly, through their involvement as client, designer, supervisor and/or producer in the construction process”. Ho et al. (2010) reveal that public leadership of green procurement determines overall effectiveness and stimulates the practice in the Hong Kong private sector. Zhang, Platten, et al. (2011) propose a green strategy plan to guide actions on the more systematic use of green technologies in China.

The government can positively or negatively affect the demand for GB through financial incentives and tax reductions (Isa, et al., 2013). The Malaysian government, for example, has acted as a facilitator since 2007, when launching the Green Building Mission to raise awareness (Shafii & Othman, 2007). They consulted the private sector and non-profit organisations in an open dialogue of critical issues, solutions and recommendations for sustainable building and construction. Buildings certified with the Green Building Index are allowed to apply for tax and stamp duty exemptions (Isa, et al., 2013). The Singapore government implemented three successful Green Building Masterplans and incentive mechanisms to promote GB across the state (Hwang, et al., 2017). Eligible GBs in Singapore receive up to 2% gross floor area (GFA) bonus. A similar GFA concession scheme is provided in Hong Kong with maximum 10% GFA (Qian, et al., 2016). In the U.S., the government can allow a higher floor area ratio or lower tax burden for GB developers (Choi, 2009).

Standards and codes are also considered effective instruments to lead the construction industry towards more environmentally friendly development. Energy standards for sustainable design and construction have been established in several countries including India, Abu Dhabi and Turkey, where the United States and United Kingdom standards have been adapted to local conditions (Komurlu et al., 2015). The Energy Conservation Building Code launched by the Government of India aims at developing voluntary minimum energy performance standards for large commercial buildings, expressed in terms of energy consumption per m^2 of area (Kumar et al., 2010).

However, Chan, et al. (2009) argue that it is debatable which government intervention instruments are the most effective and efficient tools for promoting GB. The question of whether a government should be applying a mix of economic and regulatory tools, focusing more on market-based instruments or setting up an institutional framework consisting of volunteer individuals and organisations, depends on three factors: the current situation of the market system, economic development and the political environment.

3. Research methods

A questionnaire survey was employed here to help understand the current situation of GB adoption in Vietnam. To validate the barriers involved, an instrument consisting of 25 questions divided into 4 parts was developed and tested in 3 phases, and distributed to more than 500 Vietnamese construction companies and professionals.

3.1 Design of the survey

Part 1 solicits the respondents' opinions concerning the current GB market and their familiarity with the GB concept, projects and certification; part 2 investigates the motivation for participating in GB projects and suggested solutions; part 3 involves ranking the barriers and part 4 is concerned with details of the respondents' organisations. The survey clearly introduces the concept of GB used in the study, with an image demonstrating the measures involved in greening a building.

The survey combines open-ended questions concerning the situation and recommendations for GB adoption with quantitative questions to rank the barriers on a Likert scale from 1 (not at all influential) to 5 (extremely influential) with a side choice of 0 (don't know) (Croasmun & Ostrom, 2011). Respondents were encouraged to identify any inappropriate barriers on the list or other barriers missing from the list, and asked to suggest possible means of promoting GB adoption.

The questionnaire was developed in English in consultation with four scholars to test its adequacy and accuracy. It was then translated into Vietnamese and back translated separately into English for comparison to detect any errors in translation. In the pilot phase, both English and Vietnamese versions were tested by 17 academic and construction professionals in both industry and government to ensure the appropriateness of the length and language, adequacy of barriers and limit any foreseeable misunderstandings. After this phase, barriers with multiple meanings and that could cause confusion (such as "Inadequate/inefficient fiscal incentives") were separated until they each presented single meaning. The resulting 48 barriers were then finalised and recoded as shown in the following section, with some examples being added to clarify their meaning.

3.2 Targeted respondents and type of survey

Two types of survey were applied: a web-based survey and survey by interview. A web-based survey built on the internet is easy to distribute and reach a large number of potential respondents, while a survey by interview involves the interviewer reading the questions from the questionnaire and recording the answers on the questionnaire (Oishi, 2003). This helps ensure a high valid response rate and that all response options are considered. The web-based questionnaire was sent to construction stakeholders mainly in Hanoi and Ho Chi Minh City, where most of the certified GB is located. The survey by interview was used when the respondent's schedule was tight and answering the questions in interview mode was preferred. The questionnaire was distributed to a total of 523 recipients through different channels to gain responses from stakeholders expressing a genuine interest in GB, such as the Ministry of Construction; VGBC executive leaders and their members; and Energy Efficiency for Building workshops. The number of completed responses is 225 with a relatively high response rate of 43%. Participation in the survey was voluntary.

4. Results and findings

Of the 225 completed responses, 1 was unable to be opened due to technical issues in the database, 8 were duplicates and therefore deleted and 1 contained over 30% missing critical data and was also deleted - leaving 215 responses available for further analysis (Hair, 2006). The maximum missing data (either unanswered or answered as 0) for a barrier is 6.48% indicating that all barriers may be retained according to the Hair (2006)'s 'rule of thumb'. Mean substitution is used to handle missing values as this is the most widely used method and considered appropriate for less than 10% missing data (Hair, 2006).

4.1 Analysis of respondent profiles

Table 1 summarises the respondents and their organisations' profiles. The majority (79.53%) are working in multiple cities/provinces and above and therefore expected to understand the construction industry and the GB situation in different contexts throughout Vietnam. The survey covers a diverse background of construction organisations comprising all relevant stakeholders. 47.91% of the respondents work at the managerial and directorial levels and 46.05% have worked for more than 10 years. Their high positions and long working experience in the construction industry signifies the validity and reliability of the responses. Regarding the respondents' familiarity with GB, Table 2 indicates that 62.79% of the respondents have been engaged in a GB project more than 'rarely', however, 88.84% of all respondents are either unaware of the type of GB certificate for their most recent project or none was issued. The number of certificates does not equal the number of projects as five respondents mentioned seeking multiple GB certificates from two different rating tools.

(Insert Table 1 here)

(Insert Table 2 here)

Cronbach's alpha is 0.954 for the 48 listed barriers, which is very good according to Nunnally (1978), indicating that the data is reliable and suitable for further analysis. Investigating the item-total statistics for individual variables also shows that Cronbach's alpha value cannot be improved by deleting any variables.

4.2 Perspectives of the respondents on the current situation of GB adoption

Some 147 respondents stated their opinions regarding the GB *status quo*. Overall, they believe that, after 6 years, green buildings are still a new concept and their number in growing slowly. This growth is mainly attributed to the industrial buildings of international organisations. As one respondent put it, "[the GB market is] pushed by international clients, rather than locals". Many others also claim that local investors lack motivation to pursue GB, as it is widely perceived that profits or economic benefits are valued over other sustainable aspects in the form of social and environmental benefits. The main reason why GB certification is sought is to increase the market value of a company or its building. “They honestly do not care about GB. They just [want to] apply this to raise the building level and it is an aspect for attraction”. In a more detailed response,

> Green factories were built by multi-national corporations […] to sign contracts with high standard markets such as the U.S. or Singapore. Green offices are built aimed at international companies while green multi-storey residential buildings are invested in for marketing reasons and are targeted at middle-high income households.

Some noticed that investors are unwilling to adopt GB involving public budgets. As one respondent added: “public spending on this type of building unlikely to be approved due to the high initial costs of GB”.

There are unified opinions of the popularity of information concerning GB and it is noteworthy that the perception of stakeholders has started to change. GB is attracting increased attention from the government and Architecture Universities. Many responses point out that most construction professionals have a raised awareness of GB through conferences, workshops and television programmes. In contrast, the public has limited information, leading to a lack of interest from customers and investors. As one respondent commented, “seeking GB information takes a long time and there is no reliable source”.

GB is believed to have a great potential to become the vital trend in construction, although respondents identified the numerous challenges it is facing, such as the lack of available suppliers and local consultants, investors and project teams’ unfamiliarity with GB requirements, lack of knowledge sharing and awareness, and a hesitance to commit to higher investment. The need for policy is also stressed, as it is crucial in giving a clear signal to the market.

4.3 Descriptive analysis of the barriers to GB

Table 3 presents the key descriptive values of the 48 barriers from 1 (*not at all influential*) to 5 (*extremely influential*). The mean values range from 2.95 (*BR33. Larger homes and smaller households (e.g. a one generation household may increase energy consumption*) to 4.14 (*BR40. Slow and unwieldy administration process in policymaking*). 7 out of 10 highest-ranking items are related to government and policy, while the remaining 3 are cost related. The standard deviations of the barriers are generally above 1 (0.9 to 1.28) indicating a considerable difference in responses regarding the influence of listed barriers.

(Insert Table 3 here)

Slow policymaking and the lack of a comprehensive policy package for sustainability in Vietnam are perceived as the biggest challenges to GB. This is different to studies in other developed and developing markets, in which the economic and cost barriers are the highest ranked. Responses to the open-ended questions in show there is a considerable concern over the slowness of the government response to changes in the construction market. According to the respondents, despite GB becoming a focus in academic forums and attracting the attention of both construction professionals and the public, there has not been an explicit program to promote the adoption and development of GB. “Price sensitivity” and “high initial costs” are relatively high at 3.96 and 3.95/5, respectively, indicating the similarity between the perception of Vietnam construction professionals and the respondents involved in studies in other countries. Lack of data and knowledge is also perceived to be a large hindrance to the application of GB with “insufficient cost-benefit data” and “lack of technical understanding between the project stakeholders” having the same mean value of 3.85/5. It is noteworthy that “larger homes and smaller households” was ranked the lowest, with several respondents stating that this is not happening in Vietnam’s high-density cities. “Reluctance to adopt changes” was also given a low mean value of 3.33, signifying that the construction market in Vietnam is perceived as sufficiently dynamic.

4.4 Exploratory Factor Analysis of the GB barriers

Exploratory Factor analysis (EFA) using Principal Component Analysis (PCA) is carried out to reduce the number of barriers to a set of significant variables, examine the interrelations among the variables and identify the underlying structure of those variables. To assess the suitability of the data for EFA, a preliminary test is conducted including correlation analysis, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (MSA) and Bartlett's Test of Sphericity.

The correlation matrix shows the 10 variables correlate highly ($r > 0.7$). As this may mean the two variables explain each other instead of being explained to any great extent by other variables (Hair (2006). Based on suggestions of the survey respondents, 5 variables are removed from the analysis. The KMO and Bartlett values for the reduced dataset reach 0.902 (‘meritorious’ according to Hutcheson & Sofroniou, 1999, cited in Field, 2009) and 5141.092 (df=903) respectively. Through the Anti-image Matrices, the minimum KMO value for individual variables is 0.782, which is well above the 0.5 threshold (Field, 2009). The Bartlett's Test of Sphericity is significant at the 0.000 level and therefore the set of 43 variables have sufficient correlations and is suitable to proceed to EFA.

The PCA is initially conducted using Varimax rotation under the presumption that there is no relationship between components. Loading the 43 variables freely into various components with eigenvalue >1 results in the extraction of 9 components, explaining 65.06% of total variance. The Component Transformation Matrix (Appendix E) shows the correlations between components, rejecting the assumption that the components are not related. Carrying out PCA again using Direct Oblimin rotation results in 9 components being extracted with an eigenvalue >1, explaining 65.06% of total variance. From the scree plot, the point of inflexion is at 5 components (Appendix F), which suggests the extraction of 4 components according to Field (2009). EFA is then repeated iteratively following two conditions; first, the number of components is fixed at 4; second, variables with factor loading less than 0.4 or cross loading greater than 0.4 are deleted (using the suggestion of Hair (2006) applied to a sample size of more than 200). Deleting variables sequentially in this way until all conditions are met results in a set of 39 variables loaded under 4 components. This accounts for 51.89% of the variance of the reduced dataset. Table 4 shows the final EFA analysis. To distinguish the four components further, all variables are recoded into four groups.

(Insert Table 4 here)

Component 1 with 9 variables represents Social and Cognitive Barriers (SB); it is the most influential factor with the highest eigenvalue of 12.737, explaining more than 32% of the total variance. The 6 variables in Component 2 reflect Economic and Cost Barriers (EB) – the second most important factor, with an eigenvalue of 2.945 that explains 7.5% of the variance in the data set. Component 3, comprising 11 variables, appears to represent Legislative and Institutional Barriers (LB). Component 4 is associated with the technical requirements and knowledge for GB, consisting of 9 variables that all have negative loadings, signifying that they are Technical and Knowledge Barriers (TB). LB has an eigenvalue of 2.578 while TB's eigenvalue is 1.976, explaining approximately 6.6% and 5% of the total variance respectively.

The Component Correlation Matrix in Table 5 shows the interrelationships between the 4 components. It is evident that EB is relatively independent while SB correlates highly with TB and LB.

(Insert Table 5 here)

4.5 Validating the PCA results

The reliability of the scale is examined by assessing internal consistency with Cronbach's alpha coefficient and item-total statistics. The final dataset's reliability is 0.944, with Cronbach's alpha values of the 4 components of: SB: 0.896, EV: 0.827, LB: 0.904 and TB: 0.881 – all of which are well above the recommended value of 0.7 (Field, 2009). The item-total statistics show that these values will not increase should any of the variables be deleted. It is evident, therefore, that the scale is sufficiently reliable for the results to be interpreted.

The scale is assessed to check its convergent validity and discriminant validity, where "Convergent validity is the degree of confidence that a trait is well measured by its indicators and Discriminant validity is the degree to which measures of different traits are unrelated" (Alarcon & Sanchez, 2015). To inspect the convergent validity of the scale, it is necessary to assess the correlation matrix (Ngacho & Das, 2014). The mean value of inter-item correlations is 0.303 and the minimum inter-item correlations within each component are SB: 0.203; TB: 0.219, which are statistically significant at the 5% level and EB: 0.294; LB: 0.242, statistically significant at the 1% level, indicating valid convergence. The discriminant validity of the scale is assessed through the average variance extracted (AVE) using the pattern matrix and component correlation matrix. According to the Fornell-Larcker testing system, "the levels the AVE for each construct should be greater than the squared correlation involving the constructs" (Alarcon & Sanchez, 2015). As Table 6 indicates, the four components are validly discriminant.

(Insert Table 6 here)

5. Description of the four main components and discussion

Component 1 represents the current social and cognitive conditions, which narrows the entrance for GB, or in short as "Social and Cognitive Barriers" (SB) containing 13 barriers.

SB accounts for 32.659% of total variance and is considered the most important of the 4 constructs. The highest loading is "Lack of public awareness of GB" (0.71), followed by "Lack of expressed interest from project teams" (0.685) and "Misconceptions about GB" (0.678). As mentioned in section 6.2, the respondents believe there has been a rise in awareness of construction professionals, but the public has only been provided with limited, and sometimes misleading, information. A number of property investors have advertised their projects with posters filled with trees and named them either eco or green; while Qian and Chan (2010) stress Akelof's (1970) conclusion that, if the public is given inappropriate information about GB and green labelling remains unregulated, it will result in "an asymmetric information environment in which property developers and other market players may engage in opportunistic behaviour and avoid genuine GBs and products". In a recently published article in the *Architecture Magazine of Vietnam Association of Architects*, (Nguyen, 2016) elaborates eight misconceptions leading to this low public awareness. In summary, the misconceptions are: GB is perceived as having many trees, as "green" is literally understood; architects add trees in their perspective drawing of the buildings to make them look attractive and call them green buildings or green architecture; GB only applies to new or energy efficient buildings, or buildings with certificates; GB is expensive; GB depends solely on the clients or local governments; and GB is only a product of the construction process. Although the article only claims to be the individual view of the author and has not clearly categorised those misconceptions, it provides insights into why the public has a low awareness of GB and the project teams express little interest in achieving GB. Moreover, the survey participants explain that affordable housing is more critical and GB is considered as a nice-to-have feature, therefore the public pays more attention to other criteria such as price and location.

Additionally, the item "Lack of well-known sources of information" can be theoretically associated with either the institutional factor or knowledge factor since this variable appears to be regarded as a reliable established database. The analysis illustrates that this variable is loaded under "Social and cognitive barriers", indicating that lacking the database makes it difficult to select and obtain correct information for GB, leading to communication problems and ultimately hindering the raising of social awareness (Gou, et al., 2013).

Component 2 denotes "Economic and Cost Barriers" (EB), the economic situation and costs with 6 variables associated with GB that prevent its adoption

EB explains 7.551% of the total variance and is ranked the second most important factor. "Long payback period" has the highest loading of 0.809. The payback period is generally an important criterion measuring the economic efficiency of a project. The benefits of GB are mostly gained from energy and water savings, and productivity increases in the operation phase, which may last several decades. Gou, et al. (2013) claim that the return on investment generally takes 20 years and accrues to the final owners or users of the building, not the developers. Therefore, the developers are less likely to adopt GB solely because of its long-term savings. Responses to the open-ended question concerning the *status quo* of GB adoptions also agree that investors tend to focus on such economic benefits as attracting more house-buyers/renters and raising real-estate prices. This aligns with the report of Solidiance and VGBC (August 2013), which states that property developers in Vietnam often prioritise short-term profit over a long-term returns.

High initial costs are often listed as the largest obstacle in studies of the barriers to GB in other markets (Mulligan, et al., 2014; Zhang, et al., 2011) and is the second highest loading under EB at 0.796. Gan et al. (2015), while investigating the opportunities for sustainable construction from perspective of buildings' owners in China, note that "high initial investment coupled with a long payback period present significant barriers to owners". GB is widely considered as requiring additional costs for either design or green technologies and/or materials. Those costs are borne by the investor and are not easily passed to tenants or end-owners (Gou, et al., 2013). In Vietnam, developers are highly sensitive to price and often favour low-cost designs or conventional technical solutions from local suppliers without green building materials or technologies (Solidiance & VGBC, August 2013). The short-term thinking of property developers, who pay more attention to short-term profit than a long-term return, poses a hindrance that can be helped overcome by an improved public awareness of GB. The slowdown of the real estate market due to more restrictive lending conditions and oversupply across several market segments increases price sensitivity and causes an increased hesitation of property developers and buyers to invest in GB.

Component 3 with 11 variables embodies "Legislative and Institutional Barriers" (LB).

LB is the third important construct, explaining 6.611% of the variance. The highest loading is in "Weak enforcement of legislation" (0.822), followed by "Inappropriate attitude of governmental agencies" and "Confusion arising from parallel policies/legislation" (0.811 and 0.801, respectively). The findings are similar to the situation in mainland China, where the government lacks serious enforcement or proper implementation of legal controls over the Energy Conservation Law and building standards (Qian & Chan, 2010). As Vu (2015) points out, the building standards in Vietnam are not enforced or strictly followed, considerably affecting its GB market and construction industry.

In terms of the inappropriate attitude of the authorities, Gou, et al. (2013) review U.S. GB development to find that the developers do not always take advantage of the nine popular incentives offered by the government there. The reason is that the governments tend to "move slowly and observe due process", which cannot meet the demand for quick decision making by developers. Furthermore, respondents in the survey claim that the authorities in Vietnam follow a 5-year-period, which negatively affects short-term vision and decisions. Corruption is another likely serious issue that prevents transparency in procurement and other construction project processes (Kenny, 2007).

It is noteworthy that "Slow and unwieldy administration process in policy making", being ranked the highest of all the listed barriers, has a loading of .700. Evidenced from the policies issued, the 2012 National Strategy on Green growth was the first to mention GB and the objective of its promotion. Since then, there has been only one National Construction Code enacted on energy saving in buildings, the QCVN 09:2013, which has been criticised as difficult to follow and not fully enforced. The regulatory environment is still undeveloped and support from the government for GB is limited to conferences and orientation, providing little incentive to help GB penetrate the construction market (Solidiance & VGBC, August 2013).

Component 4, containing 9 items with negative loadings, represents the technical requirements and knowledge necessary for adopting more GB, which implies that those items are statistically "Technical and Knowledge Barriers" (TB) to GB.

TB is the last component extracted and explains only 5.067% of the total variance. The highest loading is found in "Insufficient cost-benefit data from interdisciplinary research" (-0.813). This type of data is more obtainable in countries such as the U.S. (Kats, 2009; Nalewaik & Venters, 2009), U.K. (Chegut et al., 2014), Australia (BCI Economics, 2014) and China (Liu et al., 2014), where GB has occurred in large numbers and has been the focus of research since 2000. In Vietnam, however, it is not yet fully studied. Respondents from the survey state that GB has only been constructed in the last 5 years and there is a lack of demonstration projects to collect and investigate the cost-benefit data. "Lack of integrated design for life cycle management" and "Lack of technical understanding of designers, builder and project teams" are the second and third of the variables under TB with rotated factor loadings of -0.800 and -0.751. The survey's participants commented that the project team and construction workers have not yet acquired sufficiently deep knowledge and necessary skills related to GB design, materials and technology. This increases the cost and time of the design and construction phase of GB projects, thus increasing total cost.

6. Conclusions and policy recommendations

GB in Vietnam is still in its early stages and facing numerous challenges/barriers. This study collects and analyses the opinions of 215 professionals to investigate the current situation and major challenges. Legislative barriers are ranked the highest. Both industry players and government officers participating in the study expressed serious concerns regarding the slow response and unwieldly policymaking process of the government in reacting to changes and new trends in the market. As Vietnam is a one-party country and the government maintains a high level of control over the market, the lack of a clear signal from the authorities to either endorse or disapprove GB has had a considerable impact on both construction professionals and the public.

PCA of EFA is applied to reveal four main components preventing GB adoption, namely Social and Cognitive, Economic and Cost, Legislative and Institutional barriers and Technical and Knowledge requirements. This is similar to Yang and Yang (2015) study of sustainable housing in Australia, in which the barriers are also categorised into four factors comprising technological and design, economic, sociocultural and institutional factors. However, while these study findings show that the economic factor is the most important influence in implementing sustainable housing in Australia, this study revealed that social and cognitive barriers explain the largest amount of total variance, accounting for the major challenges for GB adoption in Vietnam. It can be seen that when GB development is still in its early stages, the awareness of the construction industry and the market for genuine "green" features that distinguish between a GB and a conventional building are less than adequate. This results in inappropriate information and false green labelling on buildings. Consequently, the public is soon disappointed and sceptical of green labelling, leading to other obstacles in the GB adoption pathway such as low demand and hesitation to invest in green properties.

The Vietnam government deploying its leadership role and providing increased support through policy instruments to address the GB barriers would help in further implementing the 2012 National Green Growth Strategy and towards a sustainable construction industry. Having one agency, similar to the Singapore Building and Construction Agency, responsible for promoting GB projects and obtaining support from all relevant departments would improve the efficiency of the decision-making framework for GB development. This decision-making model could be first piloted in Hanoi and Ho Chi Minh City before considering application to the whole country.

The government is needed to be more responsive to the sustainable trend in the construction industry by promulgating a strong legal statement coupling regulations with incentives to stimulate a greater market demand for GB. This could start with issuing a clear guideline of what is genuine GB, regulate green labelling and develop a reliable database for green technology, products and materials. These policies provide a clear definition of a genuine green building project that can help prevent "greenwash" by increasing the awareness of both construction professionals and the public. In the current economic and social conditions, it is unlikely that the government would offer grants or soft loans for GB developers. Such advocacy policies as investing in demonstration projects and integrating affordable housing schemes and GB schemes through green procurement such as requiring green features at the tendering stage, would incentivise more GB suppliers. Expedited permit and tax exemptions are also two potential widely used policies to encourage GB projects. For instance, eligible GB certified projects should be considered as meeting the National Construction Code on energy saving in buildings.

Training and knowledge sharing workshops and short courses about GB design, materials and technologies such as energy usage simulation software would be useful for both industry professional and government officers. Systematically including sustainability and green design standards in engineering and architecture courses would support the long-term development of GB by building the knowledge, primary experience and interest relating to GB that are essential for students to apply in future GB projects (Kelly, 2007).

A limitation of the study is that over 80% of the respondents either did not know what certification their recent project had or had nothing certified with GB rating systems. Also, the SDs of the variables ranging around 1 suggests that the respondents may not be well informed in judging what the barriers are; and approximately 50% of the variance explained is relatively low for a Factor Analysis after rotation. Future research in Vietnam could be based on the results of this study to expand to more professionals outside Hanoi and HCMC and compare the responses between different types of respondents and areas with different economic growth rates. More cross-cultural studies are needed to investigate which GB policies may be most suitable for Vietnam and other similarly placed countries from the lessons learned to date in other countries and the mechanisms that could best catalyse the adoption of GB.

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Appendices

Appendix A

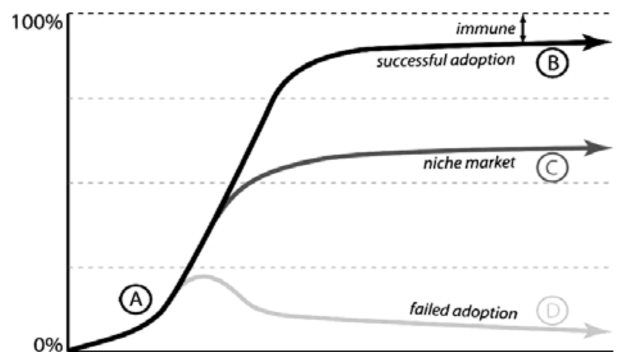
Rating systems applied in Vietnam

Rating system	Organisation	Country of origin	Definition
Leadership in Energy & Environmental Design (LEED)	U.S. Green Building Council (USGBC)	United States	A point based rating system that rewards points across several areas that address sustainability issues such as water, energy, materials.
LOTUS	Vietnam Green Building Council (VGBC)	Vietnam	A set of voluntary market-based green building rating systems developed by the VGBC specifically for the Vietnamese built environment.
Excellence in Design	International Finance	United	Certify based on EDGE standard that articulates a

for Greater Efficiencies (EDGE)	Corporation -World bank group	States	universal definition for a green building: 20 percent less energy use, 20 percent less water use, and 20 percent less embodied energy in materials.
Green Star	Green Building Council Australia	Australia	Australia's trusted mark of quality for the design, construction and operation of sustainable buildings, fit-outs and communities.
Green Mark	Building & Construction Authority	Singapore	A benchmarking scheme that incorporates internationally recognized best practices in environmental design and performance.
Green Globe Standard	Green Globe Ltd.	United States	A structured assessment of the sustainability performance of travel and tourism businesses and their supply chain partners
EarthCheck	Australian Government Sustainable Tourism Co-operative Research Centre	Australia	A scientific benchmarking certification and advisory group for travel and tourism developed based on the international standards relative to greenhouse gas protocols, responsible tourism and certification.

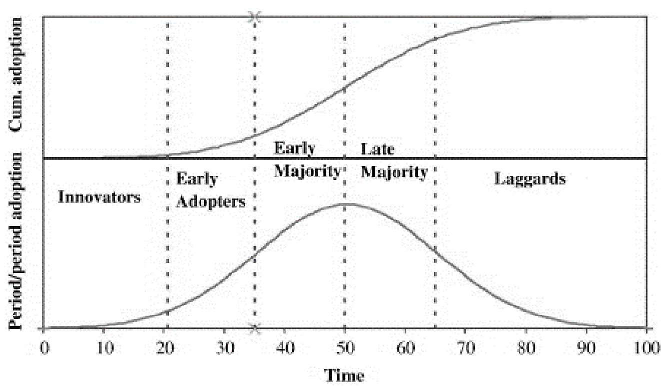
Appendix B

Adoption of green construction (adapted from Hoffman & Henn, 2008, p. 394)



Appendix C

Stylised diffusion curves (adapted from Meade & Islam, 2006)



Appendix D

Barriers to GB perceived in developed, developing markets and in Vietnam

No	Barrier to GB adoption	*Key reference*		
		Developed market	***Developing market***	***Vietnam***
1	Unavailable/unreliable sustainable technology/materials	*(Gou, et al., 2013)*	*(Teng et al., 2015)*	*(Tatarski, 2013)*
2	Insufficient cost-benefit data from interdisciplinary research	*(Chan, et al., 2009)*	*(Samari et al., 2013)*	*(Le, 2014)*
3	Lack of integrated design for life cycle management	*(Mulligan, et al., 2014)*	*(Qian & Chan, 2010)*	

4	Lack of professional education and training	*(Yang & Yang, 2015)*	*(Isa, et al., 2013; Samari, et al., 2013)*	*(Le, 2008; Solidiance & VGBC, August 2013)*
5	Lack of methods to consistently define and measure sustainability	*(Gou, et al., 2013)*	*(Samari, et al., 2013)*	*(Pham, 2015)*
6	Lack of information	*(Bond, 2011; Yau, 2012b)*	*(Zhang, et al., 2011)*	*(Vu, 2015)*
7	Lack of demonstration projects	*(Chan, et al., 2009)*	*(Potbhare, et al., 2009)*	
8	Lack of technical understanding of designers, builders and project teams	*(Li et al., 2011; Mulligan, et al., 2014)*	*(Ahn et al., 2013; Isa, et al., 2013)*	*(Solidiance & VGBC, August 2013)*
9	Different accounting methods	*(Chan, et al., 2009)*		*(Le, 2014)*
10	High risks associated with investment	*(Yang & Yang, 2015; Zhao, et al., 2016)*	*(Qian & Chan, 2010)*	
11	High initial costs	*(Ahn, et al., 2013; Li, et al., 2011)*	*(Shen, et al., 2017)*	*(Le, 2014; Vu, 2015)*
12	Inadequate/inefficient fiscal incentives	*(Yang & Yang, 2015)*	*(Samari, et al., 2013; Shen, et al., 2017)*	*(Le, 2014)*
13	Long payback period	*(Ahn, et al., 2013; Gou, et al., 2013)*		
14	Inappropriate pricing of electricity and other energy commodities		*(Qian & Chan, 2010)*	*(Solidiance & VGBC, August 2013; Tatarski, 2013)*
15	Lack of an explicit financing mechanism	*(Gou, et al., 2013)*	*(Qian & Chan, 2010)*	*(Le, 2014)*
16	Costs incurred in seeking certification	*(Gou, et al., 2013)*		*(Sayyed & Do, 2015)*
17	Split incentives due to ownership structure	*(Bond, 2011)*		*(Solidiance & VGBC, August 2013)*
18	Reluctance to adopt change	*(Choi, 2009)*		
19	Insufficient brand recognition and competitive advantage	*(Yang & Yang, 2015)*		
20	Lack of social science in climate change and natural resource preservation	*(Yang & Yang, 2015)*		
21	Misconception and lack of public awareness	*(Chan, et al., 2009; Yau, 2012a)*	*(Teng, et al., 2015)*	*(Solidiance & VGBC, August 2013; Tatarski, 2013)*
22	Contested functionality for end users	*(Yang & Yang, 2015)*		
23	Behaviour of occupants	*(Mulligan, et al., 2014)*	*(Ahn, et al., 2013; Chen et al., 2017)*	
24	Larger homes and smaller households	*(Bond, 2011)*		
25	Lack of interest from clients	*(Gou, et al., 2013)*	*(Samari, et al., 2013)*	*(Solidiance & VGBC, August 2013)*
26	Lack of interest from project teams	*(Gou, et al., 2013)*	*(Potbhare, et al., 2009)*	
27	Lack of GB movement		*(Potbhare, et al., 2009)*	*(Le, 2014; Pham, 2015)*
28	Different level of regional economic development		*(Teng, et al., 2015)*	
29	Lack of collaborative integration	*(Yang & Yang, 2015)*	*(Zhang, et al., 2011)*	*(Pham, 2015)*
30	Lack of a stakeholder communication network	*(Choi, 2009; Li, et al., 2011)*	*(Zhang, et al., 2011)*	*(Pham, 2015)*
31	Slow and unwieldy administration processes in certifying and policy making	*(Chan, et al., 2009)*	*(Qian & Chan, 2010)*	
32	Lack of a comprehensive code/policy package to guide action on sustainability	*(Yang & Yang, 2015)*	*(Isa, et al., 2013)*	*(Sayyed & Do, 2015)*
33	Duplication and confusion arising from parallel policies/legislation	*(Yang & Yang, 2015)*		
34	Negative impact of public policy		*(Shafii & Othman, 2006)*	*(Minh Do & Sharma, 2011)*
35	Inappropriate attitude of government agencies	*(Chan, et al., 2009)*	*(Samari, et al., 2013)*	
36	Weak enforcement of legislation		*(Qian & Chan, 2010)*	*(Vu, 2015)*

37	Unorganised nature of the construction industry		*(Potbhare, et al., 2009)*	
38	Lack of well know sources of information	*(Gou, et al., 2013)*	*(Potbhare, et al., 2009)*	
39	Price sensitivity			*(Solidiance & VGBC, August 2013)*
40	Constraints of existing infrastructure			*(Tatarski, 2013)*
41	Lack of sustainable energy			*(Tatarski, 2013)*

Appendix E

First EFA result - Component Transformation Matrix

Component	1	2	3	4	5	6	7	8	9
1	.516	.491	.409	.278	.292	.239	.238	.152	.158
2	-.510	.546	-.198	.570	-.144	-.193	-.080	.055	.106
3	.462	-.385	-.458	.558	-.028	-.103	-.073	.305	-.084
4	-.438	-.487	.348	.396	.498	.152	.147	-.025	.000
5	-.088	-.204	.449	-.008	-.548	-.177	.159	.566	.268
6	-.189	.111	-.092	-.137	.068	.603	-.362	.580	-.298
7	-.127	.002	-.468	-.271	.325	.037	.376	.286	.601
8	.026	.098	.147	-.181	.485	-.674	-.344	.334	-.127
9	.090	-.107	.108	.067	.000	.144	-.703	-.174	.648

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix F

Second EFA result - Scree plot of components