Performance Criteria Priorities in Green Buildings: A Proof-of-Concept Study

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Abstract

Green Buildings (GBs) are becoming increasingly popular as an alternative to resource-intensive traditional buildings. Like any other construction project, GB projects are subject to project management-related criteria, including cost, quality, and schedule performance. In addition to these criteria, GBs also include sustainability performance criteria. As a GB is being developed, some criteria may be prioritized over others. To understand the development and sustainability performance of GB projects, it is necessary to understand the priorities given to different performance criteria and the factors resulting in such priorities. Using the findings from an online survey of 46 GB professionals based in Australia and some Asian countries, it is realized that project management criteria are typically ranked higher in GB projects compared to sustainability performance criteria. The survey has also revealed that these priorities of performance criteria are driven by the choice of owner/developer, obligations from state development authorities, developer's market position, investor requirements, etc. Performance criteria priorities in GBs are also found to be associated with regional factors such as climate, availability of natural resources, regulations, and culture. The findings of this study will support the theoretical development in the field of GB project management by leading to in-depth inquiries in this area.

Keywords: Green Buildings; Performance criteria; Online survey; Sustainability; Project management

1 Introduction and Literature Review

Buildings are an essential part of the built environment owing to their critical role in human lives. Typically, the construction and operation of buildings associates with large amounts of resources. To mitigate these environmental issues, Green Buildings (GBs) are being developed which are usually more environment-conscious, socially habitable and even economically affordable in long terms. While the GB sector is still a niche sector of the construction industry, the knowledge associated with the management and development of GB projects is evolving.

1.1 Performance Criteria in Green Building projects

The conventional performance measures of time, cost, and quality have dominated the construction project and these terms have been collectively termed as the 'iron triangle' by (Atkinson, 1999). Although, for a number of recent decades, the iron triangle has found wide-spread usage, this triad of performance criteria is constrained to project management performance only. While not as widely followed as the iron triangle, the criteria of sustainability and safety are also critical in determining project success. The success of infrastructure and buildings in the future will be determined on the

basis of the well-being of end-users, sustainability, energy efficiency, as well as the flexibility and maintainability of developments (Toor & Ogunlana, 2010). While sustainability as a performance criterion is expected to become *modus operandi* in a typical construction project development in future, usually it is not considered a performance criterion in developments other than sustainable construction projects.

In GBs, project success or project performance is inherently dependent on sustainability criteria alongside project management criteria. The term "project management-related criteria" as informed by Cooke-Davies (2002) is used in this study to collectively address time, cost, and quality performance. There is a general lack of studies inquiring performance criteria in Green Building projects. A notable study in this regard was conducted by Ahmad, Aibinu, Stephan and Chan (2019) in which the associations among project management-related criteria and sustainability performance criteria were inquired for GB projects. While studies have been conducted which individually address cost, schedule, and quality performance in GBs, studies collectively considering performance criteria for GBs are generally lacking.

While GB projects continue to be developed under conventional project development and management practices, it becomes imperative to compare the priorities towards sustainability criteria and priorities towards project management-related criteria. Although the need of including sustainability as a performance criterion in construction projects is proposed in the literature, to date, no study is found that compares the priorities of sustainability performance criteria alongside project management-related criteria. Regarding the priorities of performance criteria for GB projects, a research gap exists which needs to be filled for contributing to the theory of GB project development and management. Accordingly, the objectives of this study are: (1) to determine how the project management-related and sustainability-related performance criteria are prioritized in GB projects; and (2) to investigate the factors influencing priorities of performance criteria in GB projects.

2 Methodology

With the scope of this study limited to Green Office Building projects, the study objectives are addressed by the findings from an online survey. Findings from three semi-structured interviews are also used to support the survey findings. To address the study objectives, the online survey posed three key questions: (1) Respondents to specify the priorities of performance criteria for actual Green Office projects in their regions of belonging, (2) Respondents to rank the factors influencing priorities of performance criteria, and (3) Respondents to indicate if regional context affects priorities of GB performance criteria.

For the first question, survey respondents were provided with the list of seven criteria and they could indicate the priorities of those criteria based on their previous experiences of GB projects. To inquire factors affecting performance criteria priorities, a question regarding this was included in the survey. The organization of inquiry was such that, first the survey participants were questioned about the ranks of performance criteria, and subsequently presented with a list of factors responsible for the priorities of performance criteria. When asked to rank the factors in the order of their impact on performance criteria priorities, 44 responses were obtained.

The question was asked in a way that an initial list comprised of 8 factors was presented to the respondents. The factors in the list were basically solicited from literature and through interviews with two Australia-based GB professionals who both had the experience of being involved in more than 20 green office projects during their professional careers. The respondents of online survey were

asked to rank the factors in the list from Rank-1 (Most important) to Rank-8 (Least important), and also had the option to declare if they found a factor in the list as irrelevant to the question, by selecting the NA (Not Applicable) option. Further, the respondents also had the option to mention factors in addition to those already listed, in case they found it necessary.

To conduct the survey, a list of GB professionals was compiled using the information available on online databases of the GB certification systems i.e., United States Green Building Council (USGBC), Green Building Council of Australia (GBCA), and Singapore Green Building Council (SGBC). The professionals experienced in GB development were contacted to participate and overall, 46 participants from Australia and some Asian countries contributed to the survey. The findings of the survey were supported by three semi-structured interviews conducted with GB professionals in the UK. All these interview participants had both the experience of Sustainability and Design consultancy. The interview participants were highly experienced building professionals with a minimum of 6-year experience in GB projects.

3 Results and Discussion

3.1 Performance Criteria Priorities in Green Office Buildings

In the online survey, 46 respondents provided the priorities/ranks of different performance criteria of GB projects (see Fig. **1**). Resulting from the provision in online survey, most respondents (87%; n=40) highlighted the performance criteria priorities according to different regions while agreeing with the assumption that the regional context affects these priorities. However, the rest of the participants (13%; n=6) did not agree with this assumption and provided their response according to the majority of projects they had worked on.

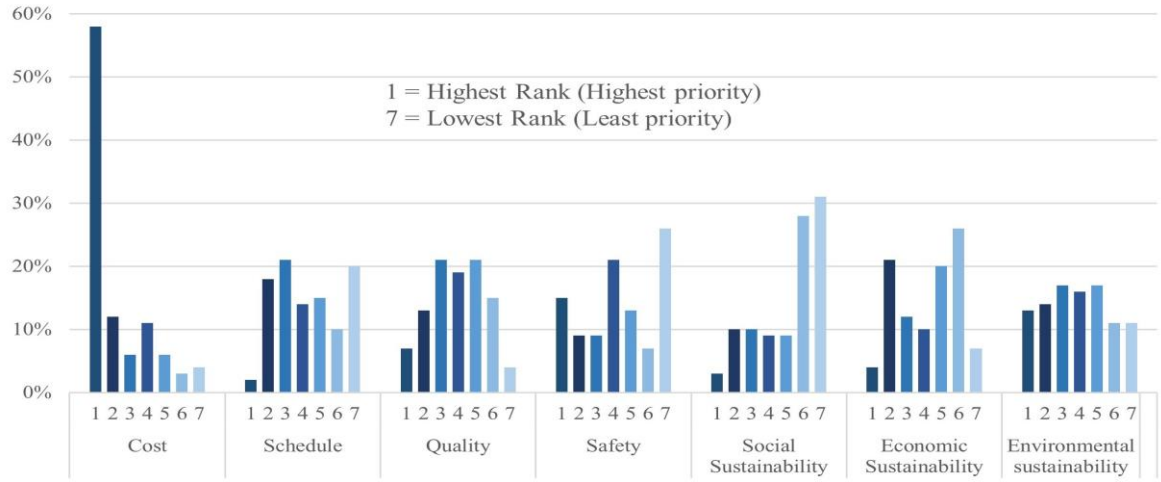

Fig. 1: Overall ranks of performance criteria in green building projects

Table 1: Descriptive statistics relating to performance criteria findings

Performance criterion	Mode	N (%) for mode	Mean	St. Dev	Skewness	Ranks
Cost	1	59	2.13	1.72	1.51	1
Quality	3, 5	22	3.91	1.55	-0.11	2
Environmental sustainability	3, 5	17	3.85	1.90	0.11	2
Schedule	3	22	4.33	1.85	0.13	3

Performance criterion	Mode	N (%) for mode	Mean	St. Dev	Skewness	Ranks
Safety	7	26	4.33	2.13	-0.17	3
Economic sustainability	6	26	4.28	1.73	-0.19	3
Social sustainability	7	30	5.17	1.84	-0.74	4
Note: Arithmetic mean values calculated by dividing the sum of sampled values by the number of items						

Based on the analysis of findings it can be seen that some criteria have clear trends such as cost, quality, social sustainability, and environmental sustainability while other criteria exhibit multiple trends requiring the use of descriptive analysis (see **Table 1**). For assigning relative ranks to the performance criteria, mean value technique is used. This technique is often used when key factors have to be highlighted amongst a number of factors (Moungnos & Charoenngam, 2003). In this study, small mean-rank values imply higher importance given to a performance criterion, while the large mean values imply lower importance given to a performance criterion. Since quality and environmental sustainability had similar mean values, they can be assigned the same rank i.e., "2". Furthermore, as schedule, safety, and economic sustainability had similar mean values, they can also be assigned the same rank i.e., "3".

Skewness is a measure of the asymmetry of a variable about its mean. In Table 1, a large negative skewness value suggests a relatively higher number of respondents opting for a low priority of a performance criterion and vice versa. The highest positive and highest negative skewness values are noticed in case of cost and social sustainability, respectively.

While the mean values provide overall ranks, they may not respond to the dispersions in data distribution. Unlike the case of cost and social sustainability (Fig. **1**) with singular trends, schedule, safety, and economic sustainability seem to have multiple trends as can be seen in terms of multiple mode values shown in Table 1.

The multiple trends in dataset for some performance criteria mean that these criteria may have low priorities in some projects while high priorities in some other projects. For instance, schedule, social, and economic sustainability performance have a mix of low and high ranks according to different respondents. The data analysis shows that cost performance is the most highly ranked (R-1) performance criterion according to mean value and its data distribution resembles a Pareto distribution with highly positive skewness. Quality performance curve has a normalized distribution and based on mean value it is ranked second. However, the multiple mode values for this criterion (i.e., 3 and 5) suggest that it can take multiple priorities depending on the project context. In case of schedule performance, the distribution of survey responses is such that either it is highly prioritized, or it has low priority. It is ranked 3rd based on the mean value. The data distribution in case of the safety criterion suggests that it could be a high, medium, or a low priority criterion. Safety is also ranked third based on the mean value. The data in case of environmental sustainability is evenly distributed, suggesting a high to medium priority for this criterion. Based on mean value, it is ranked 2nd. In case of the economic sustainability, the data has multiple peaks, suggesting both, a high as well as a low priority. Based on mean value, it is ranked 3rd. In terms of social sustainability performance criterion, data distribution is strikingly right skewed, suggesting a low priority. Based on mean value, it is ranked 4^{th}.

It can be argued that the overall project management-related criteria comprised of cost, quality, and schedule have relatively higher priorities as they are ranked 1^{st}, 2^{nd}, and 3^{rd} respectively. However,

sustainability criteria in comparison have relatively lower priorities as 2nd, 3rd, and 4th ranks are given to environmental, economic, and social sustainability respectively. Within the sustainability criteria, social sustainability has relatively lower priority than other criteria.

A variation in the priorities towards performance criteria is not surprising, as even within a region, projects are developed with different considerations and different priorities for performance criteria. While underperformance on a criterion can be acceptable for one project, it may be considered an absolute failure in another project. For instance, a schedule delay of 5 days to deliver better functionality in a particular IT project may not be given much attention. However, similar delay in developing an Olympic village, can be considered a serious setback (Müller & Turner, 2007).

A potential reason for the sustainability performance criteria to be ranked lower than the project management criteria is because sustainability is often perceived in the construction industry as an added value, and not as an intrinsic requirement. As evident from survey responses, managing the allocated project budget remains the top priority for every project to safeguard the interest of stakeholders. For a project, the schedule, built quality and safety cannot be compromised. Sustainability is prioritized if compliance is required for the issuance of building permits, in case the project is located in a country with strict legislations. Otherwise, sustainability is an added value to seek the interest of multi-national companies, with stringent set of corporate social responsibilities, such as CISCO, Google, Unilever or Citibank. These priorities identified from the survey were corroborated by another interview participant (UK-M-5), according to whom, the criteria receiving the most attention is the project cost, and it is always hard to maintain a balance between schedule, cost and quality. Following cost, reducing time on construction site is a priority, followed by quality performance, notably to reduce ongoing maintenance. Although safety receives greater attention than sustainability, it is often compromised when cost is an issue. Projects can be approved even with the minimum safety requirements. The reason why sustainability sometimes becomes a priority is because certain sustainability thresholds need to be satisfied to meet regulatory requirements. This reasoning provided by the interview participant also points to the fact that project management-related criteria often lead to direct and immediate benefits for project sponsor and project team, while sustainability and safety performance criteria may not offer tangible benefits and may only be pursued for regulatory purposes.

During the development of a GB project, the priorities towards performance criteria may also shift during different stages. As mentioned by an interview participant (UK-M-6), in the early stages of most GB projects there is a strong desire to achieve a sustainable building. However, when the project starts and as the client starts to pay the bills, cost becomes a key focus. When the project is being executed on site, schedule becomes the prime concern. Once the project is near completion, the client begins to notice quality issues, for instance those resulting from employing cheaper contractor. Years after project completion, the schedule delays incurred in development become insignificant and the sustainability and quality of project become a concerning matter. This argument by the interview participant indicates that the project management criteria that are more prioritized are usually short-lived and last up to project delivery. Other criteria such as sustainability performance are significant throughout the project's life. However, lack of priority towards sustainability criteria during the project development results in overlooking such core project aspects which are difficult and costly to address once a project becomes operational and the need of sustainability is felt.

An overwhelming focus towards cost and schedule performance in a GB project development, may have adverse effects on sustainability performance. According to an interview participant (UK-M-1),

"The thing which matters most in projects is the timely delivery of design and construction. Both the schedule and cost matter a lot in GB projects. It is always hard to maintain a balance between schedule, cost and quality. It's very difficult to keep up the sustainability performance in case speed of project delivery is the focus. Normally when focussed on project delivery time, the project team forgets the timeliness of sustainability consultants. Sustainability is ignored when the sustainability consultants are not kept on-board while the schedules are being established. This doesn't happen all the times, but it happens once in 10 times." Hence, it can be argued that a focus on time and cost performance instead of sustainability performance can have negative effects for building sustainability.

3.2 Factors Influencing Priorities of Performance Criteria

The factors which affect the priorities of performance criteria, can be considered as the driving factors of project development. It is important to account for such driving factors as they are the underlying reasons of GB project priorities. Upon analysing the responses (shown in Fig. 2), it was realized that the ranks provided to some of the factors including *Owner/Developer's choice*, and *Obligations from state development authorities/Government planning approvals* had relatively clear trends and both these factors were ranked high (R-1 to R-3) in terms of significance by the majority of respondents. The high ranks of these factors imply that they indeed influence performance criteria priorities in GBs. *Investor requirements*, and *Developer's market position* also had trends similar to each other and were left-skewed with most responses for the 4th rank. The responses in case of the factor of *Design team's advocating* were majorly skewed towards right suggesting a 5th to 6th rank for it. Two other factors i.e., *Life Cycle Cost (LCC)* and *State incentives* had multiple peaks for the extreme ranks (i.e., R-2 and R-8) and a trough in between, suggesting that in some cases these factors can become very important while in some other cases they can become least important in affecting performance criteria priorities. The factor of *user requirements*, however, was found to have no trend at all and had a spread of responses between R-2 and R-6. Based on overall analysis, it can be concluded that all the ranked factors are highly relevant in affecting performance criteria priorities of GB office projects.

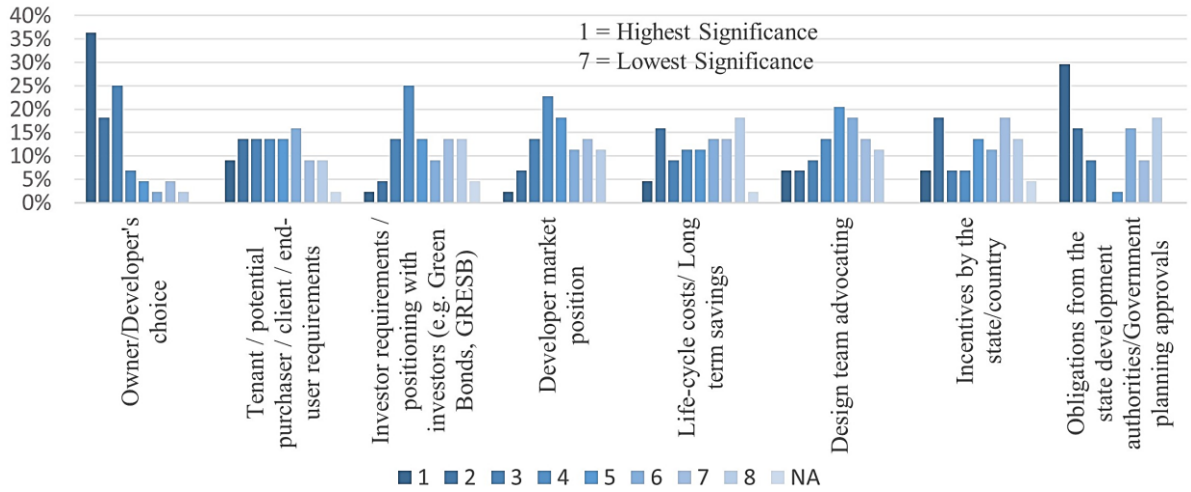

Fig. 2: Ranks of factors influencing priorities of performance criteria in GB projects

In addition to the list of factors provided in the online survey, some other factors were also mentioned by respondents that can influence the choice and priorities of performance criteria in Green Office projects. These additional factors include company brand and ability to attract talent, GB consultant's

advocating, total investment cost, technology and workmanship, corporate image, marketing, and culture. The preselected factors (provided in closed-ended question in survey) and the new factors (identified in the open-ended question in survey) are compared with each other (see Fig. 3). Their cross-comparison shows that the list of factors presented to participants for ranking purpose was reasonably exhaustive.

Fig. 3: List of participant-proposed factors and their resemblance with preselected factors

3.3 Regional Factors Affecting Priorities of Performance Criteria

The difference in priorities of GB project-related performance criteria is governed by the regional context, to some extent. For instance, delivery speed may be a major concern in a region because of the overall fast-paced market there, while for some other regions delivering sustainability may be a more pressing issue because of the regional regulations for it. A question regarding this aspect was responded by 46 survey participants. According to most of the respondents (87%), green office projects **definitely** have differences in priorities of performance criteria resulting from regional differences. According to some respondents (9%), the difference in priorities is **probably** due to regional differences while a small percentage of respondents (4%) **totally disagree** that the regional context affects performance criteria priorities.

For the majority of respondents (87%), performance criteria priorities are influenced by Geo-Specific factors. When asked to provide reasons why priorities of performance criteria in green office projects depend on the difference in regional context, the respondents provided a variety of reasons. The responses found in case of this open-ended question were analysed and a repetition was found in the factors mentioned by respondents. The reasons why performance criteria priorities depend on regional context include climate (number of survey participants indicating this reason=14), natural resource availability (n=11), regulations (n=9), culture (n=7), knowledge and awareness of sustainability (n=6), regional economy (n=5), market demand and maturity (n=3), maturity and innovation in construction methods (n=2), and building product availability (n=1).

3.3.1 Climate

Each region has unique climatic conditions and since building design is highly influenced by ambient conditions, a difference in performance criteria priorities of GB projects can be expected for different regions. According to survey findings, outside conditions impact the extent of energy efficiency and occupant comfort. Highly energy-efficient natural ventilation strategies can be adopted in areas with pleasant climate than in areas with extremely high or low temperatures. Furthermore, heat recovery performances vary in different regions, for instance in Singapore, the sensible heat recovery is not as efficient as compared to enthalpy recovery.

3.3.2 Regulations

Different regions can have different regulations, policies, and statutes for built environment which need to be complied with, resulting in a difference of performance criteria priorities. According to survey findings, while some countries require green development by law, this is voluntary in some other countries. Furthermore, different states and councils provide different incentives and benchmarks for different areas resulting in a difference in performance criteria priorities.

3.3.3 Natural Resource Availability

Different regions are associated with different levels of natural resource availability, therefore resulting in a difference in performance criteria priorities of GB projects. According to survey findings, while some regions have abundance of some natural resources they lack in other aspects. For instance, Hong Kong has a huge waste issue, but energy is not a problem for it.

3.3.4 Building Product Availability

Different regions are associated with different availability of building products, particularly sustainable building materials and systems, which can result in variations of delivery time and cost. This can result in a difference in performance criteria priorities.

3.3.5 Maturity and Innovation in Construction Methods

Different regions are associated with varying levels of maturity and innovation in construction methods, which affects performance criteria priorities of GB projects.

3.3.6 Regional Economy

Regional economy has a strong impact on the construction industry and on all its allied disciplines and niche areas. Different regions have varying economic conditions resulting in a difference in performance criteria priorities for GB projects.

3.3.7 Knowledge and Awareness of Sustainability

Different regions are associated with varying levels of knowledge and awareness regarding built environment sustainability. Since such awareness is instrumental in motivating project stakeholders for developing GBs, it also results in difference of performance criteria priorities. According to some survey participants, awareness of the availability of resources is an important factor that motivates people towards resource conservation. For instance, in case of sustainability awareness, the difference between Sydney and Melbourne would be less. However, if a comparison of these cities is made with Adelaide or Hobart, awareness could be a significant factor, because Sydney and Melbourne are major business centres while Adelaide or Hobart are small capital cities. They may be aware of more established green building schemes or energy efficiency, but less aware of the formal side of sustainability.

3.3.8 Culture

Difference in regional cultures influence end-user perceptions, tolerances, and priorities, therefore resulting in a difference in performance criteria priorities for GB projects. While reflecting on this, a survey participant opined that end-user habits impose different design criteria.

3.3.9 Market Demand and Maturity

Different regions are associated with varying built environment related market demands. Some markets can provide better Return on Investment (ROI) than others, therefore resulting in a difference

in performance criteria priorities for GB projects. According to some survey participants, some markets are more mature than others and can go beyond conventional performance.

4 Conclusion

Based on the findings of online survey, it is realized that in GBs, project management performance is prioritized over sustainability performance. The most importance performance criterion considered is cost performance and the least prioritized criterion is social sustainability performance. Such lack of attention towards sustainability performance criteria becomes a matter of much concern when performance on one criterion such as environmental sustainability needs to be sacrificed to achieve high performance on a highly prioritized criterion such as cost performance. The priorities of performance criteria are decided by the owner/developer, obligations from state development authorities, developer's market position, and investor requirements. Performance criteria priorities in GBs are also associated with regional factors such as climate, availability of natural resources, regulations, and culture. Owing to the limited number of survey responses, some of the findings of this study can only be used as a proof of concept. Studies with large sample sets need to be conducted to understand the priorities of performance criteria in further detail.

Also, the lack of priority of sustainability performance criteria compared to project management criteria is a matter requiring debate among academics and industry stakeholders to assess the outcomes of such a practice and to provide mitigation measures. In addition, this study has lead to some questions which need to be addressed by future research. For instance, (1) what are the scenarios in which preferences towards project management criteria has adverse effects on the sustainability performance criteria? Also, how critical can those adverse effects become? (2) which stakeholders are typically responsible for the prioritization of project management criteria and how a relatively balanced attention towards different performance criteria can be ensured?

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