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# Challenges and Issues in Maintaining Green Building Features and Facilities

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**Abstract**

The integration of green building features and facilities has received considerable attention in recent years due to their potential for reducing environmental impact and promoting sustainable practices. Despite the numerous benefits associated with green buildings, maintaining these features and facilities over time presents considerable challenges and issues. Thus, this paper aims to identify the maintenance challenges and issues within Green Building Index (GBI) certified green office buildings in Malaysia through a comprehensive literature review, questionnaire surveys and interviews. The study identifies the key maintenance challenges, assesses the likelihood and impact, and proposes effective solutions. Throughout the study, both challenges and issues highlighted that maintenance management is likely related to the financial availability of an organization and the shortage of skilled maintenance personnel. Additionally, the study emphasizes the importance of developing a comprehensive financial plan in advance as a way to investigate the efficiency and effectiveness of maintenance management and prevent budget overspending during maintenance work. By addressing this challenge, the study provides fundamental knowledge for sustaining the functionality of green buildings and ensuring their long-term viability.

## 1. Introduction

According to Environmental Protection Agency (EPA) [1], green building encompasses constructing sustainable buildings designed to be environmentally responsible and resource-efficient throughout their lifecycle. This concept is implemented within the framework of a defined rating system, which provides guidance on "green" measurements. In Malaysia, the Green Building Index (GBI) is used as the recognized green rating system. GBI encourages sustainability in the built environment, enhances public awareness of environmental issues, and cultivates a generational sense of responsibility [2].

Green buildings are typically constructed with remarkable design and aesthetic qualities, transforming them into iconic landmarks that define specific areas. Beyond their visual appeal, the features and facilities of these buildings embody the structural identity and play a pivotal role in supporting the daily operations and activities of their occupants. However, maintenance challenges may arise due to uncontrollable factors, precipitating issues that compromise various building features and facilities [3]. Maintaining buildings is essential for the prolonged viability of amenities, and they should be preserved to retain their investment value over a long time. Therefore,

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proper maintenance management is indispensable and should be a common practice in all nations to maintain the condition of buildings and their functionality [4].

Existing literature has extensively documented the benefits of green buildings, especially their contribution to the reduction of energy consumption and low upkeep [5] and their benefit as the antidote to sick building syndrome [6]. There are also intensive studies on the challenges that hinder green building development and integrating it into everyday life, such as the high cost of green technological features, low demand, low return on investment and lack of awareness [7-10]. Additionally, some studies point out the drawbacks of implementing green building features, revealing that green building features such as solar panels and rainwater harvesting systems often achieve only 28% to 71 % of their potential efficiency [11]. Locally, issues, such as faulty rainwater harvesting systems, further exemplify the consequences of poor maintenance practices [12]. Regardless, recent studies often focus on challenges in maintaining specific green building technologies such as building integrated photovoltaic [13], high-rise vertical greenery systems [14] and Internet of Things (IoT)-based green technology [15]. However, the overarching challenges and issues associated with maintaining unspecified facilities and features on certified green office buildings remain underexplored. Thus, the study aims to investigate the maintenance challenge and issue of GBI-certified office buildings. Through the combination of literature reviews, questionnaire surveys, and interviews with maintenance personnel, this study seeks to identify the key challenges and recommends proper solutions to overcome challenges in maintaining the facilities and features of green buildings.

## 2. Maintenance of Green Buildings

Maintaining conventional and green buildings involve several key differences, largely due to their unique characteristics and sustainability goals. The significant difference is the complexity and type of systems utilized by each building. Green buildings often integrate advanced technologies for energy efficiency, water conservation and waste reduction, which require facility managers to possess specific knowledge and skills [16]. In contrast, conventional buildings often rely on traditional maintenance practices and systems that are generally less complex and more familiar to maintenance personnel [17]. It is commonly perceived that green buildings demand higher initial construction costs than conventional buildings due to the incorporation of sustainable materials. However, they are typically associated with comparatively lower operational and maintenance costs over their lifecycle [18]. Lee and Chu [19] highlighted that conventional buildings incur maintenance costs that are 63% higher than certified green buildings if proactive maintenance strategies are not promptly implemented. According to US Department of Housing and Urban Development [20], buildings equipped with green label certified products are proven to be less costly to maintain than conventional buildings, owning to their design that prioritizes efficiency and durability. Such features will help reduce callbacks, save staff time, and reduce operation and maintenance costs for the green properties. Conversely, although simpler to maintain, conventional buildings may incur higher operational costs due to less efficient systems.

### 2.1 Challenges in Maintaining Green Building Features and Facilities

Maintaining green building features and facilities presents several unique and significant challenges that require careful planning and effective management. Firstly, inadequate maintenance practices stemming from insufficient planning and management will result in maintenance practices that fail to meet even the minimum requirement [21]. In the research by Aris [22], buildings in Malaysia generally do not meet user expectations as they are often reactively executed under poorly crafted maintenance policies. It is also necessary to review and reassess the existing safety and security standards when creating maintenance policies Mohd Nizar [23] or upgrading them to ensure alignment with technology advancements. The appropriate maintenance policies are essential to fostering the necessary improvements in green building maintenance over time [24].

Another significant challenge is the lack of occupants' awareness. According to Keleş et al. [25], insufficient information and understanding of green buildings and their significance contribute to this issue. While Au-Yong et al. [26] found the occupant's awareness of maintaining green office buildings was above average, their actual involvement in such activities was below average. A common misperception is that building maintenance responsibilities rests solely with technicians. They could be unaware of the critical role of building maintenance, which ensures the functionality, health, safety, and comfort of building occupants [27]. This lack of awareness can lead to poor resource management and numerous technical problems in maintaining facilities and features or green buildings.

The shortage of skilled and advanced technicians is also a critical challenge. In Malaysia, it was reported to have an acute shortage of manpower, especially in employing skilled and semi-skilled workers [28]. Addressing this shortfall is critical since the effectiveness of green building maintenance depends heavily on the expertise and proficiency of the maintenance staff. Aktas and Ozorhon [29] highlighted that the inexperience among technicians responsible for defect diagnosis was the major cause of limitations in green building maintenance projects. This insufficient green building expert is one of the barriers to sustaining the performance of green buildings [30; 31].

Additionally, insufficient budget allocation is also a challenge. Establishing maintenance-free structures for green buildings is highly desirable but scarcely feasible at this moment. It is frequently the case that some maintenance operations are delayed due to insufficient budget allocation, which fails to meet the ongoing maintenance demands [32]. As Li and Zhang [33] pointed out, adopting modern equipment and advanced technologies to fulfil the green building standard will exacerbate the maintenance costs. This financial burden can deter the adoption and development of green building practices. Consequently, this will lead to additional maintenance costs to repair damages or defects that occurred.

Design complexities present another hurdle. While conventional buildings often rely on more established and sometimes less efficient maintenance protocols, green buildings contribute to a fair share of hurdles due to the complexity of maintaining green structures. The design intricacy presents significant challenges for maintenance as it is a pivotal factor in the upkeep of green building features and facilities [34]. Building accessibility influences the ease of maintenance, user satisfaction, client operations, building sustainability, and the safety of maintenance personnel [35]. However, contemporary design practice often prioritizes aesthetic value, which ignores maintainability during the design stage. Design complexities should be simplified, as it would reduce the difficulty of conducting corrective or preventive maintenance [36].

A huge maintenance backlog can also inevitably lead to delays in routine tasks, with prioritization typically being given towards essential operation equipment. Various factors can lead to a maintenance backlog and further affect the operation and production of organization. Khalil et al. [37] highlight that the administrative unit frequently responds slowly, which delays timely maintenance and the completion of repairs. It is advised that administrative personnel should promptly organize maintenance teams to conduct repairs in buildings to prevent accumulated maintenance tasks that might endanger the health and safety of building occupants [38].

Resource management problems can further complicate the maintenance of green buildings. Resource management in green building maintenance entails pre-planning, scheduling, and allocating limited resources to maximize operational efficiency [39]. Assaf et al. [40] explained that the unavailability of required spare parts, equipment, and materials will significantly influence the progress and quality of maintenance tasks. This is compounded in green buildings, whereby the maintenance activities often require specialized equipment, specific materials, and skilled personnel. As a result, inadequate resource management will lead to the procurement of substandard spare parts that potentially compromise the building operations.

Organizational attitudes and priorities toward maintenance also play a crucial role. Different organizations will exhibit different philosophies on conducting building maintenance. Hauashdh et al. [41] noted that most maintenance organizations in Malaysia adopt corrective maintenance as their basic approach. Such maintenance actions are taken primarily in response to asset failure, often neglecting a comprehensive maintenance strategy. Thus, organizations that fail to implement preventive maintenance will have suboptimal building performance and escalate maintenance-related issues [37; 42; 43]. Ali and Wan [44] further justified that inadequate preventive maintenance results in unforeseen expenses and creates a shortage of supplies to complete maintenance chores.

The lack of advanced technology is another significant barrier. Modern maintenance technologies are designed to achieve energy efficiency, sustainability, and environmentally friendly building operations. However, Ha et al. [45] stated there is limited implementation of such technologies in projects leading to a lack of advanced technological support throughout the operation and maintenance of buildings. Ali and Wan [44] and Ismail [46, 47] explained that the maintenance of environmentally friendly features may be influenced by inadequate technology and software tools through building maintenance procedures. This technological shortfall can result to inappropriate maintenance planning decisions, which impact the productivity and quality of organizational operations [47-49].

Additionally, inadequate data records or information. Such records are essential as this document details each repair and maintenance procedure performed on an asset or equipment, as well as keeping track of asset failures and frequency of maintenance activity [50]. Missing or obsolete data will lead to undefined processes and complex maintenance planning [51]. Such deficiency can obstruct informed decision-making when there is an inadequate or inaccurate green performance database, which constitutes a huge challenge for the maintenance personnel in maintaining the performance of green building features and facilities.

Lastly, vandalism poses a substantial problem. Vandalism not only signifies the lack of user awareness about the importance of preserving the building facilities but also inflicts unquantifiable damage to the value of green buildings. It is found to be one of the factors that contribute to the deterioration of building features [52]. An example of financial repercussion can be seen in the report by Bavani [53], which details that Kuala Lumpur City Hall (DBKL) has spent about RM2.5 million on repairs of malfunctioning lifts, with up to 95% of the lift malfunctions due to vandalism. These incidents highlight the high costs associated with vandalism for maintenance purposes, making continual challenges for personnel to maintain green building features and facilities.

As discussed, maintaining green buildings features and facilities involve addressing a range challenges. Addressing these challenges requires comprehensive strategies and effective management to sustain their

performance and functionality. Moreover, the long-term sustainability and efficiency of green buildings can be ensured.

## 2.2 Potential Issues due to Improper Maintenance Management in Green Buildings

Green buildings are designed to be environmentally friendly, energy-efficient and sustainable. However, improper maintenance management in these green buildings can lead to a multitude of issues that affect productivity, building value, health and safety, resource efficiency, environmental sustainability and financial stability.

Firstly, reduce productivity. The effectiveness of maintenance plays a crucial role in profitability and productivity, where efficient and effective maintenance directly correlates with optimal production outcomes [54]. Furthermore, effective maintenance not only aims to enhance a company's profitability and market competitiveness but also to maintain and improve the quality of all the elements that contribute to the production process in a cost-effective manner [55]. There is a clear connection between how green buildings are maintained and their productivity since many researchers and practitioners have outlined the losses caused by improper maintenance management and continuing to be viewed as a cost centre in the production process [56].

In addition to productivity concerns, it can also reduce building values. According to Ali et al. [57], building maintenance is aimed to preserve the original condition of the building while allowing the building to function as intended. Wordsworth [58] highlighted that immediate response to faults is crucial as delays can accelerate the deterioration of the building components and increase the associated costs. This issue is widely occurring in both conventional and green buildings, which may jeopardize the owner's investment as the property value heavily depends on the quality of its maintenance [59].

Health and safety risks also arise from improper maintenance management. The safety concern in maintaining green building features & facilities can be traced back to the design complexity. For example, some energy recovery wheels and storm water harvesting systems are frequently situated in confined spaces, compromising the safety of maintenance personnel [60]. It is necessary to incorporate design for maintainability to safeguard both of maintenance personnel and the occupants. Additionally, improper handling and information management of green buildings during maintenance activities can lead to the occurrence of hazardous conditions and risk factors [24]. The advanced ventilation system in green buildings that is not properly maintained can lead to poor air quality, resulting in health issues for the occupants [61].

Furthermore, improper maintenance leads to a waste of resources. Ben-Daya et al. [62] emphasize that proper maintenance helps in minimizing material and energy consumption, maintain the efficiency of equipment, and eliminate waste and pollution due to system failures. However, faulty systems can increase energy consumption and carbon emissions, resulting in environmental losses and waste production [63]. Ali et al. [57] further asserts that the maintenance management quality will determine the maintenance cost level. They highlight that poor maintenance practices are neither cost-effective nor ideal, and they frequently result in various issues, including structural defects and compromised building functionality. This inefficiency often results in increased consumption of materials and energy.

Environmental losses are another significant concern. Throughout the investigation, Costantino et al. [64] found that there is a certain relationship between maintenance management and environmental sustainability. Green building features are expected to be environmentally friendly compared to conventional building features. Despite this expectation, Alghanmi et al. [63] highlighted that system failure can increase carbon emissions and significantly influence environmental losses. Failures of equipment may have highly negative impacts on the environment, such as leakage of hazardous materials, unrestrained resource use, and energy inefficiency resulting from inadequate maintenance management [64].

Lastly, the financial implications of neglecting maintenance are substantial. Ignoring minor maintenance issues could lead to significant problems and an unexpected expenditure backlog that would need to be covered in the future (Hopland and Kvamsdal [65]; Ihsan and Alshibani [66]. The backlog maintenance may result in an increase in initial costs due to poor coordination, inadequate emergency response, and the accumulation of unnecessary repairs [67]. Additionally, Baldi et al. [68] also claimed that ignoring any system breakdowns or deterioration not only exacerbates the condition of the facilities but also leads to an increase in financial burden on facility management and property owners.

Effective maintenance management is essential to fully realizing the benefits of green buildings. Proactive maintenance can mitigate such issues. Ultimately, robust maintenance strategies are essential for the sustainable success and longevity of green buildings.

## 3. Research Methodology

The research aimed to investigate the challenges and issues associated with maintaining features and facilities in green buildings and to provide proper recommendations to overcome those challenges. Hence, a mixed-method approach was adopted to collect data and information using both questionnaire surveys and semi-structured interviews. The surveys and interviews targeted operation and maintenance experts, including facility managers,

building executives, and maintenance personnel from green office buildings in the Klang Valley, all certified by the Green Building Index (GBI) Malaysia.

The sampling is solely focused on green office buildings within the Klang Valley, but no accurate numbers of green office buildings are quantified by the Green Building Index (GBI) Malaysia. Since the population size for research could not be determined, the data collection was expected to obtain at least 30 samples. Ultimately, the research gathered 59 completed questionnaires and three interviews. The questionnaire survey was designed in a close-ended format to examine the likeliness of challenges and issues identified from the literature review with a five-point Likert scale, ranging from 1 (Very Unlikely) to 5 (Very Likely). On the other hand, the interviews were conducted to obtain appropriate recommendations for solving the maintenance challenges and issues in green buildings.

Upon the completion of data collection, the Statistical Package for Social Sciences (SPSS) software was utilized for data processing and analysis. Initial descriptive analysis calculated the mean scores of the research variables to establish their relative importance. Subsequently, thematic analysis was applied to categorize responses and analyze recommendations received from the interviewees in overcoming the maintenance challenges of green building features and facilities.

## 4. Findings and Discussion

Based on the literature review, 11 maintenance challenges and 7 significant issues were identified, and empirical data was collected among green building professionals. The respondents evaluated the research variables based on their professional insights, while the results were analyzed using mean and ranking methods.

### 4.1 Challenges in Maintaining Green Building Features and Facilities

Based on the data shown in Table 1, the first-ranked challenge was insufficient budget allocation, which received the highest mean score (4.05) among the others. Financial challenges have been thoroughly documented by Hauashdh et al. [41] and Hauashdh et al. [69] which included the distribution of maintenance budgets, time permitted by the budget, cost requirements, purchases, and the availability of finances for building upkeep. The results were aligned with the findings by El‐Haram and Horner [70] whereby many maintenance activities are often delayed due to insufficient budget allocation. Such delays inevitably lead to exacerbation of building defects and damage escalation, thus resulting in additional maintenance expenses [57].

**Table 1** *Maintenance challenges ranking in green building features and facilities*

| Challenges | Mean | Standard Deviation | Ranking |
|---|---|---|---|
| Insufficient budgets allocation | 4.05 | 0.936 | 1 |
| Organizational attitude and priority | 3.90 | 0.904 | 2 |
| Shortage of skilled and advanced technicians | 3.90 | 0.759 | 2 |
| Resource management problems | 3.88 | 0.911 | 3 |
| Lack of occupants' awareness | 3.86 | 0.706 | 4 |
| Inadequate maintenance practices | 3.78 | 0.789 | 5 |
| Inadequate data records or information | 3.69 | 1.021 | 6 |
| Huge maintenance backlog | 3.69 | 0.915 | 6 |
| Lack of advanced technology | 3.59 | 1.019 | 7 |
| Design complexity | 3.49 | 0.935 | 8 |
| Vandalism | 3.22 | 1.146 | 9 |

Organizational attitude and priority and the shortage of skilled and advanced technicians were the second-ranked challenges, each registering a mean score of 3.90 in our study. The approach to building maintenance in Malaysia is typically contingent on available financial resources, even when the buildings are not in optimal condition [71]. This financial dependency leads many organizations to view maintenance as a non-essential aspect of the production process and often treated as a burden. Other than that, Malaysia was reported to have an acute manpower shortage, especially in employing skilled and semi-skilled workers [28]. The shortage significantly impairs the ability of green buildings to maintain it features and facilities effectively. Gan et al. [72] suggested that more demonstration projects should be introduced by professional organizations to convince stakeholders to adopt sustainability practices during green building maintenance.

Next, resource management problems were ranked third in maintenance challenges, with a mean score of 3.88. Ahmad et al. [73] examined a study across 16 properties and found that despite allocating significant

resources to maintenance activities, most of the buildings examined in the case study had insufficient upkeep. A wide range of resources are involved in building maintenance, including maintenance personnel, tools, equipment, materials, advanced technologies, energies, and utilities. In some circumstances, the absence or the inadequacy of any of these elements would influence the performance of maintenance works.

Furthermore, lack of occupants' awareness ranked as the fourth most pressing challenge under resource management problems, scoring a mean of 3.86. Au-Yong [74] noted that often, a misunderstanding of the values of maintenance results in poorly maintained building facilities and extensive costs required for maintenance activities. Additionally, Eisner [27] highlighted that occupants might not be aware of the crucial role building maintenance plays in preserving the structure's performance, occupant comfort, and safety. It has been demonstrated that tenants with a low level of engagement in maintenance management are more likely to develop maintenance difficulty.

Inadequate maintenance practices placed as the fifth-ranked with a mean score of 3.78. This ranking underscores the pervasive issues of suboptimal maintenance management, which, if not implemented, can detract from the occupant experiences within these buildings. Abdul Lateef [71] emphasizes that maintenance cannot be circumvented, but it can be maximized proactively by minimizing the expenditure and optimizing the value derived. Nevertheless, maintenance organizations in Malaysia still implement corrective maintenance instead of proactive maintenance as their basic maintenance approach [41]. As a result, more maintenance problems will arise, which will lead to difficulty maintaining green features.

Position as the sixth most significant challenge, with a shared mean score 3.69, the issues of inadequate data records or information and huge maintenance backlog undermine the efficiency of green building maintenance. Inappropriate decisions on maintenance planning may be made when there are no maintenance records, which further increases the risk of implementing any green building practices. Khalil et al. [37] found that the delay in administrative responses to taking remedial action allowed the unresolved maintenance tasks to proliferate. As a result, additional maintenance costs and work are required to address consequences like damages or defects that occurred.

Among the assessed challenges, the lack of advanced technology is the least likely challenge, receiving a mean score of 3.59. Green building features are the invention of new technologies, so updated tools and software should be utilized to maintain the operation of green features. Lack of advanced technologies and equipment within maintenance practices leads to the unsuccessful or postponed completion of maintenance tasks [46; 49; 75]. Conversely, design complexity and vandalism with mean scores of 3.40 and 3.22 respectively, are neither likely nor not likely challenges. Their impacts hover around the significant threshold, with neither challenge consistently influencing maintenance outcomes across the surveyed properties. This suggests that while they may pose issues in certain conditions, they do not universally affect all green buildings to the same extent. Both of these challenges are not more than 3.50 of the mean, as a result, they are rounded to the nearest mean score of 3.00, which is equivalent to a neutral likelihood of occurrence.

## 4.2 Potential Issues due to Improper Maintenance Management in Green Buildings

According to Table 2, the first-ranked issue falls to increased budgets for untreated faults, with the highest mean score of 3.95, indicating significant financial repercussions. The consequences of maintenance backlog may accumulate to serious building deterioration on the green building elements. Hence, more initial costs and maintenance work must be covered in the future [67]. This problem is more likely to affect how green building elements are operated and maintained.

Ranked second with a score of 3.76, the low satisfaction of occupants underscores the detrimental impact of improper maintenance management. Hopland and Kvamsdal [65] revealed that poor facility management and insufficient maintenance levels impede the delivery of top-notch services to users, thereby diminishing the occupants' contentment due to the failure of green features. Moreover, building performance evaluation standards should be based on factors directly related to stakeholder satisfaction [76]. A study suggest that the quality of building maintenance work is one of the non-environmental factors influencing the satisfaction of occupants in both LEED-certified and non-LEED-certified office buildings [77].

**Table 2** *Ranking of potential issues stemming from improper maintenance management*

| Issues | Mean | Standard Deviation | Ranking |
|---|---|---|---|
| Increased budgets for untreated faults | 3.95 | 0.860 | 1 |
| Low satisfaction of occupants | 3.76 | 0.858 | 2 |
| Waste of resources | 3.75 | 0.939 | 3 |
| Environmental losses | 3.64 | 0.943 | 4 |
| Reduce building values | 3.58 | 0.875 | 5 |
| Health and safety risks | 3.56 | 0.933 | 6 |
| Reduce productivity | 3.39 | 0.831 | 7 |

The third-ranked issue, scoring a mean score of 3.75, was wasting resources in the maintenance of green buildings. Ben-Daya et al. [62] concurred that regular maintenance not only conserves material and energy use but also maintains equipment efficiency and reduces waste and pollution by avoiding malfunctions. Echoing this perspective, Matse et al. [78] stated that more resources such as time, manpower and costs will be required to retain and preserve buildings in fully operational condition. As a result, improper maintenance in green buildings tends to lead to the waste of resources.

Furthermore, improper maintenance management would also lead to environmental losses. It received a 3.64 mean score and placed fourth among the seven (7) threats. Inadequate maintenance may certainly reduce the lifespan of green features, necessitating frequent replacement, and associate the risk of accidents with environmental consequences [64]. Green facilities will not be able to perform to a high standard without proper maintenance, which is subject to becoming obsolete and increasing carbon emissions alongside waste production [62]. Thus, lapses in maintenance routines will likely cause environmental issues associated with green buildings.

Ranked fifth with a mean score of 3.58, improper maintenance management influences the reduction of building values. Compared to conventional structures, green buildings possess greater value due to their sustainable features. However, differed maintenance will lead to progressive physical depreciation, eroding their original value. Small issues can develop into bigger problems without proper maintenance, causing physical damage to the building, like decay and degradation. This will certainly affect the health and safety of its users [79]. Hence, this shows improper maintenance will likely threaten a property's value.

Moreover, health and safety issues may arise due to improper maintenance management in green buildings, although it ranks as the least likely issue with a mean score of 3.56. According to Thompson [80], adequate building maintenance is crucial not only for ensuring the facilities and services are working at their highest level of performance but also for fulfilling the needs of the building's inhabitants. For instance, water-saving fixtures and appliances are frequently used in green buildings. However, if these devices and fixtures are not properly maintained, it may lead to the proliferation of bacteria and other hazardous microbes, which could affect the water quality and pose health risks.

Lastly, reducing productivity is neither likely nor unlikely to pose a significant threat. It received a mean of 3.39, which is not more than 3.50 of the mean. As a result, it is rounded to the nearest mean score of 3.00. This suggests that while productivity impacts are acknowledged, they do not consistently arise as a direct consequence of maintenance practices, underlining the nuanced nature of productivity-related challenges in green building maintenance.

## 4.3 Recommendations to Overcome the Challenge in Green Building Maintenance

Table 3 shows the analyzed results from the open-ended interview questions from 3 interviewees. Based on the information received during the interview sessions, it was recognized by all interviewees that insufficient budget allocation stands as a predominant challenge in maintaining green building features and facilities. Therefore, interviewees B and C suggested developing a comprehensive proposal and conducting a thorough financial analysis report in advance to investigate the efficiency and effectiveness of maintenance management. These proposals evaluate potential expenditures and investments, establishing a robust framework for managing the funds allocated for maintenance to prevent budget overspending [81]. However, interviewee A recommended investing in advanced applications or technology. Li and Yan [82] believed that technological advancement could serve as an assurance for boosting profitability, growth potential, and overall financial performance. Therefore, enhancing the capabilities for technological innovation and prioritizing efficient research and development (R&D) are crucial for enhancing financial performance and controlling financial risk [83].

**Table 3** *Recommendations to overcome the challenges in maintaining green building features and facilities*

| No. | Challenges | Recommendations to overcome maintenance challenges |
|---|---|---|
| 1 | Insufficient budgets allocation | Interviewee A: Effectively invest for advanced application. |
| | | Interviewee B: Prepare a complete proposal and financial analysis report. |
| | | Interviewee C: Prepare a proper proposal that highlighted the initial investment. |
| 2 | Organizational attitude and priority | Interviewee A: Top-down commitment with clear decision of stakeholders. |
| | | Interviewee B: Effective communication to gain attention and support for maintenance efforts. |
| | | Interviewee C: Emphasize the feedback or complaints to stakeholders. |
| 3 | Shortage of skilled and advanced technicians | Interviewee A: Engage outsourcing. |
| | | Interviewee B: Provide skills training. |
| | | Interviewee C: Engage outsourcing. |
| 4 | Resource management problems | Interviewee A: Pre-schedule to ensure the availability of resources. |
| | | Interviewee B: Develop a comprehensive maintenance plan. |
| | | Interviewee C: Engage with stakeholders to gain additional resources. |
| 5 | Lack of occupants' awareness | Interviewee A: Provide training programs, especially on the behavioral and attitude aspects. |
| | | Interviewee B: Educate and enforce tenants to adapt GBI requirement. |
| | | Interviewee C: Offer incentives for tenants who report issues. |
| 6 | Inadequate maintenance practices | Interviewee A: Develop clear Standard Operating Procedure and policy, based on environmental, social and governance (ESG) framework. |
| | | Interviewee B: Define maintenance objectives and establish goals. |
| | | Interviewee C: Perform upon Service Level Agreement, conduct regular review. |
| 7 | Inadequate data records or information | Interviewee A: Transform paperwork records to digital copies. |
| | | Interviewee B: Establish documentation and record-keeping in system. |
| | | Interviewee C: Regular backups database. |
| 8 | Huge maintenance backlog | Interviewee A: Adopting preventive maintenance programs, keep tracking and reviewing the service report. |
| | | Interviewee B: Proper arrangement of operation according to priority level. |
| | | Interviewee C: Prioritize maintenance tasks based on criticality. |
| 9 | Lack of advanced technology | Interviewee A: Embrace efficient and updated technology. |
| | | Interviewee B: Stay with the latest advancement in technology. |
| | | Interviewee C: Propose controlling and monitoring technology. |

Furthermore, interviewees also admitted that organizational attitude and priority maintenance pose significant challenges in green buildings. Effective communication between the stakeholders should be emphasized, and established a top-down commitment in order to develop sustainable features in green buildings. Au-Yong [74] highlight that it is essentially needed for the stakeholders to have close communication on maintenance-related issues. Still, many of them rarely get involved in maintenance management due to a lack of commitment. Hauashdh et al. [41] declared that an effective organization is distinguished by its successful organizational structure, and a clear definition of roles serves to lessen the confusion in an organization work. Hence, the upper management should determine organization goals and objectives in advance so that the priority of maintenance setting can align with the overarching needs of the organization [84].

Based on the information received during the interview sessions, all the interviewees agreed that the shortage of skilled and advanced technicians is one of the issues in maintaining green buildings' features and facilities. Hence, interviewees A and C suggested engaging in outsourcing services to maintain the condition of green features and facilities. Outsourcing always provides clients access to professional, expert, and high-quality services by appointing an outside contractor to do all the technical maintenance work [85]. This approach offers

better accessibility to superior quality, reduction of operation and training costs, and the opportunity to focus on the core competencies of organizations [86]. Additionally, interviewee B recommended providing skills training periodically to sustain the competency of technicians. Fatoni and Nurcahyo [87] emphasized that such training could enhance the effectiveness of maintenance performance and develop a high-performance culture within the organization.

Moreover, the interviewees concurred that one of the difficulties in maintaining green building features and facilities is related to resource management. Interviewees A and B suggested adopting pre-scheduled strategies to ensure the availability of resources and a comprehensive maintenance plan. An often-encountered challenge in resource management is the occurrence of inadequate knowledge and personnel regarding available resources. Insufficient visibility of resources will make it challenging to effectively track project advancement, meet milestones, and determine the appropriate allocation of resources [88]. Interviewee C advised engaging stakeholders to secure additional resources with a shortage for conducting maintenance activities. Communication with stakeholders should be continuous, extending beyond initial project stages, since regular communication is key to gaining and maintaining stakeholder support [89]

Additionally, the interviewees believed that the lack of occupants' awareness could be considered an internal issue within organization's maintenance management. According to the suggestions received from interviewee A and interviewee B, the occupants should be provided with training programs focused on the behavioural and attitude aspects. By providing training to the occupants, they can receive education regarding the significance of the matter and learn how to contribute to the operation and maintenance tasks [90]. Meanwhile, interviewee C proposed offering incentives to tenants who report issues. Saltzer [91] noted that incentives motivate employees to perform beyond their duties and participate in activities that advance and expand an organization, especially service companies such as facility maintenance providers. This strategy could be a good practice for increasing employee engagement while motivating them to continually commit to sustaining the conditions of green building assets.

The interviewees also verified that inadequate maintenance practices can lead to various consequences in green buildings. Appropriate maintenance policies are essential for green building maintenance to develop improvements where necessary [24]. Zubairu S.N. [92] also highlight that persistent problems with building maintenance result from the absence of maintenance policies. Intended to overcome this challenge, interviewees encouraged the upper management to develop a clear Standard Operating Procedure (SOP) and policy based on Environmental, Social and Governance (ESG) framework. This SOP would be a guideline for the maintenance personnel to perform maintenance activities upon the Service Level Agreement. As well as assist them in defining maintenance objectives and establishing goals. Additionally, the ESG framework aids stakeholders in comprehending how an organization handles risks and opportunities pertaining to sustainability matters and emphasizing well-being and protection, pollution minimization, and engaging in corporate philanthropy [93].

The interviewees acknowledged the challenges related to inadequate data records or information. Three (3) interviewees recommended adopting digital recording technology, which could assist humans in tracking and keeping information in the database system. Technology like Collection Management Software (CMS) provides organizations the ability to manipulate and access their documenting collections via a software interface. Yet, a constant upkeep of databases is also required in order to ensure that they perform as efficiently as possible [94; 95]. Though simplistic in concept, a database is a structured framework that enables effective organization and retrieval of data [96].

The interviewees also recognized that outstanding maintenance is one of the internal problems that occurred in the management of green buildings. Interviewee A suggested adopting more preventive maintenance approaches to identify factors that predict equipment breakdowns and assist in the timing of necessary repairs before failure occurs. Hauashdh et al. [41] explained that performing preventive approaches in green buildings can reduce the subsequent damage costs, avoid system downtime, mitigate delays in timely maintenance, and delay the completion of repairs. In contrast, interviewees B and C recommended prioritizing maintenance tasks based on their criticality. This recommendation aligns with the findings by Hauashdh et al. [97] which assert that effective planning and scheduling of building maintenance should be based on its criticality level of tasks to minimize the accumulation of maintenance works.

In addition, interviewees agreed that the lack of advanced technology and obsolete software brought maintenance challenges to green building operations and maintenance. Interviewees A, B, and C advocated for embracing updated technology to control and monitor green building performance. Obsolete systems for scheduling maintenance work orders cannot automatically handle a substantial volume of orders [98]. Consequently, stakeholders are encouraged to apply high-quality products and practical systems, in line with advanced technology development, to ensure the green building features and facilities are well maintained [47; 49; 99]. In general, the utilization of advanced technology in green buildings has a notable capability to prevent human errors and enhance the consistency of maintenance work.

## 5. Conclusion

In conclusion, it has been demonstrated that not all the challenges and issues identified in literature reviews are likely to influence the performance of green office buildings. However, according to the outcome, the majority of challenges and issues do contribute to certain levels of difficulty in maintaining the facilities and features of green buildings. The insufficient budget allocation emerged as the most pressing challenge, scoring a mean score of 4.05. Similarly, increased budgets for untreated faults were identified as the most likely issues, with a mean score of 3.95. Both challenges and issues highlighted in the study emphasize the importance of financial resources in maintenance management. It is suggested that a comprehensive financial plan is essential to ensure efficient and effective maintenance, thereby preventing budget overspending. Additionally, interviews conducted with the maintenance personnel provided valuable insights and practical resolutions to address these challenges. However, these suggestions can only be used as a reference for readers to gain fundamental knowledge and a basic understanding of the maintenance challenges and issues in maintaining green building features and facilities. The study is pivotal for enhancing the operational and maintenance aspects of green office buildings, and the findings serve as a reference for future research.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *Nurshafarina Jasme, Cheong Peng Au-Yong, Yi Yang Chia;* ***data collection:*** *Nurshafarina Jasme, Cheong Peng Au-Yong, Yi Yang Chia;* ***analysis and interpretation of results:*** *Nurshafarina Jasme, Cheong Peng Au-Yong, Yi Yang Chia;* ***draft manuscript preparation:*** *Nurshafarina Jasme, Cheong Peng Au-Yong, Yi Yang Chia, Huiying (Cynthia) Hou. All authors reviewed the results and approved the final version of the manuscript.*

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