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The background features a dark blue-green gradient with a glowing network of nodes and lines. A prominent horizontal bar with a glowing orange and yellow border is positioned below the title. Below this bar, a complex network of nodes and lines is visible, with some nodes highlighted in yellow and orange. The bottom of the image shows a grid-like pattern of glowing lines.

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Challenges and Way Forward for Implementing Green Roof in Construction Industry in Sarawak, Malaysia

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Abstract

There is a growing global concern about the adverse effects of today's rapid economic growth and development, which impact the environment and deplete energy supply. A green roof may lower a building's energy consumption and minimise air pollution by reducing dust particles in the air. The primary impediment to green roof implementation in Malaysia lacks local knowledge and unskilled green roof specialists. As a result, there is a shortage of green roof installers and specialised firms in the country. This article discusses the problems and solutions of adopting green roofs in building projects based on construction industry experience in Sarawak. A survey utilising a questionnaire is used to obtain data for this research. The paper revealed the possible challenges of adopting a green roof for the construction industry. The study is critical in order to adopt green roof technology quickly in Malaysia.

Keywords

Challenges; Construction industry; Green roof; Quantity surveyors; Way forward

1 Introduction

Green construction is now widely used to offer a better living environment for both the end-user and the environment. Green construction is a method for reducing resource, energy use, and the built environment's overall influence on the natural environment¹. Green construction is comprised of many practical solutions. Installing a green roof in a building is one of the solutions. A green roof is a plant system or technology that covers a portion of the roof surface. Intensive green roofs and vast green roofs are two forms of green roofs. The vegetation on an extended green roof is significantly less dense, and the layer is much thinner than the vegetation on an

intense green roof². Therefore, green roof implementation helps to minimise the amount of energy used by the structure. Also, it aids in reducing air pollution caused by the amount of dust particles in the atmosphere.

However, despite the numerous benefits the green roof may provide to promote a greener built environment, green roof adoption is relatively new in Malaysia. Owing to the lack of education and demonstration of the life cycle cost benefits of green roof implementation, most clients and users prefer the low-cost options for project delivery³. Similarly, stakeholders prefer the traditional roof design due to the familiarity and cost factors in Malaysia⁴. Generally, the perception of high cost of

green initiatives compared to the conventional ones has become an increasing challenge to green roof implementation.

Sarawak is a developing state in Malaysia that has become a cynosure for environmental sustainability and green technology in Malaysia. However, in Sarawak particularly, green construction practices^{1,5} are still far behind compared to other cities in Malaysia. According to Lee et al. (2020)⁵, among the challenges in promoting green building in Sarawak is the lack of demand from stakeholders. The lack of demand could be due to a lack of knowledge and awareness of the importance of green construction practices. Limited studies on green construction practices in Sarawak is also one of the contributing factors to the slow adoption of green practices. Therefore, this paper aims to identify the possible challenges of green roofs as green technology in Sarawak construction industry.

2 Introduction to Green Roof in Building Construction

Green roofs have been used as a rooftop garden for a long time, particularly in the Mediterranean^{6,7}. Also, the green roof system is more established in European countries such as Germany, Italy and Denmark. In North America and Asia, the growth rate of green roofing has increased over the years⁷. This is due to increased awareness of the environmental effects of non-green roofs and the economic gains green roof in these places. For instance, a green roof can provide environmental advantages to the building owner if there is a restricted space on the ground. As a result, due to its aesthetic merits and advantages, the green roof concept has been a popular choice in building construction for centuries. The green roof system is more established in European countries. As for North America and Asia, the growth rate of green roofing has shown high increases over the years⁷. The increase of green roofing adoption is also due to an increased awareness of the environmental effect and economic gain when implementing a green roof.

Green roofs are examples of landscape architecture that has progressed from the ground level to the rooftop level. Green roofs are also known as eco-roofs, living roofs, and roof gardens, where they are made up of several manufactured layer systems for medium and plant. The green roof, also known as a living plant ecosystem, serves as a protective layer over the structure with a lower soil density that can support any form of self-sustaining plant development^{2,8}. There are two types of green roof commonly used in green buildings: extensive green roofs and intensive green roof systems. In comparison, the density of the extensive green roof system is lighter than the intensive green roof system.

Compared to the regular conventional roof, a green roof helps to minimise overall direct and diffuse radiation incidence on the roof⁹. Plus, it also provides energy-saving insulation and humidity management for controlling roof membrane temperature¹⁰. As a result, it decreases the thermal stress in roofs, shortens the ageing period, and increases the life span¹¹. Moreover, it promotes social benefits and a pleasant effect on urban residents by lowering air and noise pollution¹². Green open spaces attract the eyes and connect people to roof gardening. Additionally, green roofs can create opportunities for urban agriculture. They allow the production of different vegetables and make society self-resilient in food production.

In Malaysia, green roof building is not favourable yet; nonetheless, a new method has been established to promote the green construction trend. Green roof techniques vary depending on the local legislation of various nations worldwide. These initiatives generally consist of financial incentives or reduced water or property fees¹². In Italy, the energy retrofitting policy allows for a tax benefit of up to 65 per cent of the cost of installing a green roof on an existing structure. A study further revealed that a green roof could reduce the annual costs for air conditioning by 14% to 19% compared to the existing roof¹³.

3 Challenges Involved in Green Roof Implementation

As part of the green technologies introduced to the industry, in order for green roof to provide an environmental friendly roofing option, the implementation in the Malaysian construction industry in Sarawak has been challenged by the following factors⁴.

3.1 Limitation of Green Roof Expertise

The main factors of the green roof adoption are the limited number of local green roof expertise and inexperienced professionals, leading to the challenges of implementing green roofs in Malaysia. Because of these limitations, it is not easy to get green roof installers and specialist companies for green roof systems since there are not many green roof suppliers available in the industry. With limited resources, it may result in high cost for installation and materials of green roofing.

3.2 Limited Guidelines Regarding Green Roof

In developed countries, government policies are often put in place to increase the practical implementation of green roofs⁸. For example, 14% of flat roofs in Germany are constructed with green roofs due to the supportive government policies¹⁴. Meanwhile, in a developing country like Malaysia, supportive policies for green roof construction are barely in place and not the least design standards and guidelines regarding green roofs¹⁵. Hence, it has been a challenge to achieve a universally acceptable green roof construction in the country.

3.3 High Initial and Maintenance Cost

Research has revealed that green roofs are more expensive than conventional roof systems as the initial cost of constructing a green roof is relatively high, and it may be regarded as one of the most difficult tasks^{12,16}. Regarding financial concerns, the greater cost of green roof construction must be compensated by lower operational expenses because the

complexity of the procedure and the intensity of maintaining the green roof will always rely on what was originally planned¹⁷. One of the most important aspects is the aesthetic aspect. Furthermore, the major factors that cause high maintenance cost would be maintaining the green roof itself, the challenges of dealing with colonisation by one species of plant, and the complexity of interaction among plants¹⁸. Inevitably, the maintenance requirements for the green roof installation should not be neglected during construction planning. The criteria of green roof maintenance must be highlighted when reviewing the viability of green roof installation towards sustaining the building's life span¹⁹.

3.4 Low Knowledge and Skills

A specialist's skill and knowledge are required to design green roofs devoid of design flaws such as roof leakage¹². As indicated previously, green roofing skills and knowledge are rarely available in practice. This is very complicated for green roof users who struggle to find experts who can provide green roof maintenance¹². Lack of green roofing skills and knowledge in practice has become a greater technical challenge^{20,21}.

4 Methodology

Surveyors working in construction industry in Sarawak were the respondents. Also, most studies on the green roof focused on the holistic perception of project stakeholders without cognizance for professional differences^{1,5}. Less researcher have gauged the perception quantity surveyors of the subject despite earlier predictions that they can advance sustainable building practices in the course of their service delivery. Quantity surveyor is an essential member of a project team in the construction industry, which leaned towards the contractual and cost-related issues. The sampling calculation used data from the Malaysian Board of Quantity Surveyors' (BQSM) official website, which is available publicly as a reference. There are three categories of quantity surveying registration; namely, Provisional Quantity

Surveying (PVQS), Professional Quantity Surveying (PQS) and Consultant Quantity surveying (CQS).

With the aid of a sample size calculator from the website, this study calculated the sample size for this research (<http://www.raosoft.com/samplesize.html>).

The sample size required from this study was 187 (refer to Figure 1) with a margin error of five per cent and a confidence level of 95%. In line with the quantitative methodology, a structured questionnaire was administered to the respondents in the sample size online.

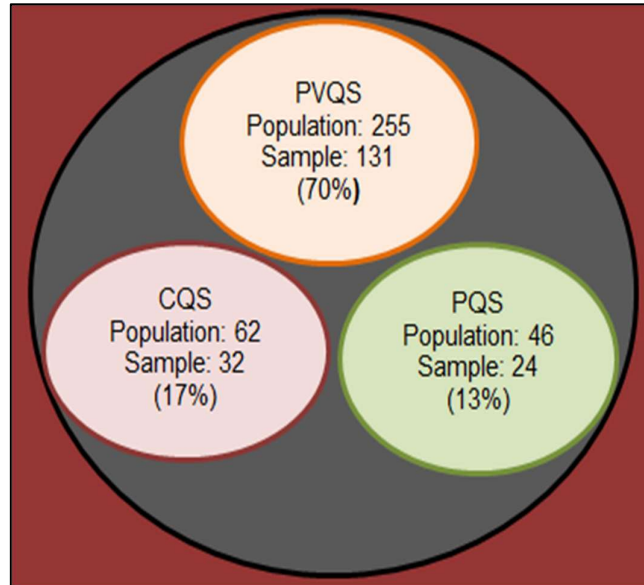


Figure 1. The sample size calculation

This study adopted a questionnaire as a data collection tool to reach a broad audience. The method is one of the most cost-effective methods to gather large volume of data from a substantial number of individuals within a short period during the Restriction Movement Order due to the heightened threat of the Covid-19 pandemic. The questionnaire was structured into two main sections; Section A focused on respondents' demographic information and Section B on the challenges of green roofs. All data obtained were analysed using a software called IBM SPSS Statistic 25. Data filled in by the respondents were keyed into the software

to generate the data analysis for this research.

5 Results and Discussion

There is a total of 51 respondents who answered the questionnaire. Several analyses were conducted to generate tabulation of data such as missing value analysis, reliability analysis, and descriptive statistics. Cronbach's alpha was used to measure the internal consistency returned a figure of 0.823, which is already considered a good internal consistency²².

5.1 Demographic of the respondents

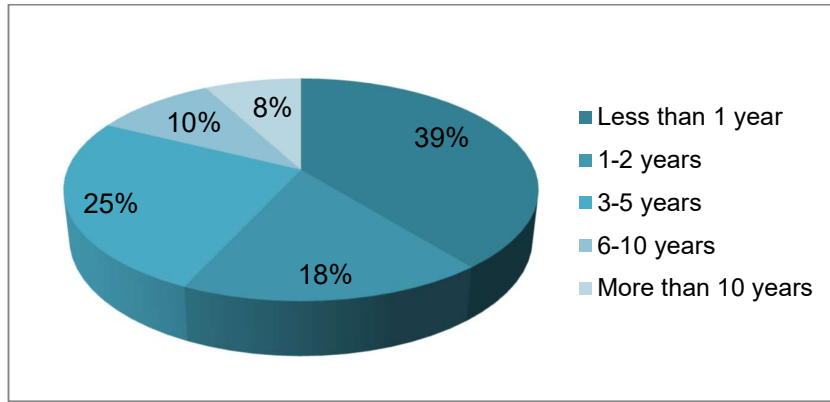


Figure 2. Working experience in the construction industry

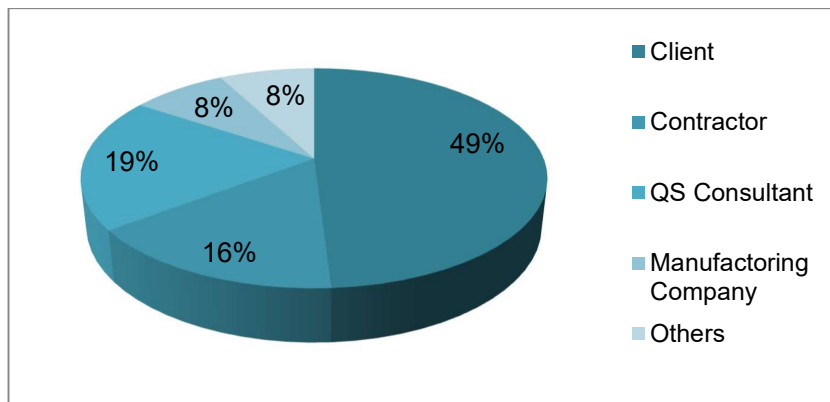


Figure 3. Nature of company

The outcome indicated that they were experienced construction players. Referring to Figure 2, although 20 of the respondents, or 39%, having less than one year of experience in green building construction, majority of the respondents at least had experience pertaining to green building. Several corporate natures were described, including working as a quantity surveyor as a project client, contractor organisation, quantity surveying consultant, manufacturing firm, and others such as local authorities (Figure 3). The result of this study represents the perspectives on the outcome

from various organisations involved in the building project.

5.2 Challenges in Implementing Green Roof in the Construction Project in Malaysia

Table 1 summarises average index of the difficulties encountered while adding green roofs into the building projects in which the respondents were involved. The data is graded based on the average index of each green roof concern highlighted by the respondents who took part in a green roof project.

Table 1. Average index of challenges in implementing green roof in the construction project

Item	Description	Average Index	Rank
B.3.f	Lack of green roof suppliers	5.82	1
B.3.a	Low knowledge of green technologies	5.78	2
B.3.e	Increase in green roof design cost	5.76	3
B.3.c	Increase in construction cost	5.76	3
B.3.b	High initial material cost	5.76	3
B.3.d	Increase in maintenance cost	5.73	4

According to the data obtained, the most common issue experienced by construction players when seeking to implement green roofs is a lack of green roof suppliers, with a 5.82 mean score. Green technology implementation earned the second-highest number of votes, with a mean score of 5.78.

The absence of green roof providers has made it more difficult to persuade the sector to adopt green roofs¹⁴. According to the supply and demand law, a smaller number of providers will result in a larger price increase, owing to a price monopoly by the limited suppliers. One approach is to promote a competitive market by attracting additional suppliers and contractors. The government's assistance is critical in providing incentives, training, and raising awareness among industry stakeholders to stimulate participation and reduce market monopolies. Based on the principles of green supply chain management, an open market that fosters competition would decrease prices and deliver more services. Apart from the price, it will also provide less competition in terms of design variables and flexibility for the client and designers to choose¹¹.

Awareness and information about green roofs may be fostered among stakeholders through various training and seminars offered by the government, institutions, and commercial enterprises. However, one of the problems impeding the dissemination of innovation in the construction sector is familiarity with the present system. Changes in stakeholder views take time, but a top-down strategy can efficiently drive the sector.

In the construction industry, cost is the most important factor alongside the quality and project duration in any part of

the world. These three factors are the baseline in designing a construction project. The client who invested in the project would expect it to stay within its budget. The inclusion of innovation in the project, such as a green roof, but with a reasonable increase, would pique the client's interest in adopting such an innovation¹⁵. As a result, it is critical to educate the client on the benefits of green roofs while cultivating an interest in contributing to sustainable development. The internalisation of costs by broadening the market and including a life cycle analysis into cost preparation will allow clients to receive a more comprehensive picture of green roof advantages, both short and long term. In addition, government incentives can help inspire clients to support green roof practices by providing financial grants, tax reductions, and rewards.

Another point to consider in ensuring the viability of green roof installation is the maintenance requirements. Despite the result showing that maintenance cost is one of the challenges in green roof installation (average index = 5.73), this challenge could be reduced by identifying the maintenance requirements in the early planning phase before deciding to design the base of a green roof. Among the significant criteria of green roof maintenance are the roof slab design, roof drainage, waterproofing, water retentions, and irrigation²³. Placing the maintenance criteria into the design phase of the roof itself will help the owners to clearly understand the maintenance process during roof operations and the expected cost-in-use derived from the maintenance.

6 Way Forward for the Potential of Green Roof Technology

A green roof has many benefits if it is properly promoted and implemented. A green roof supports the urban greenery concept to ensure a well-balanced development of an urban area. The principle-based concept of green urbanism was developed in the late 1990s to promote the development of an energy-efficient city⁶. Therefore, green roofs can be considered a great choice among the other green alternatives. It can improve the reduction of rooftop surface temperatures, reduce ambient air temperatures, improve human thermal comfort, and create energy-saving buildings.

Malaysia is already aware of green roof development, but the development is slowly being adopted²⁴. Extensive promotion and awareness need to be done to push the acceptance of this technology¹⁴. The green roof development can be extended to individual homeowners, especially within urban areas where availability of space is the main concern as well as to the private-owned commercial centre developer. Aside from the commercial and aesthetical benefits, the end-users of the building can also enjoy a perfect, relaxing escape amidst the surrounding nature, which adds more value to the property.

The policy pressure from the local government will create the needs, and the market pressure will create demands through users' interest¹². The policy and market pressure are the low-hanging fruit approaches to promote green roofs to the local construction industry market²¹. The carrot and stick concept, for example, is a push element for industrial innovation to be embraced and has proven effective in many innovation practices. This carrot represents incentives, tax exemptions, and recognition, which can create motivation. The stick represents the penalty which will help to drive compliance by the developers¹².

7 Conclusion

A green roof is an innovative technology that has been presented to

assist in minimising environmental deterioration, utilise space, and promote green habits to become ingrained into the everyday lives of end-users. Through push factors, such as government laws, the pressure for an alternative to provide cooling to buildings, and a high degree of awareness among construction stakeholders and the public, developed nations have embraced this creative approach to bring green components to buildings. In Malaysia, green roofing technology is still in its early stages, leaving plenty of space for further study.

While the data used in this study has some limitations, such as the fact that it is based on the opinions of only one profession in the project team, the findings have highlighted potential issues such as a shortage of green roof suppliers in Sarawak's construction industry. The green roof is still regarded as new to most construction players in Sarawak, indicating that they have yet to get exposure to green roof technology. The increased cost is often mentioned as a major problem that prevents practitioners and clients from including green roofs in their projects. It is hoped that more studies will be conducted to investigate a viable solution to these problems and open the door for this beneficial technology to the building sector. Every new technology introduced will require a long-term commitment and more studies to make it more effective and handled wholly by the project team.

Conflict of Interest

The authors declare that there is no conflict of interest.

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