What is Stopping the Adoption of Sustainable Residential Buildings in Malaysia?

AbdulLateef Olanrewaju, Cheang Shi Min, Shalini Sanmargaraja and Vignes Ponniah

Abstract Researchers and the government have advocated for the delivery of sustainable building projects in Malaysia; however, the rate of demand and supply of the sustainable residential buildings has been low and the increase is slow. This research aims to examine the barriers towards the adoption of a sustainable residential building. This research conducted a cross-sectional survey using a questionnaire comprising 19 barriers to adoption of sustainable residential buildings administered on 110 professionals in the building industry. The research found that 89% of the responding housing professionals observed that there are barriers obstructing the adoption of sustainable residential buildings. The research found that a lack of experience on sustainable building projects by the industry, maintenance problems, lack of technology for the delivery of sustainable building projects, lack of competent labour in sustainable buildings, and the high capital cost of sustainable residential buildings compared with the conventional buildings are the five main barriers stopping the adoption of sustainable buildings in Malaysia. Based on the findings, it infers that the delivery of sustainable housing depends on the technological advancements, policies, competencies, awareness, homebuyers' experience, and costs. The research concludes by presenting a cycle of barriers for the rapid adoption of sustainable buildings. The findings provide feedback and feedforward information to the policymakers, design and construction teams, and manufacturers.

Keywords Green buildings · Technology · Developers · Whole life appraisal

1 Introduction

For a decade, the Malaysian government has initiated a number of measures to ensure that sustainable development goals are achieved in the construction industry. At the same time, there has been research that has established the need for the rethink-

A. Olanrewaju (✉)
Universiti Tunku Abdul Rahman (UTAR), Kampar, Malaysia
e-mail: abdullateef.olanrewaju@gmail.com

C. S. Min · S. Sanmargaraja · V. Ponniah
Universiti Tunku Abdul Rahman, Kampar, Malaysia

Z. Gou (ed.), *Green Building in Developing Countries*, Green Energy and Technology, https://doi.org/10.1007/978-3-030-24650-1_10

ing of strategies to implement sustainability in construction projects [9], examined the understanding of the concept of sustainability amongst property developers [18], assessed the readiness of the developers towards green home development [8], examined the barriers to adoption of sustainable buildings [14], evaluated the benefits of supplying sustainable housing [10], and investigated the reasons for the supply of sustainable housing [11] in Malaysia. In fact, Shari and Soebarto [14] described the multiple interests towards sustainable construction in Malaysia as 'top-down and bottom-up pressures'. Paradoxically, the rate of demand and supply of the sustainable housing has been low and slow, in both absolute and relative terms. For instance, there are six sustainable construction guidelines in Malaysia, and five of them are mainly for buildings projects. The number of certified buildings after completion and verification assessment (CVA) by Green Building Index (GBI) Malaysia which is considered as the most recognised by the industrial players and stakeholders for the last six years is less than 500 (Table 1). Whilst data for the previous years since the inception of the guideline in 2009 are not available, it is not difficult to argue that the total certified buildings are less than 200. However, whilst 2069 buildings have been certified to meet the design requirements, only 368 buildings have received the final certification after construction during the last six years. This represents less than 20%. Therefore, more than 6 million housing need to be upgraded to include green features.

Meanwhile, the total number of residential buildings in 368 buildings is only about 42%. Similarly, during this period, the certifications for the residential buildings are not renewed. It is also obvious that the increment rate is not fast. In fact, the Malaysian construction industry is entangled with sustainable practices and activities on account of numerous construction defects, delays, high costs and time overruns, increasing accidents on sites, volume of generated wastes, low productivity, pollution, labour exploitation and abuse, claims and disputes, and environmental degradation. A sustainable building is a building that is designed, constructed, operated, and maintained to address these problems. Consequently, from a research perspective, there is an urgent need to close this gap that exists between practice and research/theory. Therefore, this current research aims to investigate the barriers stopping the supply of housing. By so doing, it seeks to provide reference tools for government, industry, public, academic, and homeowners towards the provision and operations of affordable housing that is in compliance with the sustainability requirements in line with the global best practices. However, before moving on, we will make a clarification regarding the sustainable buildings. Some writers tend to distinguish between sustainable building and green building. Nevertheless, in this study, both terms and phrases are the same and they are used interchangeably.

Table 1 Summary of GBI-certified projects by year, on 15 December 2018

	2013		2014		2015		2016		2017		2018	
Sector	Total certified before CVA	Final certification after CVA	Total certified before CVA	Final certification after CVA	Total certified before CVA	Final certification after CVA	Total certified before CVA	Final certification after CVA	Total certified before CVA	Final certification after CVA	Total certified before CVA	Final certification after CVA
Total	190	17	265	30	335	51	377	66	435	86	467	118
Non-residential new construction	92	7	124	13	168	24	186	31	218	40	238	47
Residential new construction	84	5	122	11	138	17	158	25	178	36	187	59
Industrial new construction	2	2	5	3	9	4	9	2	11	2	13	4
Non-residential existing construction	7	2	7	2	10	4	13	6	13	5	13	5
Industrial existing building	1	1	1	1	3	2	3	2	3	2	3	2
Interior	–	–	–	–	–	–	–	–	1	1	1	1
Township	4		6		7	–	8		11	–	12	–

CVA Completion and Verification Assessment. *Source* GBI [5]

2 Theoretical Framework and Background

An extensive review of the literature revealed that sustainable development or sustainability has many interpretations but all the definitions have taken their roots from the definition and explanations put forward in a report of the Brundtland Commission [10]. The topical issues in the efforts towards sustainable development are the need to integrate economic, environmental, and social aspects in the decision-making [1, 4, 15] to increase productivity, enhance integration, reduce wastes, and increase well-being. The bottom line is that, in the current global scenario, we are currently consuming more than what the earth can productively support, and producing and discharging wastes that are far beyond what the earth can accommodate. At a practical level, sustainable development is a practice that integrates various criteria, including energy efficiency, community, waste minimisation, water efficiency, social impacts, good indoor environment, material control, ethic practices, zoning, pollution control, life cost, user-friendliness, and user comfort [12].

The impact of building construction and operation on sustainability issues is huge. For instance, buildings consume more than 40% of the world's energy, release one-third of the CO_2, use about 25% of harvested woods, release about 50% of fluorocarbons, produce 40% landfill materials, use 45% of the energy in operations, emit 40% of greenhouse emissions, and use 15% of the world's usable water. Olanrewaju et al. [10] explained that the production [brief, design, and construction] and use of sustainable buildings influence a variety of criteria, especially the materials, components, design, layout, and delivery process. The location, size, design, materials used, procurement strategies, maintenance, and operation of housing make the housing delivery threaten the fundamental aspects of sustainability. Sustainable buildings are cheap, efficient, attractive, pleasant, and satisfying because they help to (1) reduce water requirements; (2) use localised materials, components, and labour; (3) improve energy efficiently; (4) reduce traffic and transportation costs; (5) generate their own energy; and (6) contribute to the decarbonisation of the built environment. Because of the compelling benefits of sustainable buildings, many governments have made policies to increase the uptake of the supply and demand for sustainable buildings.

The Malaysian government and the construction industry recognise the need to increase the supply of sustainable construction projects (Government of Malaysia, 2010). In particular, in order to achieve the government's aim of incorporating green technology into the country's construction industry, policies and regulations have been established and green rating tools have been developed by the industry and government. The tools are the Green Performance Assessment System (Green PASS), Skim Penilaian Penarafan Hijau JKR (PH JKR), Malaysian Carbon Reduction and Environmental Sustainability Tool, (MyCREST), Green Real Estate (GreenRE), and Green Building Index (GBI). The Sustainable INFRASTAR, which aims to act as a design and measurement tool to ensure consideration of sustainable elements and is incorporated early on in the development of the project, was developed in 2018 [2]. The Sustainable INFRASTAR is specific to infrastructure projects other than the building portion. However, despite these efforts, the rates of supply and demand for the sustainable buildings have been low and slow. Corroborating this view, Olanrewaju et al. [10] found that the major impediment obstructing the adoptions, implementations, and practices of sustainability in construction project delivery is the lack of a concise and clear framework. Apart from the policies' formulations and implementations, and supported by the industry, research, which has been advocated for the adoption and implementation of sustainability in the construction industry, has been conducted [8, 14, 18]. However, despite the scientific activities and policies, and implementation with the support from the professional bodies, the adoption of the sustainable residential building is low and, further, the previous research is not specific to housing, but rather to the general buildings of the construction industry as a whole, and is qualitatively driven; and, hence, it is hindering the systemic decisions, generalisability, and applications. This research aims to fill this gap.

3 Research Design

The question that this research seeks an answer to is 'What are the barriers to the adoption of sustainable housing?' It is imperative to know the barriers in order to provide cogent measures to improve the uptake of sustainable buildings. The primary data collected were based on convenience sampling. Like other survey methods, it is inductive in nature. Convenience sampling is a data collection method where the survey is administered to available, accessible, and willing respondents. The method is appropriate where sufficient information on the population size and sample frame is not available. Its findings may not be generalisable; however, with a large number of respondents, the findings can be typical. Thus, its basic premise is that if sufficient data are collected and objectivity is maintained, the results will be a representative of the population.

The questionnaire consists of two sections, namely participants' demographic information and perceived barriers towards green building adoption in Malaysia. Thirteen questions were prepared for Section A, and thirty questions were prepared for Section B. The specific questions can be found in the following analysis.

The questionnaires were administered to the respondents through online surveys to the stakeholders in the building industry. The online survey was launched on 6 August 2018 and was open until 10 September 2018, but because of a low response rate, it was re-conducted on 1 November 2018 until 12 December 2018. The respondents were asked, based on their current evidence, to measure the extent to which the barriers obstruct the adoption of sustainable housing in Malaysia on a five-point Likert scale, where 1 = not critical, 2 = somewhat critical, 3 = critical, 4 = very critical, and 5 = extremely critical. The extent of the criticality of the barriers to obstruct the adoption of sustainable residential buildings was determined by the Average Relative Index (ARI) (Eq. 1).

$$\text{ARI} = \frac{\sum_{i=0}^{5} a_i x_i}{5\sum_{i=0}^{5} x_i} \times 100 \quad (1)$$

where a_i was the index of a group; constant expressed the weight given to the group; x_i was the frequency of the responses; $i = 1$, 2, 3, 4, and 5; and described as below: x_1, x_2, x_3, x_4, x_5; the frequencies of the responses were corresponding to $a_1 = 1, a_2 = 2, a_3 = 3, a_4 = 4, a_5 = 5$, respectively. For interpretation, an ARI score of 1.00–20.00 was denoted as not critical, 21.00–40.00 was denoted as somewhat critical, 41.00–60.00 was denoted as critical, 61.00–80.00 was denoted as very critical, and 81.00–100.00 was denoted as extremely critical. There was a pooled difference of 1.0% between each of the scales. The barrier with the highest ARI score was the major barrier to the adoption of a sustainable residential building. All the constructs were positively worded. To ensure that the results would not be influenced by the authors, missing data were not replaced with either a mean or mode of the valid response. The mode technique was used to analyse the demography of the respondents. In order to test the hypotheses, whether each of the barriers could obstruct the adoption of sustainable buildings or not, one-sample t-test was conducted. The other statistical tests computed were the one-way t-test, Cronbach's alpha tests, validity, Kaiser-Meyer-Olkin Measure of Sampling Adequacy, Bartlett's test of sphericity, mode, standard deviation, or as the case may be. The mode was also used to determine the distribution of the respondents with respect to the scales. All data gathered adopted the SAS Enterprise Guide 7.1 for analysis.

3.1 Analysing the Results of the Survey

More than 3000 online survey forms were administered to the respondents; however, only 110 completed responses were received during the survey period, lasting more than three months. The results are presented in tables and figures and discussed in the following sections.

3.2 Demographic Profiles of the Respondents

Some 70% of the respondents obtained a minimum of B.Sc. degree (Table 2), and most (36%) of the respondents had their degrees in architecture and construction management (Fig. 1). The majority of those with Ph.D.s had their degree in architecture, and most of those with a B.Sc. had their degree in construction management. Most of the respondents held strategic positions (Table 3); more than 50% had more than 5 years of working experience (Table 4); approximately 12% had more than 20 years working experience. Most of the respondents worked with contracting organisations, whilst approximately 25% were with architectural firms (Table 5).

Table 2 Highest academic qualification

Qualification	Frequency	Cumulative percentage
PMR	1.00	0.91
SPM	22.00	20.91
Diploma	11.00	30.91
Degree	59.00	84.55
Master	6.00	90.00
Ph.D.	11.00	100.00

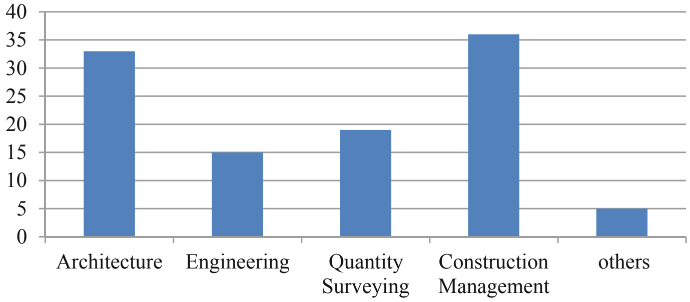

Fig. 1 Highest academic qualification

Table 3 Current position in the organisation

Position	Frequency	Cumulative percentage
Principal	5	4.545
Site coordinator	5	9.091
Architect	35	40.909
Engineer	17	56.364
Quantity surveyor	27	80.909
Project manager	6	86.364
Construction manager	8	93.636
Design manager	6	99.091
Plant manager	1	100.000

Table 4 Respondent's working experience

Year	Frequency	Cumulative percentage
Less than 5 years	52	47.273
5–10 years	35	79.091
11–15 years	7	85.455
16–20 years	3	88.182
More than 20 years	13	100.000

Table 5 Respondent's type of organisation

Organisation	Frequency	Cumulative percentage
Property development	9	8.182
Contractors	37	41.818
Building material supplier	7	48.182
Bank	6	53.636
Architectural consulting firm	28	79.091
Engineering consulting firm	6	84.545
Quantity surveying consulting firm	17	100.000

The results revealed that most of the survey respondents were involved in the development of sustainable buildings at the design and construction phases (Fig. 2).

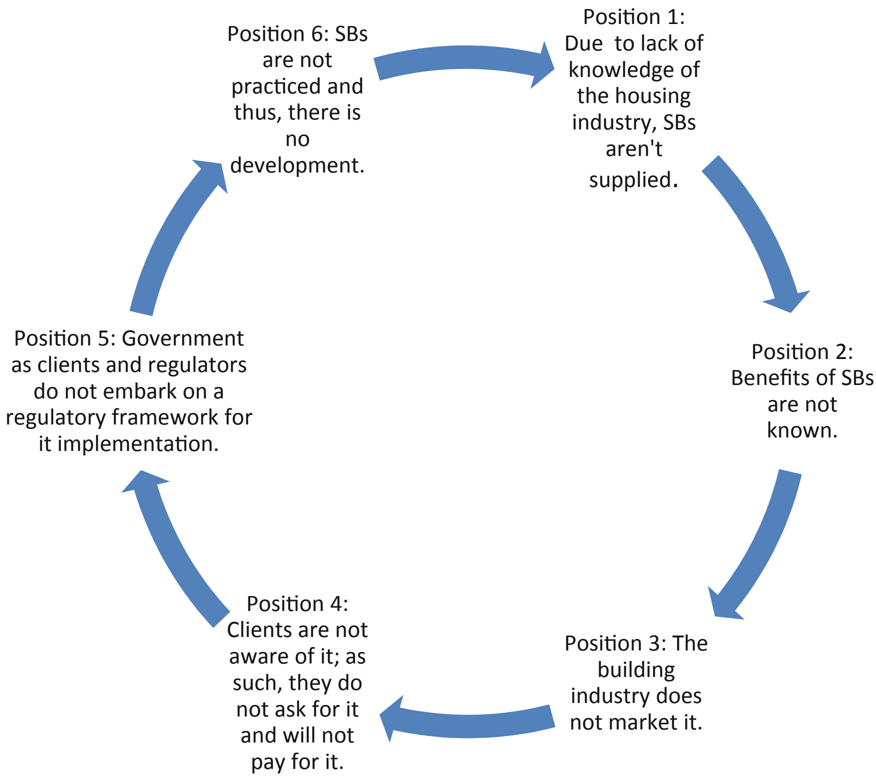

Fig. 2 Cycle of barriers

Based on their practical experience, close to 95% of the respondents confirmed that the price of sustainable buildings was higher than conventional buildings by more than 5% (Table 5). In fact, 15% of the respondents measured that sustainable buildings were expensive by more than 20% as compared to conventional buildings.

4 Survey Results

4.1 Analysis of the Barriers Stopping the Adoption of Sustainable Residential Buildings

The reliability test results indicate that the Cronbach's alpha for each of the barriers was 0.905, and the validity test, using the 'commonalities', returned a cumulative average of 0.689. Table 6 contains the t-test statistics to examine the measurements of the population with respect to each of the barriers. The null hypothesis was that each of the barriers will not stop the adoption of sustainable residential buildings (H0: U = U0) and the research hypothesis was that each of the barriers will stop the adoption of sustainable buildings (Hr: U > U0). U0 was the population mean. Two was set as the t-test level. Based on the results (Table 6), the significance (i.e. Pr > |*t*|) of each of the barriers (Hr: $U > U0$) showed that the all of the barriers was statistically significant. The degrees of freedom for all the factors were the same at 109. Furthermore, the small standard errors were close to zero. These suggest that the measurements of the respondents with respect to the barriers were reflections of the population. The KMO was very high (0.0852), and Bartlett's test significance is as follows: x^2 (171) = 1004.647, $p = 0.000$. These statistics suggest that the barriers will obstruct sustainable housing when drawn from a population with a similar background; hence, the information is suitable for the designed aim.

The average of the ARI values for all the barriers was 74.058, and the average standard deviation was 18.083 (Table 7). The standard deviation (SD) for the barriers, being less than 25, was also an indication of consistency. Furthermore, it is obvious that all the barriers based on the distribution of the ARI are very critical barriers in stopping the adoption of sustainable buildings because they fell within the ranges between 61 and 80. The plain interpretations of these statistics are that all the professionals in the housing industry measured that the barriers were those stopping the adoption of sustainable buildings. In particular, whilst 11% measured that the barriers were not critical or were somewhat critical in stopping the adoption of sustainable buildings, 23% agreed that they were actually critical. However, 66% knew that the barriers were very critical or in fact extremely critical in stopping the adoption of sustainable housing.

Table 6 One-sample test

Barrier	*t* Value	Pr > |*t*|	Mean difference	Lower	Upper	Std. error mean
High initial price of green residential buildings compared with conventional buildings	23.293	0.000	1.800	1.647	1.953	0.077
Research and development costs for green buildings	22.177	0.000	1.791	1.631	1.951	0.081
Longer construction time for green buildings	14.327	0.000	1.355	1.167	1.542	0.095
Lack of reliable cost and performance data	17.315	0.000	1.573	1.393	1.753	0.091
Lack of customer demand for green residential buildings	16.323	0.000	1.664	1.462	1.866	0.102
Technical difficulty during the construction process	16.403	0.000	1.509	1.327	1.691	0.092
Lack of relevant experience in green building projects	23.050	0.000	1.891	1.728	2.054	0.082
Lack of codes and regulations for green buildings	18.406	0.000	1.627	1.452	1.803	0.088
Lack of technology in green building projects	19.995	0.000	1.791	1.613	1.968	0.090
Lack of competent labour in green buildings	20.716	0.000	1.818	1.644	1.992	0.088
Lack of knowledge and training in green building projects	22.769	0.000	1.891	1.726	2.056	0.083

(continued)

Table 6 (continued)

Barrier	*t* Value	Pr > |*t*|	Mean difference	Lower	Upper	Std. error mean
Lack of quantitative evaluation tools for green performance	20.094	0.000	1.773	1.598	1.948	0.088
Low supply of green materials and components	19.651	0.000	1.709	1.537	1.882	0.087
Additional responsibility for construction maintenance	24.337	0.000	1.862	1.711	2.014	0.077
Divided interests; parties concerned with design and construction not associated with operators/users	19.070	0.000	1.600	1.434	1.766	0.084
Lack of enforcement	22.466	0.000	1.791	1.633	1.949	0.080
Lack of government support	20.274	0.000	1.745	1.575	1.916	0.086
Lack of public awareness	19.618	0.000	1.836	1.651	2.022	0.094
Weather conditions	11.248	0.000	1.182	0.974	1.390	0.105
Lack of strategy to promote green buildings	22.088	0.000	1.745	1.589	1.902	0.079

5 Discussion of the Findings

As previously stated, the degree of the criticality of the barriers to sustainable building delivery by the Malaysian housing market was based on the computation of the ARI. Therefore, the barrier with the highest ARI was the main barrier to the adoption of a sustainable building, whilst the barrier with the lowest ARI was the least of a barrier to sustainable building adoption. The research found the lack of experience of the Malaysian construction industry on the sustainable building as the main barrier. This finding seems to support Zainal Abidin [18] finding that the awareness of the sustainability/sustainable development by the Malaysian property sector was low. Although sustainable development has been around for many years, many industrial players are yet to fully comprehend its meaning, and in fact, many still cast

Table 7 Distribution of statistics

Barrier	Not critical	Somewhat critical	Critical	Very critical	Extremely critical	Reliability	Validity	ARI	SD
Lack of relevant experience in green building project	1	8	17	60	24	0.92	0.73	78.13	17.05
Additional responsibility for construction maintenance		6	25	56	22	0.93	0.48	77.38	16.04
Lack of technology in green building projects	3	9	17	60	21	0.92	0.74	76.64	17.91
Lack of competent labour in green buildings	3	7	19	59	22	0.92	0.76	76.64	18.32
High initial price of green residential buildings compared with conventional buildings	1	8	19	66	16	0.93	0.75	76.26	16.05
Lack of public awareness	3	7	24	47	29	0.92	0.76	76.26	19.64
Research and development costs for green buildings	2	5	26	58	19	0.92	0.75	76.07	16.81
Lack of enforcement	1	6	28	55	20	0.92	0.75	75.89	16.42
Lack of quantitative evaluation tools for green performance	3	9	17	62	19	0.92	0.69	75.70	18.43
Lack of government support	2	6	32	48	22	0.93	0.74	75.14	17.77
Low supply of green materials and components	3	9	21	61	16	0.92	0.70	74.77	17.66
Lack of strategy to promote green buildings	2	7	22	65	14	0.92	0.62	74.77	16.56
Lack of customer demand for green residential buildings	7	8	21	53	21	0.93	0.56	74.58	20.11

(continued)

Table 7 (continued)

Barrier	Not critical	Somewhat critical	Critical	Very critical	Extremely critical	Reliability	Validity	ARI	SD
Lack of codes and regulations for green buildings	2	13	24	56	15	0.92	0.73	72.71	18.51
Divided interests; parties concerned with design and construction not associated with operators/users	2	10	31	54	13	0.93	0.60	72.52	17.05
Lack of reliable cost and performance data	3	14	23	57	13	0.92	0.73	71.96	18.60
Technical difficulty during the construction process	3	14	31	48	14	0.92	0.67	70.28	19.30
Longer construction time for green buildings	6	13	37	44	10	0.93	0.57	67.85	19.38
Weather conditions	11	14	40	34	11	0.93	0.76	63.55	21.95

doubt on its purpose and whether it is achievable or not. However, this finding is compelling because it is only when the professionals in the building industry have gathered enough experience and are themselves convinced that they can 'market' the green buildings to home buyers and other stakeholders. Maintenance cost has been receiving serious attention lately as clients or homebuyers are now taking whole life appraisal of buildings instead of considering only the initial construction or purchasing cost. Therefore, it is not unexpected that the maintenance factor turned out to be the main barrier to the adoption of sustainable housing.

The sustainable buildings have different maintenance requirements, of which it seems the building industry is cognisant. The maintenance of the sustainable housing would be more challenging. A lack of technological resources to support the supply of sustainable buildings was cited as a major obstacle to the adoption of sustainable buildings. Examples of green building technologies for green housing include IBS, prefabricated concrete solar technology, and a rainwater harvesting system and recycle system. In order to promote the adoption of the sustainable buildings, there is a cogent need to have the technology that will supply the needed materials and components. In fact, it has been argued that to facilitate the adoption of green buildings, GBT must be embraced first [15]. One of the major reasons why sustainable buildings are expensive in Malaysia is because the cost of green materials and components is high since they are not available locally. To bring the cost of sustainable buildings down, a major area that needs attention is materials.

Normally, the cost of materials accounts for not less than 50% of the construction costs. It is interesting to find that the lack of competent labour in sustainable buildings comes next to the lack of technology and close to the lack of experience of building the industry on sustainable buildings. Green materials and components have different compositions as compared to conventional materials and components than the site operatives and professionals are familiar with; hence, a different set of skills and knowledge are required for the design, installation, and assembly of green materials and components. The housing industry will need to provide special training to site operatives on the construction of sustainable buildings.

Research and practice show that sustainable buildings are more expensive as compared to conventional buildings due to many causes, including the barriers discussed in this article. However, empirical evidence in countries including the UK, Australia, and the USA [12] suggests that the differential cost between sustainable buildings and conventional buildings is less than 5%. However, in Malaysia, more than 95% of the survey respondents measured that sustainable buildings were more than 5% higher to conventional buildings. In fact, 50% of the respondents believed that it was more than 15% more expensive than the conventional buildings. With this mind, it is not surprising that the high initial price of green residential buildings compared with the conventional buildings was also found to be a major barrier to the adoption in Malaysia. However, the high initial cost of green buildings as compared to conventional buildings was also found to be a major barrier in England [16]. Moving forward, the research found that homebuyers and home users are not aware of the sustainable buildings.

The general problems amongst the public are what sustainable buildings look like and how to define/describe them and how they benefit them. A lack of awareness of the benefits of green buildings was also a barrier in England [16]. To this extent, the building industry needs to promote and display sustainable buildings in order to create more awareness, especially on the success stories. Research and development costs turned out to be a major barrier to the adoption of sustainable buildings. In general, R&D in Malaysia is low. In fact, construction companies invest less than 1% of their turnover on R&D. This result is not different elsewhere. In Singapore, Hwang and Ng [7] also found the cost of R&D to be amongst the major barriers to green building adoption. For sustainable materials and components, which are mostly imported, it requires some research to examine their suitability and compatibility with the local contents. Some of the locally produced materials would require research to test their practicability and sustainability. This will require an investment in terms of time, expertise, and capital. Presently, there is no strict enforcement to promote or compel the building industry to implement sustainable materials and practices; as well, there are no regulations that compel a homebuyer or homebuyers to buy sustainable buildings. Needless to say, there are incentives for the housing industry and buyers to implement and practice sustainability, but penalties are not strictly enforced. Much of the research on sustainable construction has been qualitative. Consequently, many industrial players are not convinced regarding the benefits of sustainable housing.

One of the main motivators for the adoption of sustainable buildings is active government support. However, as the research indicates, government support is far from being enough. In fact, more than 50% of the respondents considered that government support was low. As previously explained, the technology is very critical for the supply of sustainable materials. Based on 63 in-depth interviews involving stakeholders in residential and mixed-use schemes, William and Dair [16] found that material shortages were a major barrier to green building adoption in England. These similar results were found in Singapore [7]. Therefore, it is not surprising that a lack or shortage of sustainable materials was found to be a barrier to the adoption of sustainable buildings. The research shows that the lack of clear strategies to promote the adoption of sustainable buildings was also a major barrier. The benefits of sustainable buildings need to be communicated to the potential homebuyers. It seems that the Malaysian government is yet to understand and promote the adoption of sustainable buildings. The government and the industry have much to benefit from if sustainable buildings are widely developed. For instance, in China, the government promotes sustainable building development more than the housing developers [4].

The CIDB Malaysia, the Ministry of Works, and other relevant agencies need to be proactive and aggressive in marketing the sustainable building development to organisations, architects, engineers, contractors, manufacturers, and suppliers. Workshops and training are required on the development process and operation of sustainable housing. Research shows that workshops/seminars, education/training, and periodical/magazines are the major sources of information for the active adoptions of sustainable [13]. Homebuyers and occupants need to be convinced of the benefits of sustainable buildings to heighten demand. Thus, it is not surprising to find that the lack of customers' demand for green buildings will stop its adoption. A recent research in Malaysia found that the main barriers to the adoption of commercial buildings were because clients did not require sustainable commercial buildings [14]. However, it is considered that clients are by nature inexperienced with the construction business and the benefits of sustainable buildings.

Hence, it is the responsibility of the industry to educate the clients and create the awareness. Clients will demand services or products once they are convinced of the benefits. Echoing the importance of regulations and codes, this research found the need for the availability of codes and regulations. This finding is consistent with the recent research that a barrier to sustainable construction in Malaysia was a lack of regulations [3]. Research also found that a lack of regulations, policies, and codes was amongst the barriers to green building adoption in Australia and Ireland [17]. Regulations that could be introduced for sustainable development include building energy codes, appliance standards, and land-use zoning. Through building codes, USD 1.1 billion was saved in 1998 in the USA and appliance and equipment efficiency standards led to cutting electricity consumption by 2.5% and carbon emission by 1.7% in 2000 [6]. A dominant problem in the construction industry is the fragmentation of the delivery process. Therefore, it is not surprising to find that the divided interests among the consultants, contractor, developers and buyers is a clear barrier to the adoption of sustainable buildings. In fact, the lack of consideration of sustainability by project team members was also found to be a major barrier to the adoption of green buildings [14].

To provide feedback and feedforward information to the design and construction teams and to convince stakeholders, especially the homebuyers, home users, and third-party agencies, data on the cost and performance of the existing sustainable buildings are required. In Malaysia, the 'success story' data seem to be lacking or not convincing. The design and construction teams are yet to be keeping such data. However, considering that more than 50% of the respondents measured that sustainable housing could be very expensive, it calls for concern. Difficulty in the construction of sustainable buildings is a problem for the adoption of sustainable buildings. This does not come as a surprise with the general lack of experience of the industry in sustainable buildings, lack of technology, and lack of performance data. There is no empirical research that suggests that sustainable buildings take more time to construct as compared to conventional buildings. Because of this, it is surprising that this research found that one of the main barriers to the adoption of sustainable buildings was the longer time required to construct sustainable buildings. A plausible explanation for this is due to the lack of supporting technology, lack of market, and the shortage of sustainable materials and lack of labour. It is equally surprising to find that the Malaysian weather is not friendly to sustainable building development. We are sceptical to interpret this finding. However, good weather may have a negative impact on the supply of industrialised building systems. For instance, because Malaysian is good and encourages site activities throughout the year, investment in IBS construction may not be encouraging.

6 Summary and Suggestions for the Construction Industry

It is extensively recognised that sustainability requirements need to be addressed, and government and stakeholders, including developers, contractors, and third-party agencies, have introduced measures towards these objectives. Yet, there is an apparent low demand and supply of sustainable residential buildings. This article has been able to identify and quantify the barriers stopping the adoption of sustainable residential buildings. Collectively, the reasons for the apparent low supply and practice of sustainable buildings on a greater scale can be summarised in the lack of knowledge and innovation in the construction industry, which could be summarised as the 'cycle of barriers' displayed in Fig. 2. The identification and analysis of the barriers can contribute towards developing a framework that supports and promotes the implementation of sustainable buildings in Malaysia. This study has both strategic and tactical implications because it provides feedback and feedforward information to the building industry and the government to achieve the sustainable development goals.

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AbdulLateef A. Olanrewaju is currently attached with Universiti Tunku Abdul Rahman under the Faculty of Engineering and Green Technology in Department of Construction Management as an Assistant Professor. He gained his Master of Science in the built environment from the International Islamic University Malaysia (IIUM) and his Ph.D. from Universiti Teknologi PETRONAS Malaysia for his research in building maintenance management. He received his quantity surveying education at Kaduna Polytechnic, Nigeria. He has authored and co-authored several scientific papers. Olanrewaju is a referee for leading journals. He has served has as panel-list and keynote speaker on different topics relating to construction industry. His current research and proficiency concentrates on building maintenance management; sustainable building research methodology; quantity surveying, value management; housing; ethical and issues in construction industry.

Cheang Shi Min obtained her Bachelor of Science (HONS) degree in Construction Management at Universiti Tunku Abdul Rahman. Her research is about the construction, sustainable buildings and homebuyers' satisfactions.

Shalini Sanmargaraja is currently attached with Universiti Tunku Abdul Rahman under the Faculty of Engineering and Green Technology in Department of Construction Management as an Assistant Professor. She obtained her bachelor's degree with Honours in Technology Management (Construction) in 2010, M.Sc. in Real Estate and Facilities Management in 2012 and Ph.D. in Real Estate and Facilities Management in 2017. She produced 24 proceedings and 14 International journals. She was awarded with 3 best paper awards in the International Conference on Business Management and Information Technology (ICBMIT) in 2014, Multidisciplinary Academic Conference in 2017 and International Conference on Advanced Social Sciences in 2017, respectively. Her current research and proficiency concentrate on sustainable development, facility management, housing, indigenous, disabled and elderly population studies and safety in construction.

Vignes Ponniah is currently attached with Universiti Tunku Abdul Rahman under the Faculty of Engineering and Green Technology in Department of Construction Management as an Assistant Professor. He graduated with Ph.D. in Green Construction Management from School of Housing, Building and Planning in Universiti Sains Malaysia in the year of 2016. His research interests are related to sustainable development, energy modelling and energy performance of buildings. Besides, he had 9 years of experience working in companies which involves in construction and property management before joining academic institution since 2016. He is also a certified GreenRe Manager since year 2017.