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Challenges and Solutions for Sustainable Residential Development in Malaysia: A Construction Stakeholder's Viewpoint

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ABSTRACT

Green residential buildings are essential for reducing the environmental impacts of buildings and supporting the development of sustainable cities. Despite various government initiatives, their adoption in Malaysia remains limited, and little empirical work has examined the barriers experienced by construction stakeholders. This study aims to develop a stakeholder-centred approach to accelerate the implementation of green residential buildings by assessing stakeholders' awareness, identifying key barriers and prioritising effective strategies. A questionnaire survey was conducted among Malaysian construction stakeholders, and data were analysed using the Shapiro-Wilk test and the Relative Importance Index to evaluate awareness level, key barriers to green building residentials implementation, and determine preferred mitigation measures. The findings indicate that awareness of green building residentials is generally moderate to high. However, governmental and policy-related constraints constitute the most significant barriers, followed by economic and financial challenges. Stakeholders identified financial incentives, low-interest loans, subsidies, and the formation of dedicated promotional teams as the most effective strategies for improving adoption. These insights were synthesised into an integrated, context-specific model designed to guide and support the expansion of green residential building practices in Malaysia. The study contributes to sustainable construction and energy planning research by presenting a stakeholder-driven model that enhances environmentally responsible residential development and informs long-term energy-efficiency and decarbonisation strategies in emerging economies.

Keywords

Green residential building;
Sustainability;
Stakeholder perspectives;
Barriers;
Strategies

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1. Introduction

Residential buildings and the broader construction sector continue to exert significant pressure on global energy systems and the environment. It is estimated that residential buildings alone account for 22% of global final energy use and approximately 17% of direct and indirect carbon emissions [1]. These figures highlight the urgent need for more sustainable building practices, particularly in rapidly developing nations where urbanisation rates remain high.

As emphasised in energy planning research, overcoming barriers to improving energy performance in buildings requires both technical innovation and supportive policy frameworks [2]. In response, the concept of green buildings, emphasising efficient resource utilisation, reduced environmental impact, and enhanced occupant well-being, has gained global traction [3]. Green buildings also play a pivotal role in advancing Sustainable Development Goals (SDG) 3, 7, 11, and 12 [4], which aims to foster safe, resilient, and sustainable urban environments.

In Malaysia, a suite of policy incentives has been introduced to encourage green building adoptions. These measures include tax exemptions and the Green Investment Tax Allowance (GITA) for the acquisition of certified green technology assets, alongside the extension of Green Income Tax Exemptions through 2023 [5] Complementing these financial mechanisms, the

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government has also advanced renewable energy uptake through initiatives such as solar leasing under the Net Energy Metering (NEM) Scheme.

The national commitment to sustainable was further reinforced in Budget 2023, where Strategy 3 under the Economic Prosperity pillar prioritised responsible development. This included allocation of RM150 million to the Khazanah National Impact Fund for green projects, and RM75 million for the solar rooftop installation on selected government buildings in Putrajaya [6].

Despite these policy efforts, the actual uptake of green building practices, particularly green residential buildings, remains limited. Existing research shows that Malaysia is still in the early stages of green building adoption compared to other countries such as China, Singapore and Australia [7][8]. China, for example, recorded approximately 24,700 certified national green buildings in 2020 [2], whereas Malaysia's Green Building Index (GBI) listed only 625 certified green buildings as of September 2020, with merely 218 categorised as new residential projects [9].

When contrasted with Malaysia's sizeable housing stock, estimated at 6,022,030 residential units in the first half of 2022 [10], the adoption rate of green residential building remains proportionally very low. This gap indicates persistent structural and industry-level barriers that constraint the translation of policy incentives into widespread green residential development

The Malaysia case is not isolated; international studies similarly report challenges in advancing green building adoption. Research from Tanzania [11], Turkey [12], Zambia [13], and Kuwait [14] consistently identifies low stakeholder awareness as a major barrier to effective implementation. Some countries have begun addressing these challenges through context-specific frameworks, such as the Nigerian model proposed by Ebekozien, Ikuabe, Amo-Osagie, Aigbavboa & Ayo-Odifitri [15] to enhance green building integration in its construction sector. However, despite these advancements, research focusing specifically on green building residentials remains limited, even though residential projects distinct design requirements and stakeholder dynamics compared with commercial or institutional green buildings.

Research on green buildings in Malaysia has largely centred on broad green building frameworks or specific professional groups. For instance, Yassin, Musa, and Shafii [16] studied the awareness of Malaysian construction industry players, but their study did not extend to identifying strategies to overcome barriers, nor did it focus specifically on residential buildings. Similarly, the authors' previous works, such as studies on the lifecycle maintenance of vertical greenery systems in tropical climates [17] and reviews of retrofitted awarded green buildings in Malaysia [18], focused on technical and performance-related aspects of green building practice.

In contrast, the present study offers a novel contribution by examining green residential buildings through the lens of stakeholder awareness, barriers, and strategic enablers, ultimately leading to the development of an integrated stakeholder-driven model to enhance green building residentials implementation. Research in sustainable energy planning underscores that stakeholder perspectives, capacities and engagement play a crucial role in determining the success or stagnation of sustainability initiatives within the built environment [19]. Their findings highlight that even well-designed policies require active and informed stakeholder participation to achieve meaningful update; an insight highly relevant to the Malaysian construction sector, where awareess and adoption levels remain uneven.

Accordingly, this study seeks to: (1) assess the awareness levels of Malaysian construction stakeholders regarding green building residentials; (2) identify the key barriers that hinder green building residentials implementation; and (3) develop targeted strategies to mitigate these barriers. Addressing these gaps is essential for Malaysia to accelerate its transition towards sustainable residential development and achieve its national environmental objectives.

This study directly addresses these challenges by developing a stakeholder-driven model to accelerate green building residentials implementation in Malaysia's residential sector. The findings contribute valuable insights to the green building literature, particularly in developing country contexts, and offer a practical pathway for strengthening green building residentials adoption and stakeholder engagement toward sustainable development.

2. Green Building

Green building is a construction concept that maximises the utilisation of environmentally friendly materials and the use of sustainable practices and products [20]. Recent innovations in this area include optimising concrete mix designs for cost and carbon reduction [21] and utilising waste foundry sand to enhance structural sustainability [22]. The GBI defines a green building as one that focuses on the efficiency of resource use; specifically regarding energy, water, and materials [23] to reduce the negative impacts of building lifecycle on human health and the environment by utilising better design, siting, construction, operation, maintenance, and removal [24].

The concept of green building can be traced back to the 19th century. Notable examples include London's Crystal Palace, constructed in 1851 for the Great Exhibitions, and Milan's Galleria Vittoria Emanuele II, constructed in 1877. These structures used passive systems, such as the roof ventilation system and underground air-cooling chambers, to moderate indoor temperatures [25]. Progressing into the 1900s, the New York Times Building, built in 1905, utilised deep-set windows to shade the sun [26]. As the 20th century unfolded, technologies advanced further. For instance, the One Bryant Park building in New York uses an air ventilation system to filter dust on the eighth floor for fresh air and utilises groundwater to control temperature [27].

In the Malaysian context, sustainable development efforts began with Vision 2020 that was drafted in 1991 [28]. The GBI was subsequently launched in 2009, developed by Pertubuhan Arkitek Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM) [29].

2.1. Barriers to the Green Building Residentials Implementation

The sluggish progress in the implementation of green building residentials in Malaysia is attributed to various barriers, such as the high cost of the technologies, a lack of market competition [30], a lack of public understanding [31] and a lack of awareness regarding existing incentives among stakeholders [18].

In terms of categorisation, the barriers to Green building residentials can be classified into internal barriers, which manifest within the organisations and external barriers, which are beyond the company's control [32]. Internal barriers include a lack of awareness, economic issues, management challenges, and technology training. Conversely, external barriers include market attitude, government regulations, and product sourcing challenges. In addition, the barriers can be classified into five groups. The barriers extracted from the literature review are tabulated in Table 1.

Generally, the lack of awareness encompasses an insufficient understanding and unfamiliarity with green technology, which impedes its implementation in projects [33]. In addition, numerous consumers remain unacquainted with green-featured products, which constrains market growth [34]. Furthermore, the barrier related to economics and finance is due to the higher cost of Green building residentials that outweigh conventional technologies [35].

Table 1: Barriers Encountered by Green building residentials.

Category	Barriers
Barriers related to awareness/knowledge	Lack of awareness of existing incentives [32][33]. Lack of awareness of existing regulations [18][38]. Lack of awareness of the benefits of green building technologies [18][38]. Lack of environmental awareness among construction stakeholders [18][33]. Low demand for green building residentials by clients [18][33][34][38].
Barriers related to economics and finance	High cost [18][33][35][38]. Limited finance support for training [18][33]. Risk and uncertainties [18][32][38]. Concerns about the payback benefit [18][32].
Barriers related to management/organisation	Lack of communication among stakeholders [32][38]. Lack of training in green technologies [32][38]. Resistance to changing the supply chain/ implementing new technologies [38].
Barriers related to government and policy	Lack of green building regulations and codes [18][38]. Lack of subsidies for green technology [18][38]. Lack of training related to green building technologies [18][32].
Barriers related to local professionals/product sourcing	Lack of research in the local context on green building technologies [18][38]. Limited time for green practices implementation [18][38]. Resistance to change by the supply chain agents [18][38]. Limited time for green practices implementation [18][38]. Resistance to change by the supply chain agents [18][38].

Moreover, the decision-making process to incorporate green building features is influenced by management, especially when the top management lacks awareness of the benefits [36]. It is also argued that the government's involvement is pivotal to ensuring that organisations prioritise environmental issues [37]. Finally, regarding product sourcing, the scarcity of product information about new green technologies and products decreases the stakeholders' confidence [32]. The situation is exacerbated by the absence of comprehensive guidelines and references, leading to risks and uncertainties.

3. Research Methodology

This research employed a quantitative research design using a structured questionnaire survey to assess awareness, barriers and strategies relating to green residential buildings among Malaysian construction stakeholders. The methodology consisted of four phases: (i) literature review, (ii) questionnaire development, (iii) sampling and data collection and (iv) data analysis.

3.1 Research Design

The study was conducted from October to November 2023. A quantitative design was selected as it enables systematic measurement of perceptions using numerical scales. The questionnaire items were developed based on an extensive literature review using keywords such as "green building residentials", "awareness", "construction stakeholders", "barriers", "strategies", and "Malaysia". Articles published between 2003 to 2023 from the databases such as Emerald, Science Direct, and IOP Science, as well as official government websites, were reviewed.

3.2 Questionnaire Development

A structured questionnaire was designed with the following sections:

Part A: Demographic Information
Part B: Awareness of Green building residentials in Malaysia.
Part C: Barriers to Green building residentials.
Part D: Strategies to overcome the identified barriers

Part C and Part D included open-ended questions, allowing respondents to contribute additional barriers and strategies. A 5-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree) was used. It was assumed that all respondents who are registered with professional construction bodies possess a baseline understanding of sustainable practices. This assumption is justified as sustainability is embedded in professional practice guidelines.

3.3 Sampling Strategy

The targeted respondents comprised six groups of registered Malaysian construction stakeholders. These were contractors, quantity surveyors, architects, engineers, valuers, appraisers, estate agents, property managers and town planners. The population of each stakeholder group was derived from the official website of each profession, totalling approximately 348,600 individuals. According to Krejcie and Morgan [39], the required sample size for this research was 383, with an emphasis on selecting registered construction stakeholders to ensure the data were accurate and reliable, as shown in Table 2.

A total of 420 questionnaires were distributed using stratified sampling, allocating 70 questionnaires to each stakeholder group. Equal allocation of surveys was adopted to ensure fair representation of all stakeholder types, following the approach by Abdelaal and Guo [46]. Contact information was obtained through the official websites of the respective professional bodies.

To guide the survey distribution and analysis, parameters like awareness, barriers, and strategies were selected based on the study's objective to accelerate green building adoption among construction stakeholders. These dimensions are widely recognised in sustainable construction literature as critical determinants of implementation success. Awareness reflects stakeholders' understanding of green building concepts; barriers to capture constraints hindering adoption; and strategies identify actionable solutions to overcome these challenges [47][48].

Similar approaches have been adopted in studies examining green building adoption in developing countries, where awareness, barriers, and strategies are central themes [49][50]. Alternative parameters sets commonly discussed in green building adoption studies such as technological readiness, organisational capability, financial capacity were considered but not included to maintain a clear and focus analytical scope.

Regarding sensitivity of these parameters, previous studies suggest that while variation in input factors can affect adoption insights, formal sensitivity analysis is more commonly applied in building performance

Table 2: Number of Construction Stakeholders from Each Professional Board.

Construction Stakeholders	Numbers	Source
Contractors	124,062	Construction Industry Development Board [40] Website: http://cims.cidb.gov.my/smis/regcontractor/reglocalsearchcontractor.vbhtml
Quantity Surveyors	5,496	Board of Quantity Surveyors Malaysia [41] Website: bqsm.gov.my/en/
Architects	4,933	Board of Architects Malaysia [42] Website: https://www.lam.gov.my/registration-check
Engineers	206,706	Board of Engineers Malaysia [43] Website: http://bem.org.my/
Valuers, Appraisers, Estate Agents, and Property Managers	5,935	Board of Valuers, Appraisers, Estate Agents, and Property Managers [44] Website: http://search.lppeh.gov.my/
Town Planners	1,008	Board of Town Planners Malaysia [45] Website: https://www.lpbm.gov.my/www/
Total	348,140	

modelling or simulation research rather than in perception-based surveys [51][52] (Pang et. al., 2020; Roka et. al., 2025).

3.4 Data Collection

Data collection was conducted from October to November 2023 via email invitations containing a survey link and consent information. A response rate of 29.29% was achieved, which is acceptable for construction research, where the typical response rate ranges from 20% to 30% [53].

3.5 Data Analysis

Three analytical techniques were applied:

i Descriptive Analysis

This analysis was used to summarise demographic data and identify general patterns. Results were presented using a frequency table (Table 4).

ii Shapiro-Wilk Test

Shapiro-Wilk Test was conducted to verify the normality of data distribution, a method suitable for small to medium samples [54]]. The results determined whether parametric or non-parametric interpretations were appropriate.

The original formula of the test is as below:

$$W = \frac{\left(\sum_{t=2}^{n} a_t y_t\right)^2}{\sum_{t=1}^{n}\left(x_t - \overline{y}\right)^2} \tag{1}$$

where:

y_i = i^{th} order statistics

$\overline{y}$ = sample mean

the $a_i = \dfrac{m^T v^-}{(m^T v^{-1} v^{-1} m)^2}$

m = expected values of the order statistics of independent and identically distributed random variables sampled from the standard normal distribution

v = covariance matrix of those order statistics

iii Relative Importance Index (RII)

Relative Importance Index (RII) was used to rank barriers and strategies based on perceived significance. The RII formula is:

$$Relative\ Importance\ Index = \frac{\Sigma w}{AN} \tag{2}$$

where:

W = the respondent's weighting of each answer, ranging from 1- 5 on the Likert scale
N = total number of respondents
A = highest weight (in this research will be 5)

A higher RII value indicates a greater significance. The five importance levels derived from RII values are shown in Table 3.

The Relative Importance Index (RII) is a widely used method in construction management research for ranking factors based on stakeholders' experience or

Table 3: RII value and their respective importance level.

RII value	Importance level
0 ≤ RII ≤ 0.2	Low
0.2 ≤ RII ≤ 0.4	Medium-low
0.4 ≤ RII ≤ 06	Medium
0.6 ≤ RII ≤ 0.8	High-medium
0.8 ≤ RII ≤ 1	High

Source: Rooshdi, Abd Majid, Sahamir & Ismail [55]

perceptions [56]. This method ensured robustness in prioritisation and confirmed that minor variations in stakeholders' responses did not significantly alter the overall ranking of awareness levels, barriers and strategies.

4. Data Analysis and Discussion

This section presents the findings derived from the quantitative data analysis, offering a comprehensive overview of the current state of green residential buildings implementation in Malaysia. The discussion commences with an examination of the respondents' demographic profiles and data normality to establish the validity of the sample. Subsequently, the analysis evaluates the level of awareness among construction stakeholders, identifies the critical barriers hindering widespread adoption, and prioritises the strategies required to mitigate these challenges. The following sections detail these results, providing a foundational understanding of the industry's readiness to embrace sustainable development.

4.1 Background of the Respondents

Table 4 presents the detailed background of the respondents. Interestingly, the majority of respondents had never been involved in Green Residential Building projects, despite a significant proportion having more than 10 years of working experience.

4.2 Data Normality Test

The Shapiro-Wilk Test was used to test the data normality, with the p-value for each item presented in Table 5. The null hypothesis, that the data of barriers encountered bygreen residential buildings and the strategies to overcome the barriers in green residential buildings were normally distributed, was rejected, as the p-values were lower than the alpha value (0.05). Consequently, the data were found not to be normally distributed. This was an expected result due to the relatively limited sample size [57].

Table 4: Demographic Information of Respondents.

Demographic Information Profile	Category	Percentage
Age group	20-29 years old	40.7%
	30-39 years old	33.3%
	40-49 years old	11.4%
	50-59 years old	10.6%
	60-69 years old	4.0%
Occupations	Quantity surveyors	40.7%
	Engineers	20.3%
	Property/Real estate agents	
	Architects	5.7%
	Valuers	5.7%
	Town planners	5.7%
	Developers	4.1%
	Project managers	4.1%
	Contractors	2.4%
	Environmental consultant	0.8%
Working experience	1-3 years	32.5%
	4-6 years	15.4%
	7-9 years	8.1%
	More than 10 years	43.9%
Involvement in Green building residentials	0	69.9%
	1-3	24.4%
	4-6	2.4%
	7-9	0%
	More than 10	3.3%

4.3 Awareness of Construction Stakeholders

Regarding stakeholder awareness of Green building residentials, the overall concept of the subject was the most widely understood by the respondents. Among specific criteria, energy efficiency recorded the highest awareness level, followed by water efficiency, materials and resources, and indoor environment. Conversely, the two least criteria with the lowest awareness levels were sustainable site planning and management, and innovation. Notably, sustainable site planning and management is allocated with the highest point of 33 in the GBI. The results suggest that, despite its significance in the rating system, this criterion is less familiar to construction stakeholders compared to energy efficiency and water efficiency.

Table 5: Data normality of the Shapiro-Wilk Test.

Shapiro-Wilk Test		**p-value**
Barriers Encountered by Green building residentials		
BA1	Lack of awareness of existing incentives	<0.001
BA3	Lack of awareness of the benefits of green building technologies	<0.001
BA4	Lack of environmental awareness among construction stakeholders	<0.001
BA5	Low demand for Green building residentials by clients	<0.001
BE1	High cost	<0.001
BE2	Limited financial support for training	<0.001
BE3	Risk and uncertainties	<0.001
BE4	Concerns about the payback benefit	<0.001
BM1	Lack of communication among stakeholders	<0.001
BM2	Lack of training in green technologies	<0.001
BM3	Resistance to changing the supply chain/implementing new technologies	<0.001
BG1	Lack of green building regulations and codes	<0.001
BG2	Lack of subsidies for green technology	<0.001
BG3	Lack of support on training related to green building technologies	<0.001
BG4	Lack of Pressure on the green development policy	<0.001
BP1	Lack of research in the local context on green building technologies	<0.001
BP2	Insufficient guidelines as references for green residential building construction	<0.001
BP3	Limited time for green practices implementation	<0.001
BP4	Lack of product information in the market	<0.001
BP5	Lack of information on green technologies	<0.001
Strategies to overcome the barriers		
S1	Financial incentives from the government	<0.001
S2	Market-based incentives from the government	<0.001
S3	Mandatory Green Residential Building Codes and Regulations	<0.001
S4	Green labelling and information dissemination	<0.001
S5	Stricter enforcement of Green building residentials policies	<0.001
S6	Low-interest loans/ Green building residentials subsidies	<0.001
S7	Public environment awareness caption through seminars and conferences	<0.001
S8	Publicity through media (e.g.: internet, radio, and print media)	<0.001
S9	Educational programs for developers, contractors, and policymakers related to Green building residentials	<0.001
S10	Competent, active, and proactive Green building residentials promotion teams	<0.001
S11	Availability of institutional framework for effective implementation of Green building residentials	<0.001
S12	A strengthened green building technology research and education, and communication of new technologies.	<0.001

Table 6: Ranking of Awareness Level.

ID	Awareness of Green building residentials	Mean	RII	Overall ranking	Importance level
A1	Concept of Green building residentials	3.98	0.797	1	H-M
A2	Energy Efficiency (EE)	3.94	0.789	2	H-M
A3	Indoor Environmental Quality (EQ)	3.73	0.746	5	H-M
A4	Sustainable Site Planning and Management (SM)	3.72	0.743	6	H-M
A5	Material and Resource (MR)	3.78	0.756	4	H-M
A6	Water Efficiency (WE)	3.89	0.779	3	H-M
A7	Innovation (IN)	3.55	0.711	7	H-M

4.4 Barriers to the Green Residential Buildings Implementation

To investigate the reasons behind the limited implementation of green residential buildings in Malaysia, despite moderate to high awareness level among construction stakeholders, the barriers hindering their adoption were examined. These barriers are categorised into five groups (refer Table 7):

Awareness or knowledge,
Economics and finance,
Government and policy,
Local professionals or product sourcing,
Management or organisation.

The result presented in Table 7 show that barriers related to government and policy were ranked first, followed by economics and finance, and awareness or knowledge. When compared to the study in Tanzania [11], Pakistan [37], and Kuwait [14], where the most significant barrier was a lack of awareness, this comparison shows that this barrier was less significant in Malaysia. This finding is consistent with the results of the analysis on the awareness of green residential buildings, where Malaysian construction stakeholders demonstrated a moderate to high awareness level.

a) Awareness or Knowledge

The top-ranked barrier in this group was a lack of awareness of existing incentives (BA1), followed by a lack of awareness of existing regulations (BA2), even though the Malaysian government has provided various incentives to promote green building residentials, such as the Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE). The introduction of Green Technology Financing Scheme 2.0 (GTFS) provided a 2% rebate on the interest or profit rate charged (Ministry of Finance Malaysia, 2022).

Besides that, there was a lack of awareness of the benefits of green building technologies (BA3). The construction industry relies heavily on client demand and input from construction stakeholders; therefore, the lack of environmental awareness among construction stakeholders (BA4) must be overcome. The final barrier was the low demand for Green building residentials by clients (BA5).

Furthermore, a respondent stated that a lack of knowledge pertaining to green technology, especially in the public sector, was a barrier, while another respondent stated that some developers were not familiar with the concept of Green building residentials.

b) Economics and Finance

The highest ranked of this group indicated that most of the barriers had strongly agreed significance. High cost (BE1) was consistently identified as a significant barrier due to the high capital and maintenance cost of green features [18]. The perception of high cost increases the burden of developers to sell the properties, as clients often prefer affordable property prices [38]. This reason was reinforced by a respondent who explained that the cost to construct a green residential building is high; thus, the house price incurred by the end-user will be high. Another respondent also stated that only a limited number of companies in Malaysia could afford green technologies or new technologies.

Limited financial support for training (BE2) was the second barrier, as training is important to ensure that construction stakeholders possess competent knowledge and skills to implement green residential building projects [58]. Furthermore, a respondent mentioned that the accuracy of future cost analysis, including

Table 7: Ranking of Barriers Encountered by Green building residentials.

Barriers ranking	**ID**	**Sub criteria**	**Mean**	**RII**	**Group ranking**	**Importance level**
	Barriers related to awareness/knowledge					
	BA1	Lack of awareness of existing incentives	3.93	0.787	1	H-M
	BA2	Lack of awareness of existing regulations	3.89	0.777	3	H-M
	BA3	Lack of awareness of the benefits of green building technologies	3.81	0.763	4	H-M
3	BA4	Lack of environmental awareness among construction stakeholders	3.89	0.779	2	H-M
	BA5	Low demand for Green building residentials by clients	3.71	0.751	5	H-M
		Average Value	3.85	0.771		
	Barriers related to economics and finance					
	BE1	High cost	4.13	0.826	1	H
2	BE2	Limited financial support for training	4.05	0.810	2	H
	BE3	Risk and uncertainties	3.41	0.683	4	H-M
	BE4	Concerns about the payback benefit	3.98	0.795	3	H-M
		Average Value	3.89	0.779		
	Barriers related to management/organisation					
	BM1	Lack of communication among stakeholders	3.56	0.712	3	H-M
5	BM2	Lack of training in green technologies	3.93	0.785	1	H-M
	BM3	Resistance to changing the supply chain/ implementing new technologies	3.85	0.771	2	H-M
		Average Value	3.78	0.756		
	Barriers related to government and policy					
	BG1	Lack of green building regulations and codes	3.73	0.746	4	H-M
	BG2	Lack of subsidies for green technology	4.04	0.808	2	H
1	BG3	Lack of support on training related to green building technologies	4.01	0.802	3	H
	BG4	Lack of Pressure on the green development policy	4.26	0.852	1	H
		Average Value	4.01	0.802		
	Barriers related to local professionals/product sourcing					
	BP1	Lack of research in the local context on green building technologies	3.88	0.776	1	H-M
	BP2	Insufficient Guidelines as References for Green Residential Building Construction	3.77	0.754	5	H-M
	BP3	Limited time for green practices implementation	3.80	0.761	3	H-M
	BP4	Lack of product information in the market	3.83	0.766	2	H-M
	BP5	Lack of information on the green technologies	3.80	0.761	3	H-M
		Average Value	3.82	0.764		

maintenance cost, was a concern for Green building residentials, which also led to the third barrier, risk and uncertainties (BE3), followed by concerns about the payback benefit (BE4). Only when the majority of stakeholders are aware of the concept of Green building residentials will they understand the benefits of green construction, thereby reducing relative risks and uncertainties [14].

c) Management and Organisation

The lack of training in green technologies (BM2) was ranked first in the group. Most employers were unwilling to send their teams for training as they worried the workers might move to another company for a higher salary, resulting in a loss of talent, time, and money [32]. Besides that, the second barrier was resistance to changing the supply chain or implementing new technologies (BM3). This barrier was further explained by a respondent who noted that a lack of open-mindedness and a lack of willingness to discard old values will hinder green residential building implementation. Lastly, the barrier was a lack of communication among stakeholders (BM1) as a successful innovation implementation requires effective cooperation among stakeholders [59].

d) Government and Policy

The first barrier was the lack of pressure on the green development policy (BG4). In contrast, the lack of green building regulations and codes was ranked last in this group (BG1). This indicated that the more significant issue in the Malaysian construction industry was the enforcement and pressure required on green development policy. The industry will likely start to prioritize the issue when the government is concerned about it. When there is no pressure on regulations or laws to enforce green practices on-site, the implementation of Green building residentials will be neglected [32].

The second barrier was the lack of subsidies for Green Technology (BG2) while the third barrier was the lack of support for training related to green building technologies (BG3). Both are correlated, as most companies need subsidies from the government because efficient technologies require higher initial costs. In addition, a respondent pointed out that the lack of exposure regarding Green building residentials given to construction players by the government was also a barrier.

e) Local Professionals and Product Sourcing

The lack of research in the local context on green building technologies (BP1) was ranked first. A lack of research causes a lack of information in the market regarding the cost of technologies as well as the materials [32]. This barrier was further explained by a respondent who mentioned that Malaysian researchers should produce more technologies or construction materials instead of depending on other countries, as the import of technologies incurs higher costs.

The second barrier was the lack of product information in the market (BP4), which decreases the willingness to invest in green residential building. After that, the barriers of limited time for green practice implementation (BP3) and the lack of information on green technologies (BP5) were both ranked third. The last barrier was insufficient guidelines as references for Green building residentials (BP2).

Finally, a respondent stated that regional barriers were a challenge. It is notable that although many respondents chose the lack of information as a barrier, MyHijau exists as an official green recognition scheme by the Malaysian government, consisting of all certified products and services to meet local and international environmental standards [60]. It conducted various incentives, such as Seminar Session on Government Incentives In The Green Technology Sector In Malaysia Year 2023 on 9th May 2023. The scheme collaborated with 683 registered companies and has 12,045 registered green products and 907 registered green services. Their latest products include items such as Solar DC Cables and LED Street Lights.

4.5 Strategies to Mitigate the Barriers

Table 8 shows the ranking of the significance of each strategy agreed upon by the construction stakeholders.

The first-ranked strategy was financial incentives from the government (S1), followed by low-interest loans or subsidies (S6), which primarily focused on subsidies for green technologies as well as materials. Economic incentives can address the barriers of high cost and limited financial support for training. This strategy is also attractive to the stakeholders who resist change and are hesitant to adopt new technologies in their projects [61]. Examples of potential financial incentives include allowances and tax credits [62].

It is believed that the introduction of more green incentives increases the motivation of the stakeholders

Table 8: Ranking of Strategies to Mitigate Barriers.

Strategies to Overcome the Barriers to green residential building development		Mean	RII	Overall ranking	Importance level
S1	Financial incentives from the government	4.40	0.880	1	H
S2	Market-based incentives from the government	4.22	0.844	4	H
S3	Mandatory Green Residential Building Codes and Regulations	3.93	0.785	11	H-M
S4	Green labeling and information dissemination	4.07	0.815	9	H
S5	Stricter enforcement of Green building residentials policies	3.98	0.795	10	H-M
S6	Low-interest loans/ Green building residentials subsidies	4.29	0.859	2	H
S7	Public environment awareness caption through seminars and conferences	3.89	0.777	12	H-M
S8	Publicity through media	4.13	0.826	6	H
S9	Educational programs for developers, contractors, and policymakers related to Green building residentials	4.13	0.826	6	H
S10	Competent, active, and proactive Green building residentials promotion teams	4.24	0.847	3	H
S11	Availability of institutional framework for effective implementation of Green building residentials	4.16	0.833	5	H
S12	A strengthened green building technology research and education, and communication of new technologies.	4.12	0.824	8	H

to implement green building practices [63][64]. One respondent suggested that personal tax relief for those certified as Green Facilitators would be an effective incentive to encourage more people to join the green sector. Another respondent also suggested that an annual KPI system could be introduced for green construction.

For example, in China, the Ministry of Finance provided CNY 900 million in 2007 and CNY 5.3 billion in 2012 to improve the energy efficiency of residential buildings in 15 northern regions with colder climate. Furthermore, governments and banks have developed green financial mechanisms, including green bonds, green credit facilities and green funds, as targeted tools to support environmentally sustainable construction and investment by directing capital toward low-carbon and resource-efficient projects [65].These incentives led China to the top of the Leadership in Energy and Environmental Design (LEED) list, with its green building market reaching US $ 178.1 billion in 2021 and projected to reach USD180 billion in 2025.

The third-ranked strategy was the establishment of competent, active, and proactive Green building residentials promotion teams (S10). Promotion teams with adequate knowledge, skills, and professional expertise allow more people to understand the concept of green building residentials and be aware of the incentives, regulations, and benefits. For example, the Emirates Green Building Council (EmiratesGBC) of the United Arab Emirates collaborated with Egis, an international engineering, consulting, and operations company, to promote the implementation of sustainable building practices [66]. The partnership allows education and promotion on the industry sustainability, while Egis contributes its knowledge and expertise in green building design.

Furthermore, the fourth-ranked strategy was market-based incentives from the government (S2). The Gross Floor Area incentive scheme and expedited permitting for Green building residentials have been proven effective in promoting green building implementation in Hong Kong [67]. The fifth-ranked strategy was the availability of an institutional framework for the effective implementation of Green building residentials (S11). Such institutional framework would comprise various measures for promotion, including product rating, product labelling, financial incentives, market-based incentives, and enforcement of existing regulations.

Moreover, publicity through media (S8) and educational programs for developers, contractors, and policymakers related to Green building residentials (S9) were ranked sixth. Publicity can be achieved through online advertisements or social media by effectively utilising available research studies, fact sheets, and communication strategies [38]. The eighth strategy was a strengthened green building technology research and education, and communication of new technologies (S12). The government could also facilitate collaboration with local or international professionals to conduct research and development aimed at producing cost-effective green products, as suggested by a respondent.

The ninth strategy was green labelling and information dissemination (S4). Green labelling, also known as a green building rating system, is vital for providing recognition within the construction industry. For example, Leadership in Energy and Environmental Design (LEED) in the United States, the Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom, and the Green Mark Scheme in Singapore [68]. Such recognition enhances reputation and increases the motivation of other stakeholders to implement Green building residentials, while also guiding industry professionals. For instance, numerous green professionals' designators, such as Green Mark Professionals (GMPs), Green Mark Managers (GMMs), and Green Mark Facilities Managers (GMFM), were introduced through the Green Mark rating systems [69].

The lack of pressure on green development policy was ranked as the first barrier, yet tighter enforcement of Green building residentials policies (S5) was ranked as the tenth strategy. This discrepancy may be attributed to the current economic condition. The global economy has been disrupted by supply chain disruptions, inflation in the post-pandemic era, the Russia-Ukraine conflict, and worldwide political instability; therefore, many economists predicted an imminent global recession in 2023 [70]. Thus, financial initiatives are more prioritised by the stakeholders.

The eleventh-ranked strategy was mandatory green residential building codes and regulations (S3). For example, policy pressure in China was a major reason for developers adopting green practices in the construction industry [71]. The pressure exerted stimulated market interest in Green building residentials to avoid penalties associated with traditional technologies. Similarly, in Singapore, the Building and Construction Authority has highlighted mandatory environmental sustainability standards for new and existing buildings by increasing the required minimum energy performance and sustainable construction practices since 2021 [72]. Furthermore, Al Sa'fat, the latest Dubai Green Building System, mandates that all new buildings achieve the Silver Sa'fa rating, as required in Al Sa'fat – Dubai Green Building System 2nd Edition, 2023 [73].

The final strategy was public environment awareness campaigns through seminars and conferences (S7). A respondent highlighted that related courses could be prepared for real estate professionals to instil awareness and interest in Green building residentials. Another respondent suggested that school campaigns could be conducted for primary and secondary school students, as well as the general public.

5. Model to Accelerate Green Residential Building Implementation

Figure 1 illustrates the model developed to accelerate the implementation of Green building residentials in Malaysia. The model encompasses the construction stakeholders, including architects, contractors, developers, engineers, environmental consultants, project managers, property or real estate agents, quantity surveyors, town planners, and valuers.

The five groups of barriers are arranged according to their ranking, with each related to relevant strategies. The most chosen strategies, financial incentives, followed by low-interest loans and Green building residentials subsidies, can mitigate barriers across three different categories. All strategies and barriers are considered in the model, as they were all deemed to have medium to high importance levels. The proposed initiatives were derived from academic research and respondent feedback to support these strategies. These suggestions are not exhaustive, as numerous other approaches could be implemented.

The barriers, strategies, and suggestions are connected, indicating that the strategies are interrelated and can influence one another. For example, a lack of pressure on green development policy can lead to a lack of subsidies. Consequently, research on related topics is hindered. Conversely, if the government improves financial incentive scheme, increased subsidies for research can be expected, thereby enhancing product information and awareness. In summary, the successful implementation of green residential building in Malaysia depends on the collaborative efforts of all relevant authorities, construction stakeholders, and the community to ensure all strategies are successfully implemented.

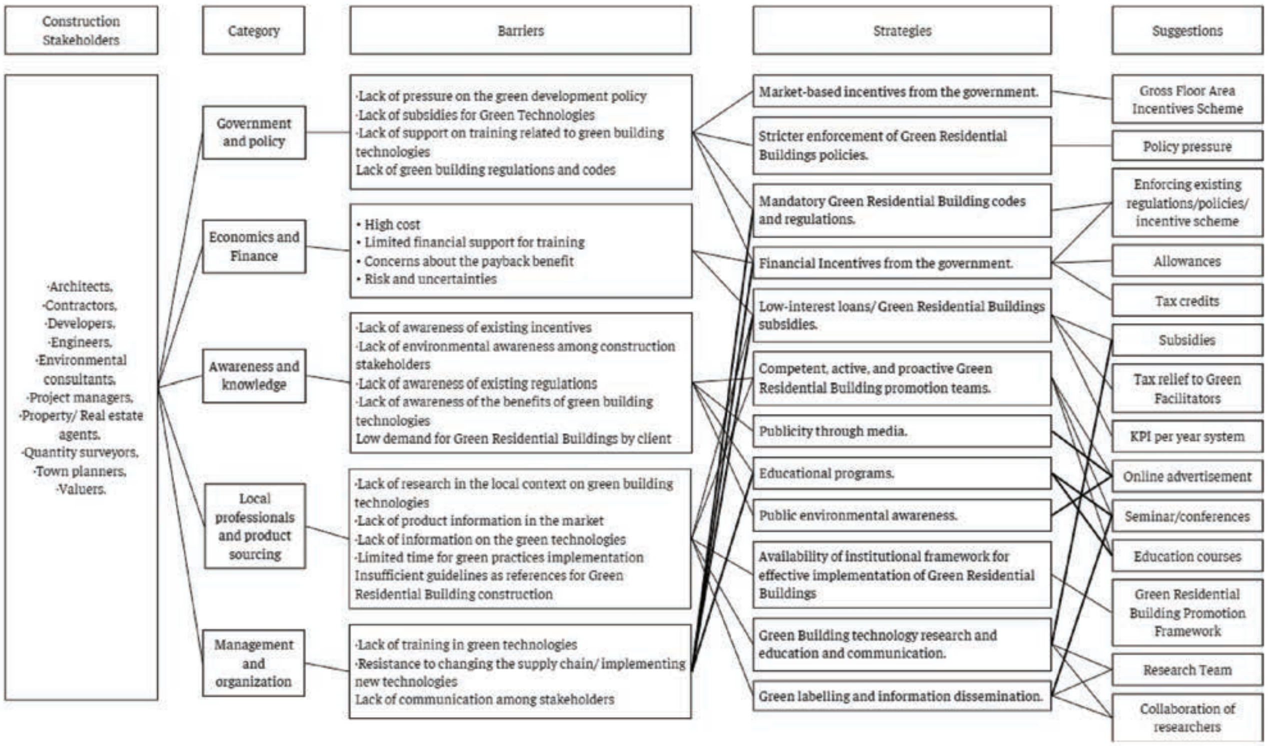

Figure 1: Model to Accelerate the green building residentials Implementation in Malaysia.

6. Conclusion

This study examined the awareness, barriers, and strategic enablers related to green residential ruilding implementation in Malaysia. The findings indicate that although Malaysian construction stakeholders demonstrate generally high awareness, particularly regarding energy efficiency, the number of green residential building-certified projects remains low. The analysis identified government and policy-related barriers as the most critical impediments, followed by economics and financial constraints, and gaps in awareness and technical knowledge. Correspondingly, financial incentives, low-interest loans or subsidies, and the establishment of competent promotional teams emerged as the most impactful strategies for accelerating its adoption.

The theoretical contribution of this study lies in the development of a stakeholder-driven, integrated model that links awareness levels, barriers, and mitigation strategies within the specific context of the Malaysian residential sector. This model advances current knowledge by demonstrating how different stakeholder groups and strategies intersect to influence green building residentials adoption, offering a structured framework that can be adapted for developing country contexts facing similar sustainability challenges. Importantly, the study also contributes to the broader field of energy planning research by illustrating how stakeholder behaviour, institutional readiness and policy mechanisms collectively influence demand-side energy efficiency outcomes. By foregrounding the role of stakeholders in facilitating low-carbon transitions at the residential scale, the model provides a theoretically grounded pathway for integrating sustainable construction practices into long-term national energy planning efforts.

Despite its contributions, the study has certain limitations. The research relied on self-reported survey data, which may be influenced by respondent bias. Additionally, the sample was limited to specific categories of construction stakeholders, which may not fully represent all players in the residential sector. Future research could expand the stakeholder categories, incorporate longitudinal data to monitor changes over time, and employ qualitative approaches such as interviews or focus groups to gain deeper insights into behavioural and organisational barriers. Comparative studies across regions or countries could also strengthen the generalisability of the proposed model.

In conclusion, the findings underscore the need for coordinated efforts among policymakers, regulatory bodies, and industry practitioners to strengthen the institutional and financial ecosystem supporting the development. The integrated model contributes new knowledge to the green building literature by offering a pathway for enhancing stakeholder engagement and accelerating its implementation, ultimately supporting Malaysia's transition towards sustainable cities and communities

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