Research in Management of Technology and Business Vol. 4 No. 1 (2023) 1374-1387

RMTB

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rmtb
e-ISSN : 2773-5044

Strategies to Enlarge the Market Availability of Green Building Materials (GBM) for Construction Works: Gathering the "Low-Hanging Fruits"

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DOI: https://doi.org/10.30880/rmtb.2023.04.01.095
Received 31 March 2023; Accepted 30 April 2023; Available online 1 June 2023

Abstract: One of the strategies to reduce environmental issues in construction is by having more green buildings. Among the approach towards green building criteria is through the green materials adoption. It starts with proper selection of green building materials (GBM) that has sustainable characteristics compared to conventional building materials. However, the applicability of GBM is still low and not a favoritism option towards greening the building. Among the contributed factor is due to its higher initial cost and lack of local construction products that are certified as eco-label by MyHIJAU directory. Therefore, this paper aims to identify the significant strategies towards promoting the GBM as the key catalyst to enlarge the market in construction, or the "low-hanging fruits" strategies. A questionnaire survey was disseminated to 205 respondents comprised of industry practitioners that are involved in green building projects. 160 respondents have answered the survey and results revealed that there are eight (8) "low-hanging fruit" strategies that can used to enlarge the market availability for GBM. The top strategies are adopting green procurement, implement more green trainings and harmonise the information on cost and benefits of GBM. The findings can assist the stakeholders, construction enablers, practitioners and policy makers in developing practical strategies towards enlarging the market availability of GBM in construction works.
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Keywords: Green Building Materials, Construction Works, Key Catalyst, Strategies, Sustainable

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1. Introduction

Building accounts for almost 40 per cent of worldwide greenhouse gas emissions and Malaysia require more renewable energy to achieve the greener nation goal (Defterios & Toh, 2019). Therefore, the Malaysia's construction industry needs to step up its game in focusing on sustainability in building. As highlighted in the Twelfth Malaysia Plan (2021-2025), the pursuance of green for sustainability and community resilience comprises one of the plans EPU (2021). This has shown that the government is committed in addressing the issues of sustainability in construction by promoting various initiatives on green procurement and green growth. To recognize the green buildings, established green rating tools were introduced to certify the building as green. Among of the recognised green rating tools in Malaysia is Green Building Index (GBI) as the first green rating tool recognised in Malaysia, and other such as MyCREST, Penarafan Hijau JKR (PhJKR), GreenRE, Building Energy Index (BEI) and Sustainable INFRASTAR (Anuar *et al*., 2022).

Among the criteria addressed in these rating tools includes on the utilisation of green products and green materials for building construction, or green building materials (GBM). For instance, in the listed criteria of Green Building Index (GBI), green materials and resources have highest 11 percentage points for evaluation requirement of green buildings (GBI, 2009). Hence, GBM is addressed as one of the strategic initiative and best practice requirements by the construction stakeholders in implementing green building projects. Moreover, application of GBM give many advantages such as increases building quality performance and prevents health problems (Hebatalrahman & Mahmoud., 2016). As supported from (Sharif *et al*., 2017), focusing on the materials and resources depicted as the easiest way to make a building green from all the criteria listed by GBI. Calrecycle (2012) claims that green building materials are environmentally friendly because the effects on the product's life are taken into consideration. Rahardjati *et al*. (2011) supported this by stating the best way to integrate sustainable design concepts into buildings is to choose environmentally sustainable building materials carefully. This subject led to the issue of how to measure green building efficiency.

Despite of its advantages, the implementation of GBM still lows even though it has been introduced since 2009 (Yee *et al*., 2020). One of the major issues that discourage construction holders from incorporating green building materials in the construction projects is due to higher initial cost to purchase the materials. Zutshi & Creed (2015) stated that construction stakeholders always concern about financial aspects as implementing GBM requires high initial costs. This is also supported by Khalil *et al*., (2021) that the significant barrier for growth in the green building market is the perception of higher initial costs associated with these buildings. Acquisition costs of green materials are also one of the top three important component costs to be considered for green projects (Khalil *et al*., 2021). Wimala *et al*., (2016) revealed in their study that over than 30% respondents voted higher costs for green building options than conventional ones as barriers to green projects movement. The established ratings of Green Product Scoring System (GPSS) has shown the government initiatives to promote and encourage the use of green products in the construction industry and constructing more sustainable buildings (JKR, 2022). The manual outlines part of Public Works Department initiatives in the government sector to promote sustainable construction in consideration on its impact to the environment The manual is prepared as such with the intention that it is user friendly, understandable and fitting for the local construction industry to develop and adopt green manufacturing process. However, the listed products are not mainly focus to local products, which means that the listed green products are also sourced from global ecolabelling network countries such as Australia, Brazil, China, Croatia, Germany, India and Indonesia.

The MyHIJAU directory by Malaysia Green Technology and Climate Change Centre (MGTC) and Ministry of Natural Resources, Environment and Climate Change (NERCC) (previously known as KASA) also shows a comprehensive effort made by the government in promoting the green products in the market (MGTC, 2022). However, the listed eco-label products registered in MyHIJAU directory

are still lacking for the category of construction materials. In other words, there are not much choices of green building materials for construction listed in the MyHIJAU directory. Thus, it becomes a challenge for the construction stakeholders to enhance the utilisation of local green materials for construction. As the result, the adoption of GBM will be sourced out from outside of the country, thus the cost would be increased and effect the client's budget.

Other than that, development of GBM in construction industry affected by the low level of knowledge in this field. Even from top level management until on-site staff lack of knowledge and experience about this green initiative and result in low level of implementation of GBM (Wright & Wilton, 2012). In addition, government are unaware of environmental problem and value of green practice and construction industry will not concern itself with the crisis. Without government interference coming up with strict legislation and encouragement, the implementation of GBM in construction projects would still be low (Chan *et al.*, 2009). Thus, this paper aims to identify the strategies that are important for promoting green building materials (GBM) as the key catalyst to enlarge the market for construction works. The findings enables to allocate the immediate strategies or "low-hanging fruits" actions in enlarging the market availability of GBM adoption in construction works.

2. Overview of Green Building Materials (GBM)

Green building materials (GBM) are defined as material that uses cleaner manufacturing method, technological and science use, minimal or no exploitation of natural resources, heavy waste use, pollution-free radioactive and recyclable material (Zhao *et al*., 2018). Meanwhile, Hsieh *et al.* (2012) defined GBM as low toxicity, low emissions, low VOCs, resource efficiency, recycling and recycled content, energy efficiency, conversation with water, air quality improvement indoors and the use of local products. Calrecycle. (2012) mentioned that GBM consists of renewables sources rather than non-renewables. GBM in accordance to the GBI. (2009) is defined as materials that encourage the use of recycled sources and recycle environmentally friendly materials. A green material assessment may include an evaluation of its requirements, depending on the project-specific objectives. Wang *et al*. (2011) added that GBM puts great emphasis on the protection, safety and wellbeing of human bodies. It also focuses on coordinating the development, processing, use and recycling life cycle with ecological ecosystems. Therefore, the concept of GBM concentrates on the manufacturing processes, technology, pollution and the possibility of recycling and health benefit.

2.1 Types of Green Building Materials (GBM) for Construction Works

Over the years, there are many types of GBM were introduced and developed extensively for construction as innovation and sustainable initiatives. Zhao *et al*. (2018) states that green building materials must have good properties such as high strength, high water resistance and lightweight. The concept is same as before which is helping to reduce overall cost of materials handling and improve quality of building. As the characteristic of GBM is considered as durable (Mehta *et al*., 2014), less energy (Lee *et al*., 2011), minimal effect to health (Cai & Sun, 2014), not harmful to environmental degradation (Zhao *et al*., 2018), (Bohari *et al*., 2020), hence, it is vital to acknowledge the types of materials suited to the local context of construction works in Malaysia. The followings are the entail description on the types of GBM in the context of construction works:.

Table 1: The types of GBM for construction works

Application	Types of GBM	Description	Source(S)
Concrete framed buildings	Precast Concrete	Construction product that are is casted in a re-usable mould and then cured in a	Mydin *et al*. (2014); Kamarul

		controlled environment and normally used for structural members (column, beam, floors, etc)	Anuar *et al*., (2011)
Concrete	Fly Ash Concrete	Fine powder which is made by a product of burning coal process as an alternative for Portland cement	Kawashima *et al*. (2013); Ziegler *et al*. (2016)
	Ferrock	Modern green cement replacement that utilises and creates concrete-like recycled stainless-steel dust that consist of iron dust, fly ash, metakaolin and calestone.	Peckenham,(2016); Vijayan *et al*. (2020); Lanuza *et al*. (2017)
	Timbercrete	Mixture of scrap mill waste, cement, sand-binding agent and non-toxic additive, and it is restored by the use of renewable wind and sun energy into a single building block.	Mishra & Pathak (2020); Hammood (2020)
Building Thermal Protection	Structural Insulated Panel (SIPs)	Panels that have an insulating form sandwiched-like between two structural facings that fabricated to any of building design and manufactured in a controlled condition in a factory.	Panjehpour *et al*. (2013); Mishra & Pathak (2020); Kamarul Anuar *et al*., (2011); Lewis, (2018)
	Glazed Façade	Structural elements that provide wind and other actions with lateral and vertical resistance that provide weather resistance and properties that resist thermal, acoustic and fire resistance.	Aktas, (2011)
	Wood Foam	Lightweight base material that can then be made into rigid foam boards and flexible foam mats.	De Luca *et al*. (2017); Coxworth, (2014)
Roof Finishing	Roof-light System	Similar to the glazed façade which provide daylight usage in buildings and improves visual comfort which can reduce glare risk.	Gürlich *et al*. (2018); Ahuja & Mosalam, (2017)
Floor Finishing	Bamboo Flooring	Giant woody stalked grass with strong natural fiber that commonly used as interior materials.	Mishra & Pathak (2020); Hammood (2020); Yu *et al*. (2019)
	Natural Fiber Carpet	Natural fibers often used is animals which is wool carpet that will able to enhance indoor air quality in a building.	Aktas, (2011)
Wall Finishing	Lime Plaster	Being used in production masonry units, such as brick as binding agents that provide concept of breathable wall.	Mohamed Sabri & Suleiman (2014)

	Eco label Paint	Paint that used unique photocatalytic technology to decompose and eliminate air toxic gases with good glossy properties, colour retention and high resistance to UV.	Uche Aliagha *et al*. (2013); Kuppusamy *et al*. (2019); Sheth (2016); Lee *et al*. (2011)
Masonry - Bricks	Sustainable Biosolid Bricks	Results of wastewater sludge which has been dewatered and properly processed by wastewater process and produce into a brick that fulfil environmental and technical criteria of a brick by minimizing brick manufacturing carbon footprint.	Hebatalrahman, & Mahmoud (2016); Mohajerani *et al*. (2019)
	Wool Bricks	Combinations of natural fiber which is wool, natural polymer, seaweed and clay that produced 37% stronger compared to normal brick.	Mishra & Pathak (2020); Aymerich *et al*. (2012)

2.2 Ways to Enlarge the Market Availability of Green Building Materials (GBM)

GBM could be promoted in various ways in order to enlarge its market in construction sectors. However, stakeholders voiced frustration finding adequate quantities for large scale projects (Griffin *et al*., 2010), and it is unpredictable for green building materials in the market (Ahn *et al*., 2013). This shows that some stakeholders are ready to adopt green building materials but hesitate to get enough green building materials in Malaysia. Esa *et al*., (2011) asserts that incentive policies such as financial and market-based for GBM adopters as financial aspect is the main concern in adopting GBM. Sufficient information must be provided to make sure stakeholders aware about the benefits of GBM to contribute the broader adoption of GBM (Darko & Chan, 2017). Zhao *et al*., (2018) suggest that the construction industry's use of GBM is a sort of operation that would not occur if legislation did not exist. As a result, one of the primary drivers of success in green adoption is government-mandated environmental rules and regulations. Government should explore widening the scope of low risk and affordable financing for owners, developers, contractors, and end users in order to increase demand for GBM (Samari, 2013).

Green logo certification systems for GBM must be strengthened to guarantee that manufacturers provide high-quality materials (Cai & Sun, 2014). Furthermore, Razali *et al*. (2021) proposed that increasing public knowledge of green buildings results in better-qualified consumers who require better products from companies and support greener buildings. A competitive pricing for GBM is also an excellent technique for expanding their market because the raw materials utilised are mostly reclaimed from waste materials (Zhao, 2018). Griffin *et al*., (2010) also proposed the necessity for analysis tools to analyse the economics and environmental consequences of different GBM applied during the design stage as the strategies in enlarging the market for GBM. Based on the literature, Table 2 shows the summary of ways to enlarge the market of green building materials to the local context of construction.

Table 2: Literature summary of variables in ways to enlarge the market of green building materials

Source(s)	Ways to Enlarge the Market of Green Building Materials								
	Financial and market- based incentive	Public awareness and availability of	Enforced government policies	Low risk affordable loans	Green logo certification system	Green Procurement Adoption	Price competitive market	New analysis tools for alternative materials	
Anuar *et al*. (2022)	/	/	/		/	/			
Khalil *et al*. (2021)	/		/		/	/	/		
Razali *et al*. (2021)		/	/			/			
Ali *et al*. (2020)					/				
Bohari *et al*. (2020)		/	/			/			
Kuppusamy *et al*. (2019)	/		/		/		/		
Leong *et al*. (2019)	/	/	/			/			
Zhao *et al*. (2018)	/	/	/			/	/		
Chan *et al*. (2009)	/	/	/		/	/			/
Darko & Chan, (2017)		/	/	/		/			
Sichali & Banda (2017)		/							
Ametepey *et al*. (2015)			/			/			
Algburi *et al*. (2016)	/	/	/						
Cai & Sun (2014)					/				
Shields *et al*. (2014)		/	/			/			
Samari *et al*. (2013)	/		/	/		/			
Ahn *et al*. (2013)	/	/							
Hwang & Tan (2012)	/	/							
Umar & Khamidi (2012)		/							
Bakar *et al*. (2011)	/								
Esa *et al*. (2011)			/						
Griffin *et al*. (2010)									/

3. Research Methodology

The study adopts quantitative method where questionnaire is used as the survey instrument. Using the purposive sampling method, the questionnaire is distributed to 205 respondents comprises of construction enablers and industry practitioners (as shown in Table 3) who have experience in handling green projects. The list of respondents was drawn with the help from the implementing agency or enablers in the green government projects such as Public Works Department (JKR), Construction Industry Development Board (CIDB), and MGTC. The survey was carried out via online platform due to the Movement Control Order (MCO) of pandemic outbreak situation that has restricted the researchers to conduct physical distribution and questionnaire workshop.

Table 3: Questionnaire's distribution to the respondents

No.	Respondents' category	Description	Total purposive samples (N)
1	Construction enablers (implementing agency)	Enablers for 25 green government projects (clients/project managers)	25
2	Industry Practitioners	Consultants and contractors for green government projects (architects, engineers, surveyors, green facilitators, contractors)	180
Total Number of Respondents (targeted population)			205 (distributed)

The online survey has received 160 responses from the survey distribution and the response rate is 78%. According to Creswell, (2012), data is valid to have more than 50% responses from the total sampling population. Hence, the data analysis is valid, reliable and relevant to the purposive sampling concept.

4. Results and Discussion

4.1 Demographic Results

Table 4 shows the demographic result of all respondents based on descriptive statistics (frequency and percentage). In terms of designation, the majority or 25% (n=40) respondents are engineers, which indicates that most of the green projects are dominated by engineers. In terms of years of working experience, the most significant number of responses came from the group with working experience between 11 to 15 years of experience, with a 43.1% percentage.

Table 4: Respondent's Demographic Background

Demographic Profile		Frequency (N)	Percentage
Designation in the green project	i) Project Managers	21	13.1%
	ii) Architects	28	17.5%
	iii) Engineers	40	25%
	iv) Quantity Surveyors	25	15.6%

	v) Green Facilitators	15	9.4%
	vi) Contractors	31	19.4%
	Total	160	100%
Years of Working Experience	Less than 5 years	28	17.5%
	6 to 10 years	33	20.6%
	11 to 15 years	69	43.1%
	16 years and above	30	18.8%
	Total	160	100%

4.2 The "Low Hanging Fruit" Strategies in Enlarging the Market of Green Building Materials (GBM) in Malaysia

In this section, respondents were asked to rate the key catalyst or the "low hanging fruit" strategies to enlarge the market of GBM in Malaysia using agreement scale level. A five-point Likert's scale was used, where "1" represented strongly disagree, "2" disagree, "3" neutral, "4" agree, and "5" represented strongly agree. The mean score for each item was calculated and ranked based on the highest attained mean score to the lowest mean.

Table 5: The Key Catalyst or "Low Hanging Fruits" strategies in enlarging market of Green Building Materials (GBM) in Malaysia construction sectors

Ways to Enlarge the Market of Green Building Materials in Malaysia ("low hanging fruit" strategies)	Mean Score	Standard deviation (SD)	Variance (V)	Coefficient of Variance (CV)	Rank (based on mean)
Provide financial and market-based incentive for GBM adopters	4.47	0.666	0.44356	14.90%	6
Raise public awareness about GBM with sufficient information	4.51	0.634	0.40196	14.06%	3
Enforcement of green building materials through government policies and regulations	4.52	0.682	0.46512	15.09%	2
Regulate low risk and affordable financial loans for GBM adopters	4.39	0.641	0.41088	14.60%	8
Establish more eco label certification for GBM	4.49	0.650	0.42250	14.48%	4
Adoption of green procurement for green products and services	4.54	0.616	0.37946	13.57%	1
Improve competitive market price for GBM in lowering their price	4.49	0.666	0.44356	14.83%	5

Introduce new analysis tools as comparative in terms of economics and environmental during design stage	4.41	0.751	0.56400	17.03%	7

The result in Table 5 shows that the mean score is ranged from 4.54 (highest) to 4.39 (lowest). It depicts that the respondents' agreement level on the strategies are rated as agreed to strongly agreed by the respondents. The attained variance (V) and coefficient of variance (CV) based on the mean and standard deviations of the results showed that the ratings are relatively less variable. The standard deviations (range from 0.616 to 0.751) show a small dispersion of data, thus, indicates that the mean score is acceptable and reliable as the ratings are constant among all respondents. The highest mean score is the Adoption of green procurement for green products and services (mean=4.54, sd=0.616), which was accepted as the strategy that majorly agreed by the respondents. It was followed by Enforcement of green building materials through government policies and regulations (mean=4.52, sd=0.682) and raise public awareness about GBM with sufficient information (mean=4.51, sd=0.634), which positioned at 2nd item and 3rd rank, respectively. The lowest mean score perceived in the survey is regulate low risk and affordable financial loans for GBM adopters (mean=4.39, sd=0.641) that placed this strategy in the lowest rank

4.3 Discussion of the results

Key catalyst or "low hanging fruit" strategies are described as the ways or strategies that can be immediately achieved or less difficult to achieve towards a specific goal and objectives. From the result, *adoption of green procurement for green products and services (mean=4.54)* is ranked as the priority strategy to enlarge the market for GBM in Malaysia construction sectors. Green procurement is defined as the acquisition and process of purchasing sustainable products and services that consider environmental criteria to conserve the environment and natural resources and minimize and mitigate the negative impacts of human activities (Razali *et al*., 2021); (Adham *et al*., 2015); (Testa *et al*., 2016). The government has been serious in the highlights of green procurement as it has been addressed since 2009 through the blueprint of National Green Technology Policy (NGTP), that stating the significance of environmental-friendly and green products or services. Other than that, Hsieh *et al*. (2012) has also promoted the inclusiveness of Green Government Procurement (GGP) for construction works in the Twelfth Malaysia Plan (2021-2025). Hence, the green procurement must be comprehensively adopted by all construction stakeholders as ways to promote the utilisation of GBM in construction. This is supported by Razali *et al*., (2021); Khalil *et al.*, (2021); Anuar *et al*., (2022) that has promoted the vital role of green procurement for construction in the mitigation on the environmental adverse impact from project development. Green procurement adoption should be looked at as a whole system and the rating tool provided points for procuring energy efficient products as well as optimizing performance and building sustainability (Musa *et al*., 2013); (Razali *et al*., 2021).

The second highest ranked strategy is the *enforcement of GBM through government policies and regulations* (mean=4.52). Policy is defined as the government's direction in achieving specific performance (Wong *et al*., 2011). While the legal framework refers to the rules, rights, and obligations of companies, governments, and citizens are outlined in legal documents (Sanchez *et al*., 2014). Razali *et al*., (2021) supported enforcement of policy as strategy in enlarging of GBM. This is due to the lack of GBM availability in the market and this issue able to be solved once the policy on the green products and green procurement instruments are available. Next, the third ranked strategy is *raising awareness with sufficient information of GBM* (mean=4.51). According to Griffin *et al*., (2010), raising public awareness of green buildings leads to better-qualified customers who will need better products from companies and endorse greener buildings. Both government and private agencies should provide more campaigns, workshops and promotions that are able to disseminate awareness and involvement of the industry (Razali *et al*., 2021); (Mydin *et al*., 2014). Other than that, awareness, and information on

GBM can be enhanced through a standard and general model project to show to the public to give them a clear picture of the usage of green building materials in a building (Hwang, & Tan, 2012). When many exemplary projects use green options, it will enhance public awareness and increase the demand for green.

The next ranked strategy is establishing more eco-label certification for green materials (mean=4.49) including building materials and improving competitive market price for green building materials in lowering their price. As the raw materials used are mostly recycled from waste materials, a competitive price could be possible for the green building materials (Kuppusamy *et al*., 2019). Placed at the 6th rank strategy is to provide a financial and market-based incentive for adopters could be a way to enlarge the market of green building materials (mean=4.49). The next prioritized strategy towards enlarging the GBM in construction is by introducing new analysis tools to compare the economics and environmental implications of the alternative green building materials used during the design stage (mean=4.41). Nevertheless, developing new analysis tools could make the initial cost of adopting green building materials higher than conventional ways. This is aligned with Algburi *et al*., (2016) studies that assert lack of sustainable measurement tools. As a result, stakeholders require much time to evaluate alternative materials in the construction projects that make them reluctant to practice green (Griffin *et al*., 2010). Suppose there is a tool to measure the alternative materials in their construction projects, especially during design stages. In that case, it will help stakeholders evaluate the advantages and disadvantages of green building materials quickly. Hence, all of the ranked strategies are described in Figure 1 as the key catalyst towards enlarging the GBM into the local construction market. The implementation of these strategies will simultaneously help to reduce the emerging environmental issues in building construction and operational stage.

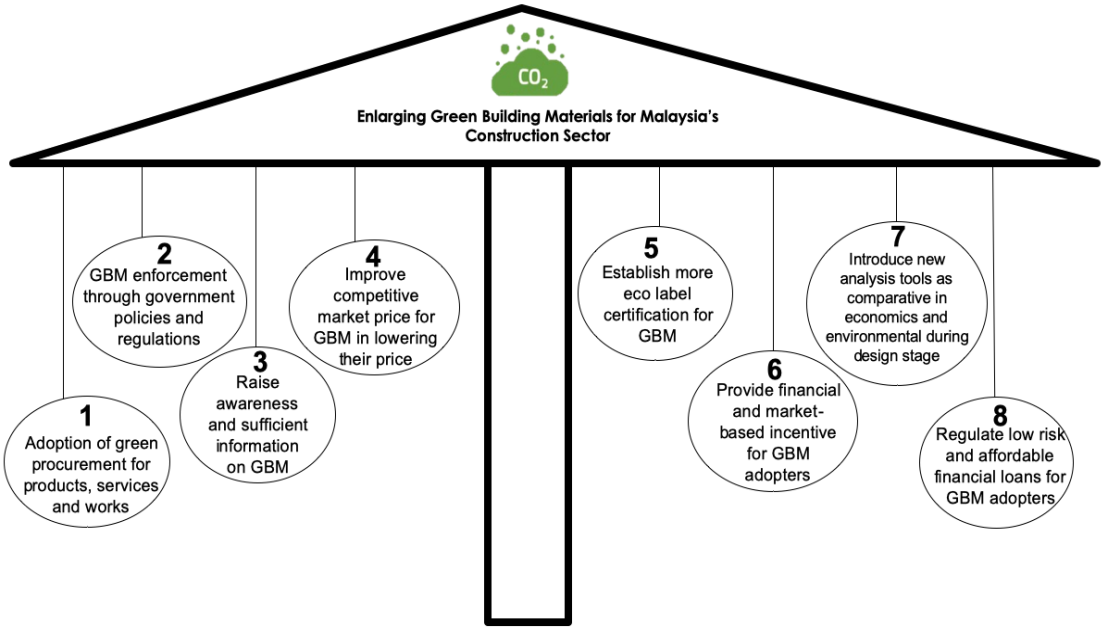

Figure 1: The key catalyst or "low hanging fruit strategies" towards enlarging green building materials (GBM) for local construction market

5. Conclusion

The findings concluded that the adoption of GBM into the construction industry can serve as a valuable input for incorporating sustainable design concepts into buildings. Among the established green building criteria, concentrating on materials reflects as a simple method to convert conventional buildings to low carbon buildings or green buildings. The research findings provide a valuable reference to assist the enablers, practitioners, and policy makers in developing practical strategies in enlarging the market availability of GBM adoption in construction works. However, the implementation towards enlarging GBM to construction sectors must address the challenges and impacts from different aspects. Hence, future research will investigate the tangible and intangible criteria among the strategies and their impacts on the GBM adoption process.

Acknowledgement

This research is partly funded under the consultation project of Scaling SCP Project (SCP-GGP) 2023 funded by Malaysian Green Technology and Climate Change Corporation (MGTC).

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