Economic Model of Green Building Construction: A Conceptual Model

Economic Model of Green Building Construction: A Conceptual Model

Afzan Ahmad Zaini[1*], Nur Khairina Khairul Hisham[1], Abdul Rashid Abdul Aziz[2] and Nurul Nadia Abd Aziz[3]

[1] Faculty of Built Environment, Universiti Malaysia Sarawak (UNIMAS), Sarawak, Malaysia
[2] School of Housing, Building & Planning, Universiti Sains Malaysia (USM), Pulau Pinang, Malaysia
[3] Faculty of Business and Management, Universiti Teknologi MARA Pahang (Raub Campus), Pahang, Malaysia
*Corresponding author: azafzan@unimas.my

Abstract. The current research shows that green building received inadequate support from industry parties due to its high up-front cost. There are no existing guidelines focussing on how to minimize the issues of high up-front cost and for that reason, not all clients willing to get involved in green building construction. Hence, to increase their interest in investing in the green building, this research aims at formulating an economic model of green building construction using Structural Equation Modelling (SEM). The objectives of this research are to identify the green buildings elements, examine the most expensive elements, recommend the strategies in minimizing the cost of green building construction and to formulate and validate an economic model of green building construction. The model is one of the strategies to minimize the total cost, increase the client's interest to invest in green building as well as facilitate construction stakeholders from inception to completion stage; in line with the Twelve Malaysia Plan "Economic Empowerment and Environmental Sustainability".

1. Introduction

United Nation Environment Programme (2020) recognized construction as one of the industries that has shown a steady increase in energy consumption and government is urged to make a strategy to reduce the energy consumption a priority. In Malaysia, Green Technology Master Plan Malaysia has been introduced in 2016 which includes building sector to incorporate design, construction and materials which are sustainable to the environment. Green building construction will not only bring benefits to the building constructed but also benefitted the global market [1]. Some of the advantages of green building construction are cost effectiveness, availability of construction material, efficiency of energy, cost and waste reduction improving community's economy, promoting cultural heritage, adaptability to the environment, eco-friendly, enhancing social wellbeing and reduced carbon emission [2].

The cost and complex nature of green construction adoption has caused hesitancy among stakeholders to implement green construction [3]. There are few policies and programmes of green building implementation that has been introduced to achieved greener environments. Some of these policies are National Green Technology Policy (2009), National Energy Efficiency Master Plan Study (2010) and Low Carbon Cities Framework & Assessment System (2011) [4]. To assist in implementation of green building construction, different rating tools are developed which are Green Building Index (GBI), PWD Green Rating Scheme or pH JKR Malaysia, Green Performance Assessment System (Green PASS) and Green Real Estate (GreenRE). It can be observed that available

policies and rating system focuses on the implementation but not the economical aspect of green building construction.

Therefore, this research aims at formulating an economic model of green building construction which is expected to encourage and motivate the industry stakeholders to invest in green building construction in line with the twelve Malaysia Plan "Economic Empowerment and Environmental Sustainability". As the national economic is now facing a great challenge in terms of Economics and sustainability, and currently become the main government agenda, therefore this research more significant and idealistic will attempt to fill in this gap.

Objectives of the topic of the research will direct and address research problems then answer the research questions. The main objectives of this research are, to identify the green building elements and examine the most expensive elements in green building construction, to recommend strategies in minimizing the overall cost of green building, and to formulate and validate an economic model of green building construction.

For this paper, conceptual framework will be developed for the purpose of achieving research aims and objectives. The model will be developed based on extensive readings of literature review obtained from resources such as research paper, journals and books related to the issues of green building construction.

2. Literature Review

2.1. Green Building Elements

Green or sustainable building utilised energy, water and materials which are key resources efficiently [5]. Building construction shall adhere to few principles of environmental sustainability to be recognised as green building. These principles are fulfilling the needs of the society, preservation of diversity, capacity to regenerate, reuse and recycle, and reducing the production of waste and using eco-friendly building materials [6]. Selection of materials for green building construction must implement strategies with steps such as efficient use of materials, use renewable energy and recycled resources and use materials with low environment impact [7]. Green Building Index rating system, which is widely used in Malaysia, scored building points in Energy Efficiency (EE), Materials & Resources (MR), Water Efficiency (WE), Indoor Environment Quality (IEQ), Sustainable Site Planning & Management (SM) and Innovation (IN). Conventional and green building shared the same building elements, but green building shall fulfil requirements of green building construction. Table 1 presented some of the green building materials and criteria of few building elements: -

Table 1. Conventional and Green Building Materials & Criteria.

Building Elements	Conventional Building	Green Building
Concrete Works	Cement and aggregate	Rice husk concrete stretcher hollow unit block (GCH Block) [8]
Wall	Clay brick	Interlocking brick system [9]
	Cement hollow block	Green concrete hollow block [10]
Facades	Aesthetic purposes	Heat mitigating elements [11]
Roof	Concrete roof tiles	Rice husk roof tiles [12]
Road	Asphalt concrete	Olive oil waste ash concrete [13]

2.2. Green Construction Cost Premium

Project budgeting is important to construction project owner [14]. Green building construction often will need 30% higher upfront cost compared to a conventional building [1]. Additional of 5% to 10% of the total construction budget applied to green building construction [15]. Large investment cost is needed for the implementation of green building construction and at often cost for other building elements were being reduced to fulfil requirement of green building construction. This observable fact

will not be an issue if client is willing to fork out extra money on green building to benefit the industry in terms of its long-term cost saving.

Capital increase in construction in commercial buildings and larger residential sector is not caused by green building rating tools [16]. Green building construction implementation has more benefits in the long run despite of high initial cost [17]. Green building construction will not only benefit the environment but also saving the operating cost by reducing the energy consumption [18].

Other causes of cost increase of green building construction include changing of requirement from conventional to green construction and scarcity of materials due to the industry and green market that are still budding [19].

2.3. Building Construction Cost Minimisation

Asides than the classification of either platinum, gold, silver, bronze, and certified, other external factors will affect the overall cost of green construction. The external factors are site location, design specifications, construction condition, material and equipment selection and construction expertise [14].Overall cost reduction may be achieved by applying variables of high adaptability to any external and internal stress situations, revealing professional risks in timely manner and processes optimisation in green building construction [20].

Few strategies can also be implemented to reduce green construction cost. Table 2 laid out few strategies that can be taken to make green building construction more cost economical thus reducing cost premiums [15].

Table 2. Solutions to Reduce Cost Premium [15].

Solutions to Reduce Cost Premiums	Rank
Government to provide incentives/subsidies for green building projects	3
Low-interest loans	7
Financial institutions to introduce lending schemes customized for green building projects	8
Government to provide subsidies for research and development of green building products, systems, and technologies	5
Tax relief for developers and contractors for use of green building products, systems, and technologies	1
Availability of skilled and experienced project team and contractors	2
Government to provide green building educational courses for key building players so as to flatten the learning curve of green construction	6
Government to provide subsidies for green building professional and specialist courses	4

2.4. Existing Model Pertains to Green Building Construction

There are various of existing model related to green building construction. Below are some of the available models which pertains to the issue of green building construction.

2.4.1. Model 1 - Performance Indicator Model.
Green construction is a vital aspect of green building, and the implementation process is long and strenuous task [21]. Management Performance Indicator involved 6 indicators which are involvement of management, training, investment, environmental management program, environmental training, and management program [22].

2.4.2. Model 2 - Operational Performance Indicators (OPIs).
Green Construction Assessment is part of the important aspect of Operational Performance Indicator (OPIs). Equipment maintenance as well as control for air, noise, water, and waste pollution control must be carried out. Ecological impact and energy consumption shall also be taken in consideration under this model [22].

2.4.3. Model 3 - Green Construction Framework.
Theoretical framework of green building construction includes environmental regulations, managerial concerns, and project stakeholder pressure. [23].

2.4.4. Model 4 - Implementation of Green Construction.
Implementation of green building construction must take few general statements under this model. The statement suggest environmental requirements, guide and specification must be easily accessible internally, green factors must be considered for public projects, green factors must be considered for private constructions, company must prepare ample green construction information and database, mandatory requirements to be fulfilled with green considerations, voluntary participation in green construction and lastly, mandatory green building implementation is to be urged by the government [24].

2.4.5. Model 5 - The Path of Achieving Sustainable Development.
For this model there are three aspects that must be considered towards the path to achieve sustainable development. The first one is environmental protection that preserve built and natural environment and prevent adverse effect towards the environment. The second aspect is social well-being that focuses on human satisfaction, safety, and comfort. Lastly, economic prosperity also needs to be examined to achieve sustainable development [25].

2.4.6. Model 6 - BEACON model.
This readiness assessment model development is to purposely measure the readiness of construction organizations before concurrent engineering application. This model is based on four major components known as a process component, people component, project component, and technology component. Process maturity level of construction organisation will be assessed by using process components. People components involves assessment of management team issues within the organisation. Client's requirements and issues related design is to be assessed with project components. Technology introduction and utilisation is to be achieved by using technology component [26].

2.4.7. Model 7 - Green Construction Model.
This model was developed to facilitate construction stakeholders to implement green construction [19]. They must be fully aware and understand the concept and definition, benefits, innovation, and current practices of green building construction. On the other hand, the moderators in this model will help the construction stakeholders be more attentive to the disadvantages and challenges that might occur before or during the implementation of green construction [19, 27].

It can be observed that the existing models of green building construction are mainly focusing on awareness, readiness, design, and environment. Economic aspects are absent in the existing models. Hence, there is a need to examine the most expensive elements in green building construction and to propose recommendations to minimize the overall cost of green building construction. Based on the recommendations, an economic model based on developmental process will be formulated to encourage the clients and contractors to invest in green building construction.
[

2.5. Industry Stakeholders' Satisfaction

Implementation of green building construction will not affect the cost of construction but also satisfaction of stakeholders. Employee satisfaction must be taken in consideration for an exemplary implementation of green building construction [28]. Building occupants of green certified building showed higher satisfaction rate as to compare with occupants of non-certified building [29]. Thermal comforts and air quality in a green certified buildings performed better than those in a non-certified building thus resulting in increase of satisfaction among building occupants [30]. Cost is observed to be one of the internal driver barriers that demotivated stakeholders towards a successful implementation of green building. This can be combatted by attitudes and behavioural change through enhancing financial and economic value as well as introducing credible policies and regulation tools [31].

3. Conceptual Model and Research Proposition

Based on the literature review, conceptual model of this research then being formulated as per figure 1.

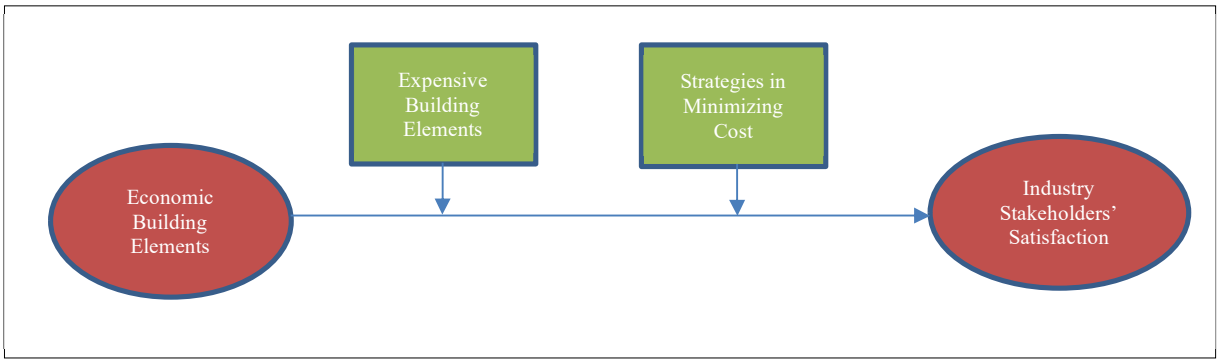

Figure 1. Conceptual Model

Proposition 1: There is a significant relationship between the Economic Building Elements and the Industry Stakeholder Satisfaction.

Proposition 2: Expensive Building Elements moderates the significant relationship between the Economic Building Elements and the Industry Stakeholder Satisfaction.

Proposition 3: Strategies in Minimizing Cost moderates the significant relationship between the Economic Building Elements on Industry Stakeholder Satisfaction.

4. Conclusion

The model emphasizes on the economic building elements and industry stakeholder satisfaction with two moderators as external factors namely expensive building elements and strategies in minimizing cost. This model is expected to minimize the total cost which in return will increase the client's interest to invest in green building. This model is aimed to facilitate construction stakeholders to construct building and infrastructure in economical and sustainable approach from inception to completion stage; in line with the Twelve Malaysia Plan of "Economic Empowerment and Environmental Sustainability".

5. References

[1] World Green Building Council (WorldGBC) 2013 *The Business Case for Green Building—Review of the Costs and Benefits for Developers, Investors and Occupants* Retrieved on November 15, 2021, from http://www.worldgbc.org

[2] Adeniyi S M, Mohamed S F, Ola-awo W A, Yosuf Z M and Saidin M 2021 Benefits of Using Green Materials for the Construction of Low-Cost Building in Nigeria, *Proc. of Int. Conf. Sustainable Housing, Land Management (Minna)*

[3] Issa M H, Rankin J H and Christian A J 2010 Canadian practitioners' perception of research work investigating the cost premiums, long-term costs and health and productivity benefits of green buildings, *Building and environment* **45**(7) 1698-1711
[4] Suhaida M S, Tan K L and Leong Y P 2013 Green buildings in Malaysia towards greener environment: challenges for policy makers, *IOP Conference Series: Earth and Environmental Science* **16** 012121
[5] Kats G, 2003 *Green building costs and financial benefits* (Boston, MA: Massachusetts technology collaborative) pp 2-8
[6] Morelli J 2011 Environmental sustainability: A definition for environmental professionals, Journal of environmental sustainability **1**(1) 2
[7] Broome J, 2007 *The green self-build book: how to design and build your own eco-home. Sustainable Building* (Green Books) pp 97-128
[8] Samad A A A, Mohamad N, Tambichik M A, Bosro M Z M and Goli M 2021 Strength properties of green concrete mix with added palm oil fibre and its application as a load-bearing hollow block, *IOP Conference Series: Materials Science and Engineering* **1144** 012031
[9] Mirasa A K and Chong C S 2020 The Construction of Green Building Using Interlocking Brick System, *Green Engineering for Campus Sustainability* 35-49
[10] Bosro M Z M, Samad A A A, Mohamad N, Goh W I and Tambichik M A 2020 Finite Element Analysis of Green Concrete Hollow Block (GCH block) System, *Earth and Environmental Science* **498** 012039
[11] Aldoumani N 2020 *Assessment of green building codes relating to building facades for mitigating urban heat island in Malaysia* Master's Thesis (Kuala Lumpur: International Islamic University Malaysia)
[12] Muhamad K, Zainol N Z, Yahya N, Noor S N A M, Hashim N H and Shahrazi D Z 2020 Influence of rice husk ash (RHA) on performance of green concrete roof tile in application of green building, *IOP Conference Series: Earth and Environmental Science* **476** 012038
[13] Abuaddous M, Dahim M, Ismail R, Taamneh M, Alomari A H, Darwish W and Al-Mattarneh H 2021 Sustainable asphalt concrete for road construction and building material, *IOP Conf. Series: Earth and Environmental Science* **801** 012-023
[14] Taemthong W and Chaisaard N 2019 An analysis of green building costs using a minimum cost concept, *Journal of Green Building* **14**(1) 53-78
[15] Hwang B G, Zhu L and Ming J T T 2017 Factors affecting productivity in green building construction projects: The case of Singapore, *Journal of Management in Engineering* **33**(3) 04016052
[16] Ade R and Rehm M 2019 Buying limes but getting lemons: Cost-benefit analysis of residential green buildings-A New Zealand case study, *Energy and buildings* **186** 284-296
[17] Long G, Xu T and Li C 2021 Evaluation of green building incremental cost and benefit based on SD model, *Web of Conferences* **237** 03012
[18] Pauzi N N M, Yeow P K, Go Z H and Hadibarata T 2021 Overview on the Implementation of Green Building Design in Malaysia, Singapore, Vietnam and Thailand, *International Journal of Advanced Research in Technology and Innovation* **3**(3) 35-48
[19] Ahmad Zaini A and Endut I R 2018 Major challenges in implementing green construction, *Journal of Engineering and Applied Sciences* **13** 8865-8869
[20] Borkovskaya V, Degaev E and Burkova I 2018 Environmental economic model of risk management and costs in the framework of the quality management system *MATEC web of conferences* **193** 05027
[21] Shi Q and Xie X 2009 A fuzzy-QFD approach to the assessment of green construction alternatives based on value engineering, *Int. Conf. on Mgt. and Service Science* 1-6
[22] Tam C M, Tam V W and Tsui W S 2004 Green construction assessment for environmental management in the construction industry of Hong Kong, *International Journal of Project Management* **22**(7) 563-571
[23] Qi G Y, Shen L Y, Zeng S X and Jorge O J 2010 The drivers for contractors' green innovation: an industry perspective, *Journal of cleaner production* **18**(14) 1358-1365

[24] Shi Q, Zuo J, Huang R, Huang J and Pullen S 2013 Identifying the critical factors for green construction–an empirical study in China, *Habitat international* **40** 1-8
[25] Lombardi P L, 2001 Responsibilities toward the coming generation forming a new creed, *Urban design studies* **7** 89-102
[26] Khalfan M M, Anumba C J and Carrillo P M 2001 Development of a readiness assessment model for concurrent engineering in construction, *Benchmarking: An International Journal* **8**(3**)** 223-239
[27] Ahmad Zaini A 2016 *A model for implementation of green construction* Doctoral Dissertation (Selangor: Universiti Teknologi MARA)
[28] Presley A, Meade L and Sarkis J 2007 A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration, *International Journal of Production Research*. **45**(18-19) 4595-4620
[29] Liu Y, Wang Z, Lin B, Hong J and Zhu Y 2018 Occupant satisfaction in Three-Star-certified office buildings based on comparative study using LEED and BREEAM, *Building and Environment* **132** 1-10
[30] Fard S A, 2006 *Post occupancy evaluation of indoor environmental quality in commercial buildings: Do green buildings have more satisfied occupants?* Doctoral Dissertation (Berkeley: University of California)
[31] Mustaffa N K, Isa C M M and Ibrahim C K I C 2021 Top-down bottom-up strategic green building development framework: Case studies in Malaysia, *Building and Environment* 108052

Acknowledgments
This paper draws from grants awarded by the Ministry of Higher Education (MOHE), Malaysia under the Fundamental Research Grant Scheme (FRGS) Phase 1/2020, Grant No: FRGS/1/2020/SSI02/UNIMAS/02/1.