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Barriers to the implementation of green construction: a case study in Bandung, Indonesia

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Abstract: This study is conducted in order to find a set of obstacles in implementing green construction concept in Indonesia. The study objective is achieved through an assessment of a case study of an apartment in Bandung, Indonesia. The assessment was performed using Assessment Green Construction model which was introduced by W. I. Ervianto in 2015. This assessment was conducted through the fulfilment of several indicators. The barrier is identified based on the reason behind the unimplemented indicator. The identified barrier from the highest percentage of occurrence to the lowest are no client demand, cost of investment, awareness, and site condition. The client demand issue could be overcome by the establishment of pertinent policy, official assessment system, and incentives. Contractor should aware about the business benefit of the investment. Further socialisation about several aspect of green construction is required to enhance the awareness of contractor. The site condition barrier should be addressed in the development of the Assessment Green Construction model.

Keywords: Green construction, assessment, barrier

1. Introduction

Construction industry has globally recognised as a substantial contributor of greenhouse gas (GHG) emissions [1] [2] [3]. A research by [4] described that the construction industry produced 5.7 billion tons of GHG emission. This value was equivalent to 23% of the global economics activity in 2009 [8]. During the same period of study, construction sector generated much greater value of GHG emission intensity (0.67 kilotons/million US$) compared to the average value of global economic activities (0.22 kilotons/million US$) [4].

The construction phase, which covers procurement, mobilisation, and construction stage, could potentially be the source of GHG emissions. During fabrication stage, the GHG emissions is generated during the fabrication of building components, both concrete and/or steel [1] [2]. The mobilisation of building component, material, and equipment to project site also contributes to the emission [1] [2]. The use of fossil fuel-based equipment during construction stage also generates an enormous amount of GHG emissions [2].

Furthermore, it was found that the amount of GHG emissions from construction process is larger in the developing country than in the developed country [3]. In particular, among four developing countries such as Turkey, Mexico, and Brazil, Indonesia generated the largest amount of GHG emission [3]. During 2009, Indonesia produced 43% of the total GHG emissions from construction sector among those four countries [3].

Indonesia has addressed those issues through the Indonesian construction masterplan named "Indonesian Construction 2030" [5]. This masterplan has included green construction as one of the main agenda. This agenda is aimed to utilize the natural resource efficiently as well as minimise the environmental impact of the whole construction process in Indonesian project.

This study is conducted in order to support the enhancement of green construction implementation in Indonesia. The objective of this study is to find a set of obstacles which could potentially be a barrier to implement green construction concept. These barriers should be addressed properly in order to enhance the development of green infrastructure in Indonesia.

2. Literature Review

The commencement of green infrastructure development in Indonesia is considered recent. A notable milestone of the progress is the conformation of Green Building Council Indonesia (GBCI) in 2009 [6]. GBCI has launched Greenship Rating Tools, covering sets of assessment for home, new building, existing building, and interior space. Those tools focus on the green aspect of the respective object during design and operational phase.

Within the construction phase, Ervianto [7] introduced an assessment tool which is called Assessment Green Construction model. In general, this model sequentially consists of aspects, factors, and indicators. The aspects are health and safety; air quality; building environmental management; material source and cycle; land use; water conservation; and energy conservation [7]. Each aspect consists of several factor and each factor is assessed through several indicators [7]. The hierarchy of this model is presented in the Table 1.

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Table 1 The hierarchy of *Assessment Green Construction* by Ervianto [7]

Aspect	Factor	Indicator
A.1 Health and Safety	F.1 Health and Safety Program	3 indicators
	F.2 Health and Safety Aspect during Construction	17 indicators
A.2 Air Quality	F.3 Air Quality during Construction	6 indicators
	F.4 Selection and Operation of Construction Equipment	5 indicators
	F.5 Material Storage	5 indicators
A.3 Building Environmental Management	F.6 Documentation and Inventory	8 indicators
	F.7 Environmental Management	15 indicators
	F.8 Training for Worker	4 indicators
	F.9 Construction Waste Management	12 indicators
A.4 Material Source and Cycle	F.10 Material Usage	10 indicators
	F.11 Project Planning and Scheduling	5 indicators
A.5 Land Use	F.12 Land use	4 indicators
	F.13 Ecological Footprint	6 indicators
	F.14 Site Protection Plan	12 indicators
A.6 Water Conservation	F.15 Water Efficiency	10 indicators
A.7 Energy Conservation	F.16 Energy Efficiency	20 indicators

The assessment is conducted by filling each indicator through a closed question. The complete indicators are presented in Table 2. Each indicator has a unique weight which is obtained from analytic hierarchy process, resulting an overall score of green construction implementation of the assessed project [7].

The literature review also covers several studies regarding the barrier of green construction implementation from another country. Dodge Data & Analytics [8], Kibert [9], Bond & Perrett [10], Hwang & Tan [11], and IGEL [12], has stated that client demand and high cost of investment are the main obstacle of green construction implementation.

Besides, Hwang and Tan [13], and Simpeh and Smallwood [14] has found that the poor knowledge and understanding of contractor about green construction concept could detain the implementation. This obstacle could lead to the reluctance in investing resources to implement the concept.

3. Methods

The methodology to identify the barrier starts on the green construction assessment of the case study, using the Assessment Green Construction model. The case study is an apartment in Bandung, Indonesia, which was under construction phase during the period of study (year 2017). This project is selected because of the size of the project in terms of cost; as well as the class of contractor who build the project.

This project is considered as one of the biggest project in Bandung which was still constructed in 2017. Furthermore, the contractor of the project is categorized as B2 class in accordance with the Indonesian Ministry of Public Works standard [15]. This class indicates the capabilities of the contractor who could execute a project with no maximum value in terms of cost.

The assessment is conducted through field observation method. Each indicator is filled based on the interview with the site manager from contractor. So that all results are based on the contractor's point of view. The site manager has more than 15 years of experience and was involved in this project from the beginning. This is to ensure the reliability of all given answers and opinions. The barrier is identified based on the reason behind the unimplemented indicator. The barriers are ranked in accordance with its frequency in order to understand the overall issue.

4. Results and Discussion

The results of the indicator fulfilment are shown in the table 2. The table also presents the barrier of each unimplemented indicator. The summary of the identified barrier is presented in the Table 3.

The most significant barrier based on the result is no client demand. This is in line with several previous studies from the literature review such as Dodge Data & Analytics [8], Kibert [9], Bond & Perrett [10], Hwang & Tan [11], and IGEL [12], in which client demand is one of the main trigger to the implementation of green construction. This barrier is a consequence of the lack of public awareness regarding the advantage of green aspect [8]. Moreover, client should be educated about the importance of business benefit from green construction [12], since its market grows rapidly in the recent years [8] [11] [16]. The public awareness issue could be overcome by the establishment of pertinent policy [9] [17], official assessment system [9] [12] [18], and incentives [8] [12].

The high cost of investment is also a significant barrier in the implementation of green construction [4] [12]. Tagaza and Wilson [19] found that the investment for green construction is greater by 1 to 25% compared to the conventional one.

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Table 2 The indicator fulfilment and barrier

No	Remarks	Implementation		Barriers of Implementation
		Yes	No	
F.1	**Health and Safety Program**			
1	Create schedule of high emission activity	✓		
2	Separate worker's plot from working area		✓	Cost of Investment
3	Ensure the airflow during construction	✓		
F.2	**Health and Safety Aspect during Construction**			
1	Prioritise worker's health and safety	✓		
2	Put attention to the community health around site		✓	No Client Demand
3	Perform construction method selection based on dust contamination		✓	No Client Demand
4	Perform construction method selection based on pollutant characteristic		✓	No Client Demand
5	Utilise low-emission and energy-efficient tools and equipment		✓	Cost of Investment
6	Minimise dust contamination during deconstruction/demolition		✓	Site Condition
7	Put attention to the hazardous material	✓		
8	Install no-smoking sign on the site		✓	Awareness
9	Install no-smoking sign on the site office		✓	Awareness
10	Provide a smoking area which is located ± 5 metres radius away from contractor's office		✓	Awareness
11	Provide a smoking area which is located ± 5 metres radius away from working area.		✓	Awareness
12	Prevent asbestos material usage	✓		
13	Prevent mercury lamp utilisation	✓		
14	Prevent Styrofoam usage	✓		
15	Install safety net	✓		
16	Perform water sprinkling during construction to minimise dust	✓		
17	Install washing bay facility	✓		
F.3	**Air Quality during Construction**			
1	Conduct clean-air program in accordance with government policy		✓	No Client Demand
2	Conduct air quality measurement periodically		✓	No Client Demand
3	Ensure that all stakeholders understand, take responsibility, and perform clean-air program		✓	No Client Demand
4	Monitor the execution of the clean-air program		✓	No Client Demand
5	Fulfil the air quality criteria in accordance with the contract		✓	No Client Demand
6	Enclose the readiness to fulfil the air quality criteria on the contract		✓	No Client Demand
F.4	**Selection and Operation of Construction Equipment**			
1	Observe the cycle time of the equipment to enhance productivity		✓	Awareness
2	Conduct a training to the operator to enhance productivity	✓		
3	Minimise equipment idle time	✓		
4	Replace fossil fuels with other renewable fuel		✓	Cost of Investment
5	Utilise public transportation for site workers		✓	Cost of Investment
F.5	**Material Storage**			
1	Plan material storage	✓		
2	Prevent material contamination	✓		
3	Store dust-prone material off site		✓	Cost of Investment
4	Perform material storage using adhesive method		✓	Awareness
5	Perform pipe protection	✓		
F.6	**Documentation and Inventory**			
1	Perform the inventory of residual material	✓		
2	Perform the inventory of recycle material utilisation		✓	No Client Demand
3	Perform the inventory of locally-sourced material utilisation		✓	No Client Demand

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No	Remarks	Implementation		Barriers of Implementation
		Yes	No	
4	Perform the inventory of certificated wood material utilisation		✓	No Client Demand
5	Perform the inventory of renewable material utilisation		✓	No Client Demand
6	Perform the inventory of material delivery	✓		
7	Perform the documentation of clean-air program		✓	No Client Demand
8	Perform the documentation of construction waste management		✓	No Client Demand
F.7	**Environmental Management**			
1	Provide trash bin	✓		
2	Perform project waste sorting		✓	Awareness
3	Perform household waste sorting		✓	Awareness
4	Monitor the waste		✓	Awareness
5	Cooperate with third party to minimise waste	✓		
6	Provide a categorised trash bin on site		✓	Awareness
7	Provide a buffet meal for worker o minimise plastic waste		✓	Cost of Investment
8	Prevent packaged drinking water	✓		
9	Provide refill drinking water	✓		
10	Install drinking water storage to minimise waste		✓	Cost of Investment
11	Utilisation of double-sided paper for office needs		✓	No Client Demand
12	Provide mould for concrete aggregate waste		✓	Cost of Investment
13	Utilise concrete deconstruction for land fill	✓		
14	Utilise the residual of steel cutting	✓		
15	Create bio pore pit to prevent erosion	✓		
F.8	**Training for Worker**			
1	Conduct a training for worker about waste reduction		✓	Cost of Investment
2	Conduct a training for worker about waste management		✓	Cost of Investment
3	Conduct a training for worker which is focussing on dust-producing activity		✓	Cost of Investment
4	Conduct a training for worker about air quality		✓	Cost of Investment
F.9	**Construction Waste Management**			
1	Order material in accordance with the requirement	✓		
2	Minimise packaging on material delivery	✓		
3	Utilise product standard measurement	✓		
4	Perform construction method selection based on waste reduction	✓		
5	Resemble material to minimise waste	✓		
6	Optimise the material usage to minimise waste	✓		
7	Optimise the estimation to minimise waste	✓		
8	Re-use construction waste	✓		
9	Re-use deconstruction material		✓	Site Condition
10	Perform material down cycle		✓	Cost of Investment
11	Perform material recycle		✓	Cost of Investment
12	Perform material up cycle		✓	Cost of Investment
F.10	**Material Usage**			
1	Utilise material from existing building onsite		✓	Site Condition
2	Utilise prefabricated material which is made of recycle material	✓		
3	Utilise certified wood material		✓	No Client Demand
4	Increase the efficiency of material usage to minimise waste	✓		
5	Reduce carbon footprint on material transportation by utilising locally-source material	✓		
6	Utilise container for contractor's office	✓		
7	Utilise temporary facility during construction	✓		
8	Utilise prefabricated material		✓	No Client Demand

No	Remarks	Implementation		Barriers of Implementation
		Yes	No	
9	Utilise recycle material		✓	No Client Demand
10	Utilise locally-source material	✓		
F.11	**Project Planning and Scheduling**			
1	Prioritise local supplier during procurement	✓		
2	Perform material care	✓		
3	Perform equipment care	✓		
4	Put attention on the work order during material procurement	✓		
5	Put attention on the work order during material procurement	✓		
F.12	**Land use**			
1	Perform tree planting around contractor's office		✓	Cost of Investment
2	Prohibit logging during construction		✓	Site Condition
3	Create infiltration well	✓		
4	Perform wastewater filtration if it has to be drained to the local drainage		✓	No Client Demand
F.13	**Ecological Footprint**			
1	Produce a document which consists of existing site condition and preservation plan if such a cultural fixture exists		✓	Site Condition
2	Plan the equipment storage	✓		
3	Plan a on-site-plant preservation		✓	Site Condition
4	Conduct a logging prohibition within a radius of 12.2 metres from the building		✓	Site Condition
5	Plan and perform the runoff water simulation which could damage the environment		✓	No Client Demand
6	Select environmental-friendly land clearing method	✓		
F.14	**Site Protection Plan**			
1	Plan water usage during construction	✓		
2	Measure construction water runoff to the environment		✓	No Client Demand
3	Plan the erosion prevention	✓		
4	Prevent noise pollution		✓	No Client Demand
5	Utilise the top soil from land clearing	✓		
6	Plan the on-site-plant preservation		✓	Site Condition
7	Plan the on-site plant protection		✓	Site Condition
8	Perform waste water management		✓	No Client Demand
9	Organise the material/equipment loading and unloading	✓		
10	Install project border around site	✓		
11	Organise vehicle transfer into or from site	✓		
12	Prevent erosion form surface runoff water	✓		
F.15	**Water Efficiency**			
1	Collect rain water for corresponding need		✓	Cost of Investment
2	Install water gauge on all water outlet		✓	Cost of Investment
3	Perform a monthly water monitoring program		✓	Cost of Investment
4	Install automatic tap on the contractor's site office		✓	Cost of Investment
5	Post 'use water wisely' sticker on each water outlet		✓	Awareness
6	Install shower for site worker		✓	Cost of Investment
7	Perform the planning and utilisation of dewatering water		✓	Awareness
8	Create recharge well	✓		
9	Install piezometer to control ground water table		✓	No Client Demand
10	Utilise dewatering water	✓		
F.16	**Energy Efficiency**			
1	Install site lighting based on local standard	✓		
2	Install energy-efficient lamp		✓	Cost of Investment
3	Minimise pollution form lamp	✓		

No	Remarks	Implementation		Barriers of Implementation
		Yes	No	
4	Organise lighting based on work order	✓		
5	Install electricity gauge	✓		
6	Calculate carbon decrement from all energy efficiency action		✓	No Client Demand
7	Monitor electricity monthly	✓		
8	Optimise the utilisation of natural sunlight to at least 50% of the office		✓	Awareness
9	Utilise water reservoir to store clean water	✓		
10	Organise the usage of office equipment e.g. lamp and air conditioner	✓		
11	Adjust the air conditioner's temperature to 25^{o} C ± 1	✓		
12	Create a schedule for site worker's transportation		✓	Awareness
13	Provide mess for site worker	✓		
14	Install light sensor on the site lamp		✓	Cost of Investment
15	Perform light intensity measurement (min 300 lux).		✓	No Client Demand
16	Perform vibration measurement during construction		✓	No Client Demand
17	Perform noise measurement during construction		✓	No Client Demand
18	Provide absorbent for hazardous material storage	✓		
19	Ensure all project vehicle and tool passed the low emission test		✓	No Client Demand
20	Install air conditioner with a COP which is at least 10 % higher that local standard		✓	Awareness

Table 3 The occurrence percentage of each barrier

Barrier	Percentage of occurrence (%)
Awareness	14.71
No Client Demand	41.18
Cost of Investment	23.53
Site Condition	20.59

The additional cost is due to material [20] [21] [22] and technology [21]. The solution of this barrier corresponds to the previous barrier. Means that if the client demand of green construction has increased, contractor should response accordingly. Besides, contractor should be educated about the long-term financial benefit from several indicators such as 'Install water gauge on all water outlet'; 'Install energy-efficient lamp'; and 'Utilise low-emission and energy-efficient tools and equipment', in which the cost of investment could be equilibrated with a decrement of operating cost.

The awareness barrier means that the contractor is not aware of the indicator despite the fact that the investment to fulfil the indicator is low. This barrier is caused by contractor's lack of familiarity with the system [13] [14]. For instance, it was found that several indicators such as 'Install air conditioner with a COP which is at least 10 % higher that local standard' and 'Perform the planning and utilisation of dewatering water' are not implemented due to the unfamiliarity. Furthermore, contractor should be aware that the implementation of several indicators could enhance other aspect. For example, 'Provide a smoking area which is located ± 5 metres radius away from working area', it requires a considerably low cost, but it could contribute to the health and safety issues on site.

The site condition factor means the site condition is not suitable with the indicator. For example, 'Utilise material from existing building onsite '; 'Conduct a logging prohibition within a radius of 12.2 metres from the building'; and 'Minimise dust contamination during deconstruction/demolition'; are not suitable due to the fact that there is no existing building and plantation on site. This issue should be addressed within the development of the *Assessment Green Construction* tool, so that any unsuitable site condition would not affect the result of the assessment

5. Summary

In order to accelerate the implementation of green construction concept in Indonesia, the barrier against it should be identified and solved. Based on the result of this study, the identified barrier from the highest percentage of occurrence to the lowest are no client demand, cost of investment, awareness, and site condition. The client demand issue could be overcome by the establishment of pertinent policy, official assessment system, and incentives. Contractor should aware about the business benefit of the investment. Further socialisation about several aspect of green construction is required to enhance the awareness of contractor. The site condition barrier should be addressed in the development of the *Assessment Green Construction* tool.

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References

[1] Akan, M.O.A; Dhayale, D.G.; Sakirs, J. Greenhouse gas emissions in the construction industry: An analysis and evaluation of a concrete supply chain. *Journal of Cleaner Production*, volume 167, (2017), pp. 1195-1207.

[2] Yan, H.; Shen, Q.; Fan, L.C.H.; Wang, Y.; Zhang, L. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong. *Building and Environment*, volume 45, no.4, (2010) pp. 949-955.

[3] Huang, L.; Krigsvoll, G.; Johansen, F.; Liu, Y.; Zhang, X. Carbon emission of global construction sector, *Renewable and Sustainable Energy Reviews*, volume 81, no.2, (2018) pp. 1906-1916.

[4] WIOD, World Input-Output Tables, WIOD, 2012.

[5] Lembaga Pengembangan Jasa Konstruksi Nasional (LPJK), Konstruksi Indonesia 2030 Untuk Kenyamanan Lingkungan Terbangun,' LPJK, Jakarta, 2007.

[6] GBCI, Green Building Council Indonesia, Green Building Council Indonesia, 2017. [Online]. Available: http://gbcindonesia.org/. [Accessed 24 March 2017].

[7] Ervianto, W.I. Capaian Green Construction dalam Proyek Bangunan Gedung Menggunakan Model Assessment Green Construction, in Konferensi Nasional Teknik Sipil 9, Makassar, 2015.

[8] D. D. &. Analytics, World Green Building Trends 2016: Developing Markets Accelerate Global Green Growth, Dodge Data & Analytics, Bedford, 2016.

[9] Kibert, C.J. Sustainable Construction: Green Building Design, New Jersey: Wiley & Sons, Inc., 2012.

[10] Bond, S. and Perrett, G.The key drivers and barriers to the sustainable development of commercial property in New Zealand, *Journal of Sustainable Real Estate*. volume 4, no. 1, (2012) pp. 48-77.

[11] Hwang, B. and Tan, J. SUSTAINABLE PROJECT MANAGEMENT FOR GREEN CONSTRUCTION: CHALLENGES, IMPACT AND SOLUTIONS, in World Construction Conference 2012 – Global Challenges in Construction Industry, Colombo, 2012.

[12] IGEL, Special Report: The Rapid Rise of Green Building, IGEL, Pennsylvania, 2013.

[13] Hwang, B. and Tan, J. Green building project management: obstacles and solutions for sustainable development. *Sustainable Development*, (2010) .

[14] Simpeh, E.K. and Smallwood, J. Fraunhofer IRB, 2015. Available: http://www.irbnet.de/daten/iconda/CIB_DC28812.pdf.

[15] Peraturan Menteri Pekerjaan Umum Republik Indonesia, Pembagian Subklasifikasi Dan Subkualifikasi Usaha Jasa Konstruksi', No. 8, 2011.

[16] Compact, U.N.G. UN Global Compact, 2013. [Online].Available: https://www.unglobalcompact.org/docs/about_the_gc/Global_Corporate_Sustainability_Report2013.pdf.

[17] Windapo, A.O. Examination of Green Building Drivers in South African Construction Industry: Economics versus Ecology. *Sustainability*, volume 6, no. 1, (2014) pp. 6098-6099.

[18] Council, U.G.B. USGBC, 2003. Available: http://www.usgbc.org/resources/building-momentum-national-trends-and-prospects-high-performance-green-buildings.

[19] Tagaza, E. and Wilson, J.L. Green buildings: drivers and barriers e lessons learned from five melbourne developments, University of Melbourne and Business Outlook and Evaluation, Melbourne, 2004.

[20] Zhang, X.L.; Shen, L. Y.; and Wu, Y. Green strategy for gaining competitive advantage in housing development: a China study. *Journal of Cleaner Production*, volume 19, no. 1, (2011) pp. 152-167.

[21] Griffin, C.T.;Knowles, C.; Theodoropoulos, C.; and Allen, J. CRCnetBASE, 2010..Available: http://www.crcnetbase.com/doi/pdfplus/10.1201/b10428-180.

[22] Eisenberg, D.; Done, R.; and Ishida, L. Development Center of Appropiate Technology, 2002. Available: http://www.dcat.net/resources/breaking_down_barriers.pdf.