

Green construction capability for environmental sustainability performance: an empirical study on construction sector in Indonesia

R Ariff, S Sharif and K Yahya

School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor Bahru, Malaysia

Email: ramariff2017@gmail.com

Abstract. This paper reports on the findings on the relationship between green construction capability (GCC) and environmental sustainability performance (ESP). Accordingly, many ESP issues have several impacts on green construction, these include waste reduction and ecology. In a business world, there is a positive trend among construction sector to start reporting over GCC keeping their role as ESP alive. Self-administered questionnaires were distributed respective stakeholders to gather data from employees of construction industry. In order to analyse the collected data, regression analysis and correlation coefficient were employed to check the hypotheses. Statistical package mainly used for social science studies has been used for the data analysis. Results revealed that there is a direct positive relationship between GCC and ESP. The three aspects of GCC, i.e., material, machine and labour also have significant association with ESP. ESP carries with itself sensational openings for the construction management role and with the opportunity that originates responsibility. This study emphasizes the revised planning of risk and causes root to create awareness among employees and strategies to improve ESP and environmental performance level of companies in the competitive world. This research carries a new horizon to explore the association of GCC with ESP in construction sector. The study presents first-ever empirical evidence about the relationship between ESP and GCC from developing countries.

1. Introduction

[1] revealed that environmental pollution is caused by the process of landfill waste and this could be developed by measures of control over pollution. Moreover, the construction industry and infrastructure development have contributed to the reduction of forests because of the need for processing energy, products, and shelter. So that increasing industrial waste has severe consequences for living things and the environment. Whereas [2] has analyzed the main issues that must be addressed in developing a framework for eco-costs of construction waste. This is based on the relationship between processes, policies, technology, impacts and discussion of costs including the relationship between environmental costs and development activities.

2. Background of ESP

[3] reported that from the perspective of environmental impacts, the building sector has a significant influence on the entire environment. Residential buildings represent a large percentage of the built environment, and the selection of materials and spatial planning are needed for general sustainability.



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The selection of construction materials that have a minimum environmental burden is useful in a country's sustainable development. [4] claimed that modern building materials need to pay attention with impact of construction on the environment by sustainable building and construction of buildings using methods and materials that are resource efficient and will not compromise the environment.

2.1 Green Construction

The indicators of green construction were adopted from green construction factors that have been developed by [5]. In addition to, this study also looked at the factors issued by two institutions in Indonesia: (a) Green Contractor Assessment Sheet of P.T. Pembangunan Perumahan (Persero) Tbk Indonesia, (b) the GREENSHIP 1.0 rating system of Green Building Council Indonesia. The description of those aspects in this study are explained as follows: energy conservation, water conservation, appropriate land use, sources and life cycle of materials, environment management, air quality, safety and health [6]. In this study, construction company in a project need to have a green construction capability (GCC) that is reflected in their processes, policies, technology, impacts, activities, cost and behavior.

2.2 Environmental Sustainability

[7] performed performance measurements on environmentally friendly supply chains with sustainable principles in the economic sector by measuring direct and indirect environmental impacts (i.e. supply chains or upstream) such as CO₂, SO₂, biodiversity, water consumption and pollution to name a few applications. In this study, construction company in a project needs to have a environmental sustainability performance (ESP) that is reflected in their aspects, factors, and performance results. Based on the green behavior model on environmental quality, the factors of ESP are waste recovery cost, water consumption, biodiversity, ecology, pollution, CO₂, SO₂ and social impact.

3. Literature Review

[1] reports that there is a relationship between green buildings and sustainable development by comparing green buildings and traditional buildings about the impact on the environment. [5] created the The Green Construction Site Index (GCSI) tool that is adapted to conditions in Indonesia to assess ongoing projects to meet the concept of green construction. Nevertheless, in green construction technology recognizes among others: solar power, biodegradable materials, green insulation, the use of smart appliances, cool roofs, sustainable resource sourcing, low-energy house and zero-energy building design, electrochromic smart glass, water efficiency technologies, sustainable indoor environment technologies, self-powered buildings, and rammed earth brick [8].

4. Research Model and Hypotheses

4.1 Research Model

GCC is independent variable (Predictor). Environmental Management Optimization is taken as moderator and ESP has been employed as dependent variable (outcome) (figure 1).

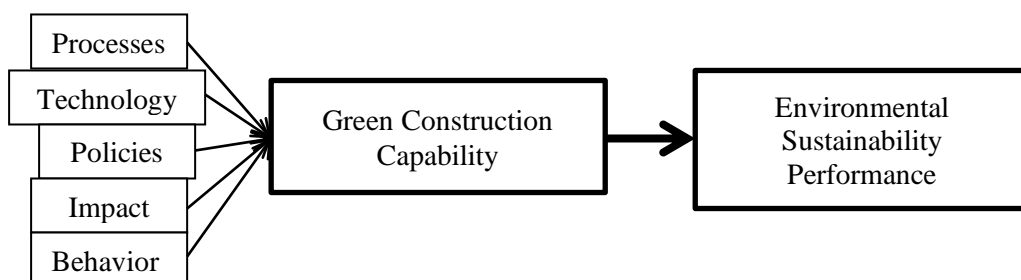


Figure 1. Research model.

This is in accordance with the model developed with regards to the impact of green performance on environmental sustainability [9]. In this study the impact of green construction capability to the environmental sustainability performance was examined.

4.2 Hypotheses

This research proposed alternative hypotheses as below:

- H1. GCCs are positively related to ESP

As GCCs have been classified into five categories, these sub-groups will have definitely positive impact over ESP:

- H1a. Green Construction Processes are positively related to ESP
- H1b. Green Construction Technology are positively related to ESP
- H1c. Green Construction Policies are positively related to ESP
- H1d. Green Construction Impact are positively related to ESP
- H1e. Green Construction Behavior are positively related to ESP

5. Methodology

5.1 Research Design

The sample population of this study constitutes the employees working in construction sectors of Indonesia. Convenience sampling technique was used to gather data through online questionnaire. Data were collected from employees of state company located in Jakarta. This study determined whether there are relations between the two variables, how the direction of the relationship is, and how big the relationship is. Moreover, this study only measures the strength of linear relationships and not non-linear relationships. Although, there is a consideration of a strong linear relationship between variables, it does not always mean there is a causality, cause-effect relationship. In the linear regression test, the data uses interval scales.

5.2 Pilot Testing and Data Screening

Pilot testing was performed to identify the instrument's reliability using Cronbach's α values based on 40 cases. Missing values were explored through frequency table in Statistical Package of Social Sciences (SPSS) for each variable. Cases with missing data for each variable were deleted leaving 245 cases with complete data for analysis. Outliers in the study were addressed using winsorizing techniques. Google application was employed to create an online link for data collection. Response rate in this study is 85 percent. No extreme outlier was diagnosed in the data. Also, Normality Test is carried out using the Kolmogorov-Smirnov technique. Based on the normality test, data obtained were normally distributed with a Sig (2-tailed) value of 0.993. Reliability test was run to know internal reliability of items used in questionnaire based on Cronbach's α value. Correlation coefficient and regression analysis were employed to check association of GCC with ESP.

5.3 Measurement Scale

GCC. A 133-item descriptive norms scale is developed by [5]. In addition to, this scale measures all the five categories of GCCs, i.e., processes = 5 item, policies = 5 item, technology = 6 item, impact = 5 item and behavior = 6 item. Cronbach's α value of GCC is 0.912. Cronbach's α values of five dimensions, i.e., processes, policies, technology, impacts and behavior are 0.907, 0.912, 0.912, 0.912

and 0.912, respectively ESP. A scale developed by Acquaye et al [7] and the GREENSHIP 1.0 rating system of Green Building Council Indonesia having 15 items was used to measure ESP. This scale measures sustainability in terms of economic, social and environmental sustainability. Cronbach’s α value of ESP is 0.918.

6. Data Analysis and Interpretation

From Pearson correlation coefficient table, it is clear that GCCs and all its five dimensions have positive association with ESP. GCC has strong positive association with ESP, i.e., Pearson $r = 0.514$, 0.523 , 0.531 for processes, impact and behavior have moderate positive relationship with ESP. technology and policies dimensions have positive linkage to the ESP, i.e., Pearson $r = 0.662$ and Pearson $r = 0.847$, respectively (Table 1). It is obvious from above regression analysis that GCC has significant positive impact over ESP, i.e., $R^2 = 0.326$, $\beta = 0.571$, $F = 117.469$ and $p = 0.000$, consequently, H1 is accepted (Figure 2). Conserving dimension of GCC has significant positive impact over ESP, i.e., $R^2 = 0.264$, $\beta = 0.514$, $F = 87.240$ and $Sig. = 0.000$. consequently, H1a is accepted (Figure 3). There is significant positive impact of processes over ESP, i.e., $R^2 = 0.438$, $\beta = 0.662$, $F = 189.537$ and $Sig. = 0.000$, consequently, H1b is accepted (Figure 4). A voiding harm has significant positive technology over ESP, i.e., $R^2 = 0.718$, $\beta = 0.847$, $F = 617.476$ and $Sig. = 0.000$, consequently, H1c is accepted (Figure 5). Because of policies dimensions, there is high influence, i.e., $R^2 = 0.273$, $F = 291.333$, $\beta = 0.523$ and $Sig. = 0.000$. There is significant positive impact of impact dimensions over ESP; thus, H1d is accepted (Figure 6). It is clear from regression analysis that ESP is positively influenced by behavior, i.e., $R^2 = 0.281$, $\beta = 0.531$, $F = 95.173$ and $Sig. = 0.000$, consequently, H1e is accepted (Figure 7).

Table 1. Pearson’s correlation coefficient

	processes	technolog y	policies	impact	behavior	GCC	ESP
Processes							
Pearson correlation	1	0.776	0.578	0.623	0.641	0.569	0.514
Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000
Technology							
Pearson correlation	0.776	1	0.731	0.662	0.651	0.611	0.662
Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000
Policies							
Pearson correlation	0.578	0.731	1	0.577	0.540	0.568	0.847
Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000
Impact							
Pearson correlation	0.623	0.662	0.577	1	0.808	0.892	0.523
Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.000

Behavior							
Pearson correlation	0.641	0.651	0.540	0.808	1	0.820	0.531
Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.000
GCC							
Pearson correlation	0.569	0.611	0.568	0.892	0.820	1	0.571
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000
ESP							
Pearson correlation	0.514	0.662	0.847	0.523	0.531	0.571	1
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	

Table 1 above explains the correlation coefficient (r). If the number approaches 1 then the correlation is very strong. Conversely, if the number is close to 0, the correlation is very weak. Table 1 shows that the output is at an interval of 0.514 to 0.892, which means it is relatively strong. Positive values indicate that the higher the GCC score, the higher the green GCP. The significance value can be seen at the value of 0.000 (<0.05) which means the null hypothesis (H0) is accepted (there is a relationship between GCC and GCP). Table 2(a), 2(b) and 2(c) show regression model result of H1. Table 3(a), 3(b) and 3(c) show regression model result of H1a. Table 4(a), 4(b) and 4(c) show regression model result of H1b. Table 5(a), 5(b) and 5(c) show regression model result of H1c. Table 6(a), 6(b) and 6(c) show regression model result of H1d. Table 7(a), 7(b) and 7(c) show regression model result of H1e.

Table 2(a). Model Summary of Regression Model Result of H1

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.571	0.326	0.323	0.73111

- a. Predictors: (Constant), GCC
- b. Dependent Variable: ESP

An R of 0.571 indicates that the correlation between GCC and GCP: Very strong. The number of R square or Determination Coefficient is 0.326 (derived from 0.571X0.571), for independent variables more than 2 use Adjusted R Square. Meaning R square 0.571 (57%) means that 57% of the variations of the GCC can be explained by variations of GCP. While the rest (43%) is explained by other causes. The Standard Error of Estimate (SEE) is 0.73111. The smaller the SEE will make the regression model more precise in predicting the dependent variable.

Table 2(b). ANOVA of Regression Model Result of H1

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	62.790	1	62.790	117.469	0.000
Residual	128.888	243	0.535		
Total	192.678	244			

- a. Dependent Variable: ESP
- b. Predictors: (Constant), GCC

From the ANOVA test or F test, obtained an F count of 117.469 with a significance level of 0.000, far less than 0.05, then the regression model can be used to predict GCC.

Table 2(c). Coefficients of Regression Model Result of H1

Unstandardized Coefficients					
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	62.790	1	62.790	117.469	0.000
GCC	128.888	243	0.535		

- a. Dependent Variable: ESP

Regression Equation: $Y = a + bX$ ($GCP = 62.790 + 117.469 GCC$). A constant of 62.790 states that if there is no GCP, the GCC is 62.790. The regression coefficient of 117.469 states that for each addition (due to the + sign) the GCP score is 1 score, the GCC will increase by 117.469.

Table 3(a). Model Summary of Regression Model Result of H1a

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.514	0.264	0.261	0.76384

- a. Predictors: (Constant), GCC
- b. Dependent Variable: ESP

Table 3(b). ANOVA of Regression Model Result of H1a

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	50.900	1	50.900	87.240	0.000
Residual	141.778	243	0.583		
Total	192.678	244			

- a. Dependent Variable: ESP
- b. Predictors: (Constant), GCC

Table 3(c). Coefficients of Regression Model Result of H1a

Unstandardized Coefficients					
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	1.083	0.183		5.931	0.000
GCC	0.515	0.055	0.514	9.340	0.000

- a. Dependent Variable: ESP

Table 4(a). Model Summary of Regression Model Result of H1b

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.662	0.438	0.436	0.66743
a. Predictors: (Constant), GCC				
b. Dependent Variable: ESP				

Table 4(b). ANOVA of Regression Model Result of H1b

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	84.431	1	84.431	189.537	0.000
Residual	108.246	243	0.445		
Total	192.678	244			
a. Dependent Variable: ESP					
b. Predictors: (Constant), GCC					

Table 4(c). Coefficients of Regression Model Result of H1b

Unstandardized Coefficients						
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.	
1					0.007	
(Constant)	0.464	0.170		2.735		
GCC	0.746	0.054	0.662	13.767	0.000	
a. Dependent Variable: ESP						

Table 5(a). Model Summary of Regression Model Result of H1c

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.847	0.718	0.716	0.47320
a. Predictors: (Constant), GCC				
b. Dependent Variable: ESP				

Table 5(b). ANOVA of Regression Model Result of H1c

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	138.265	1	138.265	617.473	0.000
Residual	54.413	243	0.224		
Total	192.678	244			
a. Dependent Variable: ESP					
b. Predictors: (Constant), GCC					

Table 5(c). Coefficients of Regression Model Result of H1c

Unstandardized Coefficients					
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.
1					0.020
(Constant)	0.244	0.104		2.339	
GCC	0.905	0.036	0.847	24.849	0.000

a. Dependent Variable: ESP

Table 6(a). Model Summary of Regression Model Result of H1d

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.523	0.273	0.270	0.75915

a. Predictors: (Constant), GCC
b. Dependent Variable: ESP

Table 6(b). ANOVA of Regression Model Result of H1d

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	52.636	1	52.636	91.333	0.000
Residual	140.042	243	0.576		
Total	192.678	244			

a. Dependent Variable: ESP
b. Predictors: (Constant), GCC

Table 6(c). Coefficients of Regression Model Result of H1d

Unstandardized Coefficients					
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.
1					0.076
(Constant)	0.436	0.245		1.781	
GCC	0.731	0.076	0.523	9.557	0.000

a. Dependent Variable: ESP

Table 7(a). Model Summary of Regression Model Result of H1e

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate
1	0.531	0.281	0.278	0.75482

a. Predictors: (Constant), GCC
b. Dependent Variable: ESP

Table 7(b). ANOVA of Regression Model Result of H1e

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	54.226	1	54.226	95.173	0.000
Residual	138.452	243	0.570		
Total	192.678	244			

a. Dependent Variable: ESP
b. Predictors: (Constant), GCC

Table 7(c). Coefficients of Regression Model Result of H1e

Unstandardized Coefficients					
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.
1 (Constant)	0.871	0.196		4.436	0.000
GCC	0.539	0.055	0.531	9.756	0.000

a. Dependent Variable: ESP

7. Discussion, Limitation, and Implication

7.1 Discussion

Indonesia has implemented green construction. This has become a concern because green construction can increase profits and attract customers, moreover in the construction of buildings and housing. This practice has been applied all over the world including in the green performance in construction industries. Consequently, the behavior of green employees has now been widely applied. Indonesia must be more vigorous in the application of assessments of green construction capabilities and their significant impact on environmental sustainability performance. Results of the data showed that the Sig. the regression model has an average of 0,000 which means the regression model can predict GCC. However, R values for H1, H1a, H1b, H1c, H1d, and H1e have values of 57%, 51%, 66%, 85%, 52%, and 53%, respectively. This shows that some of them are explained by other causes. In the relationship process on the GCC and ESP, recorded the smallest R value, while the policy relationship on the GCC and ESP has the largest R value. This findings shows that the policy dimension on the GCC is the most important dimension to be realized by both the authority and construction company. Consequently however, the process dimensions of the GCC that need more attention.

7.2 Limitation

This study has described the direct relationship of GCC with ESP. Further research needs to analyze the influence of moderators and mediators on their relationship. It was also inevitable from the limitations of research as this study is conducted accordingly in the construction sector in Indonesia. Data was collected under a cross-sectional design (questionnaire) so that this study had typical limitations associated with this kind of research methodology. Respondents can provide biased feedback due to confidentiality issues and lack of trust. A longitudinal study can overcome this obstacle by providing reflective understanding.

7.3 Implication

The relationship between GCC and ESP can be a useful tool for evaluating construction performance capabilities that are more applicable and as a framework for environmental sustainability performance capabilities. This can be implemented in the construction industry with the right policy recommendations suggested. This measurement model of green construction capability can be used as an assessment of the ability of contractors to build buildings and housing that takes into account the green construction performance in the form of environmental sustainability. In addition, this study adds to the knowledge about the relationship of green construction and environmental impacts presented in empirical findings in the Indonesian construction industries.

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