Balanced sustainable implementation in the construction industry: The perspective of Korean contractors'

Whang, Seoung-Wook[1] **Kim, Sangyong**[1]

[1] *University of Reading, School of Construction Management and Engineering, Whiteknights, Reading, Berkshire, UK*

Abstract

Successful sustainability cannot be realized considering only environmental issues. Along with these, economic and social issues must also be considered in a balanced approach toward ensuring sustainability. In this study, the importance and performance value of factors related to these three issues as well as the gap between their importance and practical performance are investigated. In addition, correlations among these three issues are also examined by means of a survey of Korean contractors. According to data analysis results, there are large gaps between the importance and performance value of soft skill and long-term benefit factors. Moreover, it is found that balanced application with economic and social issues is more essential for sustainable development, even if environmental factors are revealed as quite effective. Environmental factors generally are closely correlated with economic factors, except for several social factors that have the strongest correlation with environmental issues. Hence, from the perspective of Korean contractors, a balanced application between important and tangibly performed factors as well as between environmental, economic, and social issues is essential for successful sustainability and not just the application of an isolated dominant factor.

Keywords : Balanced implementation, Correlation, Economic and Social issue, Sustainability

1. Introduction

Since the Industrial Revolution, the world has witnessed rapid industrialization, excessive urbanization, unsustainable economic growth, and a corresponding increase in resource utilization. In recent decades, the world has become aware of the negative effects of these activities [1-3]. The international community is also beginning to recognize the importance of sustainable development, that is, the harmony of the environment with industrialization. According to the United Nations World Summit [4], economic development, social development, and environmental protection are interdependent and mutually reinforcing sustainable development. Therefore, it is important to maintain the balance between environmental, economic, and social objectives harmoniously for sustainable development [5].

United Nations Economic Commission for Europe [6] reported that the construction industry contributes to over 6% of the global gross domestic product (GDP) and around 10% including relevant industries such as real estate or manufacturing [7]. Simultaneously, the construction industry has also had an enormous impact on the environment as compared to other industries [8]. In this situation, the construction industry needs to find a solution that will harmonize development with the environment. Sustainable development is an indispensable concept for solving environmental problems. It is the most important and challenging issue faced by the construction industry [9]. Many advanced and developing countries have already introduced sustainable building assessment systems, and extensive research is being conducted in the field of sustainable construction. The more widely known include the BRE Environmental Assessment Method (BREEAM) in the UK and the Leadership in

Energy and Environmental Design (LEED) in the United States, the Evaluation Standard for Green Building (ESGB) in China, the Eco-Management and Auditing Scheme (EMAS) in the European Union, Comprehensive Assessment Scheme for Built Environment Efficiency (CASBEE) in Japan, Sustainable Building Assessment Tool (SBAT) in South Africa [10,11]. Several assessment tools can be used to manage sustainability issues at the construction project level. However, most of these tools and studies concentrate more on environmental factors than on the economic and social dimensions. For instance, most of the rating content of international sustainable building assessment tools, such as BREEAM, LEED, SBTool (Sustainable Building Tool), and GBCC (Green Building Certification Criteria) in the Korea are focussed on only environmental issues such as energy efficiency and resource conservation [12]. More than half of the global research on sustainable construction has been focused on environmental factors, and hence, there is a serious lack of studies and tools based on economic and social issues.

According to Riley et al. [13], contractors have an increasing role in the implementation of sustainable building projects. All the stakeholders involved in a construction project, including the client, the designer, and even the government, play an important role in ensuring sustainability. However, it is the contractor's awareness and performance regarding sustainability that has the greatest effect on delivering a sustainable solution. This study aims to evaluate the level of awareness and performance regarding sustainable construction and the specific value of sustainability factors are obtained from the viewpoint of contractors in Korea. Therefore this research also could be an assessment of factors for successful implementation of sustainable construction project in Korea. The result of this assessment would be useful to provide recommendations for overcoming the current barriers to the successful integration of environmental, economic, and social issues.

2. Literature review

At present, environmental protection is recognized that it is related not only sustainable element, but others including economic and social elements [5]. Sustainable development is based on three foundations: environment, economy, and society, as shown in Figure 1 [14].

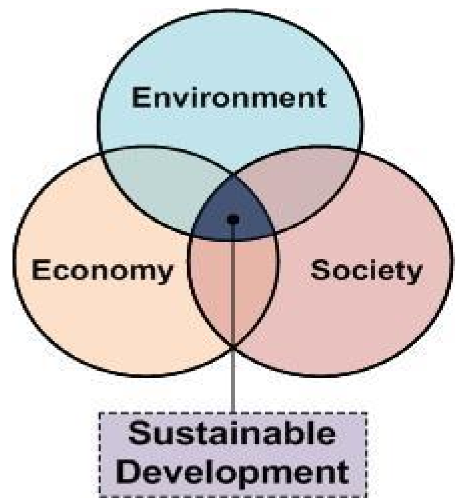

Figure 1 Themes of Sustainable Development [14]

According to the International Council for Research and Innovation in Building and Construction [15], there is a general perception that sustainable development should be seen as an integrative and holistic concept, striving for harmony and balance among the three elements. This balance is crucial in the construction industry, because of the strong impact it has on the environment, economy, and society, as compared to other industries [5,15,16]. Moreover, the construction industry offers different kinds of infra-structure such as factories, roads, bridges, dams, and other facilities, which affect society and the economy. Houvila and Koskela [17] argued that sustainable construction should be considered in a global context and must move away from the traditional construction process, which focused on time, cost, and quality, to a new paradigm as shown in Figure 2. This involves creating synergistic relationships between the environmental, economic, and social aspects of sustainability [18]. To achieve sustainable construction, it is important to implement a balanced and harmonized approach which integrated diverse sustainable aspects including the above three aspects and move away from the distorted approach, which focuses on environmental impacts in construction industry.

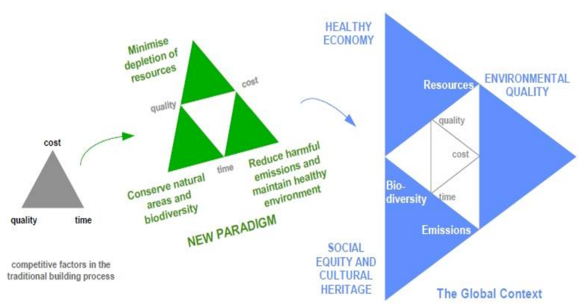

Figure 2 Challenges of Sustainable Construction in a Global Context [17]

However, despite the insistences on balanced development, environmental research have been much more than other research subjects such as economic and social aspect. Research regarding environmental aspect is somewhat more easily to be conducted than economic and social researches which are related diverse and complex aspects outside the construction area. It is reason that despite the growing importance and role of economic and social aspects, there are more environmental researches in construction industry. In order to analyze this research trend, the present study examines approximately 900 research papers related to sustainable issues published by the ACSE (American Society of Civil Engineers, USA), ScienceDirect, and AURIC (Architecture and Urban Research Information Centre, Korea) between 1999 and 2013. Although there are diverse research issues in below institutions, because this research focuses and counts on only sustainable-related papers, sustainable research trend is analysed by about 900 papers including environmental issue, economic sustainable issue, and social sustainable issue. Table 1 compares the number of papers regarding sustainable construction published by the three entities. Nearly half of the research is regarding environmental issues. In Korea, 62% of research is dedicated to environmental issues, while only 11% and 7% deal with economic aspects, and social issues, respectively. It means that specifically in Korea, despite the importance of other sustainable aspects, distorted research trend is dominant. Thus, there has been limited research into economic and social sustainability [18,19].

Issues	ASCE (USA)		ScienceDirect (Global)		AURIC (Korea)	
Environmental	226	48%	60	47%	186	62%
Economic	117	25%	39	31%	33	11%
Social	76	16%	17	20%	21	7%
The Other	46	11%	6	2%	62	20%
Total	**465**	**100%**	**126**	**100%**	**302**	**100%**

Table. 1 Research trends in Sustainable Construction

3. Factors affecting project success

3.1 Sustainable assessment tools

BREEAM was the first environmental assessment method in the world. It has four main aims and six objectives as presented in the BREEAM Fact File [20]. BREEAM awards credits according to performance within each issue, which are then added together to yield a single overall score on a scale of Pass, Good, Very Good, Excellent, and Outstanding. This score is represented by a star rating of 1 to 5 stars [21,22]. In 2006, the UK government developed the Code for Sustainable Homes, which aims at protecting the environment by providing guidance [21-23]. The Code includes 9 categories comprising 34 issues. Each category includes a number of environmental issues that may have a potential impact on the environment [24]. Mandatory minimum performance standards exist regarding the following four key issues: environmental impact of materials, management of surface water run-off from developments, storage of non-recyclable and recyclable household waste, and construction site waste management [24,25]. If the mandatory minimum performance standards for these four uncredited issues have been met, two more mandatory issues need to be considered: dwelling emission rate and indoor water consumption (Communities and Local Government, 2008).

LEED, developed by the United States Green Building Council (USGBC), is a green building rating system that assesses the sustainability of green buildings based on their design, construction, and operation. LEED rates the sustainable performance of buildings over their entire lifecycle based on their environmental impact and sustainable features [26,27]. LEED has become the most widely recognized green building assessment system in the USA, and it is rapidly being adopted worldwide [28]. According to the USGBC [26], LEED for Homes is an assessment system that improves the design and construction of high-performance green homes. LEED for Homes includes 8 categories comprising 44 criteria. The assessment categories of LEED for Homes are basically divided into mandatory and optional criteria [28]. Based on their credits, homes are awarded the following level: platinum (more than 52 credits), gold (39-51 credits), silver (33-38 credits), and certified (26-32 credits).

The SBTool is the Green Building Challenge (GBC) assessment method for rating the sustainable performance of buildings and projects [29]. The SBTool covers a wide range of sustainable building concepts, and not just green buildings; it reflects socio-economic issues as well [29,30]. Moreover, the SBTool is designed to consider regional conditions and cultural values [30]. The SBTool for buildings evaluates the sustainability of a building against seven issues of which energy and resources, environmental loadings, and indoor environmental quality are the mandatory issues. The SBTool comprises 7 issues, 25 categories, and 138 individual criteria, and has the highest number of rating elements as compared to other assessment tools. SBTool's transnational vision can be applied to all types of buildings in different regions. Each category is comprised of criteria that can be assessed quantitatively. The criteria are scored according to the following scale: -1 = Deficient, 0 = Minimum Acceptable Performance, +3 = Good Practice, +5 = Best Practice.

GBCC is a sustainable building assessment system in Korea that aims to estimate the environmental performance of buildings. GBCC has three types of parameters: issues, categories, and criteria. GBCC has 9 issues, 25 categories, and 44 individual criteria and a total possible score of 136 points comprising basic credits (100 points) and additional credits (36 points). The GBCC has seven assessment tools for different types of buildings, including multi-unit residential buildings, mixed-use dwellings, office buildings, commercial buildings, schools, retail shop facilities, and accommodations.

A review of these four sustainable building assessment tools reveals that most assessment tools focus on environmental factors. This finding indicates that the environmental aspects of sustainability continue to be the most commonly considered factors as compared to the economic and social objectives [31]. However, it must be noted that the SBTool includes more social, economic, cultural, and perceptual aspects of buildings and projects than the other tools, as shown in Table 2.

Issues	Categories	Criteria
F. Social and Economic aspect	F1. Social aspect	Minimization of construction accidents
		Access for physically handicapped persons
		Access to direct sunlight from living areas of dwelling units
		Access to private open space from dwelling units

		Visual privacy from the exterior in principal areas of dwelling units
		Integration of project with local community
	F2. Cost and Economics	Minimization of life-cycle cost
		Minimization of construction cost
		Minimization of operating and maintenance cost
		Affordability of residential rental or cost levels
		Support of local economy
		Commercial viability
G. Cultural and Perceptual aspects	G1. Culture and Heritage	Relationship of design with existing streetscapes
		Compatibility of urban design with local cultural values
		Maintenance of heritage value of existing facility

Table. 2 Social, Economic and Cultural Criteria of SBTool

3.2 Economic sustainability

Sustainable construction may not have economic benefits in the short-term, because of the increased initial cost. However, the economic benefits can increase in the long-term because building sustainably can reduce maintenance and operating costs during the building's lifecycle. However, the high initial capital cost and lack of any visible market value is a deterrent to the practical implementation of economic sustainability [32]. Some studies consider the economic issue associated with sustainable building. Kim and Kang [33] suggested the development of the economic factors of an environmental performance rating system for existing office buildings. Yeom et al. [34] conducted an economic feasibility evaluation of sustainable technologies using life-cycle cost analysis to take into account the long-term view. Bebbington [35] also presented a model of the economic costs and benefits of sustainable construction. This model demonstrates the positive aspects of economic issues in four tiers: traditional cost saving, productivity, reputation, and environmental benefits. This study focuses on how the reputation aspect, which is related with the enhancement of goodwill and brand image, can be used to acquire community, government, and regulatory support. In a notable study, Adetunji et al. [36] investigated the key economic issues facing the construction industry in the UK using a questionnaire survey. The respondents described certain economic advantages such as competitiveness and value for money. Furthermore, Adetunji et al. [36] illustrated some key themes and principles for economically sustainable construction. The total maintenance cost can be minimized by considering life-cycle cost and sustainable performance [37]. Economic sustainability is a major contributor toward the maintenance of a high and stable level of economic growth and employment through increased productivity and improved project delivery.

3.3 Social sustainability

Social sustainability is crucial element for sustainable development [38,39], however, it is difficult to consider the practical impact of the social issues in sustainable construction, apply them in practice, and, most importantly, measure them quantitatively. As a result, conclusive studies on social sustainability within construction projects are relatively few. Generally, research regarding social sustainability tends to highlight the importance of effectively dealing with people-related issues such as work environment, health and safety, and training and development aimed to appraise the comprehensiveness of the systems that measure the social issues of sustainability using cultural factors as well as social factors [40-42]. For this purpose, they compared four building assessment tools: GB-Tool (Green Building Tool), BREEAM, LEEDS, and CASBEE (Comprehensive Assessment System for Built Environment Efficiency). In addition, Shen et al. [19] classified and illustrated social sustainability factors to develop a performance checklist for sustainable projects such as the conservation of cultural and natural heritage, employment, community, safety, security, and communication to public. Edum-Fotwe and Price [43] recently presented an ontology that will enable all stakeholders to attain a more extensive viewpoint of sustainability. They also indicated a model of the social dimensions and categories at the building level.

Based on an analysis of the dominant sustainable assessment tools, including these four tools and relevant research, the three issued categories comprising 35 individual key factors are categorized as follows: environmental issues (10 factors), economic issues (16 factors), and social issues (9 factors) as seen in Table 3. Because this research is limited to Korean sustainable construction, all sustainable factors are focused on Korean sustainable situation. Survey is also distributed to only Korean contractors. In addition, to give more objectivity on factor selection, only factors which correspond with Sustainable Development Guideline published by Government of Kora were selected for this research.

Environmental Issues	Economic Issues	Social Issues
1. Energy Efficiency	1. Competitiveness	1. Employment
2. Material and Resources	2. Productivity / Profitability	2. Health and Safety
3. Water Efficiency	3. Value for Money in the Delivery	3. Well-Being
4. Use of Land	4. Partnering	4. Education / Training
5. Waste Management	5. Project Delivery	5. Partnership Working
6. Atmosphere	6. Knowledge Management	6. Culture / Heritage
7. Indoor Environmental Quality	7. Retention of Skilled Labour	7. Security
8. Ecological Environment	8. Quality Management for Durability	8. Community
9. Transport	9. Life Cycle Cost	9. Service Quality
10. Management	10. Construction Cost	
	11.Operating and Maintenance Cost	
	12. Affordability of Cost Levels	
	13. Support of Local Economy	
	14. Commercial Viability	
	15. Innovation / R&D	
	16. Image and Reputation	

Table. 3 Key common factors for Sustainable construction

4. Methodology

4.1 Research approach and methods

This study adopts a triangular approach, consisting of an analysis of previous studies, a questionnaire survey, and a follow-up computational analysis. The questionnaire was designed based on an analysis of previous research and the key factors extracted from sustainable assessment tools to obtain validation regarding the critical impact and combination recognized by Korean construction experts. Hence, questionnaire was utilized as a basic data for assessment of sustainability factors in Korean construction industry. Most participants have headed the building department of their respective companies for an average of 12.6 years. The questionnaire sought empirical knowledge of sustainable construction using these extracted factors.

In this study, the survey participants validated appropriate factors with respect to the sustainable balance between factors. They were asked how to implement the identified factors in sustainable construction and to estimate their performance level in practice using a 5-point Likert scale, where 1 is the lowest perceived factor and 5 the highest as follow: Very Low = 1, Low = 2, Moderate = 3, High = 4, and Very High = 5. This approach may bring distorted results, because result of survey is obtained only by subjective experiences and recognition of respondent. To avoid distorted survey result, this research took several telephone interviews by 8 industry professionals before determining of main questionnaire survey structure. They are asked to comments and suggestions on question items, item wording, item sequence, and the directions are also solicited. In questionnaire, importance value means the critical factor for sustainable development from the construction perspective, while performance value indicates that degree of application of the sustainable issues in actual project. A total of 82 valid responses were received for analysis among 252 distributed questionnaires, and the overall response rate was about 32%. The 82 returned questionnaires consisted of 39 respondents from general contractors, 18 from subcontractors, and 25 from ssustainability specialist trades. They are all registered with the Construction Association of Korea or Korea Special Construction Association and have sustainable construction performance more than 3 projects. The average working period of respondents is 8.4 years. Each respondent was contacted and informed by e-mail including detail descriptions of each sustainable factor to increase accuracy of the survey as well as decrease the survey period. Entire survey period took 4 months. In addition, the correlation of each factor with other factors, belonging to different categories was analyzed. Each individual factor was reviewed not only for its importance value but also for its balance with other factors. The degree of correlation is expressed numerically between 0 and ±1. The closer the value to ±1, the greater the degree of correlation. Figure 3 shows the flow chart of the research.

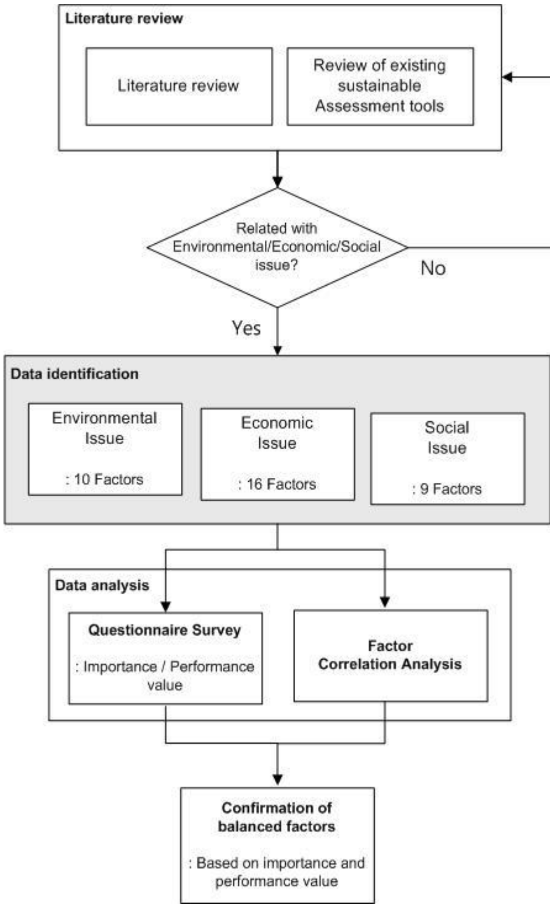

Figure. 3 Research flow chart

4.2 Data analysis method

To determine the importance and correlation of factors from different categories for practical sustainable construction, this study utilizes the "mean score (average index)" method according to the 5-point Likert scale ratings. The 'mean score' (MS) method is suitable for identifying the importance and balance of factors for the development of sustainable construction. The MS is computed based on the following formula [44-46]:

$$MS = \frac{\sum(f \times s)}{N} \quad (1 \leq MS \leq 5) \quad \text{.....................(Eq. 1)}$$

where **s** = is the score given to each factor by the respondents, rating from 1 to 5 where 1 is "Very Low" and 5 is "Very High," **f** = is the frequency of responses to each rating (1-5) for each factor, and **N** = is the total number of respondents for that factor. Where total point score is the summation of all the ratings for a given factor, and 5 is the maximum rating possible [45].

In order to investigate the correlation among individual factors, correlation coefficient analysis is utilized, which is a mathematical method to express correlation numerically [47,48]. It is commonly represented by the letter "r" and may be referred to as the sample correlation coefficient. The formula for r can be obtained by substituting the estimates of the covariances and variances as follows [49]:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}} \quad \text{...........(Eq. 2)}$$

Where r = is the score centered by subtracting out the mean of each variable, and the sum of cross-products of variables (X,Y).

An equivalent expression gives the correlation coefficient as the mean of the products of the standard scores [50]. Based on a sample of paired data (X_i, Y_i), the sample correlation coefficient is obtained as follows:

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{X_i - \bar{X}}{s_X}\right)\left(\frac{Y_i - \bar{Y}}{s_Y}\right) \quad \text{.................(Eq. 3)}$$

Where s_X , s_Y= is the standard deviation of X and Y respectively.

5. Data analysis: Importance and Performance value

Environmental issues

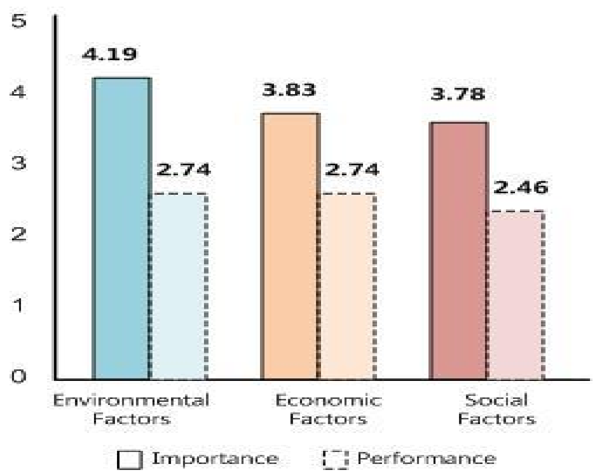

Figure 4 Comparison between factors (Importance / Performance)

Figure 4 shows the factor comparison, according to the level of importance and performance, between the environmental, economic, and social issues of sustainable construction, from the contractors' perspective. It is evident that the degree of importance given by the respondents is higher than their actual performance. This importance value when compared to performance means that most contractors are aware of the importance of sustainability in construction; however, their practical performance is implemented by the decision of developer or client. There cannot but be a difference between importance and performance value. Because sustainable development is interconnected with different technical and social issues within limited budget, concept and application of sustainability are different respectively between contractor and client. Although contractors recognize that the environmental factors (mean 4.19) are the most important for the implementation of sustainable construction, they must also recognize economic and social factors as critical factors, as can be seen from the mean score at 3.83 and 3.78 respectively.

Key Environmental Factors	**Importance**		**Performance**	
	Mean	Rank	Mean	Rank
1.Energy Efficiency	4.50	1	2.67	8
2.Indoor Environmental Quality	4.50	1	3.00	1
3.Waste Management	4.42	3	2.92	2
4.Management	4.33	4	2.83	4
5.Atmosphere	4.17	5	2.25	10
6.Ecological Environment	4.17	5	2.92	2
7.Materials and Resources	4.17	5	2.75	5
8.Water Efficiency	4.08	8	2.58	9
9.Use of land	3.83	9	2.75	5
10.Transport	3.75	10	2.75	5
MEAN	**4.19**	-	**2.74**	-

Table. 4 Importance and performance value of Environmental factors

Table 4 indicates the mean score of 10 key environmental factors and their level of importance and performance. Most participants recognized that most environmental factors are important for sustainable construction as the mean score is over 3.75. Moreover, 8 of the 10 environmental factors (80%) have a mean score of more than 4.0, which means that most factors have a high importance value. However, despite a higher degree of importance, the practical performance of environmental factors is insufficient from the contractors' perspective. Although some factors are recognized as important, they are ranked low in performance. For example, Energy Efficiency and Indoor Environmental Quality are both recognized as the most important factors. However, in terms of performance value, while Indoor Environmental Quality is still ranked first, Energy Efficiency is ranked eighth among the 10 factors. This result indicates that from the contractors' perspective, the Indoor Environmental Quality factor is more tangible and feasible than the Energy Efficiency factor. Although, energy efficiency is crucial to sustainable construction, there is a certain level of ambiguity regarding its specific implementation.

Economic issues

Key Economic Factors	Importance		Performance	
	Mean	Rank	Mean	Rank
1.Life cycle cost	4.33	1	2.75	8
2.Knowledge management	4.17	2	2.33	16
3.Value for Money in delivery	4.08	3	2.83	6
4.Retention of skilled labour	4.08	3	2.50	13
5.Innovation / R&D	4.08	3	2.42	15
6.Quality management for durability	4.08	3	2.60	11
7.Partnering	3.92	7	2.92	3
8.Construction cost	3.83	8	3.25	1
9.Competiveness	3.83	8	3.00	2
10.Productivity / Profitability	3.83	8	2.92	3
11.Operating and Maintenance cost	3.83	8	2.75	8
12.Image and Reputation	3.67	12	2.67	10
13.Project delivery	3.58	13	2.92	3
14.Commercial viability	3.40	14	2.83	6
15.Affordability of residential rental or cost levels	3.33	15	2.50	13
16.Support of local economy	3.17	16	2.58	12
MEAN	**3.83**	-	**2.74**	-

Table. 5 Importance and performance value of Economic factors

Table 5 presents the 16 key factors in economic issues for sustainable construction in terms of their importance and performance value. Most of the participants recognized that Life-cycle cost, Knowledge management, Value for money, Retention of skilled labour, Innovation/research and development, and Quality management for durability are the six key factors, which have a mean score of over 4.0 in terms of importance value. Generally, factors associated with soft skills such as Knowledge management, Innovation/research and development, and Quality management for durability are regarded as critical by contractors. However, in terms of performance value, these three soft-skill factors are ranked eleventh, fifteenth, and sixteenth respectively. This result indicates that in comparison with other practical economic factors, research and management-based factors are still low ranked by Korean contractors. In terms of actual performance, the economic aspects ranked highest are Construction cost (first), Competitiveness (second), and Productivity /Profitability (third). This result shows that most Korean contractors focus on short-term economic benefits rather than long-term investment. This explains the huge gap between the importance level and performance level for Life-cycle cost, Knowledge management, Retention of skilled labour, and Innovation/research and development factors. Thus, for a balanced sustainable construction, Korean contractors should be more interested in soft-skill factors associated with research and management and not only in the short-term economic benefits.

Social issues

Key Social Factors	Importance		Performance	
	Mean	Rank	Mean	Rank
1.Well-Being	4.17	1	2.75	2
2.Community	4.00	2	2.58	3

3.Education / Training	4.00	2	2.17	8
4.Service quality	3.92	4	2.42	5
5.Health and Safety	3.83	5	2.83	1
6.Partnership working	3.67	6	2.25	7
7.Employment	3.58	7	2.42	5
8.Culture / Heritage	3.42	8	2.17	8
9.Security	3.42	8	2.58	3
MEAN	3.78	-	2.46	

Table. 6 Importance and performance value of Social factors

Table 6 shows the ranking of nine key factors in social issues based on the mean scores of their importance and performance level. Most respondents acknowledge that Well-being, Community, and Education/Training are three major factors in social issues concerning sustainable construction. It is interesting to note that there is a critical gap between the importance and performance levels with regard to the Education/Training factor. Similar to economic issues such as Life-cycle cost and Knowledge management factors, Education/Training factor is a long-term benefit factor and is ranked lower than other social factors in terms of performance level. Culture/Heritage, another long-term benefit factor, is also ranked at the bottom.

6. Data analysis: Correlation among different factors

Correlation between environmental and economic factors

The strongest correlation exists between the environmental and economic factors as compared with other categories. This finding means that when economic aspects are balanced with environmental issues, they have more influence on sustainable construction than the social factors. Nearly half of the survey factors (46.8%) show slightly higher scores (±0.4) with each other, while only 12.5% of factors indicate no-correlation between environmental and economic issues. According to Table 7, among the 16 economic factors, the following 6 factors indicate a close correlation with the environmental issues: Project Delivery (5), Knowledge Management (6), Retention of Skilled Labour (7), Quality Management for Durability (8), Construction Cost (10), and Operating and Maintenance cost (11). Project delivery (5), in particular, has highest correlation (over ±0.4) with all the environmental factors. Retention of Skilled Labour (7) and Construction Cost (10) also have a close correlation with 9 of the 10 environmental factors. On the other hand, the following three economic factors have a remarkably low correlation with the environmental issues: Affordability of Cost Levels (12), Support of Local Economy (13), and Innovation/R&D (15). Moreover, these three economic factors are ranked comparatively low in terms of both importance and performance value. In other words, according to factor importance, performance, and correlation value, these three factors could be considered as less critical in sustainable development.

		Environmental factors									
		1	2	3	4	5	6	7	8	9	10
Economic factors	1	0.209**	0.363**	0.445**	0.352**	0.314**	0.474**	0.413**	0.455**	0.312**	0.279**
	2	0.190**	0.346**	0.437**	0.327**	0.351**	0.434**	0.425**	0.527**	0.305**	0.312**
	3	0.332**	0.399**	0.466**	0.395**	0.374**	0.441**	0.440**	0.495**	0.378**	0.374**
	4	0.283**	0.418**	0.384**	0.335**	0.288**	0.365**	0.386**	0.381**	0.387**	0.345**
	5	0.408**	0.419**	0.524**	0.513**	0.490**	0.448**	0.441**	0.525**	0.446**	0.454**
	6	0.307**	0.406**	0.451**	0.450**	0.372**	0.495**	0.491**	0.499**	0.430**	0.397**
	7	0.323**	0.437**	0.491**	0.491**	0.403**	0.552**	0.544**	0.558**	0.498**	0.473**
	8	0.328**	0.430**	0.475**	0.476**	0.392**	0.503**	0.520**	0.552**	0.486**	0.454**
	9	0.301**	0.401**	0.394**	0.342**	0.339**	0.420**	0.398**	0.408**	0.346**	0.311**
	10	0.381**	0.473**	0.492**	0.521**	0.435**	0.484**	0.441**	0.539**	0.460**	0.477**
	11	0.349**	0.439**	0.517**	0.389**	0.468**	0.458**	0.446**	0.493**	0.444**	0.417**
	12	0.173	0.255	0.060	0.429**	0.387**	0.112	0.211	0.183	0.265	-0.024
	13	0.248	0.304	0.320	-0.008	0.199	0.138	0.097	0.288	0.328	0.190
	14	0.531**	0.415**	0.417**	0.030	0.409**	0.189	0.442**	0.411**	0.197	0.159
	15	0.167	0.273	0.077	0.409**	0.288	0.394**	0.313	0.153	0.000	-0.033

	16	0.498**	0.431**	0.395**	0.339	0.232	0.387**	**0.590****	0.455**	0.486**	0.496**

* p<0.05, ** p<0.01

Table. 7 Correlation between Environmental factor vs Economic factor

Correlation between environmental and social factors

In comparison to the economic issues, social factors have relatively low correlation with the environmental issues. According to Table 8, about 35% of social factors have a slightly higher correlation with the environmental factors. However, unlike this correlation result, some factors indicate a very close correlation between social and environmental issues. Among the environmental issues, Indoor Environmental Quality (7), in particular, has the strongest correlation with the social issue, Well-Being (3). Moreover, Management (10) belonging to environmental issues also has a high correlation with social factors, Culture/Heritage (6) and Community (8) at 0.726**(p<0.01) and 0.708**(p<0.01) respectively. Where *p<0.05, **p<0.01 means significance at 0.05 level and 0.01 level.

This means that from the contractors' perspective, in order to achieve Well-Being, ensuring Indoor Environmental Quality is recognized as the most tangible method. Similarly, when Management is considered as an environmental issue, harmonization with culture, heritage, and community should be taken into account carefully.

		Environmental factors									
		1	2	3	4	5	6	7	8	9	10
Social factors	1	0.114	0.255	0.261	0.296	0.194	0.329	0.300	0.310	0.047	0.179
	2	0.261	0.386**	0.427**	0.362	0.420**	0.292	0.452*	0.428*	0.513**	0.449**
	3	0.237	0.379**	0.518**	0.594	0.374**	0.470**	0.734**	0.536**	0.563**	0.485**
	4	0.439*	0.485**	0.357	0.297	0.607**	0.270	0.231	0.217	0.386	0.483**
	5	0.511**	0.295	0.273	0.325	0.468**	0.463**	0.367*	0.154	0.542**	0.364**
	6	0.173	0.590**	0.282	0.359	0.426**	0.402**	0.252	0.388*	0.344	0.726**
	7	0.159	0.433*	0.309	0.347	0.375**	0.340**	0.349	0.380*	0.359	0.184
	8	0.179	0.388*	0.494	0.415**	0.392**	0.564**	0.376*	0.311	0.390	0.708**
	9	0.186	0.064	0.459*	0.480**	0.038	0.341	0.379*	0.252	0.299	0.140

* p<0.05, ** p<0.01

Table. 8 Correlation between Environmental factor vs Social factor

Correlation between social and economic factors

The lowest correlation exists between social and economic issues. According to Table 9, while 34.0% of the factors have slightly higher correlation values, 19.4% of factors reveal that there are almost no-correlations (below ±0.2) between issues. Half of the economic factors indicate a very low correlation; these eight factors have only one or less factor with a slightly higher correlation with the social issues. The economic factors, Competitiveness (1), Retention of skilled Labour (7), Life-cycle cost (9) have almost no-correlation with over five among the nine social factors. On the other hand, the following two economic factors show a strong correlation with social factors: Support of Local Economy (13) and Commercial Viability (14). Their correlation values are comparatively high (over +0.5) and both these factors have a high correlation with all the social factors, as seen in Table 9. These results indicate that while, there are significant correlation gaps among economic factors, these gaps depend on the practical balance between social and economic factors.

		Social factors								
		1	2	3	4	5	6	7	8	9
Economic factors	1	0.155**	0.096	0.000	0.137	0.036	0.393**	0.377**	0.344**	0.264**
	2	0.252**	0.192**	0.187*	0.244**	0.080	0.491**	0.302**	0.438**	0.349**
	3	0.430**	0.386**	0.280**	0.461**	0.403**	0.339**	0.227**	0.273**	0.361**
	4	0.456**	0.434**	0.276**	0.324**	0.241**	0.414**	0.275**	0.303**	0.373**
	5	0.307**	0.249**	0.186*	0.245**	0.265**	0.228**	0.468**	0.361**	0.177**
	6	0.439**	0.424**	0.233**	0.275**	0.336**	0.363**	0.334**	0.470**	0.230**
	7	0.145	0.113	0.177*	0.102	0.052	0.330**	0.256**	0.374**	0.034
	8	0.297**	0.202**	0.154*	0.097	0.223**	0.392**	0.349**	0.408**	0.247**
	9	0.231**	0.232**	0.196*	0.179*	0.226**	0.143	0.169*	0.148	0.212**
	10	0.247**	0.209**	0.195*	0.209**	0.293**	0.297**	0.209**	0.299**	0.144
	11	0.251*	0.280**	0.395**	0.306**	0.232**	0.135	0.236**	0.393**	0.199
	12	0.521**	0.376**	0.657**	0.521**	0.342**	0.439**	0.485**	0.373**	0.446**
	13	0.567**	0.528**	0.582**	0.602**	0.513**	0.526**	0.530**	0.625**	0.486**
	14	0.602**	0.655**	0.606**	0.628**	0.672**	0.629**	0.601**	0.495**	0.474**
	15	0.532**	0.219**	0.489**	**0.680****	0.593**	0.640**	0.565**	0.347**	0.387**

	16	0.365**	0.317**	0.379**	0.444**	0.204	0.206	0.227	0.330**	0.204

* $p<0.05$, ** $p<0.01$

Table. 9 Correlation between Social factor vs Economic factor

7. Balanced factors for sustainable development

In accordance with the presented data analysis, Korean contractors seem to recognize that environmental factors are the most important of the three issues. However, the actual performance value (2.74) does not match the surveyed importance value (4.19). Indeed, economic factors share the same performance value with environmental factors, even if their importance value is lower than that of environmental factors (3.83). This means that in terms of practical implementation, sustainable development is subject to economic issues in Korea. This economic sustainable development had been dominant issue around the world as well as Korea, because basically construction industry is a kind of profit seeker. Recently, due to distinct characteristic of construction industry which greatly contributes to building of different social infrastructures, social role of sustainability has been increasing recently [51].

Moreover, there is a substantial gap between importance value and practical performance. Although several factors indicate similar values between them, the majority of have a large gap. Factors related to soft skills such as Management and Knowledge management, and long-term benefit factor including Innovation/R&D and Education/Training have comparatively low performance value despite their high importance value in Korea. For example, even if the Knowledge management and Innovation/R&D are ranked second and third in terms of importance, they are ranked sixteenth and fifteenth in terms of performance value. Therefore, based on highly ranked factors in terms of both importance and performance, several soft-skill or long-term benefit factors should be balanced for a real sustainable development implementation. This gap would be different in other place by worldwide trends, in which there are different sustainable demand, construction situation, and infrastructure.

Another distinct research finding is the correlation between factors. Environmental, economic, and social issues are closely interconnected with each other. However, owing to limited capital and resources, the available factors have to be applied selectively in a real sustainable project. According to the data analysis on factor correlation, there is generally a high correlation between environmental and economic factors. In addition, some social factors have quite a high correlation with environmental factors. With the application of only specific factors, sustainable development cannot be implemented effectively. Hence, based on environmental and economic factors, which have a high correlation with each other, social factors indicating a substantially high correlation value should be harmonized.

8. Conclusion

To effective and practical sustainable development, this study suggests adopting a balanced approach in which the environmental issues are harmonized with the economic and the social issues, that is not by considering only the environmental issues. This study conducted a questionnaire survey on the importance and performance value of these three issues among Korean contractors, and also identified the correlation among these three issues. According to the results of the data analysis, there is a gap between the importance value assigned and the performance value achieved in the field of sustainable construction in Korea. Soft-skill and long-term benefit factors, in particularly, show a significant gap. These kinds of factors are likely to be less targeted despite their high importance.

Moreover, the environmental factors share a more close correlation with the economic issues than the social issues, even though some of the highest correlation factors are in the social issue category. Therefore, for successful sustainable development, a balanced application is essential between important factors and high-performance factors as well as among the three sustainability issues: the environmental, economic, and social issues.

The scope of this study is limited to the three main sustainability issues and research conclusion is focused on Korean sustainable construction. Therefore, based on limited result, more wide and general sustainability should be applied as well as more detailed sustainable research on the diverse issues should be implemented.

Reference

[1] Gottfried, D.A. (1996). "Sustainable building technical manual: Green building design, construction, and operation." United State of America: *Public Technology. Inc*.

[2] UNEP & WMO. (1997). "Common questions about climate change." United Nations Environment Program & World Meteorological Organization. *US global change research information office.*

[3] Erlandsson, M., and Levin, P. (2005). "Environmental assessment of rebuilding and possible performance improvements effect on a national scale." *Build. Environ,* 40(11), 1459-1471.

[4] Morgera, E., and Duran, G.M. (2006) "The 2005 UN World Summit, the Environment and the Role of the EU: Priorities, Promises and Prospects." *Review of European Community & International Environmental Law*. 15(1). 11-22.

[5] Burgan, B.A., and Simon, M.R. (2006). "Sustainable steel construction." *Journal of Construction Steel Research*, 62. 1178-1183.

[6] United Nations Economic Commission for Europe (UNECE). (2014). "Share of Construction in GDP," http://w3.unece.org/pxweb/quickstatistics/readtable.asp?qs_id=8&lang=1

[7] Economy Watch. (2010). "Economy, Investment & Finance Report-World Construction Industry, " Economy Watch website, http://www.economywatch.com/world-industries/construction/world.html

[8] Khalfan, M.M.A., Bouchlaghem, N.M., Anumba, C.J., and Carrillo, P.M. (2003). "Knowledge Management for Sustainable Construction: The C-SanD Project," *Construction Research Congress,* 1-8.

[9] Dale, J. (2007). "The Green Perspective-A UK Construction Industry Report on Sustainability," CIOB, http://www.ciob.org/sites/default/files/CIOB%20research%20-%20The%20Green%20Perspective%202007_0.pdf

[10] W.L. Lee. (2012). "Benchmarking energy use of building environmental assessment schemes," Energy

and Building, 45, 326-334.

[11] Saleh H. Alyami and Yacine Rezgui. (2012). “Sustainable building assessment tool development approach,” Sustainable Cities and Society, 5, 52-62.

[12] Ali, H.H., and Al Nsairat, S.F. (2009), “Developing a Green Building Assessment Tool for Developing Contries-Case of Jordan,” *Build. Environ.*, 44, 1053-1064.

[13] Riley, D., Pexton, K., and Drilling, J. (2003). “Procurement of Sustainable Construction Services in the US: The Contractor’s role in Green Buildings,” *Industry and Environment.* 26(2-3), 66-9.

[14] Shrlbourn, M.A., Bouchlaghem, D.M., Anumba, C.J., Carillo, P.M., Khalfan, M.M.K., and Glass, J. (2006). “Management Knowledge in the Context of Sustainable Construction,” *Journal of Information and Technology in Construction*, 11, 57-71.

[15] Chrisna du Plessis, (2001). “Agenda 21 for Sustainable Construction for Developing Countries - First Discussion Document,” International Council for Research and Innovation in Building and Construction (CIB). http://heyblom.websites.xs4all.nl/website/newsletter/0102/A21.pdf

[16] Lippiatt, B.C. (1999). “Selecting Cost-Effective Green Building Products: BEES Approach,” *J. Const. Eng. Manage.,* 125(6), 448-455.

[17] Houvila, P., and Koskela, L. (1998). “Contribution of the Principles of Lean Construction to Meet the Challenges of Sustainable Development,” 6th International Conference on Lean Construction. International group for Lean Construction (IGLC).

[18] Adetunji, I., Price, A., Fleming, P., and Kemp, P. (2008). “Achieving Sustainability in the Supply Chain,” *Engineering Sustainability*, 161(3), 161-172.

[19] Shen, L.Y., Hao, J.L., Tam, V.W.Y, and Yao, H. (2007). “A Checklist for Assessing Sustainability Performance of Construction Projects,” *Journal of Civil Engineering and Management*, 13(4), 273-281.

[20] BRE. (2012). "BRE Innovation Park: Shaping the future of the built envioronment and sustainable communities." Watford: *BRE (Building Research Establishment)*.

[21] BREEAM information at BRE, http://www.bre.co.uk/bre/BREEAM/DEFAULT.HTML

[22] BRE. (1998), “BREEAM ’98 for Offices,” BRE, Watford.

[23] BRE. (1998), “The Green Guide to Specification,” BRE Construction Publications.

[24] Communities and Local Government. (2008). “The Code for Sustainable homes-Setting the Standard in Sustainability for New Homes,” Communication and Local Government Publication. http://www.communities.gov.uk

[25] BRE. (2009). “BRE Global &ITG Sign Letter of Intent for BREEAM in Spain,” News from BRE. http://www.breeam.org/newsdetails.jsp?id=574

[26] USGBC. (2008). “LEED, U.S Green Building Council,” http://www.usgbc.org/Displaypage.aspx?CategoryID=19

[27] Lee, W. L., and Burnett. J. (2008). "Benchmarking Energy Use Sssessment of HK-BEAM, BREEAM and LEED.” *Build. Environ*, 43(11), 1882-1891.

[28] Kats, G. (2003). “The Cost and Financial Benefits of Green Buildings,” California’s Sustainable Building Task Force.

[29] iiSBE. (2007). “About SBTool 07, SBC08,” iiSBE website. http://www.iisbe.org/iisbe/sbc2k8/

sbc2k8-download_f.htm

[30] Larsson, N. (2007). “Rating System and SBTool,” The International Initiative for a Sustainable Built Environment, Seoul, Korea.

[31] Essa, R., and Fortune, C. (2008). “Pre-construction Evaluation Practices of Sustainable Housing Project in the UK,” *Engineering, Construction and Architectural Management*. 15(6), 514-526.

[32] Zhou, L., and Lowe, D.J. (2003). “Economic Challenges of Sustainable Construction,” Proceedings of The RICS Foundation Construction and Building Research Conference, RICS Foundation, University of Wolverhampton and the Contributors.

[33] Kim, J., and Kang, M. (2005). “Effective Approach for Greening of Existing Office Buildings through Economic Criteria,” The Architectural Institute of Korea.

[34] Yeom, Y., Kang, H., Park, J., and Rhee, E. (2008). “A Study on Economic Feasibility Evolution Method of Sustainable Building Technologies Using Life Cycle Cost Analysis,” The Architectural Institute of Korea.

[35] Bebbington, J. (2001). “Sustainable Development: A Review of the International development Business and Accounting Literature,” *Accounting Forum*, 25(2), 128-157.

[36] Adetunji, I., Price, A., Fleming, P., and Kemp, P. (2003). “Sustainability and the UK Construction Industry: A Review,” *Proceedings of the ICE - Engineering Sustainability,* 156(4), 185-199.

[37] Flanagan, R., and Jewell, C. (2004). “Whole Life Appraisal for Construction,” Blackwell Publishing.

[38] Rob, B. (2011). “Never Waste a Good Crisis: Towards Social Sustainable Development.” *Social Indicator Research*. 102(1), 157-168.

[39] Lehtonen, M. (2004). “The Environmental-Social Interface of Sustainable Development: Capabilities, Social Capital, Institutions.” *Ecological Economics*. 49(2), 199-214.

[40] Latham, M. (1994). “Constructing the Team Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry: Final report.” HMSO, London.

[41] Egan, J. (1998). “Rethinking Construction: The Report of the Construction Task Force,” DETR, London.

[42] Mohammad, F., and Amato, A. (2006). “Public Housing and Social Sustainability Indicators: HK-BEAM as a Case Study,” COBRA 2006: Proceedings of the Construction and Building Research Conference of the RICS, UCL, London.

[43] Edum-Fotwe, F.T., and Price, A.D.F. (2009). “A Social Ontology for Appraising Sustainability of Construction Projects and Developments,” *Int. J. Proj. Manage*., 27, 313-322.

[44] Assaf, S., and Al-Hammad, A. (1996). “Assessment of Work Performance of Maintenance Contractors in Saudi Arabia,” *J. Manage*. *Eng.,*12(2), 44-49.

[45] Park, S.H. (2009). “ Whole Life Performance Assessment: Critical Success Factors,” *J. Constr. Eng. Manage.*, 135, 1146-1161.

[46] Chan, D. W. M., and Kumaraswamy, M. M. (1996). “An evaluation of construction time performance in the building industry.” *Build. Environ.*, 31(6), 569–578.

[47] Jacob Cohen, Patricia Cohen, Stephen. G. West, and Leona. S. Aiken. (2013). “Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences,” Routledge. London.

[48] P. Ahlgren, B. Jarneving, and R. Rousseau. (2003). “Requirements for a cocitation similarity measure, with special reference to Pearson's correlation coefficient,” Requirements for a cocitation similarity measure, with special reference to Pearson's correlation coefficient, 54(6), 550-560.

[49] Rodgers, J.L., and Nicewander, W.A. (1988). “Thirteen Ways to Look at the Correlation Coefficient,” *The American Statistician*. 42(1), 59-66.

[50] E. E. Rigdon and C. E. Ferguson. (1991). “The Performance of the Polychoric Correlation Coefficient and Selected Fitting Functions in Confirmatory Factor Analysis with Ordinal Data,” Journal of Marketing Research, 28(4), 491-497.

[51] Nicola Dempsey, Glen Bramley, Sinead Power, and Caroline Brown. (2009). “The social dimension of sustainable development: Defining urban social sustainability,” Sustainable Development, 19(5), 289-300.