THE GREEN STANDARD FOR ENERGY AND ENVIRONMENTAL DESIGN (G-SEED) FOR MULTI-FAMILY HOUSING RATING SYSTEM IN KOREA: A REVIEW OF EVALUATING PRACTICES AND SUGGESTIONS FOR IMPROVEMENT

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ABSTRACT

Sustainability is an important objective for architecture as buildings contribute significantly to the quality of the environment. For this reason, various building environmental assessment systems have been developed and applied around the world since 1990. There is currently little research investigating newly developed systems unlike many previous studies on LEED, BREEAM, etc. To fill this gap, the present study focuses on the G-SEED system in Korea by comparing and contrasting its environmental categories and evaluation criteria with those of other major building environmental assessment systems. We introduce and examine the G-SEED system by addressing the Korean context and local needs to understand the forces between globalization and localization. Methods include a dense review of government documents and reports and interviews with practitioners. The results demonstrate that while the Korean rating system shares many similarities with other systems due to the influence of these predecessors on its development, the G-SEED has customized its practices to meet various local needs by developing unique evaluation criteria such as noise and safety.

KEYWORDS

Sustainability, Building Environmental Assessment System, G-SEED, LEED, BREEAM

1. INTRODUCTION

There are many building environmental assessment systems in the world that promote sustainable development. Building environmental assessment systems have been developed and utilized globally since the 1990s. For example, the United States uses LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Management) is used in the U.K., and CASBEE (Comprehensive Assessment System for Built Environment Efficiency) is the standard used in Japan. Korea has developed and

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applied the G-SEED (Green Standard for Energy and Environmental Design) rating system, which was designed specifically for its own building environmental issues and needs. It is important to see how the Korean rating system has customized its practices to meet various needs emerging from its distinctive local contexts. It is also significant to compare and contrast such different rating systems and find strengths and weaknesses of each rating system to determine what needs to be done to improve the status quo. With the increased attention to sustainability, many researchers have also investigated building environmental assessment systems. Research topics include the definition of the building environmental assessment systems (Cole, 1998), the intentions and roles of the systems (Cole, 2005), applications of building environmental assessment methods (Crawley & Aho, 1999), and the role of environmental assessment tools (Ding, 2008). However, there has been a lack of attention to new assessment systems developed in different parts of the world besides the major systems. One of these is the Korean G-SEED.

1.1 Sustainability and Architecture

In order to understand building environmental assessment systems, the first step is to define the role of sustainability in the field of architecture. In 1987, the Brundtland Commission of the United Nations argued that sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN Documents, http://www.un-documents.net). The commission intended to harmonize the interests of economic development and environmental conservation. Sustainable development, first defined by the United Nations (UN), has undergone various interpretations and has been applied to many disciplines. The term sustainability, as it relates to architecture, is not just energy efficiency, but it is an ecological approach to design. The American Institute of Architects (AIA, 2007) noted "sustainability means much more than energy conservation alone and has maintained a strong commitment to sustainability in the broadest sense of the term" (www.aia.org).

In 2008, Ministry of Land, Infrastructure and Transport (MOLIT) in Korea has defined sustainability as low carbon and green growth (MOLIT, http://www.molit.go.kr). While there are many definitions of sustainability, it seems to be more of a process than a set of fixed ideas. Thus, we need to involve the life cycle of such buildings from planning, designing, constructing, and operating, to management, when discussing building environmental assessment systems dealing with sustainable buildings.

1.2 Existing Building Environmental Assessment Systems

Building environmental assessment systems have emerged to provide an objective evaluation of resource use, environmental loadings, and indoor environmental quality. They are inspired by public awareness of climate change and higher environmental expectations. The term "assessment systems" is hard to define because there is no "precise descriptive terminology" (Cole, 2005). However, it is significant to define this term to explore the building environmental assessment systems. Cole (2005) mentioned that the assessment system is "a technique that predicts, calculates or estimates one or more environmental performance characteristics of a product or building" (p. 456). The systems include their specific intents with different methodologies that vary in complexity. Many existing building environmental assessment systems evaluate 'green' or 'sustainable' performance of buildings (Cole, 1999).

The role of these systems is to assess buildings across a broad range of considerations. They provide a method for planning, designing, constructing, and maintaining new or existing buildings in an environmentally friendly manner. A reliable building environmental assessment system and "yardstick" for measuring such systems are needed to minimize buildings' footprints and to develop sustainable and environment friendly buildings; these systems should be in place from the beginning of construction and as the project develops (Crawley & Aho, 1999).

According to Crawley and Aho (1999), building environmental assessment systems are "methods for evaluating the 'greenness' of buildings in the 1990s both for new designs and existing buildings" (p. 300). Different types of assessment systems exist based upon their functions. Todd et al. (2001) separated two building environmental assessment systems: design tools vs. assessment tools. The design team use design tools to get assistance in making design and specification decisions; the external evaluators use assessment tools to assess how the building is designed or built.

Ding (2008) also examined the development, role, and limitation of current assessment systems used in different countries and suggested a "sustainability index" based on a multi-dimensional approach because the evaluation process for a building is not a simple linear process. The sustainable index includes four main criteria, such as "maximize wealth," "maximize utilities," "minimize resources," and "minimize impact" (p. 460). In this sense, the ultimate goal of building environmental assessment systems is sustainability (Cole, 1998, 1999, 2005; Crawley & Aho, 1999; Ding, 2008; Papadopoulos & Giama, 2009; Todd, Crawley, Geissler, & Lindsey, 2001).

Various assessment systems exercise different functions (Nguyen & Altan, 2011). Rating systems are designed for assessing different types of buildings, and they can cover the life cycle of buildings according to their specific criteria and requirements (Berardi, 2012; Bondareva, 2007; Haapio & Viitaniemi, 2008; Mehdizadeh & Fischer, 2012). The systems have continued to change over the years with an effort to respond to new technologies, policies, and market transformation (Williams, 2010). Policy awareness and incentives are important motivations to build and/or occupy sustainable buildings (Hoffman & Henn, 2008; Mulligan, Mollaoğlu-Korkmaz, Cotner, & Goldsberry, 2014). They also intend to improve environmental conditions for quality of life and well-being of human beings (Baird, Leaman, & Thompson, 2012; Beauregard, Berkland, & Hoque, 2011; Guerin, Brigham, Kim, Choi, & Scott, 2012; Leaman & Bordass, 2007; Paul & Taylor, 2008).

The existing building environmental assessment systems have made significant contributions to our understanding of building–related environmental issues by investigating similarities and differences between intended initial building features and actual building performance (Cole, 1998; Ding, 2008). However, there is currently little research investigating the operations and impacts of the G-SEED as one of the newly developed building environmental evaluation systems outside North America or Europe. In a situation where the G-SEED is now looking for ways of expanding its overseas operations in the Southeast Asian market (KICT, 2016), it is important to examine this system by filling the gap in the literature as well.

2. METHODS

The methods of this study address the effectiveness of developing an indigenous building environmental assessment system in a local context. This research tries to examine the phenomenon of developing and applying the G-SEED for Multi-Family Housing rating system (G-SEED for MF) in Korea and the societal factors, such as government policy and regulations, that have shaped the system for the past decade by analysing different available data sources. The present study aims to introduce and understand the system and contextualize various issues of the Korean building environmental assessment system at the national and global levels.

The basic methodology chosen for this study is as follows. First, we reviewed different building environmental assessment systems around the world, such as LEED v4 and BREEAM 2016. Secondly, the study observed how the G-SEED for MF has been used and applied in real situations to evaluate its operations. Thirdly, government documents and description reports, such as the G-SEED for MF evaluation guidelines, policies, and statistics, were examined to uncover socio-cultural and/or situational factors related to the development and application of the rating system. Lastly, this study involved interviews with professionals who are associated with the system.

In order to understand what factors have affected each evaluation criterion of the G-SEED for MF, it is important to listen to actual professionals associated with the development and operation of the system. This study sought their opinions through in-depth focus interviews. These "depth interviews" were conducted with "key informants" (Oppenheim, 2005), such as developers, planners, architects, and engineers. They were all decision makers within middle- to senior-level management in each company. They also possessed 10 to 15 years of working experience in the field as registered architects or licensed engineers. Six professional focus groups were interviewed; each group had 4 to 6 professionals working for plan, design, and construction companies related to the G-SEED for MF projects who were available to discuss their opinions about the rating system. A total of 25 persons participated in the study. We made initial contact by e-mailing them. After they agreed to take part in our focus group interviews, we let them choose their preferred time and place. We took notes during each interview session.

During the interviews, the professional focus groups answered a group of open-ended questions related to the G-SEED for MF environmental criteria. The basic questions were:

1. What methods or design features did you use to meet each of the nine environmental categories when planning and designing the building?
2. What is your opinion regarding the different regulations suggested by the government?

Focus group meeting notes were carefully reviewed. The analysis of the data consisted of categorizing and recombining the comments collected during the focus group interviews to examine differences between expectations of professionals and applicability in real situations. Individual responses in the focus group interviews were written on cards and sorted into each relevant G-SEED for MF category. Approximately 35 cards were generated. Piles of cards were used to cluster similar extracts for analysis of qualitative data. This process of data analysis is described and supported by various qualitative researchers (e.g., Lincoln & Guba, 1985).

In summary, the research data gathered on-site included focus group interviews and interpretations of relevant documents such as the G-SEED-MF criteria and its score cards. This diverse data provided a more balanced description and understanding of relationships between the major variables—the G-SEED for MF criteria and professionals.

3. RESULTS

3.1 System Comparisons

A comparison of some of the important building environmental assessment systems provides a comprehensive understanding of their standards, mechanisms, and indicators for measuring sustainable development. Based upon their needs, several organizations have developed and managed building environmental assessment systems such as LEED in the U.S. and BREEAM in the U.K. The authors of the G-SEED in Korea utilized these internationally known systems in its development process being affected by the forces of globalization. All three systems ultimately intend to develop more sustainable buildings, while reducing environmental impacts and CO_2 emissions during a building's life cycle. The systems vary in how they address the life cycle of a building, the content of the categories, and the criteria for evaluating buildings. The systems also differ considerably in their structures and ranges of criteria since they are affected by different cultural factors and various regulations in different countries in their localization processes.

This study is limited to a discussion of the three building environmental assessment systems due to limited space: G-SEED, LEED and BREEAM. These tools are selected since they share system-wide similarities. For instance, they intend to evaluate existing or newly constructed buildings. However, the scope and application processes of the assessment methods vary widely. Each assessment system is described in Table 1 based on information from their official websites.

3.2 The G-SEED for Multi-Family Housing Rating System

In 2000, the G-SEED rating system was developed by the MOLIT (Ministry of Land, Infrastructure and Transport) and the MOE (Ministry of Environment) in Korea. The rating system has been operated by the KICT (Korea Institute of Civil Engineering and Building Technology) since 2002. The system has 10 certification bodies (http://greentogether.go.kr/, 2016). The G-SEED aims to understand and promote green buildings by conserving energy and resources, reducing CO2 emissions, and increasing the quality of built environments. According to Korea Statistics (2013), buildings account for 40% of total Korea energy consumption, 50% of the country's total carbon dioxide emissions, and 20–50% of the country's waste (www.kostat.go.kr). To operate the system more efficiently, the G-SEED for MF (Green Building Certification System for Multi-Family Housing) rating system was integrated into the Housing Performance Rating System in 2011. The name of the rating system was changed from the GBCS-MF to the G-SEED for Multi-Family (MF) Housing based on the Green Building Construction Assistant Act, 2013 (MOLIT, http://www.molit.go.kr). Among the different types of buildings in Korea, 64.7% are residential. Given this number, it is significant to develop an evaluation system for multi-family housing in the country where about 60% of Koreans live in apartments as a preferred housing type (The Seoul Institute, 2015). In addition, these apartments use 27.9% of the total residential energy consumption (Korea Energy Economics Institute, 2015). However, in the U.S., apartment buildings with five or more units account 17% of the total households. They use less energy than other home types with only 9% of home energy use (US Energy Information Administration, 2013).

The G-SEED for MF rating system includes nine categories: Land Use & Transportation, Energy and Pollution, Material and Resource, Water, Maintenance, Ecology, Indoor Environment, Housing Performance and Innovative Design. The Housing Performance category is a new category added in 2011 (MOLIT), which was part of the categories for the Housing Performance Rating System, but it has no credit score to evaluate the G-SEED for MF Housing certification. In addition, another category of Innovative Design was added in 2016 (MOLIT). The ID category is for evaluating Green 1 & Green 2 certified buildings only. Submitting documents related to building performance is required in the certification process. These elements have been shown to have a tremendous effect on the economic, environmental, and social impact of buildings, often referred to as low carbon and green growth sustainability. By obtaining credit points in the nine credit categories, the G-SEED for MF Housing rating system allows building owners to obtain various levels of G-SEED certification as shown in Table 1.

Since the first version of the G-SEED for MF Housing rating system was initiated, it has undergone several changes. These changes show that the system is still in flux to incorporate different needs or issues constantly emerging from the local context. The changes over the years also demonstrate that the G-SEED has evolved into a more comprehensive and flexible system with the same shared philosophy with LEED, which recognises that modern buildings function or perform like living, breathing organisms, working as a vigorous approach to measure their holistic performance or efficiency. The following Table 2 briefly illustrates the changes of the G-SEED for MF Housing rating system.

Table 3 indicates that the number of buildings certified by the G-SEED for MF has drastically increased since 2002 because it has been accompanied by policies and incentives, provided by the government and local authorities, to promote sustainable building practices. For example, the incentives include tax reductions including building property and registration tax as well as environmental improvement costs (MOLIT, 2013).

TABLE 1. Summary of Building Environmental Assessment Systems.

Systems	G-SEED for Multi-Family Housing, Korea		LEED v4 BD+C, US		BREEAM International New Construction, UK	
Year	2002		1998		1990	
Latest Revision	2016		2017		2016	
Organization	MOLIT & MOE		USGBC		BRE Group	
Evaluation Scopes	Whole building assessment frameworks and rating system		Whole building assessment frameworks and rating system		Whole building assessment frameworks and rating system	
Certification Levels	4		4		5	
Rating Levels	Green 1	74%	Platinum	80 to 110	Outstanding	≥ 85%
	Green 2	66%	Gold	60 to 79	Excellent	≥ 70%
	Green 3	58%	Silver	50 to 59	Very good	≥ 55%
	Green 4	50%	Certified	40 to 49	Good	≥ 45%
					Pass	≥ 30%
No. of Credit Items	66		58		55	
Total Credits/ Points	134 points = 100% (Achieved/Available) *Environmental Category Weighting		110 points Impact Category Weight (Climate change 50%, Human Health 25%, Water Resources 25%)		110% (Achieved/Available) *Environmental Section Weighting (Based on the relative value, Energy, 18.5~22.0%)	

TABLE 1. *(Cont.)*

Systems	G-SEED for Multi-Family Housing, Korea	LEED v4 BD+C, US	BREEAM International New Construction, UK
Weighting	Yes	Yes	Yes
Evaluation Categories	9	9	10
	Land Use & Transportation, Energy & Pollution, Materials & Resources, Water Management, Maintenance, Ecology, and Indoor Environment, (115 points)	Integrative Process, Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, (100 points)	Management, Health & Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use & Ecology, Pollution (100%)
	Housing Performance (no point) Innovative Design (19 points)	Innovation (6 points), Regional Priority (4 points)	Innovation (10%)
Required Criteria	Mandatory (6 items)	Prerequisites (12 items)	Minimum standards by rating levels (5–15 items)
	EP 2.1 Energy performance MR 3.6 Storage and Collection of Recyclables W 4.3 Water saving fixtures and fittings M 5.2 Providing manuals/guidelines for the building managers/operators E 6.3 Ratio of ecological areas IE 7.1 Using low VOC (Volatile Organic Compound) emitting products	SS P1 Construction Activity Pollution Prevention WE P1 Outdoor Water Use Reduction WE P2 Indoor Water Use Reduction WE P3 Building-Level Water Metering EA P1 Fundamental Commissioning and Verification EA P2 Minimum Energy Performance EA P3 Building-Level Energy Metering EA P4 Fundamental Refrigerant Management MR P1 Storage and Collection of Recyclables MR P2 Construction and Demolition Waste Management Planning IEQ P1 Minimum Indoor Air Quality Performance IEQ P2 Environmental Tobacco Smoke Control	For the Pass level, 5 minimum standards are required. Man 03: Responsible construction practices Hea 01: Visual comfort Hea 02: Indoor air quality Hea 09: Water quality Mat 03: Responsible sourcing of construction products

TABLE 2. Changes of the G-SEED for Multi-Family Housing Rating System.

Stages	Date	Descriptions
Stage 0	2000	Green Building Certification System (GBCS) was developed by Ministry of Land, Infrastructure and Transport (MOLIT) and Ministry of Environment (MOE). Two certification levels; Green 1 and Green 2
Stage 1	2002. 01	GBCS for Multi-Family Housing (GBCS-MF) was initiated
	2005. 03	Four credit categories: Land Use and Transportation, Energy, Resources and Environmental Loads, Ecology, and Indoor Environment
	2006. 05	GBCS-MF was governed by Article 65 of Architecture Law Green Building Certification System. The system was changed from recommended to required.
Stage 2	2008. 05	Developed new regulations and standards for the GBCS-MF
	2010. 05	Changed from two to four certification levels
	2011. 12	GBCS-MF was integrated into the Housing Performance Rating System
Stage 3	2013. 01	Deleted Article 65 of Architecture Law [Green Building Certification System] Developed the Green Building Construction Assistant Act GBCS-MF renamed as G-SEED for Multi-Family Housing
	2013. 06	Changed the G-SEED for Multi-Family Housing standards Changed from four to seven credit categories
	2013. 02	Enforced the Green Building Construction Assistant Act Rules on Green Building
	2016. 09	Changed the G-SEED for Multi-Family Housing standards Changed from seven to 10 credit categories Added the Innovative Design category

TABLE 3. G-SEED for Multi-Family Housing Certification Status (2002–2017).

	‘02	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10	‘11	‘12	‘13	‘14	‘15	‘16	‘17	Total
Pre-Certification	3	2	9	12	138	130	86	86	98	57	136	118	195	307	377	292	2,046
Certification	0	0	3	1	4	13	49	83	102	71	44	49	87	100	127	180	913
Total	3	2	12	13	142	143	135	169	200	128	180	167	282	407	504	472	2,959

Source: http://gseed.greentogether.go.kr/

3.3 The G-SEED for Multi-Family Housing Criteria

Since the G-SEED for Multi-Family Housing rating system is not well-known worldwide, it is helpful to explain each criterion. Overall, the G-SEED for MF Housing rating system is similar to other building environmental assessment systems, but it has distinctive features due to its unique local context. For example, Korean apartments are highly standardized high-rise buildings with a large number of residents. Given the context, there are several unique features that make the G-SEED stand out from other assessment systems, such as flexible floor plans, noise, fire safety, and egress safety. Since there was no prior system in Korea, the G-SEED for Multi-Family Housing rating system was initially based on other renowned systems including BREEAM and LEED in its development process. Table 4 shows evaluation criteria for the G-SEED for Multi-Family Housing rating system, such as categories, evaluation criteria, and allocated credits.

Figure 1 shows the relationships among the three building environmental assessment systems. The dotted lines demonstrate how one particular feature corresponds to another among the three systems. For example, Location and Transportation in LEED is closely related to Land use and Transportation and Ecology in the G-SEED for MF. BREEAM has similar categories, such as Land Use and Ecology.

3.4 Focus Group Interviews Regarding G-SEED for MF Categories

This section particularly examines professional opinions on each category of the G-SEED from focus group interview participants, which yield insight into the operation of the system interplaying between global standards and local practice in the Korean context, for the future of its on-going development to be one of the leading building assessment systems.

3.4.1 Land Use and Transportation (LT)

This results summary discusses comments from the professional focus group interviews relating to the Land Use and Transportation category and criteria. The professionals who participated in the focus group interviews noted that there are three methods to construct apartment complexes in Korea. The first one is that apartment construction companies purchase sites and develop complexes on them. In this case, a construction company is a developer and constructor at the same time. The next method is that construction companies are appointed by developers to construct complexes. Finally, residents make a union for redeveloping their apartment complex and employ a developer and a contractor for their purpose. In all of these cases, the most important factor is cost. When the cost for a site is very expensive, which is common in Korea as one of the most densely populated nations, the Land Use and Transportation in the G-SEED for MF criteria receives less attention and investment.

The professionals commented that site issues relating to ecological value, minimizing excavation, and cutting on construction sites are important for the G-SEED for MF rating system, which addresses sustainable development. They are trying to minimize harmful physical or social factors resulting from new development. However, there are gaps between the G-SEED for MF goals and new development in real situations. In addition, the evaluation criteria in the G-SEED for MF are rigid, and the documentation required for the certification is burdensome. One argued that some of the requirements are inflexible, and costs greatly exceed benefits. Given the comments of the interviewed professionals, it appears that the G-SEED for MF had very little influence on the Land Use and Transportation category for the projects applying for certifications.

TABLE 4. Evaluation Criteria about the G-SEED for Multi-Family Housing Rating System. (MOLIT & MOE, 2016)

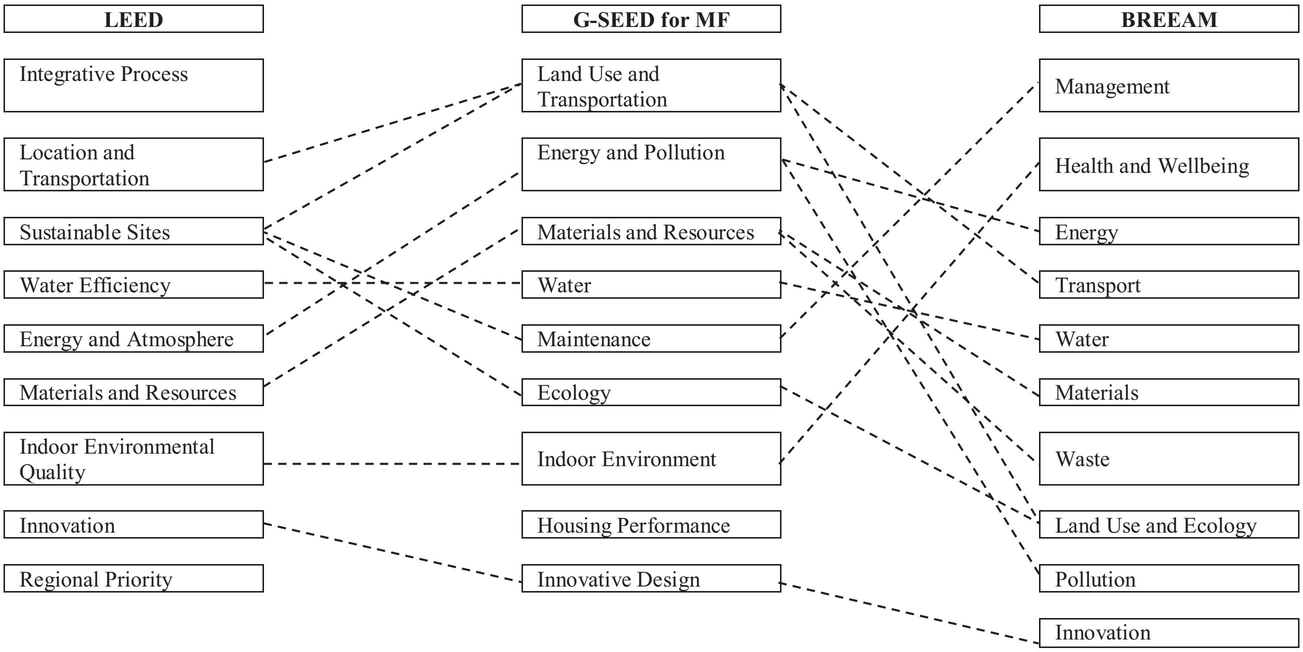
Category	Criteria	Mandatory	Credits
1. Land Use and Transportation	1.1 Ecological value of sites		2
	1.2 Avoiding excessive excavation		3
	1.3 Minimizing cutting on construction sites		2
	1.4 Feasibility of the measure to prevent interference of daylight right		2
	1.5 Providing pedestrian walkway		2
	1.6 Accessibility to public transportation		2
	1.7 Bicycle storage and bicycle roads		2
	1.8 Accessibility to diverse facilities		1
2. Energy and Pollution	2.1 Energy performance	V	12
	2.2 Energy monitoring		2
	2.3 Use of renewable energy		3
	2.4 Reducing CO2 emissions		1
	2.5 Preventing use of Ozone depletion materials		2
3. Materials and Resources	3.1 Use of EPD (Environmental Product Declarations)		4
	3.2 Use of low-carbon materials		2
	3.3 Use of recycled materials		2
	3.4 Use of low-emitting materials		2
	3.5 Use of green materials (G-SEED Materials Certification)		4
	3.6 Storage and collection of recyclables	V	1
4. Water Management	4.1 Feasibility of measure to reduce rainwater load		5
	4.2 Use of rainwater and greywater		4
	4.3 Water saving fixtures and fittings	V	3
	4.4 Water monitoring		2
5. Maintenance	5.1 Reasonableness of site management plans		2
	5.2 Providing manuals/guidelines for building managers/ operators	V	2
	5.5 Providing user manuals for occupants		2
	5.4 Providing G-SEED information for owners		3
6. Ecology	6.1 Providing green axis		2
	6.2 Ratio of natural ground		2
	6.3 Ratio of ecological areas	V	10
	6.4 Creating biotopes		4

TABLE 4. *(Cont.)*

Category	Criteria	Mandatory	Credits
7. Indoor Environment	7.1 Applying low-emitting products	V	6
	7.2 Natural ventilation		2
	7.3 Ventilation performance of units		2
	7.4 Installing individual thermal controllers		1
	7.5 Sound reducing surfaces (Light-weight floor impact noise)		2
	7.6 Sound reducing surfaces (Heavy-weight floor impact noise)		2
	7.7 Sound insulation between units		2
	7.8 Exterior noise intrusion		2
	7.9 Preventing toilet water noise		2
8. Housing Performance	8.1 Durability	—	—
	8.2 Flexibility	—	—
	8.3 Universal design for residential spaces	—	—
	8.4 Universal design for public spaces	—	—
	8.5 Community center and facilities	—	—
	8.6 Assurance of sunlight	—	—
	8.7 Home network systems	—	—
	8.8 Security contents	—	—
	8.9 Fire detection and alarm systems	—	—
	8.10 Smoke control equipment	—	—
	8.11 Fire resistance performance	—	—
	8.12 Horizontal evacuation distances	—	—
	8.13 Valid width of corridor and stairwell	—	—
	8.14 Evacuation equipment	—	—
	8.15 Easy to fix—residential areas	—	—
	8.16 Easy to fix—public areas	—	—
Innovative Design	1. Land Use and Transportation		1
	2. Energy and Pollution		4
	3. Materials and Resources		7
	4. Water management		1
	5. Maintenance		1
	6. Ecology		1
	G-SEED professionals		1
	Planning & designing innovative green building		3

Source: http://www.molit.go.kr/

FIGURE 1. Relationships among the Three Systems (LEED, G-SEED, and BREEAM).



The professionals in the focus group interviews added that the transportation criteria are closely related to site location. They commented that there are few ways to address the transportation criteria with design or construction. Most of the transportation criteria emphasize locating a project on a site that is within or near communities with existing infrastructure, providing opportunities to use public transportation, bicycles, and walking. Earning points in the transportation criteria is easy for apartment complexes located in the city center.

3.4.2 Energy and Pollution (EP)

For the Energy and Pollution category, the interviewed professionals said that designers focus on building insulation and windows to reduce total annual building energy consumption. Building insulation is an easy, cost effective method to help energy conservation in new residential construction. For better building insulation, they try to design buildings with regular floor plans because highly irregular floor plans increase costs and decrease the building energy efficiency due to thermal bridges and thermal breaks. Energy efficient windows installed in the buildings can also help to reduce heating, ventilation, and air conditioning costs.

The professionals commented that soil type influences which method is used for a certain apartment among different types of alternative sources. For example, they install solar panels on the roof when their estimated drilling cost is too high. In addition, the architectural law (New Energy and Renewable Energy Development, Use, and Spread Promotion Law, MOLIT, 2013) requires the use of alternative energy sources when an apartment complex has 500 units or more. In the Korean context, apartment complexes with less than 500 units have often no opportunity to get points from an alternative energy source since initial investment costs are expensive, making it less effective in a complex with a small number of units. According to the professionals who participated in the focus group interviews, the G-SEED for MF aims to reduce energy consumption. The Korean government is trying to reduce 30% of building energy consumption by 2015 and is planning to implement a Zero Energy Building in 2025 (MOLIT, 2010). For this reason, the Korean government actively regulates and governs numerous environmental building assessment systems, such as G-SEED (MOLIT & MOE, 2013), Building Energy Efficiency Certification (MOLIT & MOTIE, 2013), New & Renewable Energy System (MOLIT & MOTIE, 2013), Intelligent Building System (MOLIT, 2013) and so on. However, the interviewed professionals mentioned that the existing systems are too varied, and their evaluation criteria are too distinct from each other. They have struggled with this situation and spent enormous sums of money to meet the government's requirements. In addition, they questioned the effectiveness of some existing systems. Most of the interviewed professionals agreed to develop one universal system for assessing buildings' environmental features. For this reason, the Korean government integrated the GBCS (Green Building Certification System) and the HPRS (Housing Performance Rating System) into the G-SEED in 2011. But there are still many different rating systems in Korea as mentioned before.

3.4.3 Materials and Resources (MR)

The study found that the use of recycled materials has constraints during construction. For example, the professionals admitted that they have a limited choice of recycled materials since the government designated recycled materials and the materials are much more expensive than brand new ones in the Korean context. In addition, residents prefer using new materials to using recycled materials. There is a large difference between the G-SEED for MF evaluation criteria and resident perspectives. The professionals indicated that in reality it is uneconomical and difficult to follow these criteria. The G-SEED has set ideal goals and tried to evaluate them, but it seems not to work in real situations. Developing a database system to acquire information on suggested materials such as low-VOCs (Volatile Organic Compounds), EPD (Environmental Product Declarations), Eco-labelled, etc. is suggested by the professionals.

3.4.4 Water Management (W)

The study also sought the professionals' opinions about the Water Management category. One professional noted that residents do not want recycled water (harvested rainwater and treated greywater) since water prices are relatively cheap in Korea compared to other countries where operating costs of these systems are expensive. According to the OECD report (2010), Korea's water service prices are \$0.77 per/m^3, which is the cheapest among the surveyed OECD countries, contrary to Denmark with \$6.70 per/m^3 and Finland with \$4.41 per/m^3. Operating costs of rainwater reuse systems are more expensive than water costs in Korea. Given this reason, water from the recycling systems is usually used in landscaping and irrigation for apartment complexes.

As shown here, most Korean residents are not concerned about water costs and water reuse issues. However, when it comes to rainwater uses, the professionals pointed out a problem. After harvesting rainwater, it should be used as quickly as possible because it can develop an unpleasant odor. In this sense, the professionals added that the G-SEED for MF can influence the design of projects when residents understand and are willing to promote its sustainable goals.

3.4.5 Maintenance (M)

In the interviews, the professionals shared their opinions on the G-SEED for MF 5.5.1 Reasonableness of site management plans. One professional noted that this criterion is problematic. Contractors usually submit their work plans and documents before construction on site and earn related G-SEED for MF credits. However, there is no way to check whether or not their construction methods are environmentally friendly during the construction processes, although construction activities cause complaints from neighbors regarding noise and dust. The professional added that the G-SEED for MF needs more thorough regulation and detailed evaluation methods, such as monitoring during the construction processes. This can be another reason the G-SEED has been constantly changing to meet local needs arising from the local context.

In the focus group interview, one professional commented that submitting documents pertaining to the M 5.5.1 Reasonableness of site management plans is required to acquire points on this criterion. However, the G-SEED for MF cannot check the amount of waste during the actual building construction processes. In real situations, no one can guarantee if this criterion is properly implemented as stated in the documents.

The study also found that the M 5.5.2 Providing manuals/guidelines for the building managers/operators is evaluated based upon submitted documents including the establishment of commissioning criteria. The professionals agreed that facility managers and maintenance staff play important roles in effective operations and adequate maintenance of the G-SEED for MF certified buildings. However, the current system does not have any follow-up tests to check whether certified buildings are operating responsibly.

3.4.6 Ecology (E)

The interviewed professionals said that when a site is located in the city center, they plan and design various green paths linking the complex to outside paths. However, when a site is situated near hills or mountains, the designers just make simple connections from the complex to the outside. The former case is more effective than latter in achieving points on the E 6.6.1 Providing green axis. This criterion closely relates to site location. Artificially made pathways achieve more points, while making simple pathways connected to neighboring hills earns no or very few points.

In the interview, one professional offered explanations for low scores for most apartments on the E 6.6.4 Creating biotopes. Underground parking is a major parking area for residents in most Korean apartment complexes. The area of the existing natural site decreases during the construction process of the underground parking lot since the site is excavated until required levels are acquired and basement structures are installed. Most of aquatic and terrestrial biotopes are installed above underground parking lots.

The professionals argued that for E 6.6.2 Ratio of natural ground, it is almost impossible to get points in real construction situations since most sites have limited areas. It is extremely difficult to store and reuse natural grounds on such constrained construction sites. This criterion promotes sustainable development but has limited practical purpose. The professionals mentioned that there is a need to incorporate both priorities into the current system so that the system can identify its faults and plan for improvement.

3.4.7 Indoor Environment (IE)

The IE 7.7.1 Applying low-emitting products relates to indoor air quality by using non-toxic paints and adhesives in buildings' interiors. The interviews revealed that such materials are expensive and have limited choices compared to other materials. However, the professionals agreed that choosing appropriate adhesives for wallpapers and wood flooring and paints for built-in furniture are important because these are the best way to reduce costs and toxins causing sick building symptoms among building residents.

The study found two factors regarding the IE 7.7.2 Natural ventilation: an increased portion of operable windows and floor plan changes from square to rectangular configurations (Figure 2). The professionals explained that square shaped floor plans have better natural ventilation than rectangular shaped floor plans. The square shaped floor plans have more distance from the front (living room) to the back (kitchen) than the rectangular shaped floor plans and support higher air velocity and movement. By comparison, the rectangular ones exhibit poor air movement through the unit. They agreed that ventilation systems are not as effective as natural ventilation. At the same time, super high-rise apartment buildings need an appropriate portion of the fixed windows for safety purposes according to Korean Building Act (MOLIT, 2016). For better air movement, many professionals are now trying to develop new floor plans having more natural ventilation opportunities. As Figure 2 shows, residential unit combinations and floor plans have undergone changes over the years in Korea due to economical and aesthetic factors, while natural ventilation abilities have actually decreased.

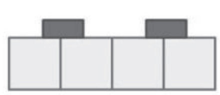
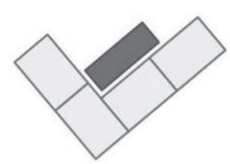
The professionals commented that noise is a major disadvantage of living in apartments in the Korean context as noted by ACRC (2013). They specify noise insulation materials in walls and floors. The IE 7.7.5, 7.7.6, and 7.7.7 criteria evaluate the thickness and installed size of noise insulation materials. However, the best way to reduce noise between floors, as the professionals argue, is to change apartment structural design from wall-bearing structures to column-bearing structures.

To prevent traffic noise from the outside, the professionals suggested several methods, such as noise walls constructed around the apartment complex, locations of windows far from the road or highways, and installed soundproof windows based on their construction costs. These interventions are not fundamental solutions for outside noise, and they admit that there will continue to be complaints from residents.

3.4.8 Housing Performance (HP)

As a newly added category, Housing Performance is closely related to residents' safety and wellbeing. The credits such as barrier-free design, fire and egress safety, and enough daylight

FIGURE 2. Multi-Family Housing Changes.

	Before 2000		After 2000
Unit combinations			
Floor plans			

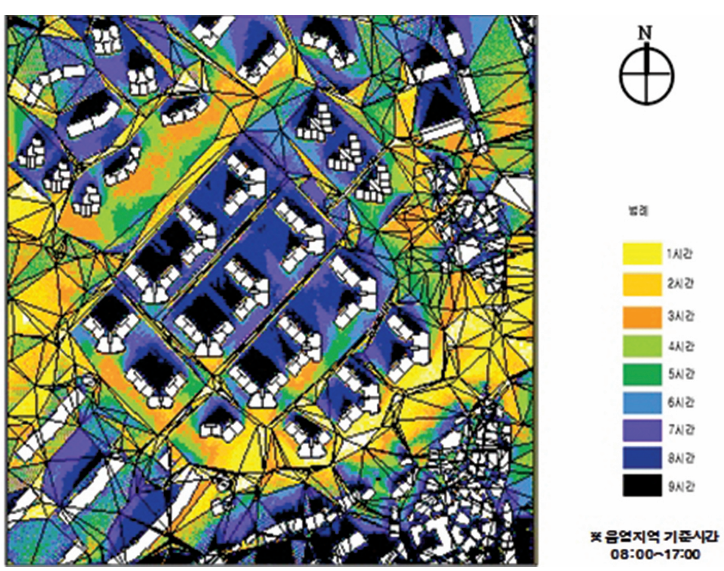
are very important factors for residents' quality of the built environment. But it does not have actual points for the certification, so the planners and designers tend to meet the minimum requirements for this category although they find daylight and quality views as the essential features of their evaluation.

For instance, in the interviews, the professionals explained that architects use simulation programs to predict daylight hours in the unit and to provide residents with adequate daylight. Figure 3 illustrates a computer simulation provided by one of the interviewed professionals. The simulation predicts daylight availability in buildings at winter solstice. In Figure 3, the numbers associated with different colors mean hours of daylight from 8 AM to 17 PM. Yellow and orange colors around the complex mean 1 to 2 daylight hours in a building and other colors are 3 to 9 daylight hours in a building. At least 2 daylight hours in a building is a minimum requirement to meet the IE 7.4.1 assurance of sunlight criterion. Buildings on the lower site have disadvantage in daylight hours compared to those on the upper site. This criterion is also very important to contractors since the amount of daylight affects apartment sales. During the interviews, the professionals explained that after the simulation, designers often change locations and directions of buildings to increase sunlight. However, some units have limited interior daylight since investors want to construct high-rise buildings with more, smaller units in response to density regulations. Issues with daylight are very important in the Korean context where most apartments are high-rise ones with at least 20 floors.

3.4.9 Innovative Design (ID)

In 2006, the ID category was added to evaluate creative ideas and concepts of green buildings. However, it is a real burden for professionals to prepare 10 additional criteria to get certified for many multi-family residential buildings in Korea. For the Innovation category in LEED and BRREAM, the credits are awarded regardless of the certification level. By contrast, Korea's additional points are exclusively for buildings aiming to obtain the Green 1 and Green 2 levels. The application of the ID category is limited in this sense.

FIGURE 3. Daylight Simulation (Apartment Complex, Korea).



4. DISCUSSION

As mentioned before, one of the major differences between the G-SEED for MF and other building environmental assessment systems is the supervisory agency. For example, the G-SEED for MF is governed by the Korean government agencies (MOLIT and MOE), while the other systems are monitored by non-profit organizations. The Korean government has exerted considerable pressure on implementers and operators of the system to reflect the Korean local context where apartments are densely populated as one of the major types of housing by incorporating some distinctive features in the Indoor Environment category unlike other certification systems. For instance, the government has proposed the heightened standards to minimize noise issues between floors and units, such as using sound reducing surfaces (light-weight floor impact noise and heavy-weight impact noise) and sound insulation/barriers. In the Building Performance category, detailed evaluating measures are enforced to ensure enough distance between buildings, south facing direction, direction/location of building, etc. Unlike LEED or BREEAM, the G-SEED for MF addresses building performance as it relates to resident quality of life, especially for the elderly and disabled by providing facilities or features for resident safety and security. In countries where LEED and BREEAM are used, other building codes, not the evaluation system itself, deal with issues of adaptability and life safety.

We also found that the Korean rating system has relatively customized their practices to meet various needs emerging from their distinctive local context. For example, the G-SEED for MF has developed many evaluation criteria necessary for standardized apartments in Korea, such as noise and flexible floor plans as discussed above. Another effort to customize the G-SEED for MF practices to local needs is to engage more professionals in the rating system such as building energy assessors. According to the Korea Energy Management Corporation, the first assessors were selected in 2013 (www.kemco.or.kr), and they plan to participate in the G-SEED while evaluating building energy performance and other building related simulations, like LEED professionals. However, most of them do not possess enough knowledge and experience required for the G-SEED certification. In reality, licensed architects and engineers who have more than three years of experience have been working as the experts to plan and design green buildings. It is suggested to train real experts who have abilities to perform the G-SEED certification practices as LEED APs do. Given this, we can conclude that the rating system in Korea is still in transition finding better ways of ensuring its on-going development as a reliable and effective green building certification system. While we have largely achieved the initially stated aim of this study to identify contextual factors regulating the G-SEED for MF, we recognize a limitation of our analysis: lack of a resident post-occupancy evaluation survey. In order to see how effective the G-SEED for MF is and how well it accomplishes its ultimate purpose to build environmentally friendly buildings and provide quality of life for residents, it is important to study resident perceptions of their experiences. In this sense, the authors suggest that future research be conducted on this topic. It is also recommended that researchers include more related professionals and personnel into research, such as building managing staff and policy makers to explore various views on the development and management of the G-SEED for MF.

5. CONCLUSIONS AND SUGGESTIONS

The G-SEED and other systems vary in how they address the life cycle of a building and use various categories and criteria for evaluating buildings. The systems differ considerably in their structures and ranges of criteria since they are affected by different contextual factors and various regulations in different countries. We conclude this section with suggestions and implications for the G-SEED's future development based on our analysis of the different systems.

- In its operation, the Korean G-SEED is governed and monitored by the government, while the systems in the U.K. and U.S. are operated by private organizations, which leads to different levels of motivation. Especially, in the U.S., developers and constructors consider building environmental assessment as one of the vital processes for their building projects and are willing to choose a rating system to guide their design and operational decisions. Thus, the rate of participating in LEED is generally very high in the U.S. On the other hand, Korean developers and constructors choose the G-SEED as a sense of obligation as a government-initiated assessment system. More active participation in the rating system should be promoted in Korea for the better development of green buildings promoting sustainability.
- One of the problems associated with the G-SEED is the lack of professionals who can be involved with the development of the rating system and work with the system. A handful of special employees from various certification bodies take charge of the rating process. However, unlike LEED professionals, they lack the necessary related training and continuing education.
- The rating system's ultimate purpose is to promote sustainable development by following each process step-by-step, but in reality, Korean developers and constructors tend to pursue the certification itself, not paying enough attention to sustainable development.
- Since the Housing Performance category addresses quality of living environments, especially for the disabled and elderly, these goals need to be developed into criteria with actual points for the certification. The criteria also require more detailed evaluation methods so that they can thoroughly evaluate building performance as the unique features of the G-SEED for MF.
- It is suggested that the G-SEED diversify its range of evaluation criteria and methods. The criteria with high importance should be promoted more by increasing the score while less important criteria should be downgraded. For example, the energy performance criterion evaluates EPI (Energy Performance Index) using heat transfer coefficient only, but it is necessary to include heating and cooling load to effectively evaluate the total energy consumption of the building. For this purpose, the following considerations are required: strategic management systems and programs, measurement and verification of actual data by monitoring, and a feedback system for optimal environmental performance.
- Making a qualitative assessment is encouraged to show the simulation of the predictions rather than quantitative evaluation of simple area ratio or installation. For example, the use of rainwater and greywater criterion should be improved to assess practical use including installation of filtrations and supply systems as well as tank capacity.
- It is important to introduce assessment criteria for smart buildings by using Big Data and IoT (Internet of Things). IoT needs to be applied to monitoring and controlling building performance to optimize the use of energy and resources. The system also needs to incorporate the information from Big Data obtained from IoT devices and sensors to improve the occupants' experience in the built environment. Adding examination criteria pertaining to smart building technology is recommended.

This study is important as one of the few studies that explores a Korean building environmental assessment system by comparing or contrasting it with other widely known systems. The study is especially meaningful since it widens and deepens the field with information on a newly developed building environmental assessment system outside of the U.S. and Europe, which is the G-SEED for Multi-Family Housing in Korea. Results show that the Korean system used important benchmarks set by other major systems in its development process but managed to adapt it to the local market to reflect the forces of globalization and localization. It also generates new knowledge from in-depth interviews with professionals based on their experiences. Findings from this study make important contributions to the existing body of literature and have significant implications for future interventions by promoting diversity in the field of building environmental standards and certification/rating systems.

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