AN ANALYSIS OF RELATIONSHIPS BETWEEN THE GREEN BUILDING CERTIFICATION SYSTEM FOR MULTI-FAMILY HOUSING (GBCS-MF) SCORES AND RESIDENT PERCEPTION RATINGS IN KOREA

A Dissertation

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ABSTRACT

This dissertation investigates the relationships between the scores of the Green Building Certification System for Multifamily Housing (GBCS-MF) and resident perception ratings in South Korea. Sustainability has become important in architecture. Several building environmental assessments systems have been developed and used to promote sustainable developments in different parts of the world. The existing building environmental assessment systems have contributed to an understanding of building related environmental issues. However, the current systems only predict building features and performance in terms of interest to professionals. The systems do not recognize the users of buildings assessed by such systems. More research is needed to understand the users' points of view and to identify effective interventions for the current systems. To investigate the relationships between the GBCS-MF scores and resident perception ratings of building features designed to meet the GBCS-MF criteria, various sets of data were collected and analyzed, including the GBCS-MF score cards, resident surveys, and focus group interviews with professionals and residents. Results show that residents in the GBCS-MF apartments have low awareness of the system. There are differences between the presence of GBCS-MF features and resident perceptions of those features. Additional differences are found between the expectations of professionals and resident ratings on GBCS-MF features. As a result, promoting a dialogue between multiple stakeholders is important in developing meaningful developments for the systems' future. This research has answered a call to provide post-

occupancy evaluations of building environmental assessment systems and has widened and deepened the field. Suggestions for future development imply that perspectives of different end users need to be examined from varied research angles and methodologies, including increasing the number of and diversifying research participants and buildings, such as facility management staff and non-GBCS-MF certified apartments. The present study is meaningful as a first time exploratory look at what a building environmental assessment system is like in Korea and how the system functions in that local setting.

DEDICATION

To my parents

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NOMENCLATURE

GBCS-MF	Green Building Certification System for Multi-Family
MLTM	Ministry of Land, Transportation and Maritime Affairs, Korea
MEV	Ministry of Environment, Korea
LEED	Leadership in Energy and Environmental Design
USGBC	U.S. Green Building Council
BRREAM	BRE Environmental Assessment Method
BRE	Building Research Establishment, UK
CASBEE	Comprehensive Assessment System for Building
JaGBCS/JSBC	Japan GreenBuild Council/ Japan Sustainable Consortium
POE	Post Occupancy Evaluation

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

1.1. Background and Significance

In recent years, policymakers and professionals working in the field of architecture have become concerned about the impact of buildings and construction on the environment. The way buildings are designed, built, and operated, in addition to the growing market demands for sustainable products and services, affects the environment. According to a statistical summary by the Environmental Protection Agency (EPA), in the U.S., there existed 128 million residential housing units in 2007 and nearly 4.9 million commercial buildings in 2003. These buildings affect different aspects of the environment, including energy use, air and atmosphere, and water use. For example, the EPA reports that buildings accounted for 38.9 % of total U.S. energy consumption in 2005, 38.9 % of the nation's total carbon dioxide emissions in 2008, and 13 % of the total U.S. water consumption in 1995.

At the same time, as society develops, resident needs for housing evolve from availability and functionality to quality of experience. Residents are now concerned about their quality of life as well as the physical conditions of housing. Many researchers have studied factors related to residential satisfaction. They have concluded that physical, social, and management aspects of the living environment are related to resident satisfaction. Morris and Winter (1978) describe residential satisfaction as "the outcome of an interaction between individual characteristics of the resident and physical characteristics of the housing" (p. 472). According to these researchers, characteristics of an individual produce his/her expectations for housing. These expectations are then compared with the physical realities of their living environment such as "structure type, space, cost, and tenure" (p.472). In this process, residential satisfaction can be constructed positively or negatively in relation to different factors. Amerigo and Aragones (1997) also depict residential satisfaction as the dynamic interaction between an individual and his/her environment. For example, there are safety, positive perceptions of attractiveness and recreation, the amount of comfort, space, and economic value of the apartment (Weidemann et al., 1982). On the other hand, Galster and Hesser (1981) found negative factors relating to residential satisfaction and categorized three contexts: residential (younger, married, female heads, those with many children), dwelling (poor condition, incomplete or inoperable plumbing, heating or kitchen facilities, few bathrooms and non-single-family dwelling) and neighborhood contexts (dilapidated structures, high densities, racial integration). These factors elicit less satisfaction. Given this, well-designed housing is recognized as one of the important features in promoting a good quality of life for residents (Orrell et al., 2013). Additionally, low energy costs (Mlecnik et al., 2012), management and utilities fees (Buys & Miller, 2012), controllability of building features (James III, 2007), and building comfort (Leaman & Bordass, 2007; Turner, 2006) have the strongest association with resident satisfaction. These factors emphasize the importance of high quality physical, social, and management aspects of the living environment that can contribute to occupant satisfaction in dwelling.

Meaningful and significant changes are needed to reduce the environmental impacts during a buildings' life cycle and to give residents an adequate living environment (Cole, 1998). Accordingly, several countries and organizations have developed building environmental assessment systems. Examples of such assessment systems include: the Leadership Energy and Environmental Design (LEED) of the U.S.; the Building Research Establishment Environmental Assessment Management (BREEAM) in the UK; the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan; and the Green Building Certification System in Korea. The primary purpose of these systems is to assess building performance according to a wide range of environmental issues. Cole (1998) suggests that building environmental assessment systems should comprehensively evaluate environmental characteristics of buildings using a set of criteria for different users. These different users have different interests. For example, developers or investors may focus on economic performance, while architects may prioritize their design issues under government regulations. Residents may consider their living conditions, which affect their physical and psychological well-being.

These energy assessment systems are gaining popularity and becoming ingrained in municipal regulations in order to promote sustainability and provide residents with better living conditions. As systems have established implementation in numerous buildings, researchers have conducted studies regarding whether or not these building environmental assessment mechanisms reduce environmental impacts and promote sustainable development. For instance, these rating systems describe a sustainable building design, which leads to optimized building performance for the intended design goals. An additional goal is to decrease environmental impact the building life cycle brings.

1.2. The Knowledge Gap

There is limited knowledge about how the systems influence residents and what residents think of their certified buildings; in many systems, there is no component for reflecting resident opinion. Most researchers and professionals have not examined relationships between evaluation criteria of different systems and residents' perception/opinions. For example, Cole (1998), Crawly and Aho (1999), and Ding (2008) examined only similarities or differences among various building environmental assessment systems. Given this, Happio and Viitaniemi (2008) note that user experience needs to be utilized in the development of more effective building assessment systems. This situation calls for more research that can connect professionals and residents. By promoting communication between the two groups, professionals can assess residents' point of view, which can result in improving the quality of residential environment.

Korea is experiencing a similar situation with regard to lack of input from residents about sustainable building features. The Green Building Assessment System (GBCS) is used at the national level in Korea and applied to a variety of typologies including housing, offices, commercials, and schools. The GBCS is limited in that it does not include opinions of the residents living in the GBCS certified buildings. The number of the GBCS certified buildings has grown rapidly, but post-occupancy evaluations (POEs) are scarce in the context of Korea. Evaluating how effectively the GBCS-MF system works through resident perception is meaningful because the GBCS-MF intends to promote green building features and provide better living environments. Therefore, this study will explore the relationships between the Green Building Certification System for Multi-Family Residential Housing (GBCS-MF) criteria and residents' perception of the building features designed to meet the GBCS-MF criteria. To that end, the study will use the GBCS-MF score cards and resident surveys in the GBCS-MF certified apartments. The study results may improve the GBCS-MF criteria in response to resident opinions.

The Green Building Certification System for Multi-Family Residential Buildings (GBCS-MF) was implemented in Korea to promote the development of green buildings in the country and to provide occupants with environmentally friendly buildings. For instance, Korea is among the top 10 countries in the world, which emit almost 70% of the world total carbon dioxide ($CO_{2)}$ emissions according to a 2012 report by the International Energy Agency (www.iea.org/). The IEA (2012) reports that Korea produced 563.1 million tons of CO_2 emissions in 2010, a 145.6% increase between 1990 and 2010. It is the top seventh country in the world by CO_2 emissions. GBCS professionals have used the system to evaluate environmental features of different building types such as office buildings, residential buildings, school buildings, etc. Among different residential building types, multi-family housing is one of the most popular and prevalent types of residential dwellings in Korea due to its high population density. Accordingly, since 2002, the Ministry of Land, Transportation and Maritime Affairs (MLTM) and the Ministry of Environment (MEV) have enforced the GBCS-MF. Professionals from several government designated building organizations have evaluated building features of apartment complexes. They scored the apartment complexes according to each criterion of the GBCS-MF at two different times; when the buildings were designed and before they are occupied by residents.

For the past decade, the GBCS-MF system has undergone significant development by updating the evaluation criteria. However, there has been no feedback via the post-occupancy evaluation of certified buildings. In addition, there is limited credible research on how residents perceive the features of buildings constructed to meet the GBCS-MF criteria. The Korean government authorized four organizations to issue the GBCS certifications using the same government created criteria. There is no significant research on perceived building features for the GBCS-MF in terms of occupants. More importantly, score cards of the GBCS-MF are not accessible to the public or most researchers; thus, prior studies which attempted to compare and contrast the GBCS-MF system with other internationally famous certification systems have not used any official GBCS-MF scores.

The current study investigates which GBCS-MF criterion work and which ones do not, when evaluating features of green building apartment complexes. For that purpose, this study will examine relationships between the GBCS-MF scores and residents' perceptions of building features designed to meet the GBCS-MF criteria. This comparison will allow me to investigate the relationships between GBCS-MF scores and residents’ perceptions of the current GBCS-MF system and find ways to improve this ten year old system.

1.3. Structure of the Dissertation

This dissertation attempts to fill this gap of knowledge by examining the relationship between residents' ratings and the professionals' scores on the GBCS-MF features. After a brief introduction about the background and significance of this topic in Chapter 1, the second chapter offers a review of the literature regarding that examine the building environmental assessment systems and the significance of user feedback. Then a research framework and a series of research questions are proposed, followed by an introduction of the study setting and population in Chapter 3. Chapter 4 covers data analysis and discussion, where survey results from residents of the GBCS-MF certified apartments are analyzed to examine the relationships between residents' ratings and the professionals' scores on the GBCS-MF features. Finally, Chapter 5 concludes with the contributions to the literature, the implications for future GBCS-MF and policy interventions in the area of the building environmental assessment systems, and the limitations of this study.

CHAPTER II

LITERATURE REVIEW

In the 21st century, global warming and sustainability are important issues to consider during the various stages of a building's life cycle since buildings continually consume energy and produce CO_2 emissions. Building environmental assessment systems are gaining popularity for their ability to reduce these environmental impacts. In addition, residents' expectations for a high quality living environment are growing. However, most current systems only evaluate physical building data and do not seek resident feedback. In the following literature review, I will discuss the importance of sustainability in architecture and trace the developmental history of building environmental assessment systems in different areas of the world including Korea. This review will demonstrate the lack of end-user post-occupancy evaluation in the current assessment systems.

2.1. Sustainability

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 UN has undergone various interpretations and has been applied to many disciplines.

According to the United States Environmental Protection Agency (2012), "sustainability is important to making sure that we have, and will continue to have, the water, materials, and resources to protect human health and our environment" (http://www.epa.gov).These interpretations of the term "sustainable" refer to the availability of natural resources and environments over many generations, and to the enhancement of quality of life through ecologically sound technological development and economic growth.

In the field of architecture, sustainable or sustainability is commonly related to a responsible use and management of resources. Various issues are considered during a building life cycle to promote sustainability. For instance, the Whole Building Design Guide Sustainable Committee (2012) suggest guidelines for green buildings with minimal environmental impacts as follows: "Optimizing site/ existing structural potential; Optimizing energy use; Protecting and conserving water; Using environmentally preferable products; Enhancing indoor environmental quality (IEQ); Optimizing operational and maintenance practices" (http://www.wbdg.org).

Other researchers and organizations approach the issue of sustainability in architecture in a similar way. The Rocky Mountain Institute, in its "A Primer on Sustainable Building (2007)," describes "sustainable design" or "green development" as "taking less from the earth and giving more to people" (p. 2). This goal offers an opportunity to create environmentally sound and resource-efficient buildings by using an integrated approach to design. According to Berkebile (1993), sustainable architecture is a "design that improves the quality of life today without diminishing it for the next generation" (p. 109).

Accordingly, sustainability has become an increasingly important issue in contemporary architecture. The American Institute of Architects (AIA) argued that "sustainability is an important component of quality design". The AIA (2007), further, 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). For example, buildings are responsible for approximately 48 percent of the total energy consumption in the United States and are partly responsible for global climate change due to increased production of greenhouse gases. No other has a greater impact on the global environment or faces a greater responsibility to its environmental performance than buildings. The term sustainability, as it relates to architecture, is not just energy efficiency, but it is an ecological approach to design. While there are many definitions of sustainability, it seems to be more of a process than set of fixed ideas.

2.2. An Emergence of Building Environmental Assessment Systems

With the rise of sustainability as an important factor in the field of architecture, the environmental impact of the construction and operation of buildings has captured the attention of professionals and decision makers for the past decades. They have been more concerned about global warming resulting from CO_2 emission and pollution from building operations and excessive use of resources from new construction activities (Cole, 1998; Crawley & Aho, 1999). The environmental performance of buildings is now a major concern for professionals in the construction and property sector to reduce those environmental impacts (Crawley & Aho, 1999). Thus, building environmental assessment systems have emerged as an important consideration in building design, construction, and operation (Cole, 1998; Ding, 2008). Aiming to minimize buildings' footprints and to develop sustainable and environment friendly buildings, reliable building environmental assessment systems and a "yardstick" for measuring such systems are needed, from starting points to monitoring progress (Crawley & Aho, 1999).

To promote sustainable developments, several building environmental assessment systems have been developed and utilized in many countries since the 1990s. For example, Leadership in Energy and Environmental Design (LEED) is a common system for assessing sustainable development of buildings in the US (US GBCS, http://new.usgbc.org/leed). Building Research Establishment Environmental Assessment Management (BREEAM) is widely used in the UK (BRE Group, http://www.bream.org). Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) is a Japanese green rating tool used for evaluating environmental building performance (JaGBC & JSBC, http://www.ibec.or.jp/). Korea uses the Green Building Certification System (GBCS) for evaluating green building features (MLTM & MEV, http://www.mltm.go.kr). Table 1 shows the developmental traces of the existing environmental assessment methods.

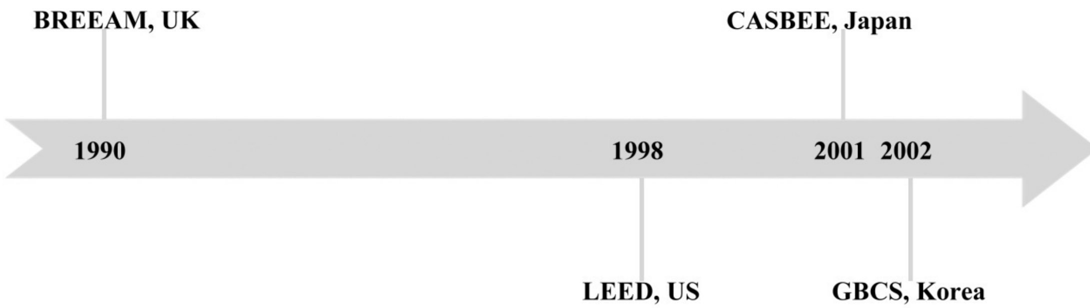


Figure 1 Timeline of Building Environmental Assessment Systems

The role of these systems is to assess buildings across a broad range of considerations. They provide a method for designing, constructing and maintaining buildings in an environmentally-friendly manner. Energy, water consumption, indoor environmental quality, and building emissions are some of the important environmental issues to be assessed by the current systems. In this sense, the ultimate goal of building environmental assessment systems is sustainability (Cole, 1998; 1999; 2005; Crawley & Aho, 1999; Ding, 2008; Happio & Pertti, 2008; Papadopoulos & Giama, 2009). 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, 2007).

2.3. Prior Studies on Building Environmental Assessment Systems

Building environmental assessment systems have recently become a popular research topic. Many researchers have compared and contrasted various building environmental assessment systems such as LEED and BREEAM, to find their strengths and weaknesses. Based upon such understandings, they have suggested some directions for future developments. Researchers also emphasize the importance of user feedback in the currently used systems. In most cases, users of building environmental assessment systems include professionals only, excluding those who reside in buildings such professionals made. This omission leads to another issue, which is these assessments focus on building planning and construction stages only. The systems do not include post occupancy evaluation. This very problem is the weakest part of many assessment systems.

It is important to understand the main purpose and definition of 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 necessary 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 systems need ‘actual’ performance values rather than predicted since actual performance is more important in assessing buildings. He further suggests three distinct roles for the building environmental assessment systems. They provide “a common and verifiable set of criteria” aiming to “stimulate owners to improve a building’s performance.” The systems also provide “the basis for making informed design decisions, and an objective assessment of a building’s impact on the environment” (p. 231).

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 design team or external evaluators use assessment tools to assess how the building is designed or built (p. 326). For example, LEED and BREEAM are intended for use during the design phase. They cannot have a performance assessment after the building was occupied. For this reason, the researcher argues that building environmental assessment systems need to assess operational performance and communicate with building occupants.

In addition to their importance as a tool to evaluate building performance in terms of sustainability, what are the benefits of using various building environmental assessment systems? Papadopoulos and Giama (2009) explain the benefits of such systems in three aspects: environmental, economic, and health and community issues.

Environmental benefits are the enhancement and protection of habitats and natural resources, improvement of air and water quality, reduction of solid waste, conservation of natural resources, and environmental optimization of buildings over their life span, from design to demolition. Economic benefits are the reduction of operational costs, enhancement of asset value and profits, improvement of employees' productivity and occupants' satisfaction, and optimization of the building's life-cycle economic performance. Health and community benefits are related to the improvement of air, thermal, and acoustic environment, enhancement of occupants' comfort and well-being, minimization of strain on the local infrastructures, and contribution to the overall quality of life. The building environmental assessments not only consider buildings' life cycle but also intend to improve environmental conditions for quality of life and well being of human beings.

The various systems aim to reduce environmental impacts during buildings' life cycle. 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). "Environmental Impact Assessment (EIA)" and "Life Cycle Assessment (LCA)" are two basic methodological frameworks that have been developed for assessing the environmental impact of buildings (p. 301). EIA focuses on "assessing the actual environmental impacts of an object located on a given site and in a given context", whereas LCA "assesses the non-site specific potential environmental impacts of a product regardless of where, when or by whom it is used" (p. 301). And they said that it is important to separate design and performance assessment since there are differences between them. For example, the performance assessment could be synthesizing the overall environmental performance of a building, while the design assessment is a top-down process targeting to technical implementation of system's criteria.

Researchers have tried to capture complexities associated with current assessment systems by delving into their different aspects. For example, Ding (2007) 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). It is based on a multiple dimensional model to bridge the gap when using a single approach model. Ding mentioned that existing building environmental assessment systems have limitations in terms of communication since building developments involve complex decisions related to the increased significance of environmental issues between members of the design team and various sectors. It is needed to use multiple criteria for improving interaction among various parties to investigate their environmental impact and assessment of sustainability.

Different researchers have developed different classification systems to understand various assessment systems. For instance, Reijnders and Roekel (1999) have divided building environment systems into two classes: "Requirement type" and "Guidance type" methods. The guidance type methods have a wide coverage of environment aspects, while the requirement type methods have only a limited scope since they mainly focused on energy-saving measure of buildings. The Guidance type methods BREEAM and LEED are based on life cycle analysis (LCA) of building components and emphasize different aspects of environmental performance with checklists. Reijnders and colleague further state that there is no coverage of user behavior in methods. To correct this deficiency in a proper way, actual users' behavior and the users' environmental impact and its relation with design and the use of building materials are needed to examine.

Happio and Pertti (2008) have used another categorization system. They have analyzed and categorized existing building environmental assessment systems which are used at a national level such as LEED and BREEAM. Building environmental assessment systems have developed for a variety of needs and purposes of many related personnel. Rating systems are designed for assessing different types of buildings, and they can cover the life cycle of buildings differently based on criteria and requirements. Most of the systems use grades and certificates to represent the results of the building environmental assessment. The study has pointed out one important issue, which is a need for a user survey to critically analyze the benefit of the tools. The reason for the user survey is because building environmental assessment systems often use the predicted service life of a building in the assessments and needed to investigate how the buildings work and affect occupants in real situations. To fill this gap, more research is needed to include occupant feedback. Previous studies comparing or contrasting those assessment systems are limited remaining on the surface level not delving into real issues of the systems like reflecting residents' opinions.

There is an increasing concern for ways to improve existing assessment systems. Cole (1998) argues that building environmental assessment systems need to comprehensively evaluate environmental characteristics of buildings using different sets of criteria for different users. These different users have different interests. For example, developers/investors may focus on economic performance, while architects may prioritize their design issues under governmental regulations. Residents may consider how their living conditions affect their physical and psychological well-being. Cole (1999) further states that building environmental assessment systems should include opinions from different parties associated with buildings. It requires greater communication and interaction between members of a design team and various parties within the building industries. However, building environmental assessment systems may have several limitations as standardized evaluations. For example, when considering different users' interests, the evaluation tool may solicit professional opinions only. Professionals evaluate buildings with a fixed set of assessment criteria before they are occupied by residents. However, the criteria are based on potential performance of buildings. In this process, there is no opportunity to acquire occupant feedback. Occupants also cannot communicate with professionals about the perceived environments and actual building performance (Cole, 1999; Ding, 2008).

Accordingly, this situation is creating gaps between users and design expectations, as well as intended and achieved performance. As a solution to close these gaps, user feedback is needed to make a meaningful evaluation. User feedback can give information on how well a building works, i.e. "effects of buildings on their occupants" (Preiser, 2002, p. 11). This information will eventually contribute to making better buildings for users and the environment, as well as promoting continuous improvement of future buildings (Cohen et al., 2001).

2.4. A Comparison of Building Environmental Assessment Systems: Their Purposes and Measuring Criteria

It is necessary to compare some of the important building environmental systems to better understand 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 GBCS in Korea utilized these internationally-known systems in its development process. All three systems ultimately intend to develop more sustainable buildings, while reducing environmental impacts and CO_2 emissions during the buildings' life cycle. The 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 cultural factors and various regulations in different countries.

This chapter focuses on only the three building environmental assessment systems due to limited space. The examples include previously mentioned GBCS, LEED and BREEAM. These tools are selected since they share system-wide similarities. For instance, they intend to evaluate newly constructed buildings. However, the scope and application processes of the assessment methods vary widely. Each assessment system is described briefly below.

2.4.1. GBCS, Korea

In 2002, GBCS was developed by Korea Ministry of Land, Transportation and Maritime Affairs (MLTM) & Ministry of Environment (MEV). Since its creation, the system has been renewed and diversified to different types of buildings following architectural laws and regulations. It was originally developed for multi-family housing, and today it has various systems to assess different types of buildings such as mixed-use, offices, retail developments, schools, accommodation buildings for the special requirements of different types of buildings. It covers a variety of systems for different phases of the buildings under assessment: planning, design, completion, operation, and renovation. (MLTM, www.mltm.go.kr/)

2.4.2. LEED, USGBC, US

LEED was established in 1998 by the USGBC; it provides third-party verification of green buildings. It was launched in a pilot program in 1999 in the US as a voluntary, market-based assessment method which intended to define a ‘green building.’ It evaluates several different types of buildings during the entire life cycle of a building, such as new or existing individual buildings, commercial interiors, retail, homes, schools and healthcare. LEED supports a whole building approach to sustainable developments. It provides owners and operators with tools to assess building's performance and also provides occupants with healthy indoor space. In evaluating a building using the LEED criteria, there are minimum mandatory requirements in each area, such as sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. Depending on the total credits, a building receives a rating level ranging from bronze to silver, gold, or platinum (USGBC, http://new.usgbc.org/leed).

2.4.3. BREEAM, BRE Group, UK

Being launched in 1990, BREEAM was the first environmental assessment method and rating system for buildings in the world. It has been a widely used tool for assessing the environmental performance of buildings in the UK. It was developed for new office buildings, and today it has evolved into a diversified system to assess different types of buildings such as offices, retail developments, education, and health care buildings. The goals of BREEAM are to reduce environmental impact and to ensure the best environmental practice in design, operation, and management. Another aspiration of BREEAM is to increase awareness of the impacts of buildings on the environment. It is a voluntary, consensus-based, and market-focused assessment method. A certificate of the assessment result is awarded to an individual building based on a single rating scheme of pass, good, very good, excellent, or outstanding. (BRE Group, http://www.breeam.org/)

The following Table 1 concisely describes the three building environmental assessment systems (GBCS, LEED, and BREEAM) in terms of their general characteristics.

Table 1 Characteristic of the Building Environmental Assessment Systems

System	GBCS, Korea	LEED, USA	BREEAM, UK
Year	2002	1998	1990
Organization	MLTM &MEV	USGBC	BRE Group
Project scopes	7	9	4
	Multi-family residential, Mixed-use (residential/ non-residential areas), Office, School, Retail, Accommodation	LEED-NC, LEED-EB, LEED-CS, LEED-CI, LEED-Retail, LEED-Schools, LEED-Homes, LEED-ND, LEED-Healthcare	Commercial (offices, industrial, retail), Public(non housing,-education, healthcare, prisons, law courts), Multi-residential accommodations (residential institutions), other (residential institutions, non residential institutions, assembly and leisure, other)
Evaluation scopes	Whole building assessment frameworks and rating systems	Whole building assessment frameworks and rating systems	Whole building assessment frameworks and rating systems
Certification levels	4	4	5
	Green I, II, III, and IV	Platinum, Gold, Silver, Certified (Bronze)	Outstanding, Excellent, Very good, Good, Pass
No. of credit items	44	57	48
Total credit scores	136	110	155
Credit categories	9	7	10
	Land Development, Transportation, Energy, Materials & Resources, Water Efficiency, Atmosphere, Maintenance, Ecological Environment, Indoor Environmental Quality	Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, Innovation in Design or Innovation in Operations Credits, Regional Priority Credits	Management, Health & Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use & Ecology, Pollution, Innovation

2.5. Prior Studies on Building Environmental Assessment Systems and User Feedback

Since this research tries to fill the gap between building environmental assessment systems and residents, it is also needed to understand how user feedback has been treated in prior studies on such systems. Many researchers argue that a user feedback is important in conducting meaningful assessments of buildings. The history of formal evaluations including a building performance and an occupant feedback can be traced back to the 1960s. Since then, British and American organizations and researchers have conducted numerous evaluations using different methods.

Preiser et al. point out some important historical steps of post-occupancy evaluation. They said, "Post-occupancy evaluation is the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time" (2002, p.9). The authors also state that individuals who occupy a building are significant in the evaluation process since they are influenced by the performance of the buildings. They further note that the history of POE began with "one-off case study evaluations" in the late 1960s and evolved into "systemwide and cross-sectional evaluation efforts" in the 1980s and 1990s, which focused on the performance of buildings.

Sustainability adds more meaning to the discussion of POEs. Since the early 1990s, sustainability has become one of the important priorities for building construction as stated by Bolin (2009). Thus, facility evaluation within the context of sustainability focuses on assessing the ecological performance of buildings. For example, Cole (1998) emphasizes environmental assessment methods to "measure and promote improvements in the environmental performance of buildings," which can lead to "the collective reduction in resource use and ecological loadings by the building industry" (p. 232). He insists that our understanding of sustainability will transform future environmental assessment methods as sustainability is a complex notion embracing many dimensions such as social, economic as well as environmental.

Many researchers emphasize the necessity of POES in building environmental assessment systems. According to Cole (1999), it is important to distinguish between "the potential (anticipated) performance and actual performance" of the building by examining "occupant expectations and use patterns" (p. 233). Leaman and Bordass (2001) emphasized the need for POEs to understand how the buildings really work for the users since there is no perfect building, stating that "it is unrealistic to expect everything to work well everywhere, all the time" (p.132). Andreu and Oreszczyn (2004) mentioned that architects and designers need POEs to make more informed decisions through a "feedforward process from early design decisions to commissioning, occupation and feedback (p.314)".

To fill the gaps in the building environmental assessment systems, several POEs have been conducted. For example, the Post-occupancy Review of Buildings and their Engineering (PROBE) projects were started in the middle of 1995 by a group of researchers and professionals. They were supported by the UK government funds (Derbyshire, 2001). Since then, the group has undertaken a series of post-occupancy surveys and energy analysis of commercial and public buildings in the UK. A study by Cohen and others (2001) provides feedback and information on how well buildings work given the disparity between design expectations and achieved performance. Accordingly, the PROBE team developed occupant survey and energy analysis tools (Bordass et al., 2001) Their occupant survey collected information on "background (age, sex, etc.), the building overall, personal control (over heating, cooling, lighting, etc.), speed and effectiveness of management response, temperature, air movement, air quality, lighting, noise, overall comfort, health, productivity at work" (Cohen et al., 2001, p.89). In some cases, supplementary questions were added on the occupant survey. Their energy analysis included an assessment of fossil fuel and electrical consumption (Cohen et al., 2001).

The team tested several buildings using the tools they developed and kept revising to make them more powerful and cost-effective techniques for post-occupancy evaluation (Cohen et al., 2001). Beginning with a few buildings for their first survey, the PROBE group has expanded their research scope by including different types of buildings and increasing the number of buildings. For example, in 1995, PROBE 1 only surveyed two buildings due to busy occupiers and technical problems. Broadening its scope, PROBE 2 included another eight buildings in early 1997. The PROBE group's work is significant in that they identified and listed "all the generic opportunities and problems…and how the various parties involved could participate in improvements" (Bordass et al., 2001, p.156). They have contributed to "continuous improvement of both performance and associated design and management benchmarks" (Cohen et al. 2001, p.100).

Besides the PROBE group, the Center for the Build Environment (CBE) works on facility evaluations using a tool developed to access indoor environmental quality, named IEQ. Their methods intend “to measure the performance of occupied buildings in terms of occupant comfort and productivity, energy efficiency, and operations” (The Center for the Built Environment). For instance, Abbaszadeh and his colleagues (2006) conducted a series of occupant surveys of office buildings. They compared green (LEED-certified) building with non-green (conventional) buildings. Their findings showed that occupants in the green building were more satisfied with their air quality and thermal comfort. On the contrary, lighting and acoustic quality in the green buildings showed no significant difference compared to those of non-green buildings. By examining the performance of building from the viewpoint of its occupants, CBE’s IEQ presents “immediate feedback” for building owners and operators. This will eventually assist designers and professionals in developing future buildings.

In relation to sustainability, Turner (2006) also conducted an online survey to evaluate building comfort and functionality from the perspective of occupants. The following categories were examined: temperature, air quality, lighting, noise and plumbing fixtures of LEED-certified offices and residential buildings in the Cascadian Region. Results showed that the occupants were highly satisfied with the certified buildings except for noise conditions. The effectiveness of LEED certified buildings was attested by Turner’s study.

Another organization working on sustainability and POEs is the New Building Institute (NBI). According to its website, NBI is “a nonprofit organization working to improve the energy performance of commercial buildings." Their goal is to provide direction and promote design practices and technologies for energy efficient buildings. In 2005, NBI developed a POE to examine building performance using "a user survey, energy bill analysis, facility interview" and "diagnostic tools" and finally provides guidelines necessary for better performance (http://www.newbuildings.org, 2012). For example, Turner and Frankel (2008) examined energy savings and surveyed the perceptions of occupants in 121 LEED New Construction (LEED-NC) buildings. They asked occupants to rate "the key functional comfort areas of acoustics, lighting, temperature and air quality, as well as the overall building" (p.31). Results concluded that 25% energy savings and higher satisfaction levels of occupants in the certified buildings. They provided a critical information link between intention and outcome for LEED projects. It has been an influential and widely-cited study since its release.

Facility performance evaluation (FPE) is also related to environmental building assessment systems and post-occupancy evaluations. In their study (2008), Zimring, Rashid, and Kampschroer described FRE as "a continuous process of systematically evaluating the performance and/or effectiveness of one or more aspects of buildings in relation to issues such as accessibility, aesthetics, cost-effectiveness, functionality, productivity, safety and security, and sustainability" (http://www.wbdg.org/resources/). FPE is an evolved version of POEs.

Many researchers have tried to examine user feedback through different methods. For example, Leaman and Bordass (2007) conducted a Building Use Study (BUS) survey in 177green and conventional buildings in the UK. They examined whether green buildings are perceived as better by their users. The survey results showed that the users' ratings of the physical variables of temperature, air/ventilation, noise and lighting were overall lower in green buildings than conventional buildings except for "comfort overall" or "lighting overall" (p.672). Scores on other relevant variables (design, image, needs, health and perceived productivity) were better on average for the green buildings than conventional buildings.

Paul and Taylor (2008) measured the occupant comfort and satisfaction perceptions from one green and two conventional university buildings. They asked occupants to rate their environments regarding aesthetics, serenity, lighting, acoustics, ventilation, temperature, humidity, and overall satisfaction. Their results found that the occupants could not perceive any differences between the green and non-green buildings except temperature.

Lee and Guerin (2009) also conducted a study to find the effectiveness of the indoor environmental quality in 15 LEED-certified office buildings regarding occupant satisfaction and performance. This study found that office furnishing quality showed the highest occupant satisfaction and performance, while indoor air quality affected occupants' performance only.

Baird et al. (2012) compared commercial and institutional sustainable buildings with conventional buildings to determine whether there were any significant differences in the users' perception of a range of factors. The study was concerned about the operation, environmental conditions, control and degree of satisfaction. The research found that the users of the sustainable buildings showed higher satisfaction compared to those in conventional buildings. Especially, there was noticeable improvement in how the users perceived "productivity" and "health" (p.143).

These previous studies attempted to find a solution to close the information gaps using surveys. GBCS-MF also needs researchers to examine the differences between intended and performed features of buildings designed to meet the GBCS-MF criteria using user surveys for improving buildings in future.

2.6. Building Environmental Assessment System in Korea: Green Building Certification System (GBCS)

It is important to learn more about the Korea GBCS, which is the focus of this study. The Korea GBCS was the first nationally available building environmental assessment system. It was initiated in 2002 by two national departments: the Ministry of Land, Transportation and Maritime Affairs (MLTM) and the Ministry of Environment (MEV). It aims to reduce the use of energy and environmental impacts during buildings' life cycle including design, construction, operation, maintenance and demolition. It also promotes sustainable developments between human beings and natural environment by assessing buildings' life cycle and the quality of life to occupants.

The Korea GBCS expects three benefits in terms of environmental, technical and economical aspects (MLTM, 2002). For example, the environmental benefits contain protection and enhancement of land and natural resources, protection of the atmosphere and water resources, reduction of CO_2 emissions and other green gases. The system also expects to promote the use of recycled materials and energy saving technologies.

Developing environmentally-friendly design, construction and materials is one of the technical benefits of the GBCS-MF. Its technical benefits also aim to provide occupants with the overall quality of life such as occupants' comfort and health. The economical benefits are reduction of buildings' operational costs and improvement of air, thermal and acoustic environment for occupants.

The GBCS comprise not only environmentally-friendly technologies, but also sustainability considerations and requirements. At the same time, it has accompanied by policies and incentives, provided governments and local authorities, to promote sustainable building practices. For example, the incentives include tax reduction such as building property and registration tax as well as environmental improvement costs (Architectural LAW 65.4, MLTM, 2010).Since the first version of the GBCS-MF was initiated, it has undergone several changes. The following figure briefly shows the changes of the GBCS-MF.

- September 2002 - GBCS-MF was developed by Ministry of Land, Transportation and Maritime Affairs (MLTM) and Ministry of Environment (MEV).
- January 2003 - GBCS-MF was initiated with 5 categories, 120 points, and two levels (Green I or II).
- October 2005 - GBCS-MF was revised to 9 categories and 136 points
- May 2008 - GBCS-MF is governed by Architectural Law 65 [Green Building Certification System]. The system was changed from recommended to require.
- May 2010 - GBCS-MF levels were changed to Green I, II, III and IV.

- December2011 - GBCS-MF criteria was revised to required, recommended, and optional items.

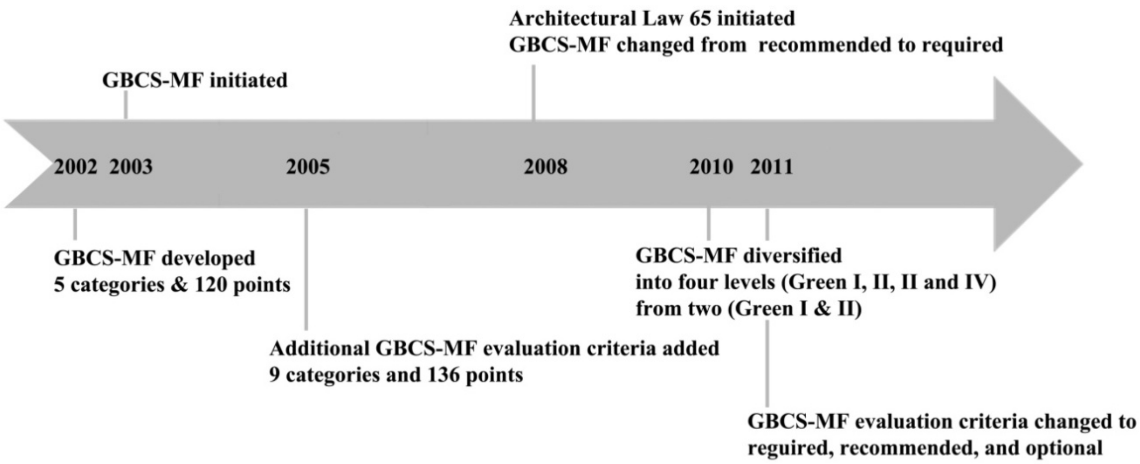


Figure 2 Changes of the GBCS-MF

In general, the GBCS includes a number of mandatory (basic) items as well as supplementary (bonus) items whose points can be earned toward a certification. The GBCS has several assessing systems for building types, including multi-family residential buildings, mixed use buildings (residential/ non-residential areas), office buildings, schools, retails, and accommodation. This study only uses the GBCS for Multi-Family Residential Buildings (GBCS-MF) since those buildings are the most prevalent type of housing in Korea. This reason is because the country is highly populated with about 50,000,000 (fifty million) persons; and more than 50% percent of Koreans live in Seoul, which is the capital.

The GBCS-MF evaluates projects on nine environmental categories: Land Development, Transportation, Energy, Materials and Resources, Water Efficiency, Atmosphere, Maintenance, Ecological Environment and Indoor Environmental Quality. Table 2 shows information on each environmental category along with related criteria and points.

Table 2 Summary of the GBCS-MF Criteria and Points

Environmental Categories	Number Of Criteria	Possible Points
1. Land Development	8 (5 Mandatory & 3 Recommended)	22 (15 Mandatory &7 Recommended)
2. Transportation	4 (3 Mandatory &1 Recommended)	8 (6 Mandatory &2 Recommended)
3. Energy	2 (1 Mandatory &1 Recommended)	15 (12 Mandatory & 3 Recommended)
4. Materials and Resources	8 (6 Mandatory &2 Recommended)	15 (12 Mandatory & 3 Recommended)
5. Water Efficiency	4 (3 Mandatory &1 Recommended)	23 (14 Mandatory & 9 Recommended)
6. Atmosphere	1Mandatory	3 Mandatory
7. Maintenance	3 (2 Mandatory &1 Recommended)	7 (6 Mandatory &1 Recommended)
8. Ecological Environment	6 (5 Mandatory &1 Recommended)	18 (17 Mandatory & 1 Recommended)
9. Indoor Environmental Quality	8 (5 Mandatory &3 Recommended)	27 (18 Mandatory & 9 Recommended)
Nine Categories	44 Criteria (20 Mandatory + 14 Recommended)	136 Possible Points (100 Mandatory + 36 Recommended)

A project is required to earn a minimum of 50 points for the GBCS-MF certification (MLTM &MEV, 2010). Projects earning higher scores can be rewarded with different certification levels (MLTM & MEV, 2010), depending on the specific thresholds they reach. As shown in Table 3, the GBCS-MF uses the following certification levels: Green I (Excellent) above 80 points, Green II (Very good) 70 -79 points, Green III (Good) 60 -69 points, and Green IV (Pass) 50 - 59 points. To earn the

GBCS-MF certification, the applicant project must acquire minimum points which are a combination of required and recommended possible points. The system has two kinds of certification according to occupancy status in buildings: pre-certified vs. certified.

Table 3 GBCS-MF Certification Levels

Ratings	Scores
Green I	80
Green II	70-79
Green III	60-69
Green IV	50-59

From 2002 to 2012, a total of 1,052 multi-family residential buildings (Pre-certification: 693, Certification: 359) were certified through the associated organizations (MLTM, 2012). Figure 3 shows more detailed information on the numbers of the GBCS-MF certified projects and their certification levels.

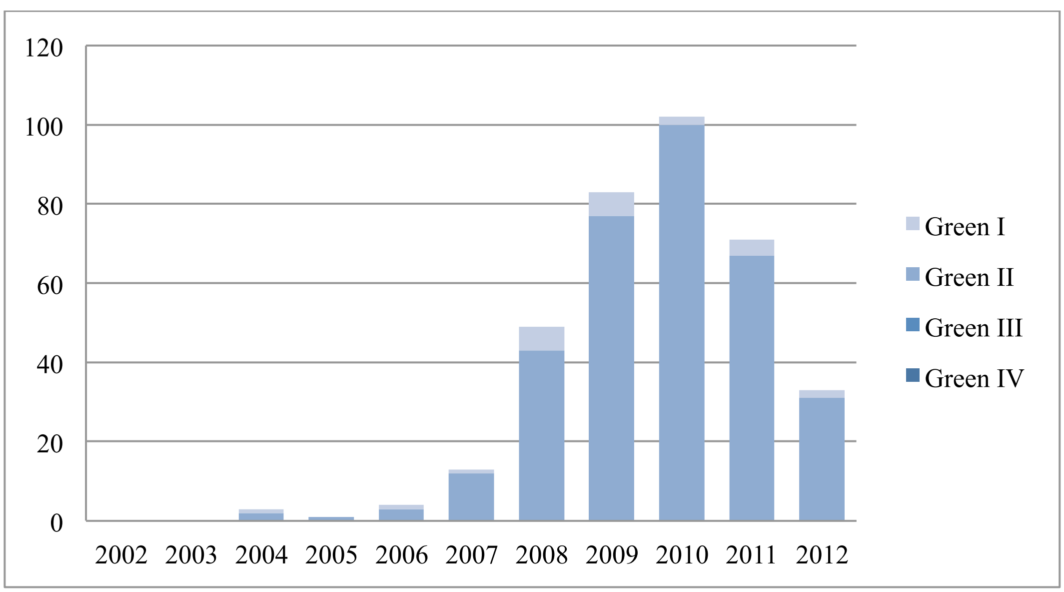


Figure 3 Numbers of the GBCS-MF Certified Projects (2002-2012)

2.7. Explanations of the GBCS-MF Criteria

Since the GBCS-MF is not the world wide assessment system, it is necessary to explain each criterion for the reader's better understanding. Overall, the GBCS-MF is quite similar to other building environmental assessment systems; this system is developed only from the perspective of professionals (government officials). The GBCS-MF benchmarked other renowned systems including BREEAM and LEED in the developing process. The GBCS-MF professionals evaluate design features of buildings and give scores for the buildings. Post-Occupancy Evaluation (POE) is a missing component in the GBCS-MF.

Table 4 describes detailed information about the GBCS-MF, such as categories, evaluation criteria and allocated points.

Table 4 GBCS-MF Categories, Evaluation Criteria and Points (May 2010).

Categories	Criteria	P	M	O
1. Land Development	1.1.1Ecological Value of Site	2	X	
	1.1.2Preservation of Existing Natural Resources	3		X
	1.2.1 Density	6	X	
	1.2.2Establishment of Urban Development	2		X
	1.3.1Interference with Daylight to Adjacent Properties	2		X
	1.4.1 Provision of Community Center and/or Facilities	3	X	
	1.4.2 Creation of Walkways in Apartment Complex	3	X	
	1.4.3 Connection of On-Site Walkways to Outside Walkways	1	X	
2. Transportation	2.1.1 Accessibility to Public Transportation	2	X	
	2.1.2 Installation of Bicycle Racks And Roads	2	X	
	2.1.3 Installation of High-Speed Internet	2		X
	2.1.4 Accessibility to City or Community Center	2	X	
3. Energy	3.1.1 Annual Energy Consumption	12	X	
	3.2.1 Use of Alternative Energy Sources	3		X
4. Materials and Resources	4.1.1 Plans for Life Cycle Change	3	X	
	4.1.2 Application of Environmentally Friendly Construction Methods	3	X	
	4.2.1 Built-In Furniture	1	X	
	4.3.1 Installation of Recycling Containers	2	X	
	4.3.2 Installation of Food Waste Containers	2	X	
	4.4.1 Use of Recycled-Content Materials	3	X	
	4.4.2 Reuse-Structural Elements	7		X
	4.4.3 Reuse-Nonstructural Elements	2		X
5. Water Efficiency	5.1.1 Water Efficient Landscaping	3	X	
	5.2.1 Water Use Reduction	4	X	
	5.2.2 Installation of Stormwater Reuse Systems	2	X	
	5.2.3 Installation of Graywater Reuse Systems	4		X
6. Atmosphere	6.1.1Reduction of CO2 Emissions	3	X	
7. Maintenance	7.1.1 Construction Waste Management and Reduction Planning	1		X
	7.2.1 Provision of A Building Manager's Manual or Binder	3	X	
	7.3.1 Provision of An Occupant's Operations and Maintenance Manual	3	X	
8. Ecological Environment	8.1.1 Consistent Green Space in The Complex and Connection to Local Green Space	2	X	
	8.1.2 Green Space Area Ratio	5	X	
	8.1.3 Application of Planned Landscaping for Protecting or Improving the Local Ecological Environment	4	X	
	8.2.1 Creation of Aquatic Biotopes	3	X	
	8.2.2 Creation of Terrestrial Biotopes	3	X	
	8.3.1 Topsoil Reuse	1		X
9. Indoor Environmental Quality	9.1.1 Use of Low-Emitting Materials	6	X	
	9.1.2 Increased Ventilation	3	X	
	9.2.1 Installation and Controllability of Thermal System	2	X	
	9.3.1 Noise Between Floors	4	X	
	9.3.2 Noise Between Walls	3	X	
	9.3.3 Noise from Outside The Apartment Complex	3		X
	9.4.1 Daylight in Your Unit	4		X
	9.5.1 Accessibility for The Disabled and Elderly	2		X
9 Categories	44 Criteria	136	31	13

This section explains the GBCS-MF evaluation criteria and methods for how professionals evaluate building features designed to meet the GBCS-MF criteria and give scores on the criteria. Each of the GBCS-MF criteria has intentions of creating better environments for residents or reducing negative impacts of buildings on the environment. Most of criteria cannot be perceived by residents. However, the building features designed to meet the GBCS-MF criteria that can be perceived by residents directly or indirectly. These criteria and their intentions are described in the followings.

2.7.1. Land Development (LD)

The Land Development (LD) category has five mandatory evaluation items and three recommended items, along with a total of 22 possible points with eight items. LD evaluation items are concerned primarily with the ecological value of the site, land use, influence of adjacent land use, and construction of the living environment for apartment complexes. A building's location is generally selected before its design is completed. Additionally, architectural laws and regulations influence several evaluation criteria of the Land Development category.

The purpose of LD 1.1.1 (Ecological Value of Site) and LD 1.1.2 (Preservation of Existing Natural Areas) is to avoid developments of inappropriate sites and reduce environmental impacts from a new building construction on a site. 1.1.1 Ecological Value of Site means protecting and saving the original conditions of the site from any harmful physical or social factors that result from new development. The criterion 1.1.1 includes land use and zoning. The criterion 1.1.2 calculates a ratio of preserved existing natural areas to a project site area. It refers to saving the habitat for animals and plants by reducing the development's footprint.

LD 1.2.1 (Density-Floor Area Ratio) seeks to provide residents with landscape, a comfortable environment, and sufficient daylight by minimizing the building's footprint; the possible point is six under this criterion. This criterion is calculated using the following formula: Y = (-X +220) /10 (Y: points, X: FAR). For example, 160% FAR is the moderate ratio recommended by the architectural law and is awarded six points. High density 220% FAR is the baseline to earn one point.

LD 1.2.2 (Establishment of Urban Development Planning) examines developments connected to nearby communities for the purpose of minimizing environmental impacts resulting from new construction activities. This criterion allocates two points in total.

LD 1.3.1 (Interference with Daylight to Adjacent Properties) requires that the construction of multi-family housing on the site does not interfere with daylight to nearby properties. LD1.3.1 criterion measures an angle of elevation from the adjacent property line to the angle of each building within the apartment complex.

LD 1.4.1 (Provision of Community Center and/or Facilities) aims to encourage residents' interaction by providing a community center and/or facilities in the apartment complex. If a community center is built on the site, three points are awarded. Only having facilities that are not independent buildings or, results in 1.5 points.

LD 1.4.2 (Creation of Walkways in Apartment Complex) requires a provision of pathways for residents to access their units and community centers/facilities with convenience. The LD 1.4.2 criterion is worth three points. This item requires the followings: minimum 4m width, a quarter of site's perimeter, and 2% cross slope. Land Development 1.4.3 (Connection of On-Site Walkways to Outside Walkways) requires a network to be provided that links the pathway inside the site to public transportation and other infrastructure for residents' accessibility. Successful implementation of 1.4.3 is worth one point.

2.7.2. Transportation (T)

The environmental category of Transportation (T) has three mandatory evaluation criteria, one recommended criterion, and this category has four possible points.

T 2.1 (Accessibility to Public Transportation) examines walking distance from an apartment complex to public transportation stations such as bus stops/terminals, metro stations or train stations.

T 2.2 (Installation of Bicycle Racks and Paths in the Apartment Complex) requires installing secure bicycle racks with 20 racks per 100 units and designated bicycle roads inside apartment complexes. This criterion intends to make units more bike-friendly, also resulting in reduced CO_2 emissions.

T 2.3 (Installation of High-Speed Internet) has the intent of reducing the need of transportation use indirectly by providing high-speed internet and communication systems for residents. This criterion has two points and is recommended.

T 2.4 (Accessibility to City or Local Center) intends to give residents very easy and fast access to the city center or major locations using cars or public transport. This criterion measures the linear distance from an apartment complex to a city/local center to reduce the needs for driving or using public transportation. In addition, T2.4 is required for the convenience of the residents living in the apartment complex.

2.7.3. Energy (E)

The environmental category of Energy has one mandatory evaluation and one recommended criterion with 15 possible points.

E 3.1 (Annual Energy Consumption) can be worth up to 12 points. Energy use in the buildings' operation phase is the most abundant in the life cycle of buildings. Thus, the intent of E 3.1 is to reduce CO_2 emissions by pre-evaluating the amount of a building's annual energy consumption. Points are earned by proving percentage-reduced energy consumption in a proposed building's energy performance rating, based on Energy Performance Index (EPI), which is compared to the building's base line standard as outlined in Building's Energy Saving Design Standard 2010-1031 (MLTM, 2010). E 3.1's equation is Y=12*(EPI points -60) / 25. 60 EPI points mean 100% energy consumption and the lowest energy performance, while 100 EPI points mean 60% energy consumption and 40% energy saving, with each 11.2 % improvement providing one additional point. E 3.1 is targeting to reduce energy consumption up to 30% compared to non-certified buildings' energy consumption.

E 3.2 (Use of Alternative Energy Sources) is a recommended criterion that allocates three points. Points are earned by installing on-site renewable energy systems to reduce buildings' fossil energy consumption. The systems' performance is calculated with the ratio of the energy produced by renewable systems to the buildings' annual energy consumption. Types of on-site renewable energy are solar, bio, wind, and earth.

2.7.4. Materials and Resources (MR)

The environmental category of Materials and Resources (MR) has six mandatory evaluation and two optional criteria. It has 23 possible points;

MR 4.1.1 (Plans for Life Cycle Change) allocates three points by evaluating flexibility of floor plans in apartment units. It intends to reduce materials or resources used during buildings' renovations. MR 4.1.2 (Application of Environmentally Friendly Construction Methods/Technologies) is to decrease energy use and construction waste by applying new construction technology/methods. It also intends to encourage professionals to develop new methods for eco-friendly construction. MR 4.1.2 has three points.

MR 4.2.1 (Built-In Furniture and Storage per Unit) tries to reduce the demand of private furniture by replacing them with built-in furniture and providing spacious storage for residents. This is a mandatory criterion with three points.

MR 4.3.1 (Installation of Recycling Containers) has the intent of reducing waste generated by residents. The MR 4.3.1 criterion requires providing a number of recycle containers for sorting waste into different categories, sized $8m^2$ per 150 residential units.

MR4.3.2 (Installation of Food Waste Containers) requires providing food waste recycling systems/storage for building occupants. MR4.5 promotes the reduction of food waste to save landfills and prevent groundwater contamination. The MR 4.3.2 has two mandatory points.

MR 4.4.1 (Use of Recycled-Content Materials) concerns recycled materials used in construction. Three points are available under MR 4.4.1 evaluation criterion. Using nine recycled materials attains maximum three points. At least one recycled material must be used to get one point. Both MR 4.4.2 and MR 4.4.3 are applicable to renovations/remodeling but not to new constructions. MR 4.4.2 (Reuse-Structural Elements) promotes extending a building's life cycle by reusing the existing building's structural elements. Reusing over 70% of the existing building structure is worth seven points, 50% reuse of existing building structural elements is worth 5.6points, and 30% reuse of existing building structural elements is worth 4.2 points. MR4.4.3 (Reuse-Nonstructural Elements) concerns reusing of the existing building's non-structural elements. If 50% of non-structural elements are reused, two points are obtainable. 30% reuse of existing building's non-structural elements equates to 1.6 points, and 10% reuse of existing building's non-structural elements equates to 1.2 points.

2.7.5. Water Efficiency (WE)

The environmental category of Water Efficiency (WE) has three required and one recommended evaluation criteria with 13 possible points. WE 5.1.1 (Water Efficient Landscaping) requires permeable paving for irrigation or landscaping to reduce storm water runoff loads. For example, 30% permeable paving of the total pavement is worth three points, 25% permeable paving is worth 2.4 points, 20% permeable paving is worth 1.8 points, 15% permeable paving is worth 1.2 points, and 10% or more permeable paving is worth 0.6 points.

WE 5.2.1 (Water Use Reduction) requires installation of water efficient fixtures such as faucets, shower heads, toilets or low pressure water valves to reduce residential water demand. One point for each water efficient material is allocated, so up to four points are awarded for WE 5.2.1.

WE 5.2.2 (Installation of Stormwater Reuse System) tries to capture or recycle rainwater used for landscaping and sprinkling. 5% or more of reducing water usage is worth two points, and 2% or more of reducing water usage is worth one point.

WE 5.2.3 (Installation of Graywater Reuse System) requires adding grey water collection/distribution systems to purify residential grey water and to reuse it for landscaping or sprinkling. 10 % or more reuse of grey water equates to four points, 8-10% reuse of grey water equates to three points, 6-8% reuse of grey water equates to two points, and 4-6% reuse of grey water equates to one point. With each 2% increased reuse of grey water, one additional point is gained.

2.7.6. Atmosphere (A)

This environmental category of Atmosphere has one required evaluation criterion with three possible points. A 6 .1 (Reduction of CO_2 Emissions) applies to low emitting and fuel efficient systems to reduce environmental loads caused by CO_2 emissions generated by residents during the building's operation. When occupants use 20% or more energy from cogeneration systems, the building gets three points. If the building does not install the cogeneration systems, the amount of CO_2 emissions must be evaluated. In this case, the building attains no points for this evaluation criterion.

2.7.7. Maintenance (M)

The environmental category of Maintenance includes two required and one recommended evaluation criteria with total seven possible points. M 7.1.1 (Construction Waste Management and Reduction Planning) is to minimize pollution during building constructions by employing ISO14001 environmental management systems and plans.

The intent of M 7.2.1 (Provision of a Building Manager's Manual or Binder) is to efficiently maintain and operate building systems as buildings were planned and is worth three points.

M 7.3.1 (Provision of Occupant's Operations and Maintenance Manual) requires provision of a manual that the occupant can consult in order to use their unit appropriately and allocates three points. The occupant's manual includes floor plan, lighting, fire safety, and etc. Both M7.2.1 and M7.2.2 consider not only buildings' new construction but also buildings' life cycle.

2.7.8. Ecological Environment (EE)

The environmental category of Ecological Environment (EE) has five required and one recommended evaluation criteria with 18 possible points. EE evaluation criteria are concerned with site developments regarding green space, creation of biotope, and reuse of topsoil. EE 8.1.1 (Consistent Green Space in the Complex and Connection to Local Green Space), EE 8.1.2 (Green Space Area Ratio) and EE 8.1.3 (Application of Planned Landscaping for Protecting or Improving the Local Ecological Environment) calculate green space areas around buildings in the apartment complex to examine connectivity and functionality of the planned landscape. Particularly, EE 8.1.2 includes vegetated roof surfaces, green walls, and restored natural slopes. If the apartment complex has 25% planned landscape, it is awarded a maximum of five points. But most apartment complexes acquire some points when they exceed the minimum regulation requirements by at least 5%.

EE 8.2.1(Creation of Aquatic Biotopes) and 8.2.2(Creation of Terrestrial Biotopes) requires creations of aquatic and terrestrial biotopes to increase the quality of ecological environments in apartment complexes. They assign a total of six points.

The intent of EE 8.3.1(Topsoil Reuse) is to evaluate a ratio of the reused topsoil to landscape areas in the apartment complex and it equates to one point. Thus, EE evaluation criteria are not available in the construction phase when the apartment complex design is processing.

2.7.9. Indoor Environmental Quality (IEQ)

Indoor environmental quality is an important category, since it directly affects residents' quality of life. As a result, this category allocates many points. The environmental category of IEQ has five mandatory and one recommended evaluation criteria. Its total 27 possible points makes it the most important category in the GBCS-MF system. IEQ 9.1.1 (Use of Low-Emitting Materials) seeks to increase indoor air quality by reducing air pollutants from painting, coating, adhesives and sealant used in buildings' interiors and is worth six points. The intent of IEQ 9.1.1 is to provide residents with comfort and health in their living environments.

IEQ 9.1.2 (Increased Ventilation) requires an installation of ventilation systems and an appropriate portion of operable windows to increase air ventilation, which introduces outside air into the inside of buildings. The intent of IEQ 9.1.2 is to provide occupants with controllability of mechanical/natural ventilation systems for indoor air quality. For instance, installing 15% or more operable window ratio to the unit is the baseline requirement with 1.2 points, both 15 % or more operable window ratio to the unit and ventilation system is worth 2.1 points, and both 15 % or more operable window ratio to the unit and installation of heat recovery ventilation system in the unit is worth three points.

IEQ 9.2.1 (Installation and Controllability of Thermal System) requires automatic thermostats to provide residents with system controllability for comfortable living environments. It is worth two points.

IEQ 9.3.1 and 9.3.2 consider designing quieter buildings regarding noise transmission between floors and walls in units. The intent of IEQ 9.3.1 (Noise between Floors) and 9.3.2 (Noise between Walls) is to reduce sound transmission between walls and floors. IEQ 9.3.1 considers light-weight and heavy-weight impact sound levels, while IEQ 9.3.2 calculates the thickness of walls used in units.

IEQ 9.3.3 (Noise from Outside the Apartment Complex) requires an approved test document based on MEV's environmental noise standard and is worth three points. The criterion prevents other types of noise from permeating the apartment complex. The system tests noise in the two following places: property line in the apartment complex and one meter away from window within units. The tests are done two times per day: in the daytime and nighttime. Their means are considered when evaluating this criterion.

IEQ 9.4.1 (Daylight in Your Unit) requires a minimum of two continuous hours of daylight into the living room between 9am to 3pm. Using a computer simulation, the number of units meeting the requirement is calculated to award the points. For example, when more than80% of units meet the requirement, the apartment complex gains four points.

IEQ 9.5.1 (Accessibility for the Disabled and Elderly) requires a barrier-free design for the disabled and elderly so that they have easy access and use of buildings and fixtures. IEQ 9.5.1 examines the width of corridors, stair dimensions and installation of continuous handrails, low threshold for buildings and doors, elevator size, and low-height bathtubs. Installing three or more of these provisions earns two points.

2.8. GBCS-MF Related Studies in Korea

Though various international researchers began to demonstrate the importance of user feedback/opinions on their buildings, most Korean research on the GBCS-MF does not address the issue of user feedback. Since the GBCS-MF was applied in housing developments, only several studies have tried to find the relationships between GBCS-

MF certified buildings and residents' perceptions of those buildings. This study managed to find 11 studies published between 2004 and 2011 and investigated them based upon two selection criteria. Six studies (Bae et al., 2004; Yu et al., 2006; Jo et al., 2010; Kim, H. & Kim, B., 2007; Kim et al., 2010; Lee et al., 2011) used resident surveys as their data collection methods. Five studies (Kang, S. J., 2006; Kwon et al., 2011; Kim et al., 2011; Lee et al., 2010; Lee & Yeom, 2009) included both resident surveys and interviews.

First of all, some research found that residents' perception on the GBCS-MF is not particularly related to sustainability. Residents who have prior knowledge of the GBCS-MF system and their apartment complexes are certified by the system, already recognize that their GBCS-MF certified apartments have more economic value compared to non-GBCS-MF certified ones (Kang, 06; Kim et al.10; Kim et al.,11; Kwon et al., 2011; LEE & Yeom, 09). In fact, residents are not much interested in green features in the GBCS-MF certified apartments compared to increased economic values of their properties through a certification. These results are contrary to Noiseux and Hostetler's (2010) findings that residents prefer green design features to economic values when they buying homes. This fact shows that the government's initial attempt to promote green buildings through the GBCS-MF has not been successfully perceived by residents.

However, many residents agree that the GBCS-MF certified apartment can improve the quality of their living environments. They show positive opinions of the GBCS-MF system and recognize the necessity of the GBCS-MF system (Kim, H.

&Kim, B., 2007; Kwon et al., 2011). Still, most residents do not recognize the GBCS-MF system, and evaluation criteria of the GBCS-MF are limited in that they rely on a quantitative analysis without qualitative features. These research studies show that a variety of factors are related to resident satisfaction. Particularly in the GBCS-MF apartments, resident satisfaction varies according to residents' prior knowledge of the GBCS-MF system.

It is necessary to investigate whether the GBCS-MF certified apartments are performing as intended and how residents are satisfied with their living conditions since the GBCS-MF aims to provide residents with pleasant and environmentally-friendly living environments. Lee and Yeom (2009) selected one GBCS-MF certified apartment complex and investigated resident satisfaction. Residents showed higher satisfaction levels in the Ecological Environmental category compared to others; however, the Energy and Indoor Environmental Quality categories showed lower levels of residential satisfaction. According to Kwon et al. (2011), the GBCS-MF certified apartment complexes' scores by professionals and levels of resident satisfaction are different from each other. For example, one GBCS-MF certified apartment complex gained high scores in the Land development and Transportation categories, but levels of resident satisfaction are low in both categories. Kwon and colleagues (2011) pointed out the GBCS-MF needs to have more intricate evaluation criteria and methods than accurately reflect residents' needs.

These research studies show that evaluation criteria of the GBCS-MF are limited in that they rely on a quantitative analysis of building systems and features without investigating the impact on building occupants. However, there were limitations on previous studies. None of these studies used the GBCS-MF score cards since the GBCS-MF score cards are not accessible to the public or to most researchers. The use of the GBCS-MF score cards is important to find the relationship between intended/designed building features and resident perceptions of those features. GBCS-MF criteria score cards are provided by professionals and do not include resident perceptions. Through comparisons of the GBCS-MF score cards and residents' perceptions of building features of the GBCS-MF criteria, my study will find the differences between them and provide suggestions for modifications to the evaluation system.

2.9. Summary

Overall, research on building environmental assessment systems has undergone a great development for the past decades as sustainability became an important priority in the field of architecture. However, most studies focus on only a few worldly renowned building environmental assessment systems such as LEED and BREEAM. Since many different versions of environmental building assessment systems are developed and utilized in different parts of the world, there is a call for more research on such systems. Among them, there exists the GBCS-MF, which is the focus of this study. Most importantly, most of current systems, including the GBCS-MF, lack user feedback between their designed features and performed features. It is important to note that a tailored and well developed approach is needed for more rigorous research and more effective interventions on the building environmental assessment systems. The following section will demonstrate the methodological choices and theoretical grounding of this study.

CHAPTER III

METHODOLOGY

In this chapter, I intend to describe the methods and theoretical frameworks of my study about relationships between the GBCS-MF scores and post occupancy evaluation by residents. Based upon resident survey and focus group approaches, my research tries to delve into how scores measured by professionals accurately reflect building features perceived by residents. To analyze my research data, different statistical tools will be used including descriptive statistics and correlation analysis. The methodological triangulation of using various data collection methods will increase the credibility and validity of my research results by looking into the situation from multidimensional viewpoints. The research results from this analysis will inform future developments in the current GBCS-MF will be pursued.

3.1. Conceptual Framework

The following diagram depicts a conceptual model of the structure of this study. It describes the relationship between design practitioner and building occupant, and its resulting impacts for modifying the certification.

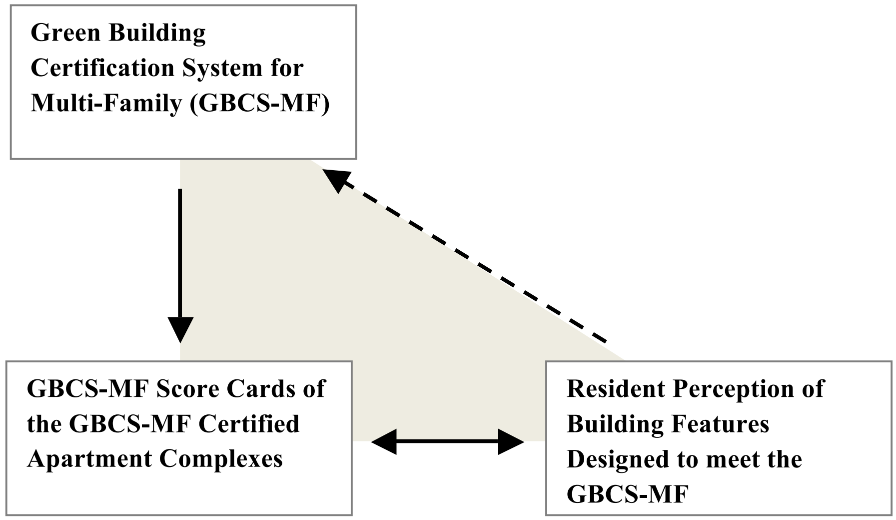


Figure 4 Study Diagram

3.2. Research Questions and Aims

This study addresses how residents evaluate/rate the GBCS-MF features. Furthermore, I will investigate the relationships between residents' ratings and the professionals' scores on the GBCS-MF features. What are the characteristics of such relationships? How adequately does the GBCS-MF reflect residents' perceptions? What are the implications of residents' perceptions on the GBCS-MF features for improving the system?

More detailed research questions and hypothesis for this research can be found below.

- Question 1.

  How do residents evaluate/rate the GBCS-MF features?

- Sub-question 1-1.

  How adequately does the GBCS-MF reflect resident perceptions?

- Sub-question 1-2.

  What are the implications of resident perceptions on the GBCS-MF features for improving the system?

- Question 2.

  What are the perceptions of design professionals regarding GBCS-MF criteria and their impact on residents?

Based on these questions, the following hypotheses were generated:

- Hypothesis 1a.

  There are differences between the presence of GBCS-MF features and resident perceptions of those features.

- Hypothesis 1b.

  There are differences between the presence of GBCS-MF features and resident perceptions of the overall environment.

- Hypothesis 2.

  There are differences between the expectations of professionals and resident ratings on GBCS-MF features.

In order to answer these questions and address these hypotheses, the following aims were identified: (1) to develop a set of tailored and comprehensive measurement tools that capture resident perceptions of building features related to the GBCS-MF criteria, using a resident survey and focus group; (2) to examine if there are differences between the present of the GBCS-Mf features and resident perception of those features; (3) to investigate if there are differences between the presence of GBCS-MF features and resident perception of the overall environment; (4) to examine if there are differences between the expectations of professionals and resident ratings on GBCS-MF features; (5) to identify the relationships between the expectations of professionals and resident ratings on GBCS-MF features. Individual survey questions for residents and focus groups are provided in the appendix x.

3.3. Research Design

3.3.1. Study Settings and Population

This study was carried out in South Korea. According to Statistics Korea, Korea had an estimated population of 50,004,000 in 2012 (http://kostat.go.kr/). The population density of Seoul is 16,587 per square kilometer. Almost 48.3% of the total population of South Korea lives in Seoul, which makes the capital city the largest metropolis of the nation. Due to the higher population density, multi-family residential buildings are one of the most typical living environments in Seoul. In 2011, the total number of multi-family residential housing units was 8,587,000. More than 47%of Koreans live in this type of building. Since 2010, the number of people per household has been decreasing every year. Four people per household accounts for 22.5 % of households, 24.3% have two people per household, and 29.3% have a one person household (http://www.index.go.kr/). As the number of multi-family housing units increases, the Korean government is trying to promote more green apartments which decrease the environmental impacts from these buildings. Accordingly, the Korean government and people's interest in the GBCS-MF has been continuously growing.

3.3.2. Data Collection

3.3.2.1. Score Cards of the GBCS-MF Certified Projects

I gathered 41 score cards from several construction and design companies. Since GBCS-MF score cards are not publicly available, it is difficult to obtain them. In my case, some internal personnel helped me. Initially, I requested copies of score cards from about 20 companies and organizations. Most of them denied my requests, but I finally collected 41 GBCS-MF score cards from three construction and two design companies. Company names were removed to protect their privacy. The GBCS-MF criteria are translated from Korean to English in Appendix 3.

3.3.2.2. Resident Surveys

A pilot study was conducted using a convenience sample of residents from ten apartment complexes. This pilot study helped determine whether or not the survey questionnaire needed to be improved. After the pilot study, I conducted a formal survey to investigate the residents' perception of building features designed to meet the GBCS-

MF criteria in the chosen 41 GBCS-MF complexes. Approximately 400 subjects participated in the study.

3.3.2.3. Focus Groups

The results of the survey served as the basis for the interviews of design and construction professionals, and residents. Due to their effectiveness as a research tool, I used several focus groups consisting of the GBCS-MF related professionals and residents. Focus groups are a series of discussions based on a specific topic of interest. Each group typically consists of seven to ten participants and is moderated by one or two skilled interviewers. As a qualitative method, focus groups can generate a rich understanding of people's perceptions and behaviors (Zeisel, 2006). According to Merton and Kendall (1946), "the focused interview can perhaps be the best summarized by indicating how such qualitative materials have been integrated with quantitative data" (p.557). This study addressed two types of focus groups as below:

- Professional focus groups: A total of six groups, consisting of 25 professionals from construction and design companies, were sought out, and they answered a group of open-ended questions related to the GBCS-MF criteria (19 out of 44).
- Resident focus groups: Six groups of residents from the survey participants volunteered to focus groups. I encouraged a total of 30 residents to provide reasons for each rating and share their opinions on the features of the GBCS-MF apartment.

As a facilitator of focus groups, I gave my interviewees a brief description of this study. I first explained why it is important for the respondent to respond fully and thoughtfully to my questions. I also tried to create a permissive environment that nurtures different points of view without pressure and encourage group members to respond to one another's ideas and comments. While interviewing, I took notes during each session that was simultaneously shared with the participants. A laptop and an overhead projector were used to show computer typed notes to the participants. This method helped me collect data based on what participants said. See Appendices 5 and 6 for the focus group questions.

3.3.3. Study Variables and Data Sources

3.3.3.1. Score Cards

The following Table 5 is a summary of 41 collected GBCS-MF score cards. Only one apartment complex achieved Green I certification, 20 complexes are Green II, and other 20 complexes are Green III.

Table 5 Summary of 41 Collected GBCS-MF Score Cards

GBCS-MF Category (Points)	Certification Level (# of projects)							
	Green I (1)		Green II (20)		Green III (20)		Average (41)	
	Mean of Gained points (M)	(M/P) *100%	Mean of Gained points (M)	(M/P) *100%	Mean of Gained points (M)	(M/P) *100%	Mean of Gained points (M)	(M/P) *100%
LD(22)	15	68.2	10.9	49.6	9.5	43.2	10.3	46.9
T(8)	7.6	95	6.6	82.5	6.8	85.2	6.7	84.1
E(15)	9.6	64	9.1	60.7	8.7	58.1	8.9	59.5
MR(23)	7.4	32.2	8.9	38.5	7.5	32.8	8.2	35.6
WE(13)	11	84.6	7.0	54.0	6.3	48.9	6.8	52.2
A(3)	1.37	45.7	2.1	71.6	1.9	63.9	2.0	67.2
M(7)	7	100	7.0	99.6	6.6	94.7	6.8	97.2
EE(18)	11.7	64.8	7.2	40.0	6.8	37.7	7.1	39.5
IEQ(27)	14.5	53.7	15.4	57.2	13.8	51.1	14.6	54.1
Total (136)	85.1	62.6	74.3	54.6	68.1	50.1	71.5	52.6

3.3.3.2. Resident Survey

Prior to gathering data, I obtained permission from the Institutional Review Board at Texas A&M University. To investigate residents' perception of building features designed to meet the GBCS-MF, survey items for a questionnaire were developed from the GBCS-MF criteria. In the process of making the questionnaire, some items were excluded from the GBCS-MF criteria because those items only applied to professionals such as owners, contractors, planners, and designers of the selected apartment complexes. A total of 25 out of 44 evaluation criteria were used to establish residents' perception of building features in the GBCS-MF. The study variables are described in Table 6. To help participating residents better understand my questionnaire, some of its technical terms were translated into layman's terms.

Table 6 Study Variables and Data Sources

Type	Categories	Variables	Sources
Independent Variables	GBCS-MF Scores	Score cards of the GBCS-MF certified projects	Construction Companies and Design Companies
Dependent Variables	Resident Perception	1.4.1 Provision of Community Center and/or Facilities	Resident Surveys
		1.4.2 Creation of Walkways in Apartment Complexes	
		1.4.3. Connection of On-Site Walkways to Outside Walkways	
		2.1.1 Accessibility to Public Transportation	
		2.1.2 Installation of Bicycle Racks and Paths in the Apartment Complex	
		2.1.3 Installation of High-Speed Internet	
		2.1.4 Accessibility to City or Community Center	
		3.1.1 Annual Energy Consumption	
		3.2.1 Use of Alternative Energy Sources	
		4.2.1 Built-In Furniture and Storage Ratio per Unit	
		4.3.1 Installation of Recycling Containers	
		4.3.2 Installation of Food Waste Containers	
		5.1.1 Water Efficient Landscaping	
		5.2.1 Water Use Reduction	
		5.2.2 Installation of Stormwater Reuse Systems	
		7.3.1 Provision of an Occupant's Operations and Maintenance Manual	
		8.1.1 Consistent Green Space in the Complex and Connection to Local Green Space	
		8.1.2 Green Space Area Ratio	
		9.1.2 Increased Ventilation	
		9.2.1 Installation and Controllability of Thermal Systems	
		9.3.1 Noise between Floors	
		9.3.2 Noise between Walls	
		9.3.3 Noise from Outside the Apartment Complex	
		9.4.1 Daylight in Your Unit	
		9.5.1 Accessibility for the Disabled and Elderly	
Confounding	Personal Characteristics	Floor, Unit location, Length of stay Age, Gender, Home Ownership, Awareness of the GBCS-MF	Resident Surveys

3.3.3.3. Focus Groups

I included the following focus groups: professionals from construction companies and architects from design companies. I interviewed the focus groups about 19 environmental categories of the GBCS-MF. Additionally, resident focus groups were conducted after the resident survey. Residents were encouraged to provide reasons for each rating and share their opinions on the features of the GBCS-MF apartments.

3.3.4. Subject Recruitment

3.3.4.1. Resident Surveys

Forty-one apartment complexes have their own online community sites, and their contact information is available to the public. I started making initial contact by e-mailing representatives in apartment complexes whose score cards I had collected for this study. When they expressed interest in my study, I met with the representatives in the selected apartment complexes. I first explained the purpose of my research and asked him/her to invite residents to take part in resident survey. Initially, I sought approximately 200-300 subjects for this study, but due to large interest from participants, a total of 418 subjects participated in my study. The 41 apartment complexes represented in this survey include 23,467 residence units. If each unit has an average of 2.5 occupants, the represented pool was likely to be approximately 58,700. To be qualified, the resident respondent needed to: 1) be 20-75 years old; and 2) have lived in the apartment for at least 6 months. On average, the 5 point scale Likert survey took 20-30 minutes to complete. The survey had spaces for additional written comments, and some residents included remarks about related survey questions.

3.3.4.2. Focus Groups

When the apartment representatives allowed me to conduct the survey, I attended their regular resident meetings. As a survey administrator, I explained my study and distributed questionnaires to residents. Four out of nine apartment complexes participating in the survey volunteered to take part in the focus group interviews.

Each focus group interview was conducted separately in their apartment meeting room. When the subjects decided to participate in the focus group, they chose a time and place for an interview. Each focus group session took approximately 45-50 minutes and consisted of six to eight participants. For professionals, I made initial contact by e-mailing them. After they agreed to take part in my focus group interviews, I let them choose their preferred time and place. I took notes during each interview session. As a result, four groups participated in the professional focus group interviews. Each group had four to six professionals working for design and construction companies related to the GBCS-MF. In summary, the recruitment process was as follows:

- Professional focus groups: I invited professionals who worked (design and construction companies) for the GBCS-MF projects to discuss their opinions about the GBCS-MF system.
- Resident focus groups: I distributed a recruitment letter to residents after the resident survey.

3.3.5. Data Analysis

All the 41 collected GBCS-MF score cards and resident survey data were imported to SPSS statistical software V. 20.0. For data analysis, descriptive statistics, such as means, medians, standard deviations, variances, and ranges were computed for each variable. This method seized and depicted "a graphic picture" of some important aspects of the variables (Locke, Silverman, and Spirduso, 2004, p. 134). I used a regression model to assess the relationships between the GBCS-MF scores (independent variables) and residents' perceived ratings of the GBCS-MF criteria (dependent variables). The regression analysis is a useful statistical method for my research since it investigates relationships between a dependent variable and one or more independent variables (Ott and Longlecker, 2008).

Given this, I first investigated whether or not any relationship exists between the two variables by testing the hypothesis of statistical independence. For example, I tested a relationship between the score of the GBCS-MF 3.1.1 Annual energy consumption and residents' perceived ratings of this feature. Second, I studied the strength of their relationship using a measure of relationship called correlation.

To test my hypothesis, I calculated the correlation coefficient (Spearman correlation coefficient) between the GBCS-MF scores and the residents' perceived ratings of those features. The correlation coefficient (r) is a positive number if y increases as x increases and it means a positive relationship between x and y. If y decreases as x increases making the correlation coefficient (r) a negative number, we can say a negative relationship exists between x and y (Ott and Longlecker, 2008). For instance, if the correlation coefficient is 1, x and y are perfectly positively related. The study yielded results whether or not statistically significant correlations exist among variables.

Finally, I studied the form of the relationship between the variables, using the collected data. I estimated an equation that predicts a subject's score in the independent variable. An equation of this type predicts that the higher the GBCS-MF scores get, the higher the residents' perceived ratings get.

3.4. Mixed Research Methods

The diverse approaches I chose regarding relationships between the GBCS-MF scores and resident ratings of the GBCS-MF features try to investigate the effectiveness of the system by illuminating related resident perception from multiple aspects. As researchers note, a mixed-methods approach can build and confirm interpretations from various perspectives by combining surveys, interviews, and document analyses. According to O'Donoghue and Punch (2003), triangulation is significant as a "method of cross-checking data from multiple sources to search for regularities in the research data" (p. 78). Altrichter et al. (2008) also note that triangulation "gives a more detailed and balanced picture of the situation" (p. 147). My research data gathered on-site in Korea include resident surveys, focus group interviews, and interpretations of relevant documents such as the GBCS-MF criteria and its score cards. This diverse data will make more balanced the description and understanding of relationships between the major variables—the GBCS-MF criteria and residents.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter addresses the analysis process and main findings based on the focus group methods and questionnaires described in Chapter III. It is to establish an understanding of the data. Thus, the chapter identifies significant results, patterns, or focus from the primary research data I have collected to examine differences between the GBCS-MF scores and resident perception of the GBCS-MF features.

4.1. Data Analysis

4.1.1. Focus Groups

Six groups of residents were interviewed as focus groups (6-8 residents in each group), and another six professional focus groups (4-5 professionals in each group) participated in in-depth interviews. The resident focus groups provided reasons for each rating and shared their opinions on the features of the GBCS-MF apartment. In addition, the professional focus groups answered a group of open-ended questions related to the GBCS-MF criteria. How the focus group data were analyzed is as follows. Interview notes were transcribed, carefully reviewed, and coded as necessary. I put them into categories that were similar to the resident questionnaire items. The analysis of the data consists of categorizing and recombining the comments collected during the focus group interviews to examine differences between expectations of professionals and resident ratings on GBCS-MF features for the study. Individual responses in focus group interviews were sorted into each relevant GBCS-MF category. Piles were used to cluster similar extracts for analysis of qualitative data. Interpretation involves a development of a summary statement which is true of each extract or piece of text in the pile or group. Next, the comments from the resident focus groups were described after the statistic results of each criterion. It helps to understand resident views of features designed to meet the GBCS-MF criteria. The professional opinions on each category were included lastly. This process clearly shows between opinions of the residents and the professionals.

4.1.2. Questionnaire

In March and April, 2013, a convenience sample of nine GBCS-MF apartment complexes voluntarily participated in these surveys. From the nine apartment complexes, a total of 459 responses were returned. 417 of them were selected as valid ones, yielding a mean response rate of 5.1% and a range of 3.7% to 7.8% across the apartment complexes. 42 surveys were eliminated for data analysis from the original 459 surveys since a minimum of six months residency was one of the requirements for survey participation. Data for several key variables (floor, age group, gender, and home ownership) were available for the entire population and were used to investigate the non-response bias. No serious bias was found based on these variables. A few apartment complexes had low response rates, but they were retained in the analysis because their respondents were representative of the resident population. The survey results were analyzed using IBM SPSS Statistics version 20.0.

Validity and reliability of the resident questionnaire were tested using factor analysis and the Cronbach's alpha test. GBCS-MF scorecards were not tested because they are an officially authorized scoring system. Descriptive statistics were employed to analyze respondents' background information. In addition, Spearman's correlation coefficient analysis and the Independent-Samples T-test were used to find relationships between the GBCS-MF scores and resident perception ratings and to investigate differences in resident perceptions based on their awareness of the GBCS-MF.

4.1.2.1. Validity of the Resident Questionnaire

Factor analysis was conducted to understand the structure of a set of variables on the 25 questions. Factor analysis checks the validity of the questionnaire to find relationships between the variables measured (Field, 2009). In Table 7, Total Variance Explained, Components Q 1.4.1 to Q 9.5.1 were generated using SPSS 20.0. An initial analysis was conducted to obtain Eigenvalues for each component in the data. Five components had Eigenvalues over Kaiser's criterion of 1 and in combination explained 69.12 % of variance. Table 8 shows component matrix numbers, which are larger than .5 except Q 9.3.1. It is well above the acceptable limit of .5 (Field, 2009).

Table 7 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.510	46.040	46.040	11.510	46.040	46.040
2	1.925	7.701	53.741	1.925	7.701	53.741
3	1.441	5.764	59.505	1.441	5.764	59.505
4	1.314	5.258	64.763	1.314	5.258	64.763
5	1.090	4.361	69.124	1.090	4.361	69.124
6	.955	3.820	72.944			
7	.806	3.226	76.170			
8	.678	2.713	78.883			
9	.629	2.515	81.398			
10	.572	2.286	83.684			
11	.497	1.988	85.672			
12	.451	1.804	87.476			
13	.419	1.676	89.153			
14	.330	1.321	90.474			
15	.323	1.292	91.766			
16	.314	1.258	93.023			
17	.295	1.178	94.201			
18	.254	1.016	95.217			
19	.243	.973	96.191			
20	.216	.865	97.056			
21	.183	.730	97.786			
22	.165	.662	98.448			
23	.156	.624	99.072			
24	.126	.504	99.576			
25	.106	.424	100.000			

Extraction Method: Principal Component Analysis.

Table 8 Component Matrix

	Component				
	1	2	3	4	5
Q 1.4.1	.674	-.091	-.010	.546	-.174
Q 1.4.2	.699	.004	-.079	.556	-.090
Q 1.4.3	.691	.135	-.156	.408	-.092
Q 2.1.1	.664	.037	-.462	-.029	-.200
Q 2.1.2	.671	-.015	-.338	-.140	-.137
Q 2.1.3	.726	-.334	-.162	-.082	-.160
Q 2.1.4	.587	-.270	-.248	.020	-.301
Q 3.1.1	.698	.017	.313	-.165	-.266
Q 3.2.1	.628	.035	.520	.010	-.263
Q 4.2.1	.703	-.200	.249	-.032	-.020
Q 4.3.1	.807	-.179	-.107	-.108	.121
Q 4.3.2	.725	-.248	-.263	-.214	.168
Q 5.1.1	.751	-.026	-.229	-.337	-.056
Q 5.2.1	.759	.073	.228	-.079	-.193
Q 5.2.2	.746	-.012	.269	-.066	-.240
Q 7.3.1	.582	-.035	.470	-.079	.109
Q 8.1.1	.656	-.416	.095	.238	.429
Q 8.1.2	.686	-.330	.151	.159	.418
Q 9.1.2	.677	.122	-.119	-.041	.377
Q 9.2.1	.658	.023	.066	-.379	.064
Q 9.3.1	**.468**	**.691**	**.024**	**-.109**	**.111**
Q 9.3.2	.612	.649	-.084	.096	.063
Q 9.3.3	.653	.604	-.034	.117	.148
Q 9.4.1	.674	-.011	-.128	-.169	.063
Q 9.5.1	.687	.101	.102	-.077	.168

Extraction Method: Principal Component Analysis.
a. 5 components extracted.

4.1.2.2. Reliability of the Resident Questionnaire

Cronbach's alpha (α) was used for this study since it is “the most common measure of scale reliability” (Field, 2009, p.674). It is also one of the most commonly used analysis methods when you have multiple Likert questions in a survey or questionnaire that form a scale, and you wish to determine if the scale is reliable. From the survey questionnaire, we can see that Cronbach's alpha is 0.950, which indicates a high level of internal consistency for the response scale. This fact illustrates that all the items are positively contributing to the overall reliability.

Table 9 Reliability Statistics

Cronbach's Alpha	N of Items
.950	25

4.1.2.3. Spearman's Rank Order Correlation Analysis

After a series of tests on normality and homogeneity of variance, the data was determined to be non-parametric. For example, the GBCS-MF scores are not normally distributed due to limited score scales. For this research, the Spearman's Correlation analysis was employed to analyze the relationship between the GBCS-MF scores and resident perception ratings. According to Field (2009), Spearman's correlation coefficient is "a non-parametric statistics and so can be used when the data have violated parametric assumptions such as non-normally distributed data" (p.179).

4.1.2.4. Independent-Samples T-Test

The Independent-Samples T-Test was used to examine whether the awareness of the GBCS-MF affects resident perception ratings. This test is effective in "situations in which there are two experimental conditions and different participants have been used in each condition" (Field, 2009, p. 334). Accordingly, the t-test was effective in comparing perception ratings between two groups of residents: those with and without an awareness of the GBCS-MF.

4.2. Descriptive Statistics of Resident Background Information

Residents in the chosen apartment complexes represent various demographics in terms of age and socioeconomic status. The reported age groups of participants include the following: under 30 (20.4%), 31-40 (44.4%), 41-50 (15.6%), and above 50 (19.7%). The sample of raters consisted of 417 residents in the nine GBCS-MF certified apartment complexes (196 male and 221 female). Aside from age groups and gender, no demographic information about the raters was obtained. Other descriptive characteristics of the sample are in Table 10, including ownership.

Table 10 Descriptive Statistics of Participants from the Resident Survey

	Overall	
	n	%
Which floor do you live on?		
1-10	258	61.9
11-20	148	35.5
21-30	11	2.6
What age group are you in?		
Under 30	85	20.4
31-40	185	44.4
41-50	65	15.6
Above 50	82	19.7
What is your gender?		
Male	196	47.0
Female	221	53.0
Home ownership?		
Owned	262	62.8
Rented	155	37.2
Do you know if your apartment complex is certified by the GBCS-MF?		
Yes	114	27.3
No	303	72.7

Table 11 APT * GBCS-MF Cross-tabulation

		Do you know if your apartment complex is certified by the GBCS-MF?		Total
		Yes	No	
APT	A	10(18.5%)	44(81.5%)	54
	B	15(22.1%)	53(77.8%)	68
	C	11(26.2%)	31(73.8%)	42
	D	9(22.5%)	31(77.5%)	40
	E	14(34.1%)	27(65.9%)	41
	F	13(31.7%)	28(68.3%)	41
	G	13(35.1%)	24(64.9%)	37
	H	13(30.2%)	30(69.8%)	43
	I	16(31.4%)	35(68.6%)	51
Total		114(27.3%)	303(72.7%)	417(100.0%)

Table 11 shows the residents' awareness of each apartment's certification status. The residents in apartment complex G showed the highest awareness rate, 35.1%, while those in apartment complex A showed the lowest rate, 18.5%.

Two apartment complexes (F and I) among the nine surveyed complexes attached the GBCS-MF certification plates on their entrance walls (Figure 5). However, the GBCS-MF certification did not seem to attract much resident attention. In the resident focus group interviews, some residents reported that they did not have any awareness of the certification on the wall. One resident said, "I've never heard of the certification and seen before it. Where is it?" Those who have prior knowledge of the GBCS-MF certification learned about their apartment certification statuses from advertising brochures introducing the complexes.

Figure 5 GBCS-MF Certification Plates (D, F and I Apartment Complexes)

For the pooled sample, Tables 12and 13show differences in resident awareness of their apartments' GBCS-MF certification by gender and home ownership. Male (32.1%) and owned (35.9%) residents have a higher awareness of the GBCS-MF certified apartment compared to female (23.1%) and rented (12.9%) residents.

Table 12 Gender * GBCS-MF Cross-tabulation

		Do you know if your apartment complex certified by the GBCS-MF?		Total
		Yes	No	
Gender	Male	63(32.1%)	133(67.9%)	196(100.0%)
	Female	51(23.1%)	170(76.9%)	221(100.0%)
Total		114(27.3%)	303(72.7%)	417(100.0%)

Table 13 Home Ownership * GBCS-MF Cross-tabulation

		Do you know if your apartment complex certified by the GBCS-MF?		Total
		Yes	No	
Ownership	Owned	94(35.9%)	168(64.1%)	262(100.0%)
	Rented	20(12.9%)	135(87.1%)	155(100.0%)
Total		114(27.3%)	303(72.7%)	417(100.0%)

4.3. Analysis of Relationships between the GBCS-MF Criteria Scores and Resident Perception Ratings

All resident perception variables were measured on a 5-point Likert-type scale, covering the Land Development, Transportation, Energy, Materials and Resources, Water Efficiency, Maintenance, Ecological Environment, and Indoor Environmental Quality aspects. Some variables were captured by dichotomous measures (e.g., know or don't know and yes or no). In a survey, participants expressed their perception of the GBCS-MF features, running from excellent at rating 5 to poor at rating 1.

4.3.1. Land Development

A Spearman's Rank Order Correlation was run to determine relationships between the GBCS-MF scores and resident perception ratings. Table 14 shows that the GBCS-MF criteria 1.4.1, 1.4.2 and 1.4.3 in the Land Development category have no statistical significant correlation between the GBCS-MF scores and resident perception ratings. Spearman's rho correlation coefficients are -.053, -.013 and .026 at p-value = .01. This means there are differences between the GBCS-MF scores and resident perception ratings. In the following section I discuss important points about resident perception ratings and related residents' opinions as well as professionals' opinions regarding each GBCS-MF criterion. In the process, figures will show differences between residents' and professionals' obtained scores (%). Several criteria excluded from the resident questionnaire will be discussed with information obtained from professional focus group interviews.

Table 14 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Land Development Criteria Scores and Resident Perception Ratings

1. Land Development	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
1.4.1 Provision of Community Centers and/or Facilities	2.90	.829	-.053	.281
1.4.2 Creation of Walkways In Apartment Complex	3.15	.797	-.013	.790
1.4.3 Connection of On-Site Walkways to Outside Walkways	3.14	.787	.026	.602

**. Correlation is significant at the 0.01 level (2-tailed).

4. 3.1.1. Provision of Community Centers and/or Facilities

Figure 6 depicts differences between GBCS-MF 1.4.1 scores and means of the resident perception ratings (%). The GBCS-MF scores are high, but the resident perception ratings are low. The reason is that apartment complexes automatically get some points when they acquire a certain amount of space for community facilities in proportion to the number of units. When apartment complexes have a small number of units, community spaces may be limited. In other cases, residents agree that their community facilities are well planned and decorated. However, some of the apartment complexes require their residents to pay for using such facilities according to the resident focus group interviews. Due to this membership system, residents rarely use their facilities even though they are conveniently located. These community facilities are also related to accessibility of the disabled and the elderly. In some apartment complexes, their facilities are constructed with sunken entrances, making it difficult for them to enter (Figure 7). In this case, community center accessibility is very low because these people can access the building only through elevators from the underground parking lot.

Figure 6 GBCS-MF 1.4.1 COMMUNITY CENTERS Scores and Means of Resident Perception Ratings (%)

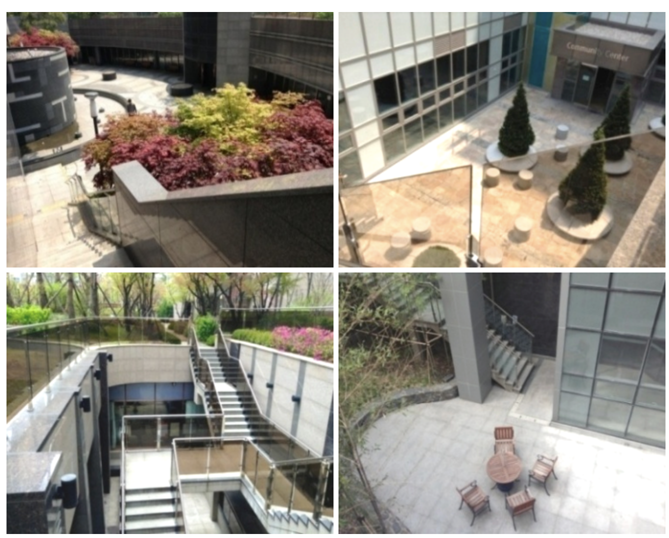


Figure 7 Sunken Community Centers (A, B, I and G Apartment Complexes, Clockwise)

4.3.1.2. Creation of Walkways

Figure 8 shows differences between the GBCS-MF 1.4.2 scores and means of resident perception ratings. For example, apartment complex A earned higher points, but resident perception ratings were the lowest. F and I apartment complexes earned lower scores but resident perceptions were high. According to the resident focus groups, the pedestrian roads are narrow, especially for operating baby carriages and wheelchairs. The residents are also not satisfied with their pedestrian road safety because of many vehicles operating in the complexes.

Figure 8 GBCS-MF 1.4.2 WALKWAYS Scores and Means of Resident Perception Ratings (%)

4.3.1.3. Connection of On-Site Walkways to Outside Walkways

In Figure 9, we can see differences between the GBCS-MF 1.4.3 scores and resident perception ratings on the nine apartment complexes. Interviewed residents mentioned that their complexes are gated communities; the connections between on-site walkways and outside walkways are not good. When they leave the complexes, they meet roads immediately or find pedestrian pathways inappropriate since all the roads in the complex connected to outside ones are designed for vehicles. The residents requested more pedestrian-friendly walkways from on-site to outside.

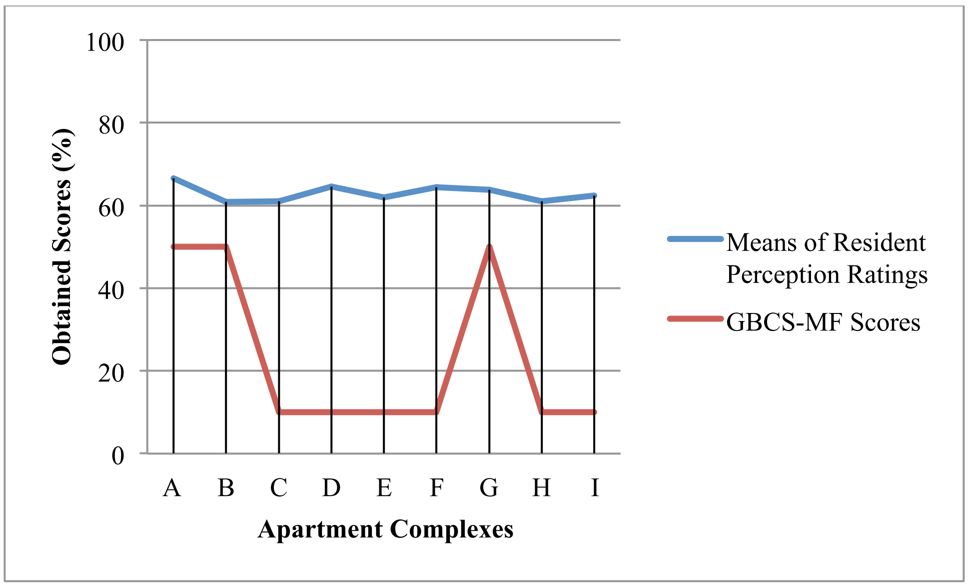


Figure 9 GBCS-MF 1.4.3 CONNECTION TO OUTSIDE WALKWAYS Scores and Means of Resident Perception Ratings (%)

As the figures in the Land Development category show, resident responses are relatively consistent, while the GBCS-MF scores of the buildings vary greatly. A new project in the city center or near the city center, with huge construction costs, will usually get more points on the Land Development criteria than a project in a non-city area with limited construction costs since the category usually evaluates site locations and distance from/to the city center. This may cause large variation in the GBCS-MF scores between projects. Also, this type of resident response is related to cultural attitudes. In Korea, house market value is extremely high. For example, many of the houses in the capital area cost a few million dollars, which is much higher than other similar countries' housing markets. This phenomenon is understandable considering Korea is a small peninsula with high population density. Koreans traditionally place their entire savings into houses. They think their house is the most valuable and expensive commodity (Kim & Jeong, 2013). According to Kang (2006), buying a home with a high resale value was one of the most important considerations for homeowners in the GBCS-MF certified apartment complex. When the homeowners decide to buy GBCS-MF apartments, they focus more economic benefits or values than the GBCS-MF green features installed in the certified apartments. In fact, most residents' awareness of the GBCS-MF is low. Rogelberg et al. (2001) surveyed residents' attitudes and found many "survey respondents were concerned about how the survey data were used, considered, or not used" (p. 22). It is assumed that the residents' attitudes toward their houses relate to resident perception ratings. Although they have some complaints about living in the GBCS-MF apartment complex, they may be concerned if their responses would negatively affect their housing values. These reasons may explain the phenomenon that there is relatively little variation in resident perception ratings.

4. 3.1.4. Professional Focus Group Response to Land Development Issues

I will add comments from the professional focus group interviews relating to the Land Development category and excluded criteria from the resident questionnaire since those items are only applied to professionals of the selected apartment complexes.

Professionals who participated in the focus group interviews commented that there are three methods to construct apartment complexes. 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 a cost for a site is very expensive, which is common in the Korean situation, GBCS-MF criteria other than the Land Development get less attention and investment.

The professionals commented that site issues relating to ecological value and preservation of existing recourses are important issues for the GBCS-MF, which aims sustainable development. They are trying to minimize any harmful physical or social factors resulted from new development. However, there are gaps between the GBCS-MF goals and new development in real situations. In addition, the evaluation criteria in GBCS-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 the benefits. Based on the comments of the interviewed professionals, it appears that the

GBCS-MF had very little influence on the Land Development category of the projects applying for certification.

4.3.2. Transportation

The transportation category is closely related to the site location. Once a site location is set, the transportation criteria obtain their allotted points. As Table 14 shows, the transportation criteria results are not statistically significant. In the following part, I present important points about resident perception ratings and related residents' opinions as well as professionals' opinions regarding each GBCS-MF Transportation criterion

Table 15 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Transportation Criteria Scores and Resident Perception Ratings

2. Transportation	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
2.1.1 Accessibility to Public Transportation	3.48	0.863	.014	.778
2.1.2 Installation of Bicycle Racks and Paths in The Apartment Complex	3.28	0.826	.006	.905
2.1.3 Installation of High-Speed Internet	3.62	0.824		
2.1.4 Accessibility to City or Community Center	3.42	0.906	-.037	.451

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.2.1. Accessibility to Public Transportation

In the focus group interviews, some residents commented that their apartment complexes are far from city bus stops or subway stations. This means that those complexes are not easily approachable by foot from nearby public transportation stations. The GBCS-MF 2.1.1criterion is evaluated by the straight line distance from the main entrance to the nearest public transportation. This criterion also gets points based upon kinds of available public transportation services. In this sense, the actual walking distance from the unit to public transportation is different from one from the main entrance. Figure 10 shows that differences between the GBCS-MF scores and resident perception ratings. For example, G apartment complex has no point on the GBCS-MF 2.1.1, but resident perception ratings are higher than other apartment complexes. Actually, one of the apartment complexes (B) was holding community meetings to submit to their county office requests to add more public transportation (Figure 11).

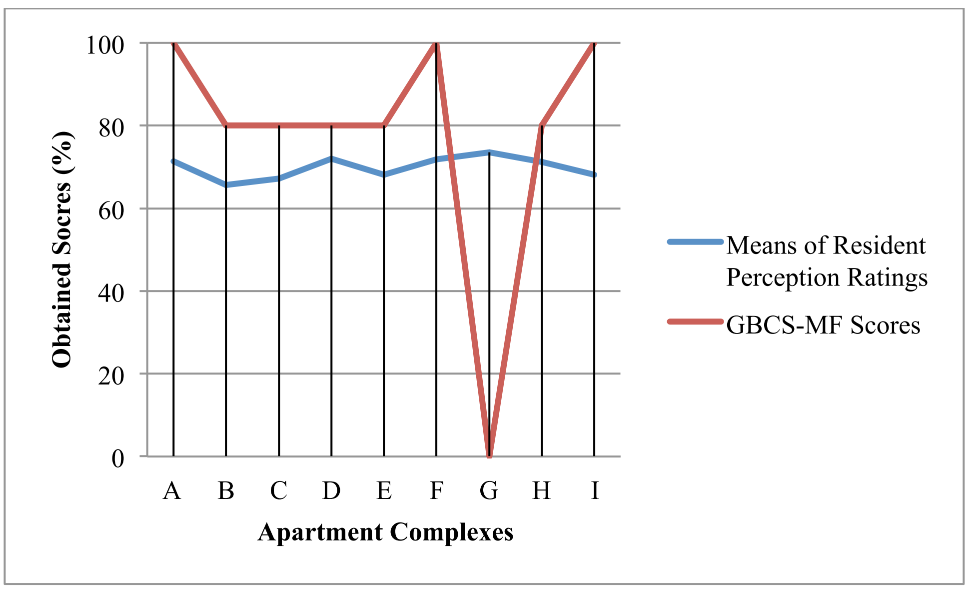


Figure 10 GBCS-MF 2.1.1 ACCESSIBILITY TO PUBLIC TRANSPORT Scores and Means of Resident Perception Ratings (%)

Figure 11 Flyers for Requesting Additional Public Transportation (B Complex)

4.3.2.2. Installation of Bicycle Racks and Paths in the Apartment Complex

The GBCS-MF 2.1.2 criterion does not show correlation between the GBCS-MF score and resident perception ratings (Figure 12). According to the focus groups, most residents felt that the bicycle roads are narrow and hard to use because of other pedestrians and vehicles. Other residents added that there are no planned bicycle roads though bicycle racks were installed. The criterion actually evaluates only the installation of bicycle racks and paths in the apartment complex and suggests the minimum width of the bicycle road. In other cases, bicycle racks are installed (Figure 13), but residents store their bikes in their units or emergency stairs areas due to lost or stolen issues (Figure 14).

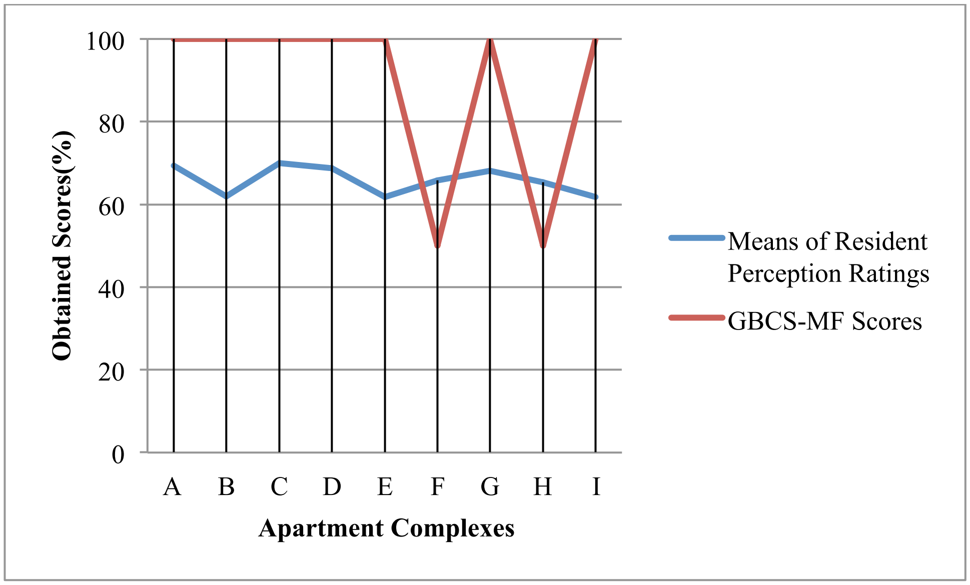


Figure 12 GBCS-MF 2.1.2 BICYCLE PATH & RACKS Scores and Means of Resident Perception Ratings (%)

Figure 13 Bicycle Racks (B, C, E, F and I Apartment Complexes, Clockwise)

Figure 14 Bicycle Stored in Places Other Than Designated Racks

4.3.2.3 Installation of High-Speed Internet

The criterion 2.1.3 covers the installation of high-speed Internet. In terms of the Internet, its infrastructure is installed during construction, but internet providers are chosen by residents through contracts with private companies. Figure 15 shows that the criterion is not related to resident perception. The internet speed results from an individual internet provider and different plans. Thus, this criterion does not play an important role in the environmental building assessment system.

Figure 15 GBCS-MF 2.1.3 INTERNET Scores and Means of Resident Perception Ratings (%)

4.3.2.4. Accessibility to City or Community Center

When a site is located in a city center, it provides good accessibility to the city or other community centers. On the other hand, apartment complexes located in city suburbs provide poor accessibility to different facilities or stores in the city center. Items 2.1.1 and 2.l.4 are closely connected to the site location. In Figure 16, resident perception ratings on the GBCS-MF 2.1.4 are 60-80%, while the GBCS-MF scores are 100%. This demonstrates a difference between resident perception ratings and the GBCS-MF scores.

Figure 16 GBCS-MF 2.1.4 ACCESSIBILITY TO CITY CENTER Scores and Means of Resident Perception Ratings (%)

4.3.2.5. Professional Focus Group Response to Transportation Issues

The professionals in the focus group interviews added that the Transportation category is closely related to the Land Development category, especially, site location. They commented that there are few ways to address the transportation category with design or construction. Some apartment complexes have commercial stores on their sites or are separated from the commercial spaces below (Figure 17).

Figure 17 Commercial Spaces Below (D, G and H Apartment Complexes)

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, bicycle and walking. Earning points in this category is easy for the surveyed complexes since most of them are located in the city center. However, resident perception ratings differ from the GBCS-MF evaluation criteria.

4.3.3. Energy

Most of the criteria in the Energy category focus on construction technology that makes the GBCS-MF project use energy more efficiently and reduce its carbon footprint. Table 14 summarizes the Energy category results from all 419 resident surveys. In addition to showing means and standard deviations of resident perception ratings for each criterion, Table 14 shows the correlation coefficient and p-value for each criterion. There is no relationship between scores of the GBCS-MF 3.1.1 Annual Energy Consumption and resident perception rating, $r = .049$, p-value (two-tailed) > 0.01.

Furthermore, for the GBCS-MF 3.2.1 Use of alternative energy sources, the Spearman test coefficient is about .013 at p-value = .848. There is no statistical significance.

Table 16 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Energy Criteria Scores and Resident Perception Ratings

3. Energy	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
3.1.1 Annual Energy Consumption	3.07	0.725	.049	.322
3.2.1 Use of Alternative Energy Sources	3.02	0.760	.013	.848

**. Correlation is significant at the 0.01 level (2-tailed).

4. 3.3.1.Annual Energy Consumption

Figure 18 depicts that the higher GBCS-MF scores are, the lower resident perception ratings are; there is a big difference between them. For example, apartment complex A achieved over 80% of the allocated 12 points, but the mean of the resident perception ratings is about 60%. On the other hand, apartment complex C earned less than 20% of the allocated points; the mean of resident perception rating is above 60%. The residents in the focus groups agreed that energy is the most important factor for the GBCS-MF. The criterion of 3.1.1 shows no significant statistical relationship between the GBCS-MF scores and the resident perception ratings. Most of the residents mentioned that they have found no difference in their utility fees since they started living in the GBCS-MF certified apartments.

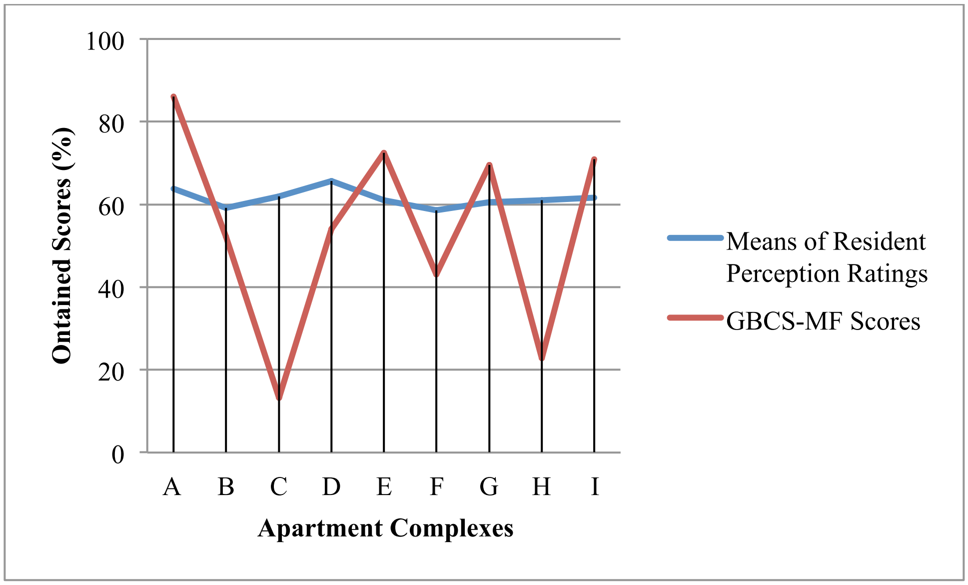


Figure 18 GBCS-MF 3.1.1 ENERGY CONSUMPTION Scores and Means of Resident Perception Ratings (%)

4.3.3.2. Use of Alternative Energy Sources

For the 3.2.1 criterion, 212 of 417 surveyed residents are aware of using alternative energy sources in their apartment complexes, such as geothermal and solar energy. Figure 19 shows that GBCS-MF scores are less than 50% of the potential allocated points. However, residents who have prior knowledge on the installation of alternative energy sources in their apartment complexes gave high perception ratings since they expect to reduce their utility fees by using them (Figure 20). However, during the focus groups interviews, some residents said that using alternative energy sources cannot help to reduce their utilities fees.

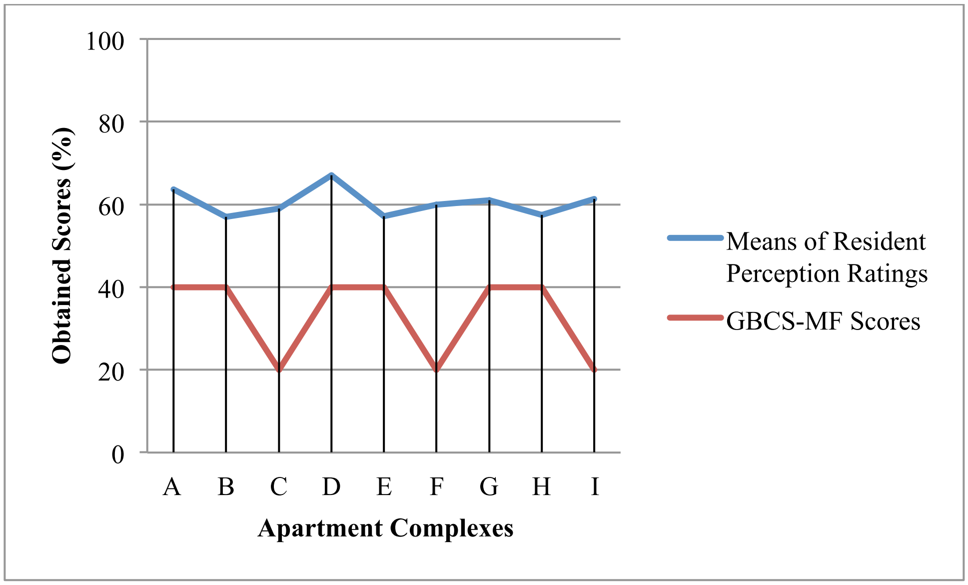


Figure 19 GBCS-MF 3.2.1 ALTERNATIVE ENERGY SOURCES Scores and Means of Resident Perception Ratings (%)

Figure 20 Alternative Energy Source Sign and Solar Panel System on the Roof (A and H Apartment Complexes)

4. 3.3.4.Professional Focus Group Response to Energy Issues

According to the interviewed professionals, designers focus on building insulation and windows to reduce total annual building energy consumption. Building insulation is an easy, cost effective method to help conserve energy in new residential construction. For better building insulation, they design buildings with regular floor plans because highly irregular floor plans increase costs and decrease the building energy efficiency. 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 requires the use of alternative energy sources when the apartment complex has over 500 units and more. Sometimes, apartment complexes with less than 500 units have no opportunity to get an alternative energy source since initial investment fees are expensive, making it less effective in a complex with a small number of unit. According to the professionals who participated in the focus group interviews, the GBCS-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 policy in 2030 (MLTM, 2010). With this reason, the Korean government actively regulates and governs numerous environmental building assessment systems such as GBCS, Housing Performance Certification System, Energy Star Buildings, and so on. However, the interviewed professionals mentioned that the existing systems are too varied, and their evaluation criteria are too differing from each other. They have struggled with this situation and spent enormous money to meet the government's requirements. In addition, they questioned the effectiveness of some existing systems. Most of the interviewed professionals agreed to developing one universal system for assessing buildings' environmental features.

4.3.4. Materials and Resources

The Materials and Resource category is one of the biggest allocated points in the GBCS-MF. It consists of 8 criteria, but the residents were surveyed about only three of them since the remaining criteria are about remodeling, not related to new developments, and they do not have knowledge on the construction process. The results show that most of projects received relatively low scores on each criterion. This may reflect that some criteria, such as reuse of structural and non-structural elements, do not relate to new developments being the least utilized criteria. Table 14 presents the mean and standard deviation of resident perception ratings, and correlation coefficient and p-value between the GBCS-MF scores and resident perception ratings on each criterion. There is no significant relationship between them.

Table 17 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Materials and Resources Criteria Scores and Resident Perception Ratings

4. Materials and Resources	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
4.2.1 Built-In Furniture and Storage Ratio per Unit	2.95	0.813	-.015	.761
4.3.1 Installation of Recycling Containers	3.26	0.815	.073	.174
4.3.2 Installation of Food Waste Containers	3.31	0.842	.051	.295

**. Correlation is significant at the 0.01 level (2-tailed).

4. 3.4.1 Built-in Furniture and Storage Ratio per Unit

There is no significant statistical correlation between the GBCS-MF 4.2.1 scores and resident perception ratings, r = -.015 at p-value < .01). Figure 21 shows that the residents' rating is high compared to the low GBCS-MF score. The interviewed residents said that they like the amount of built-in furniture and storage and think those are useful for saving space (Figure 22). However, some residents complained about locations and durability. Some storage is rarely used due to inappropriate door locations. In addition, the furniture and storage are made of fiberboard and particleboard. The residents argued that low quality materials are not durable or dependable. Sometimes the furnishings break apart or break down in some manner or another.

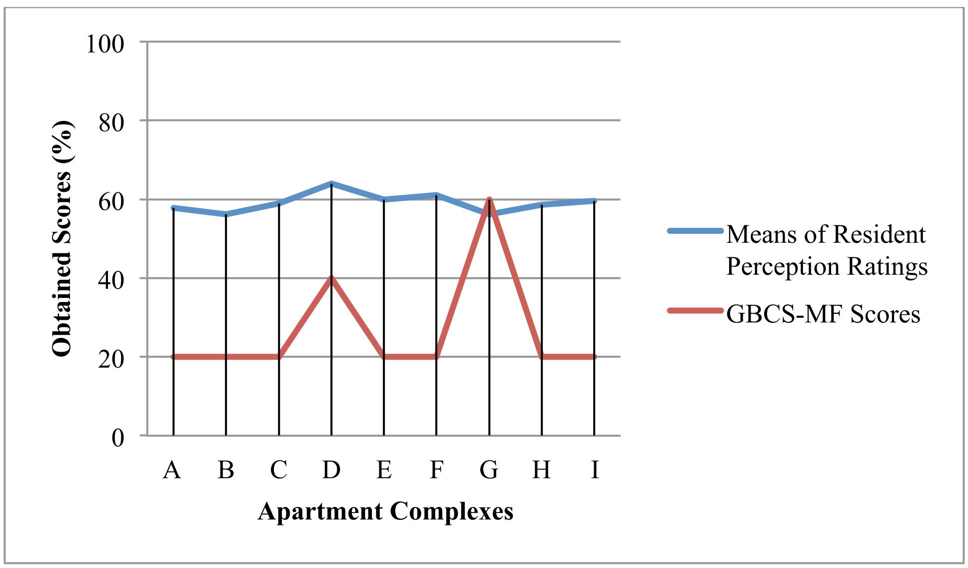


Figure 21 GBCS-MF 4.2.1 BUILT-IN FURNITURE & STORAGE Scores and Means of Resident Perception Ratings (%)

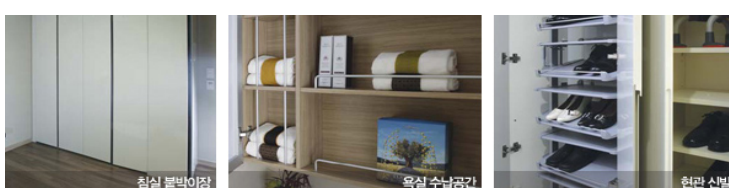


Figure 22 Built-in Furniture (F Apartment Complex)
(Source http://www.raemian.co.kr/sales/sub/twinpark/?menuSeq=1866)

4. 3.4.2. Installation of Recycling Containers and Food Waste Containers

There were no significant statistical relationships between GBCS-MF 4.3.1 and 4.3.2 scores and resident perception ratings, r = .073 and .051 at p-value < .01). Figures 23 and 24 show that there are differences between the resident perception ratings and the GBCS-MF scores. The interviewed residents commented that recycling containers and food waste containers are well installed in their apartment complexes (Figure 25). But they added that locations and types of containers are important to promote their use. In addition, they wanted their containers to be well-maintained without odor, especially in summer.

Figure 23 GBCS-MF 4.3.1 RECYCLING CONTAINERS Scores and Means of Resident Perception Ratings (%)

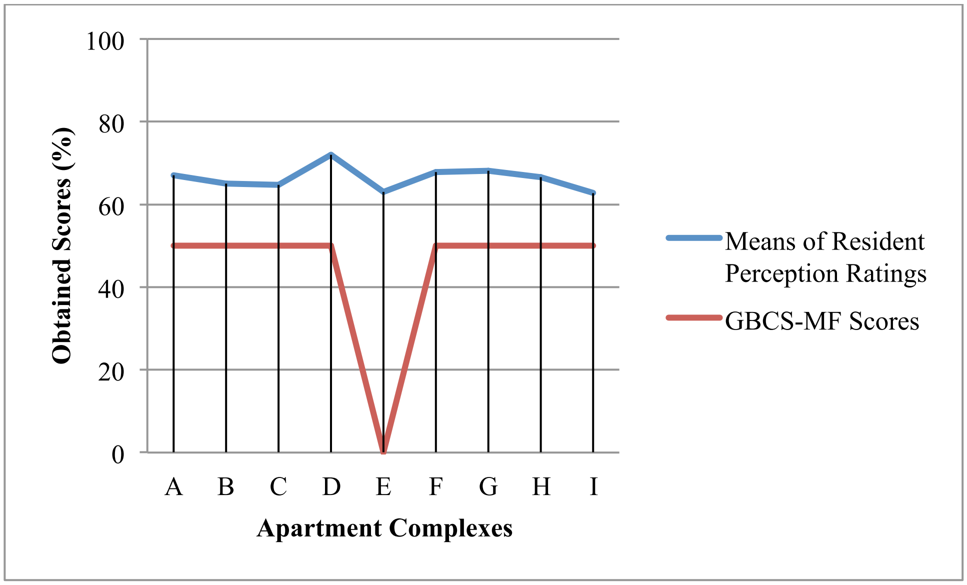


Figure 24 GBCS-MF 4.3.2 FOOD WASTE CONTAINERS Scores and Means of Resident Perception Ratings (%)

Figure 25 Recycling and Food Waste Containers in Nine Surveyed Apartment Complexes

4. 3.4.3. Professional Focus Group Response to Materials and Resources Issues

In this part, I will add additional comments from the professional focus groups about the Materials and Resource category. The GBCS-MF 4.1.1 Plans for Life Cycle Change relates to apartment structure rather than design. They try to design and build unit plans with flexibility and variability. For example, wall-structures were common until a few years ago, but column structures are more commonly used in recent years (Figure 26). In column structures, two rooms can be changed to one room with a removal of the wall between rooms. In addition, architects design typical floor plans without irregular space. These typical floor plans improve building energy efficiency and heat insulation by reducing energy loss from irregular plans.

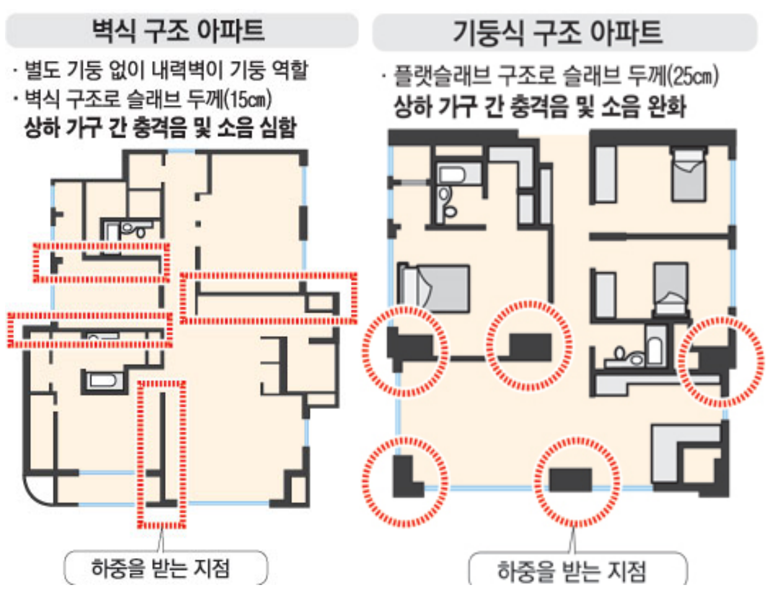


Figure 26 Wall Structure and Column Structure Apartment Plans (Source: http://news.mk.co.kr/newsRead.php?year=2013&no=464568)

In the interviews, the professionals also shared their opinions on GBCS-MF 4.1.2 Application of Environmentally Friendly Construction Methods. One professional noted that this criterion has a problem. Contractors usually submit their work plans before construction on site and earn related GBCS-MF scores. However, there is no way to check whether or not their construction methods are environmentally friendly during the construction processes. It causes complaints from neighbors about noise and dust. He added that GBCS-MF needs more thorough regulation and detailed evaluation methods such as monitoring during the construction process.

In the focus group interviews, one professional commented that many Koreans do not prefer built-in furniture. Traditionally, they want to install their own furniture according to their preferences. However, built-in furniture in apartment units are usually designed and installed by apartment contractors, not reflecting user preferences. Other interviewed professionals added that installation of the built-in furniture in resident units have both advantages and disadvantages. They stated some residents complain their rooms are too narrow because of built-in furniture, while others complain that there is not enough storage without built-in furniture. The professionals questioned how much furniture is appropriate for residents' needs while reducing their cost.

Additionally, the professionals mentioned in the interviews that use of recycled-content materials have constraints during construction. For example, they have a limited choice of recycled-content materials since the government designated recycled-content materials and the materials are much more expensive than brand new ones. In addition, residents prefer using new materials to using recycled-content materials. There is a large difference between the GBCS-MF evaluation criteria and resident perspectives. The professionals think that in reality it is uneconomical and difficult to follow these criteria. The GBCS has set ideal goals and tried to evaluate them. The professionals also mentioned that it is allowed to reuse structural elements and non-structural elements when remodeling and renovations, but this feature is meaningless because there have not been any remodeling cases since the GBCS-MF has started. In the focus group interviews, one professional explained a possible reason for this difference. He mentioned that there is a difference between the GBCS-MF scores and the resident perception ratings since the GBCS-MF scores were evaluated based on efficiency of recycling and food waste containers, but residents evaluate the containers' easiness to use. Most of these professionals seem to believe that the GBCS-MF does have a few limitations due to differing views.

4.3.5. Water Efficiency

This section discusses some important points about resident perception ratings and related residents' opinions as well as professionals' opinions regarding water efficiency by pointing out each criterion in this category.

Table 18 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Water Efficiency Criteria Scores and Resident Perception Ratings

5. Water Efficiency	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
5.1.1 Water Efficient Landscaping	3.26	0.840	.108	.100
5.2.1 Water Use Reduction	3.11	0.740	.068	.307
5.2.2 Installation of Storm Water Reuse Systems	3.09	0.720	-.057	.416

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.5.1. Water Efficient Landscaping

Based on responses of 232 out of 417 residents, who are aware of water efficient landscaping, there was no statistically significant relationship between GBCS-MF 5.1.1 scores and resident perception ratings, r_s (232) = .108 with p-value = .100. However, Figure 27 shows large differences between the GBCS-MF 5.1.1 scores and resident perception ratings. Some residents provided some additional comments. According to them, installed irrigation systems are working well, but some corners in their complexes receive less attention and are often wet. Others said they want more improvement in irrigation design.

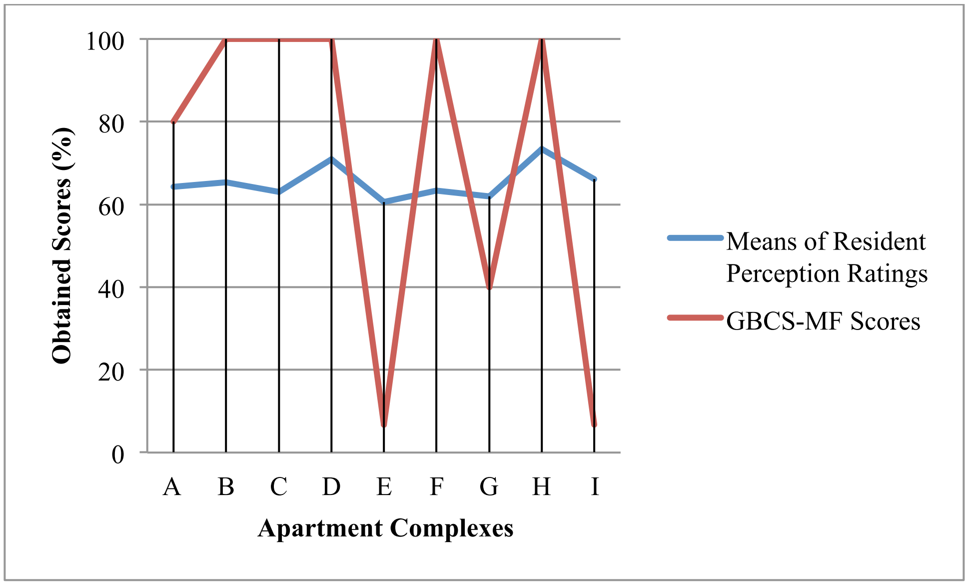


Figure 27 GBCS-MF 5.1.1 WATER EFFICIENT LANDSCAPING Scores and Means of Resident Perception Ratings (%)

4.3.5.2. Water Use Reduction

Two-hundred and twenty-eight out of 417 surveyed residents are aware of the installation of water efficient fixtures such as low pressure water valves and sink foot pedal. There was no statistically significant relationship between the scores for GBCS-MF 5.2.1 Water Use Reduction and resident perception ratings were r_s (228) =.068 with an associated p-value = .307. However, Figure 28 depicts a discrepancy between the GBCS-MF 5.2.1 scores and resident perception ratings. The residents agreed that their water consumption amounts have decreased with the installation of water efficient fixtures such as low flush toilets, sink foot pedals (Figure 29) and low pressure water valves. However, the residents cannot find any decrease in their water use costs. In the interviews, some residents complained that the water efficient fixtures often reduce water pressure since those features maintain a minimum water pressure throughout the water distribution system. They indicated that the fixtures are often out of order causing much inconvenience.

Figure 28 GBCS-MF 5.2.1 WATER USE REDUCTION Scores and Means of Resident Perception Ratings (%)

Figure 29 Foot Pedal for Sink (B and F Apartment Complexes) (Source http://www.raemian.co.kr/)

4.3.5.3. Installation of Storm Water Reuse System

There was no statistical significant correlation between the GBCS-MF 5.2.2 scores and resident perception ratings, which was (r_s (203) = -.057, p-value = .416). This again shows that there is difference between what residents perceive and what the GBCS system evaluates. Figure 30 describes that the surveyed nine apartment complexes earned higher points on the GBCS-MF 5.2.2 Installation of Storm Water Reuse Systems criterion, but resident perception ratings are low compared to the GBCS-MF scores. The survey shows that most of residents are not aware of the fact that storm water reuse systems are installed in their apartment complexes. Meanwhile, some of the residents in the focus group interviews, who know this installation, do not prefer to use recycled water from these systems for their daily life. For this reason residents may be giving lower ratings on the GBCS-MF 5.2.2.

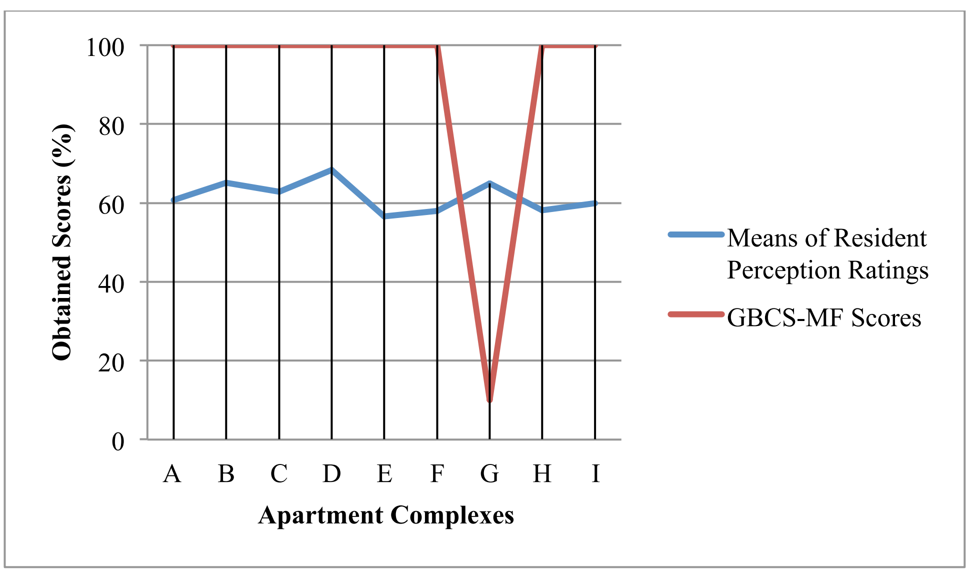


Figure 30 GBCS-MF 5.2.2 STORM WATER REUSE Scores and Means of Resident Perception Ratings (%)

However, other interviewed residents viewed recycling water from the public water supply for landscaping and sprinkling positively. They know it can help to reduce water demands and cost for landscaping in their complexes.

4.3.5.4 Professional Focus Group Response to Water Efficiency Issues

During the focus interviews, the professionals also shared opinions about this category. One professional noted that residents do not want recycled water 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 (1999), Korea water service prices are \$ 0.34 per/m^3, the cheapest among other OECD countries such as Denmark \$3.19/m^3 and Netherland \$3.16/m^3 (www.oecd.org). Operating costs of rainwater reuse systems are more expensive than water costs in Korea. For this reason, recycling water from the systems is usually used in landscaping and irrigating. 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 unpleasant odor. In this sense, the professionals added that the GBCS-MF can influence the design of projects when residents understand and are willing to promote its sustainable goals.

The interviewed professionals commented that the 5.1.1 criterion calculates the size of installed landscape irrigation systems rather than perforating performance and maintenance related issues.

4.3.6. Maintenance

This section examines major findings about resident perception ratings and related residents' opinions as well as professionals' opinions on the subject of the GBCS-MF Maintenance criteria.

Table 19 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Maintenance Criteria Scores and Resident Perception Ratings

7. Maintenance	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
7.3.1 Provision of an Occupant's Operations and Maintenance Manual	3.13	0.743	-.081	.187

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.6.1. Provision of an Occupant's Operations and Maintenance Manual

The results do not show any statistically significant relationships between the GBCS-MF 7.3.1 scores and resident perception ratings from those who have occupant operation and maintenance manuals (r_s (270) = -.081 and p-value = .187).Figure 31 shows a large difference between the GBCS-MF 7.3.1 and resident perception ratings. Contractors provide residents with manuals when they move to apartments, but residents cannot utilize them for several reasons. Two hundred and seventy out of 417 residents are aware of the occupant operations and maintenance manual. However, the interviewed residents who have manuals said that it is hard to find and understand a solution for malfunctions in their units. For this reason, one apartment complex attached a brief manual on frequently asked questions on each elevator so that their residents could easily find it (Figure 32). Another resident added that the manual is outdated and sometimes does not include any solution for problems. Instead, most interviewed residents find it easy to contact the maintenance office in their complexes and get repairs from them rather than use their manuals.

Figure 31 GBCS-MF 7.3.1 OCCUPANTS' MANUALS Scores and Means of Resident Perception Ratings (%)

Figure 32 Brief Repair Manual on the Elevator wall (G Apartment Complex)

4.3.6.2. Professional Focus Group Response to Maintenance Issues

In the focus group interview, one professional commented that submitting documents related to the GBCS-MF 7.1.1 Construction Waste Management and Reduction Planning is required to get points on this criterion. However, the GBCS-MF cannot check the amount of waste during the actual building construction process. In real situations, no one can guarantee if this criterion is properly implemented as stated in the documents.

The interviewed professionals commented that the GBCS-MF 7.2.1 Provision of a Building Manager's Manual or Binder is evaluated based upon submitted documents including the establishment of commissioning criteria. The professionals agreed that facilities managers and maintenance staff play important roles in effective operations and adequate maintenance of the GBCS-MF certified buildings. However, the GBCS-MF does not have any follow-up tests to check whether certified buildings are operated responsibly and maintained properly based on the provided manager's manual or binder.

When it comes to manuals, the professionals commented that they are provided to residents when they initially move to new apartments. Sometimes, residents have no opportunity to get manuals when they move to old ones. One professional noted that printed manuals should be changed to digital ones. Residents can access digital manuals with more ease whenever they want, while constructors can easily improve their manuals' contents. Mutual communication and continued training and support to building managers, management staff, and residents can help to keep all building systems functioning as designed to meet the GBCS-MF criteria.

4.3.7. Ecological Environment

This part focuses on some important points about resident perception ratings and related residents' opinions. It also covers professionals' opinions regarding each GBCS-MF Ecological Environment criterion.

Table 20 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Ecological Environment Criteria Scores and Resident Perception Ratings

8. Ecological Environment	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
8.1.1 Consistent Green Space in the Complex and Connection to Local Green Space	3.18	0.801	-.030	.546
8.1.2 Green Space Area Ratio	3.06	0.825	-.054	.270

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.7.1. Consistent Green Space in the Complex and Connection to Local Green Space

The results indicated no significant relationship between the GBCS-MF scores and resident perception ratings, (r = -.030 and -.054, p (two-tailed) < 0.01). Figure 33 illustrates differences between the GBCS-MF 8.1.1 scores and resident perception ratings. For example, apartment complex B earned no points on the GBCS-MF 8.1.1, but resident perception ratings were the highest among the nine surveyed apartment complexes. According to the resident focus group interviews, they have convenient connection paths with stairs from the complex to neighboring hills. Figure 34 (left side) describes this. However, apartment complex G achieved the highest points of the GBCS-MF 8.1.1 criterion among the complexes; the mean of resident perception ratings is rather low compared to others. The interviewed apartment G residents commented that they have good green pathways in the complex, but connections to outside greens are not convenient since there are fences around the apartment complex.

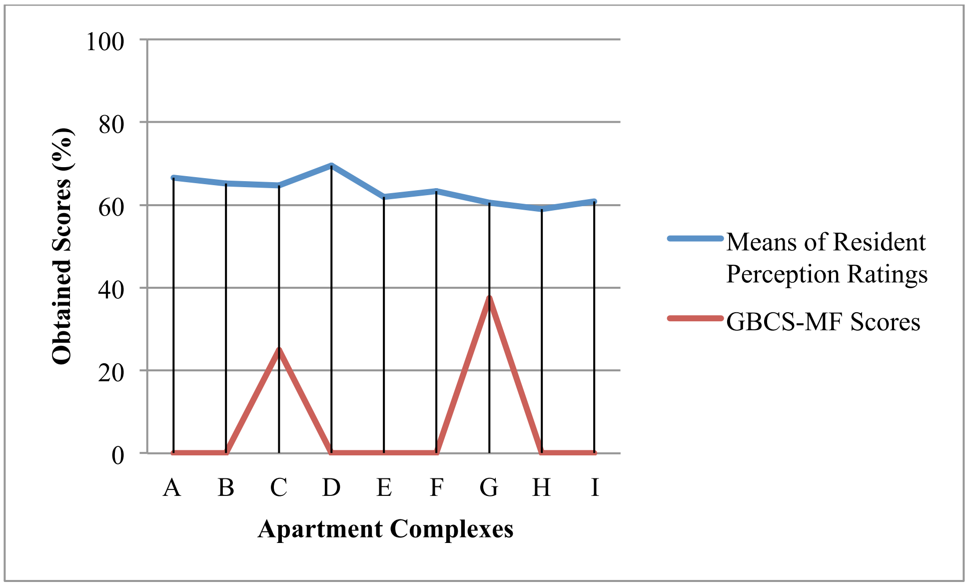


Figure 33 GBCS-MF 8.1.1 GREEN SPACE CONNECTION Scores and Means of Resident Perception Ratings (%)

Figure 34 Green Pathways from the Complexes to Local Green Space (B and G Apartment Complexes)

4.3.7.2. Green Space Area Ratio

In Figure 35, we can see a large difference between the GBCS-MF8.1.2 scores and resident perception ratings. For example, apartment complex F received five out of five points, but the resident perception ratings do not differ from other apartment complexes. From the interviews, the residents expressed their concern about maintenance issues rather than the size of the green space in their complexes. They added that careful planning is needed throughout the year since Korea has four seasons. In summer, there are issues related to insects, and in winter, cold weather can harm plants, making the designated green space look barren with no protection.

Figure 35 GBCS-MF 8.1.2 GREEN SPACE AREA Scores and Means of Resident Perception Ratings (%)

4.3.7.3. Professional Focus Group Response to Ecological Environment Issues

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 in achieving points on the GBCS-MF 8.1.1 than the latter. 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 on the GBCS-MF 8.2.1 and 8.2.2 Creation of Aquatic and Terrestrial Biotopes (Figure 36). Underground parking (Figure 37) 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.

Figure 36 Aquatic and Terrestrial Biotopes (H and I Apartment Complexes)

Figure 37 Underground Parking Lot (B Apartment Complex)

The professionals argued that for GBCS-MF 8.3.1 Topsoil Reuse, 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 dug topsoil in such constrained construction sites. This criterion promotes sustainable development but has limited practical purpose. Regarding environmental issues, the professionals agreed with the residents' opinions. But they argued that their starting points are different. Residents prioritize maintenance related issues, but designers and constructors are in favor of efficiency and cost. 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 improvements.

4.3.8. Indoor Environmental Quality

There are no significant relationships between the GBCS-MF scores and resident perception ratings in the Indoor Environmental Quality (Table 14). The following text adds more detailed information about this criterion based upon comments from the residents and professionals who participated in the focus group interviews.

Table 21 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Indoor Environmental Quality Criteria Scores and Resident Perception Ratings

9. Indoor Environmental Quality	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
9.1.2 Increased Ventilation	3.25	0.793	-.071	.150
9.2.1 Installation and Controllability of Thermal System	3.26	0.780	.010	.860
9.3.1 Noise between Floors	2.66	0.860	.084	.087
9.3.2 Noise between Walls	2.88	0.846	-.009	.849
9.3.3 Noise from Outside the Apartment Complex	2.89	0.832	-.010	.836
9.4.1 Daylight in Your Unit	3.43	0.815	-.012	.805
9.5.1 Accessibility for the Disabled and Elderly	2.92	0.771	.082	.096

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.8.1. Increased Ventilation

As demonstrated in Figure 38, most of the apartment complexes have no points on the GBCS-MF 9.1.2 Increased Ventilation criterion except apartment complex H. However, resident perception ratings are a little over 60% regardless of the GBCS-MF scores. In the interviews, residents mentioned that one ventilation fan in the kitchen is not enough to improve indoor air quality. In addition, some residents complained about the inappropriate sizes and locations of operable windows. Some apartment complexes have a limited number of operable windows. When the residents cook, the smell of food fills their units and moves to the hallway. In addition, the residents rarely operate the ventilation system in their units since they find it expensive and dislike the fan noise.

Figure 38 GBCS-MF 9.1.2 VENTILATION Scores and Means of Resident Perception Ratings (%)

4.3.8.2 Installation and Controllability of Thermal System

All apartment complexes achieved high scores on the GBCS-MF 9.2.1 Installation and Controllability of Thermal System. However, resident perception ratings are a little lower than the earned GBCS-MF scores (Figure 39). In the focus group interviews, the residents discussed advantages and disadvantages of the system. Many residents control humidity and ventilation systems as well as maintain a desired temperature using the systems. They feel discomfort since the systems are often out of order. Another disadvantage is that the system is too complex to use, especially for the elderly.

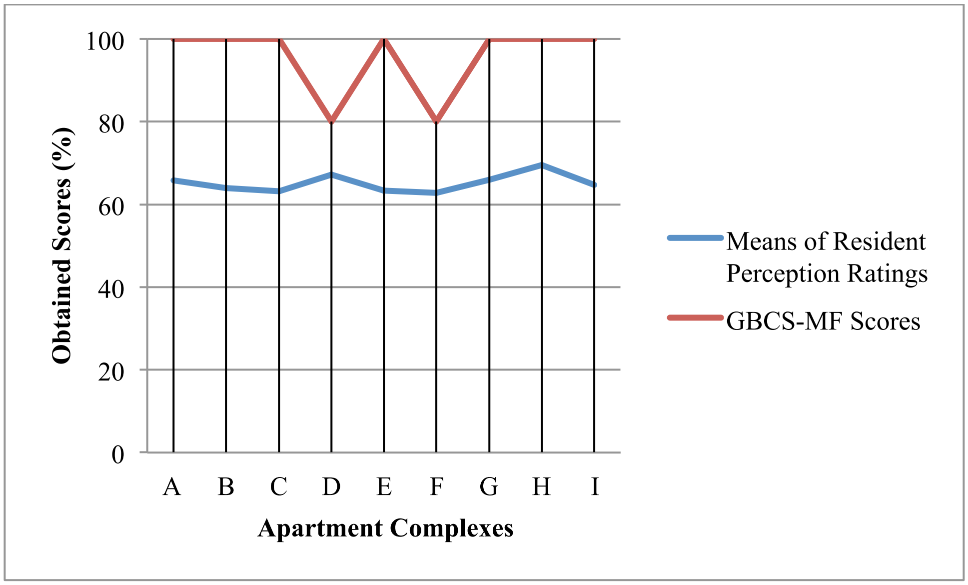


Figure 39 GBCS-MF 9.2.1 THERMAL CONTROL Scores and Means of Resident Perception Ratings (%)

4.3.8.3. Noise between Floors and Walls

For people living in apartments with numerous other residents in a single building, noise can be a huge problem. The results of this research indicate that all nine complexes received low scores on the GBS-MF 9.3.1 Noise between Floors. The resident perception ratings are the lowest among all the GBCS-MF criteria (Figure 40). Additionally, resident perception ratings of the GBCS-MF 9.3.2 Noise between Walls are low (Figure 41). Noise is the most frequent complaint by residents according to the resident focus group interviews. They often have noise complaints from their downstairs neighbors and express complaints to their upstairs neighbors. Several apartments attached notices on how to cut down or manage noise on the wall in public spaces (Figure 42). For example, wear socks or slippers to reduce noise and no dog barking after 10 pm and etc.

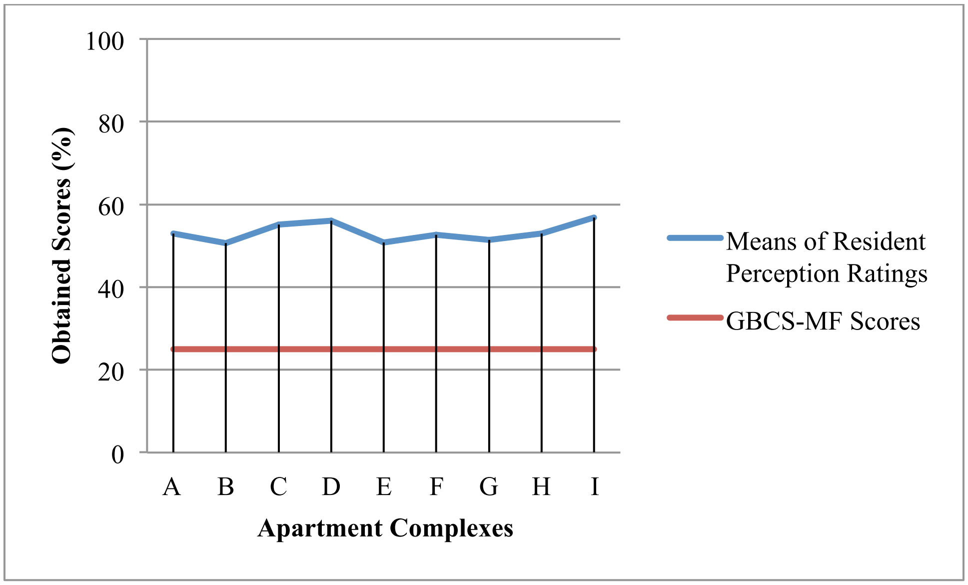


Figure 40 GBCS-MF 9.3.1 NOISE BETWEEN FLOORS Scores and Means of Resident Perception Ratings (%)

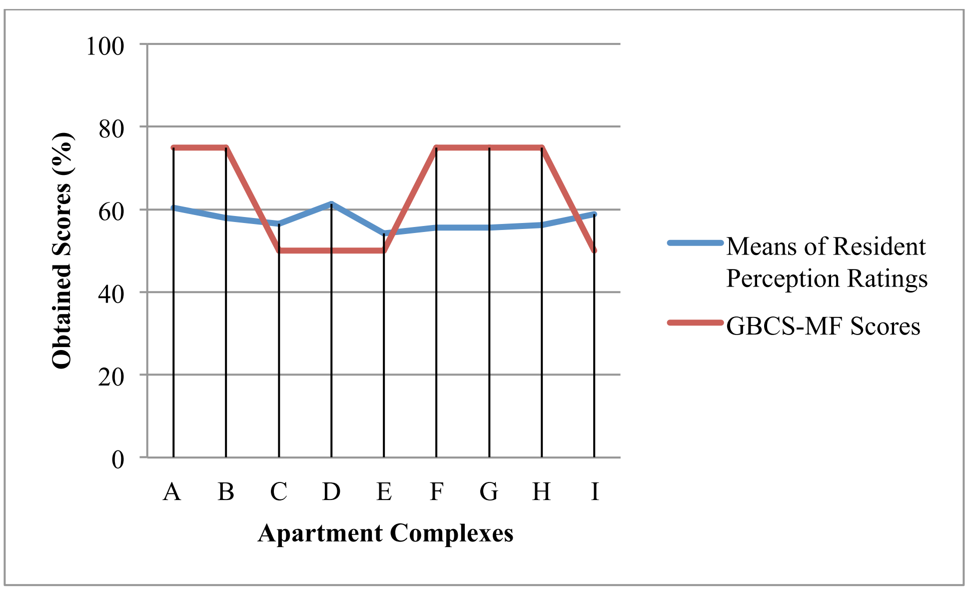


Figure 41 GBCS-MF 9.3.2 NOISE BETWEEN WALLS Scores and Means of Resident Perception Ratings (%)

Figure 42 Cut Down Noise (E and I Apartment Complexes)

4.3.8.4. Noise from Outside the Apartment Complex

Noise from outside the apartment complex also bothers residents. Figure 43 indicates that the resident perception ratings are low on the GBCS-MF 9.3.3 Noise from Outside the Apartment Complex. For example, for apartment complexes near roads, noise is common in the units. Residents living in such complexes are often disturbed by noise levels. One apartment complex submitted complaints to county administration due to excessive road noise (Figure 44).

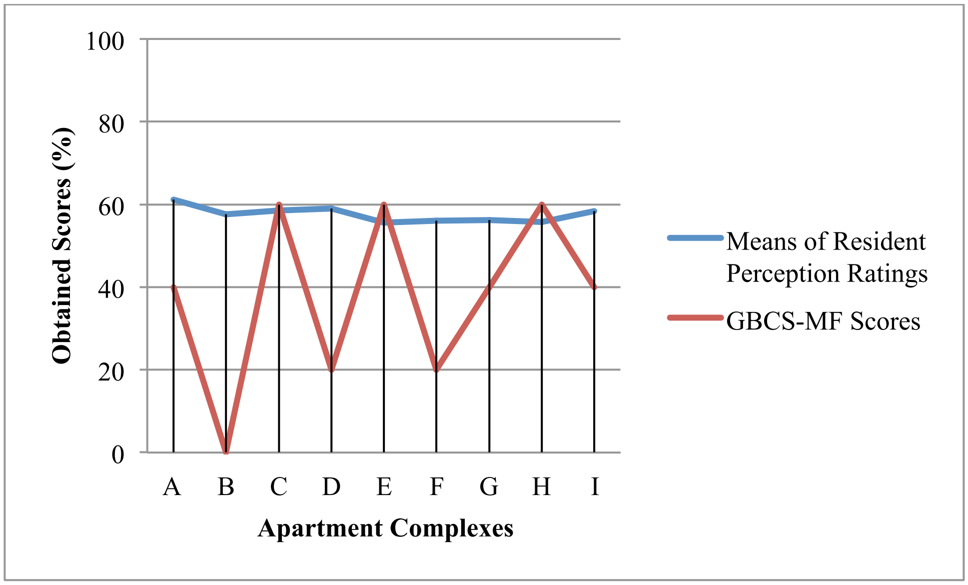


Figure 43 GBCS-MF 9.3.3 OUTSIDE NOISE Scores and Means of Resident Perception Ratings (%)

Figure 44 Noise Complaint Banner and Noise Wall (D Apartment Complex)

4.3.8.5. Daylight in Your Unit

The survey results indicate that the GBCS-MF scores are relatively low on criterion 9.4.1 compared to the resident perception ratings (Figure 45). Residents who live on higher floor levels are more satisfied with the amount of daylight in the unit than residents residing on lower stories.

Figure 45 GBCS-MF 9.4.1 DAYLIGHT Scores and Means of Resident Perception Ratings (%)

4.3.8.6. Accessibility for the Disabled and Elderly

Figure 46 depicts differences between the GBCS-MF scores and resident perception ratings. Most of the apartment complexes have no points in the GBCS-MF 9.5.1 Accessibility for the Disabled and Elderly. C and F complexes are exceptions, and the resident perception ratings are about 60%. The resident focus group interviews reveal that the reasons for these low ratings are narrow pathways for baby carriers, and wheelchairs, steep ramps, gravel pavement, sunken gardens, and similar problems. The elderly and disabled cannot access their desired destinations.

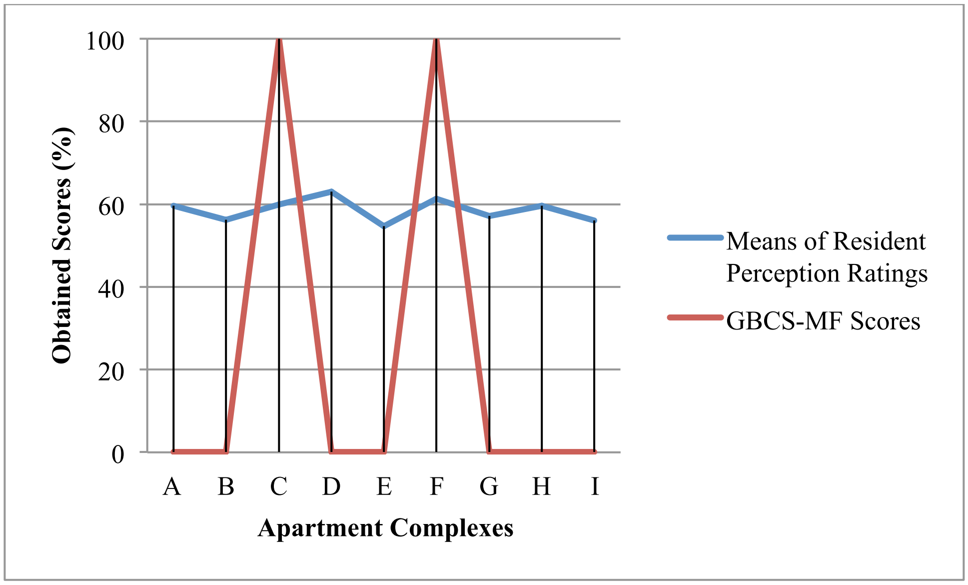


Figure 46 GBCS-MF 9.5.1 ASSESSIBILITY Scores and Means of Resident Perception Ratings (%)

Figure 47 Moving Walk and Map for Wheelchair Users (C Apartment Complex)

Apartment complex C achieved the highest points due to an installation of elevators, escalators and maps (Figure 47). From the interview, apartment complex C residents like these moving machines, but the operating costs concern them at the same time.

4.3.8.7. Professional Focus Group Response to Indoor Environmental Quality Issues

The professionals also expressed their opinions about IEQ 9.1.1 Use of Low-Emitting Materials. This criterion relates to indoor air quality by using non-toxic paints and adhesives in buildings' interiors. They mentioned 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 professionals suggested two factors regarding ventilation: an increased portion of fixed windows, and floor plan changes from square to rectangular configurations (Figure 48). They 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 give a 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 fixed windows for safety purposes according to Korean architectural regulations (MLTM 2012). For better air movement, many professionals are trying to develop new floor plans having more natural ventilation opportunities.

Figure 48 Floor Plan Changes from 1990 to 2010
(Source: http://biz.chosun.com/site/data/html_dir/2013/04/08/2013040801782.html)

The professionals commented that noise is a big disadvantage of living in apartments. They specify noise insulation materials in walls. The GBCS-MF 9.3.1 and 9.3.2 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 outside noise, 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. Regardless of these interventions, they are not fundamental solutions for outside noise and admit that there will continue to be complaints from residents.

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 49 illustrates a computer simulation provided by one of the interviewed professionals. The simulation predicts daylight availability in buildings at winter solstice. In Figure 49, the numbers associated with different colors mean hours of daylight from 8 AM to 17 PM. Yellow and orange colors around the complex mean one to two daylight hours in a building and other colors are three to nine daylight hours in a building. At least two daylight hours in a building is a minimum requirement to meet the GBCS-MF 9.4.1 criterion. Buildings on the lower site have a disadvantage in daylight hours compared to those on the upper site. Also, this criterion is very important to contractors since the amount of daylight affects apartment sales. During the interviews, the professionals also explained that after the simulation, designers sometimes 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 the density regulations.

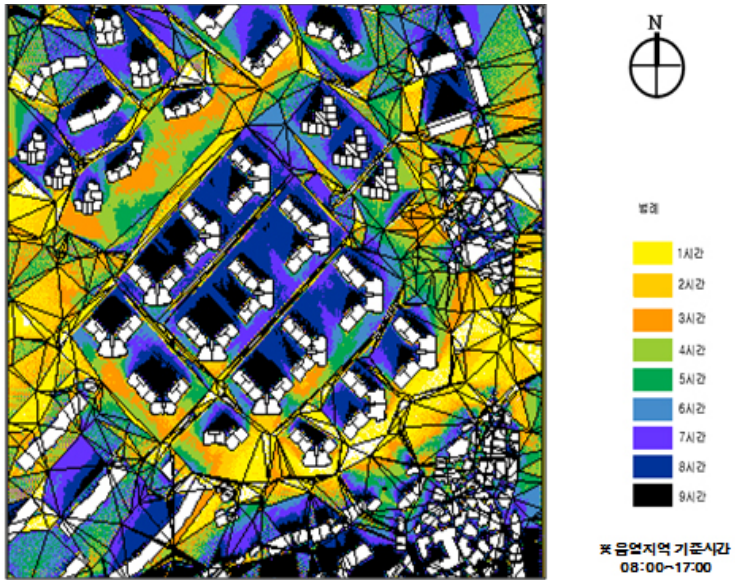


Figure 49 Daylight Simulation (B Apartment Complex)

The interviewed professionals also indicated that building core areas need to be expanded for a barrier free environment. Korea also has other certification systems for the barrier free design. They commented that one single system including universal evaluation criteria are needed to promote better accessibility for those.

4.3.9. Overall GBCS-MF Scores and Resident Perception Ratings

Finally, 25 out of 44 GBCS-MF scores and related resident perceptions ratings were used in combination to examine the relationships between them. The results are shown in Table 14. There is no statistically significance, Correlation Coefficient = .121, p = .167. However, Figure 50 shows differences between the presence of GBCS-MF features and resident perception of the overall environment. For example, apartment complex F shows the lowest resident perception ratings compared to the higher earned

GBCS-MF scores. In the focus group interviews, most residents said that they are not aware of any big difference in living in the GBCS-MF certified apartments versus non-certified apartment in terms of the quality of living environment and the utility costs. However, they expect higher resale.

Table 22 Descriptive Statistics for the Residents' Perception Variables and Correlation Coefficient, P-Value between the GBCS-MF Overall Criteria Scores and Resident Perception Ratings

GBCS-MF scores and resident perception ratings	Resident Perspective Rating Mean	Resident Perception Rating Std. Deviation	Spearman's rho Correlation Coefficient	Sig. (2-tailed)
Overall	78.03	13.210	.121	.167

**. Correlation is significant at the 0.01 level (2-tailed).

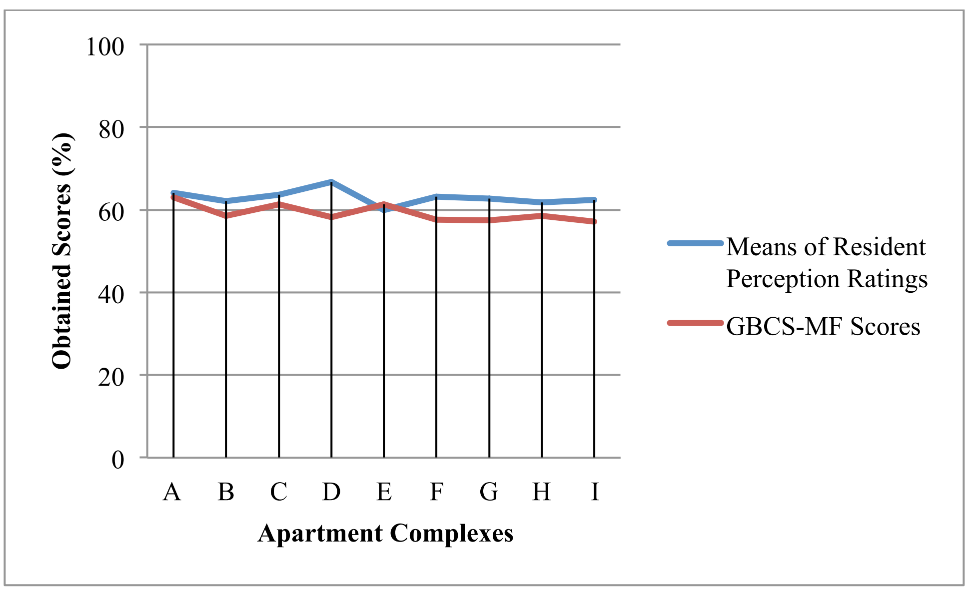
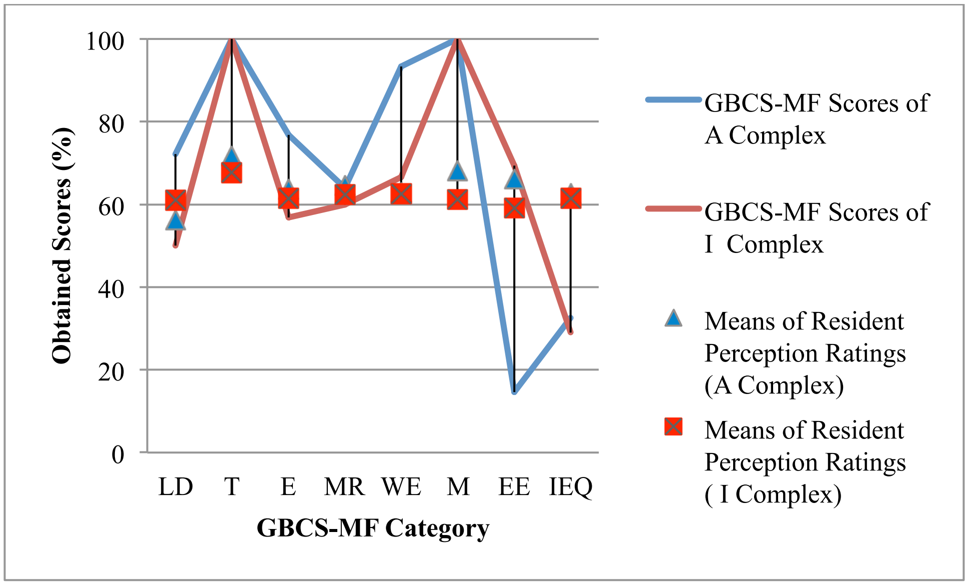


Figure 50 GBCS-MF Scores and Overall Resident Perception Ratings

4.3.10. Comparison of the Buildings with High and Low GBCS-MF Scores by Category

The following figures compare and contrast two complexes (A and I) regarding the GBCS-MF scores by category and means of resident perception ratings of the GBCS-MF category. Complex A achieved higher scores on all the GBCS-MF categories, except the Ecological Environment category, compared to Complex I. As we can see Figure 51, differences between the GBCS-MF scores are greater than the means of resident perception ratings. In the Land Development and Indoor Environmental Quality, resident perception ratings of Complex I are higher than Complex A. However, resident perception ratings between A and I complexes are almost the same as compared to large differences in their GBCS-MF scores; the medians of the resident perception ratings are all on nearly the same level. (Several outliers with small circles and stars are plotted above/below the whiskers.)The box plots below show distributions of resident perception ratings between the A and I complexes and the GBCS-MF categories. The box plots for Complex A and Complex I are similarly distributed except for the maintenance category. This suggests lack of consensus in resident perception ratings on maintenance between the two complexes. Maintenance is one of the few categories that is clearly visible to residents, and as various individuals provide maintenance, the delivery of this service could be uneven.



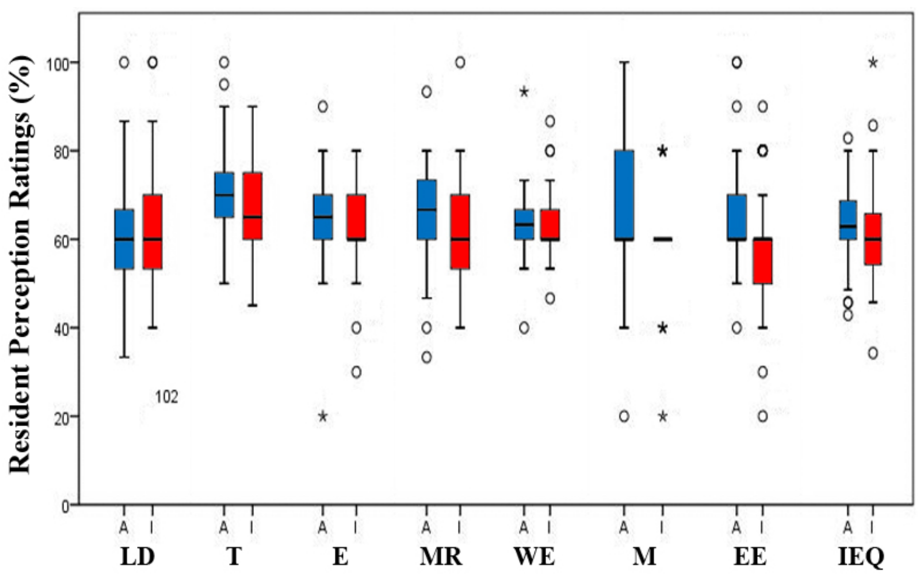


Figure 51 Comparison of A and I Complexes by the GBCS-MF Category

4.4. Differences between Resident Perception Ratings Based on an Awareness of the GBCS-MF

The following t-test results show that the resident awareness of the GBCS-MF does not greatly influence resident perception ratings of the GBCS-MF features. The residents rated differently only six out of 25 GBCS-MF criteria based on their awareness of the GBCS-MF. Also, overall resident perception ratings on the GBCS-MF features have a similar result: no difference between residents who are aware of the GBCS-MF and those who not. Therefore, the resident awareness of the GBCS-MF has a minor impact on their perception ratings on the GBCS-MF features in this study. Table 15 and 16 include the criteria that have statistically significant differences in perception ratings between residents who are aware of the GBCS-MF and those who are not. For the GBCS-MF 1.4.1 variable, the F value for Levene's test is 5.120 with a Sig. (p) value of .024 ($p < .05$). Since the Sig. value is less than our alpha of .05 ($p < .05$), we reject the null hypothesis (no difference) for the assumption of homogeneity of variance and conclude that there is a significant difference between the two groups' variances. That is, the assumption of homogeneity of variance is not met. If the assumption of homogeneity of variance is not met, we must use the data results associated with the "Equal variances not assumed" (Field, 2009, pp. 371-377). For this example of the GBCS-MF 1.4.1 (testing the difference based on the residents' awareness of the GBCS-MF), we reject the null hypothesis in support of the alternative hypothesis and conclude that residents' awareness of the GBCS-MF differed significantly on their GBCS-MF 1.4.1 perception ratings since the t value (3.548, which indicates that the second group was higher than the first group) resulted in a Sig. (p) value that was less than our alpha of .05 ($p < .05$, which puts the obtained t in the tail). By examining the group means for this sample of subjects (Table 15), we see that residents who were aware of the GBCS-MF (with a mean of 3.12) perceived significantly higher on the GBCS-MF 1.4.1 than those who were not aware of the GBCS-MF (with a mean of 2.82). The results of the GBCS-MF 4.2.1, 4.3.2, 8.1.1, 8.1.2 and 9.5.1criteria show that the assumption of homogeneity of variance is met (Levene's test $p > .05$). We must use the data results associated with the "Equal variances assumed" (Field, 2009, pp. 371-377). Table 16 shows the following results: GBCS-MF 4.2.1 $t(415) = 4.860$ with $p = .000$, GBCS-MF 4.3.2 $t(415) = 1.966$ with $p = .050$, GBCS-MF 8.1.1 $t(415) = 2.759$ with $p = .006$, GBCS-MF 8.1.2 $t(414) = 2.260$ with $p = .024$, and GBCS-MF 9.5.1 $t(415) = 4.175$ with $p= .000$.

Table 23 Group Statistics by Criteria

Awareness of the GBCS-MF		N	Mean	Std. Deviation	Std. Error Mean
P 1.4.1	yes	114	**3.12**	.742	.070
	no	303	**2.82**	.846	.049
P 4.2.1	yes	114	**3.25**	.850	.080
	no	303	**2.83**	.769	.044
P 4.3.2	yes	114	**3.44**	.831	.078
	no	303	**3.26**	.842	.048
P 8.1.1	yes	114	**3.36**	.742	.070
	no	303	**3.12**	.813	.047
P 8.1.2	yes	114	**3.21**	.836	.078
	no	302	**3.01**	.815	.047
P 9.5.1	yes	114	**3.18**	.790	.074
	no	303	**2.83**	.744	.043

Table 24 Independent Samples Test by Criteria

GBCS-MF		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
1.4.1	Equal variances assumed	**5.120**	**.024**	3.343	415	.001	.301	.090	.124	.478
	Equal variances not assumed			**3.548**	**229.981**	**.000**	**.301**	**.085**	**.134**	**.468**
4.2.1	Equal variances assumed	**3.785**	**.052**	**4.860**	**415**	**.000**	**.423**	**.087**	**.252**	**.594**
	Equal variances not assumed			4.644	186.632	.000	.423	.091	.243	.602
4.3.2	Equal variances assumed	**.550**	**.459**	**1.966**	**415**	**.050**	**.181**	**.092**	**.000**	**.362**
	Equal variances not assumed			1.977	205.549	.049	.181	.092	.000	.362
8.1.1	Equal variances assumed	**.603**	**.438**	**2.759**	**415**	**.006**	**.241**	**.087**	**.069**	**.412**
	Equal variances not assumed			2.875	221.235	.004	.241	.084	.076	.406
8.1.2	Equal variances assumed	**3.531**	**.061**	**2.260**	**414**	**.024**	**.204**	**.090**	**.027**	**.381**
	Equal variances not assumed			2.234	199.062	.027	.204	.091	.024	.384
9.5.1	Equal variances assumed	**.779**	**.378**	**4.175**	**415**	**.000**	**.347**	**.083**	**.184**	**.510**
	Equal variances not assumed			4.063	192.951	.000	.347	.085	.179	.516

Table 17 and 18 demonstrate that there is no significant difference between the presence of GBCS-MF features and resident perception of the overall environment based on the residents' awareness of the GBCS-MF, t (130) = 1.672 and p = .097. The F value for Levene's test is .010 with a Sig. (p) value of .921 (p > .05). Because the Sig. value is more than our alpha of .05 (p < .05), we cannot reject the null hypothesis (no difference) for the assumption of homogeneity of variance. We, therefore, conclude that there is no significant difference between the two groups' variances. That is, the assumption of homogeneity of variance is met. If the assumption of homogeneity of variance is met, we must use the data results associated with the "Equal variances assumed" (Field, 2009, pp. 371-377).

Table 25 Group Statistics by Overall

Awareness of the GBCS-MF		N	Mean	Std. Deviation	Std. Error Mean
P	yes	68	79.8824	13.48026	1.63472
	no	64	76.0625	12.72777	1.59097

Table 26 Independent Samples Test by Overall

GBCS-MF		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
P	Equal variances assumed	**.010**	**.921**	**1.672**	**130**	**.097**	**3.820**	**2.28512**	**-.701**	**8.341**
	Equal variances not assumed			1.675	129.998	.096	3.820	2.28112	-.693	8.333

4.5. Summary

This chapter analyzed surveyed resident questionnaires. It also included opinions from the residents and professionals who had participated in separate focus group interviews. The study found differences between the GBCS-MF scores and resident perception ratings rather than relationships between them. Some of the most interesting differences are as follows. In some criteria, high scores of the GBCS-MF criteria show low level responses of the residents. For example, the researched apartment complexes provide occupant manuals for their residents. However, most of the residents do not use the manual due to its complexity. In some criteria, low scores of the GBCS-MF criteria are contrary to high level responses of the residents. For example, the residents who enjoyed green paths in their complexes and green connections to get to a local green rated these factors highly. However, the complexes achieved low scores on this criterion because the evaluation requirements are inflexible or rigid regarding specific aspects. In some criteria, fluctuating scores of the GBCS-MF criteria contrasted with fairly level responses of the residents. For example, the achieved scores among the surveyed nine complexes have large differences in the GBCS-MF 3.1.1 Annual Energy Consumption criterion. However, the responses of residents are fairly the same because the residents do not recognize benefits of energy savings through their utility costs.

As evidenced by the nature of the comments and resident perception ratings on the GBCS-MF features, noise issues were by far the most common source of complaint. Noise within the GBCS-MF certified apartment complexes could probably be alleviated by the establishment of appropriate etiquette and some education of the residents on the implications of moving from wall to column structure buildings, as well as acoustical design. The next chapter is the discussion and conclusion, will include related the results to other literature and studies, limitations of research and recommendations for future research.

CHAPTER V

CONCLUSION

This dissertation research is one of few studies that explore the relationship between a building environmental assessment system and resident perception of its features. The study is especially meaningful since it widens and deepens the field with information on a building environmental assessment system newly developed outside of the US, which is the GBCS-MF, Korea. It also generates important new knowledge about the differences between design professional and resident perceptions. Findings from this study make important contributions to the existing body of literature and have significant implications for future interventions.

5.1. Summary

In order to understand the relationships between the Korean building environmental assessment system and resident perception, I asked the following questions: How do residents evaluate/rate the GBCS-MF features? and What are the perceptions of design professionals regarding GBCS-MF criteria and their impact on residents?.

In an effort to find answers to these questions, I started with a description of the GBCS-MF features and its scoring system. By using both quantitative and qualitative measures, my research provided a comprehensive assessment of the similarities and differences between resident and design professional perceptions as expressed in surveys and focus group discussions. I collected and analyzed 417 survey responses from residents living in the nine apartment complexes chosen for this study. I also conducted separate focus group interviews with residents and professionals. More detailed information on perceptions and the factors associated with different GBCS-MF features and scores was examined in the process. My findings show that there are differences between GBCS-MF scores and resident perceptions. Higher scores of the GBCS-MF features do not mean higher resident perception ratings of the features. Residents' points of view sometimes differ from those of professionals. The professionals are more inclined to focus on the construction cost of a project rather than resident living environments. Getting more GBCS-MF points directly relates to increasing the construction cost of a project. The GBCS-MF is evaluated on its economic benefits and energy consumption disregarding the perspective of its residents.

5.2. Implications for Practice and Future Research

Based upon the results of this research, I found that there is a need to increase the effectiveness of the GBCS-MF. A number of approaches can be pursued to enhance the current GBCS-MF in response to resident perceptions.

5.2.1. Increasing Resident Awareness of the GBCS-MF

In the nine complexes surveyed, approximately 27% of the surveyed residents are aware of the GBCS-MF and approximately 73% are not. However, residents who know the certification do not recognize differences between the GBCS-MF features and other non-certified apartments. Contrary to previous studies (Kang, 2006; Kwon et al, 2011; Lee et al., 2011), possibly due to differences in the perception of criteria designed to meet the GBCS-MF, most surveyed residents are not aware of the GBCS-MF. However, the lack of knowledge about GBCS-MF may not be relevant, Resident perceptions based on their awareness of the GBCS-MF did not show any difference in terms of response to related features. This finding raised an important question about the validity and interpretability of the environmental perception measures used in the GBCS-MF research (Bae et al., 2004; Jo et al., 2010; Kang, 2006; Kim, H. & Kim, B., 2007; Kim et al., 2010; Kwon et al., 2011; Lee et al., 2010; Lee & Yeom, 2009; Yu et al., 2006) and the need to address the interactive nature of the awareness and perception variables.

Further, the analysis of the GBCS-MF scores and means of resident perception ratings revealed large differences in the GBCS-MF features. The professionals evaluated the projects based on the installation of the GBCS-MF features and the degree to which they achieve the criteria requirements and the efficiency of the features, but the residents evaluate the projects based on the easiness of use, safety, and maintenance. In addition, the professionals focus on the public spaces in the apartment complexes and the residents focus on their own units and private spaces. I speculate that the resident perception of the GBCS-MF may be confounded by safety and maintenance conditions of the GBCS-MF environment, and by the availability of the GBCS-MF features.

Future research should consider ease of use, safety, and maintenance at multiple spatial scales, using both objective and subjective measures, to better understand their complex relationships in influencing resident perceptions. In addition, the GBCS-MF process should include a commitment to introduce residents to their features. Educating residents about such features can help to increase their awareness of this building environmental assessment system and encourage them use the intended GBCS-MF features. Residents and professionals, including developers, contractors and architects can share the goals of the GBCS-MF and act properly.

5.2.2. Changing Certification Process Methods in Both Pre-certification and Certification

The GBCS-MF has two certification processes: pre-certified before construction and certified after the completions. The GBCS-MF pre-certification is conducted during construction of the apartment complex, and the GBCS-MF certification is conducted upon completion of the complexes.

Many projects apply for only the pre-certified GBCS-MF. Only one project of the nine complexes that served as sites for my research applied for the certification after the completion. The pre-certification has two benefits: tax reduction and sales improvement. In the pre-certified process, developers are required to submit a project documentation package that states their intended goals. For pre-certified apartments, it is not guaranteed that the GBCS-MF features are applied as intended in each apartment since there are no ways to conduct on-site performance tests. Visual inspections of various measures are also impossible in the apartment complex after it is certified. For this certification process, the developer submits the project documentation package based on the project's GBCS-MF checklist. This method evaluates only whether those lists are implemented or not. The submitted package is the result of the completed buildings rather than field inspection and performance testing during construction. In summary, a need exists for detailed field inspection and performance testing, as well as a system for qualified professionals with expertise in the design and construction phases of green buildings, such as LEED-AP.

Additionally, the Korean government should require both pre-certification and certification of the newly completed projects. The pre-certification plays an important role in the early design process because developers, contractors, and architects can develop a goal to incorporate unique and valuable green features in a proposed building. Without the pre-certification, labeling a green building with a certification means that professionals support "point chasing" for superficial green motives that have nothing to do with sustainable developments. It is meaningless to achieve a certification without any pre-certification. The certification will help ensure the installment of the intended GBCS-MF features in the residential complexes. Clear goals and strategies for features to meet the GBCS-MF for the pre-certification and rigorous implementations of features for the certification are needed to create sustainable developments. I also recommend that building performance evaluations be conducted on a regular basis after the certification to ensure that the sustainable features are still effective.

5.2.3. All Certified Projects Required to Meet Minimum Levels in All Categories

I recommend that the GBCS-MF require projects to achieve a minimum number of points for each category rather than over emphasize specific categories. Most of the projects in this study earned a high number of points in the Land Development, Transportation and Maintenance category, and a low number of points in the Materials and Resources, Ecological Environment and Indoor Environmental Quality category. While mandatory criteria earned the maximum allocated points, most of the recommended criteria earned no points in the surveyed apartment complexes. It is possible that owners push their architects to achieve a high-performance score by using a specific design method, resulting in "points-chasing". For fiscal reasons, developers, contractors and architects are likely to place a significant focus on the construction cost effectiveness of each criterion needed for certification, rather than address those features with broader environmental implications.

For example, GBCS-MF 3.2.1 Use of Alternative Energy Source is a recommended criterion. Usually, the costs of the alternative energy source overshadow the perceived long-term benefits making professionals ignore the criterion. However, the mandatory and recommended criteria are equally important for achieving sustainable development. I suggest that the all the criteria be required to ensure that all certified projects meet minimum levels of energy and water efficiency such as 3.2.1 Use of Alternative Energy Source and 5.2.3 Installation of Graywater Reuse Systems. In addition, the GBCS-MF rating scale needs to be changed to emphasize environmentally friendly construction methods and the energy and water efficiency criteria while to reduce the emphasis on location-related criteria.

5.2.4. Criteria to be Expanded

The GBCS-MF needs to restructure its evaluation criteria. Some of the criteria need to include more detailed sub-criteria. For example, potential improvement relates to the current approach which is to evaluate the complex as a whole rather than evaluate the components of the complex individually. However, residents in each building component have different orientations and locations. For example, GBCS-MF 9.4.1 Daylight in Unit criterion relates to unit locations and directions in the apartment complex. Instead of the current way of evaluating the entire complex, I recommend more detailed and subdivided criteria so that each unit can be considered separately in the process.

In addition, the GBCS-MF needs more barrier free design criteria for the elderly and disabled allowing them easy access and use of building and fixtures. IEQ 9.5.1 examines the width of corridors, stair dimensions and installation of continuous handrails, low threshold for buildings and doors, elevator size, and low-height bathtubs. Installing three of these provisions earns two points. This evaluation method is not enough to provide accessibility to the disabled and elderly. For example, a barrier-free path of travel for persons in wheelchairs is required within those parts of a floor area that are not at the same level as the entry level, such as any raised or sunken level. Most apartment complexes do not actually have these barrier-free paths. Regarding barrier free design, more energy efficient elevator systems and/or escalators should be installed in different parts of the GBCS-MF certified complexes.

5.2.5. Need for Energy Simulation

Energy takes up the largest portion of the GBCS-MF points, which is 12 out of 136. For the professionals, it is the most important criteria for achieving points. For the GBCS-MF, the 3.1.1 criteria points are earned by providing a percentage of reduced energy consumption based on the Energy Performance Index (EPI). The EPI may not relate to the actual use of energy. The following Table 19 shows utility fees and CO2 emissions of the surveyed apartment complexes (Korea Apartment Management Info System, http://www.k-apt.go.kr/, 2013). The utilities fees of A, F, and G complexes are extremely high relative to national and city averages, yet as seen in Figure 18 (p. 88) resident perception indicates no apparent concern about the high rates for buildings A, F and G.

Table 27 Utility Fees and CO_2 Emissions (1,000 Won = 1 Dollar)

Name	Utility Fees (Won/m2)	CO2 Emissions (Kg/m2)
Korea Avg.	1,360	1.97
Seoul Avg.	1,614	2.46
A	**3,146**	**2.19**
B	1,555	1.67
C	1,487	1.78
D	1,693	1.96
E	1,522	1.92
F	**2,533**	**2.26**
G	**2,631**	**2.10**
H	1,559	2.10
I	1,603	0.87

In the interviews, the professionals pointed out that they do not have a method for estimating the amount of energy consumption. The Korean government operates several energy certification systems such as Energy Star Building and Housing Performance Certification System (HPCS), using different criteria and evaluation methods. Professionals cannot focus on the GBCS-MF due to requirements of these different systems. In addition to the GBCS-MF, they have to meet the Star and/or HPCS depending on architectural regulations of different cities. The Korean government needs to develop one universal energy evaluation criteria and set of methods. For residents, energy is directly related to utility fees. To better evaluate the energy performance of buildings and reduce residents' utilities fees, it is necessary to develop more calibrated evaluation methods in the energy category.

5.2.6. Including Quantitative and Qualitative Aspects into Evaluation Methods

Professionals should reflect on the resident points of view in their certification application processes. Instead, professionals design and construct GBCS-MF features to meet the required criteria and achieve points for the GBCS-MF certification. For example, 1.4.2 Creation of Walkways in Apartment Complex and 2.1.2 Installation of Bicycle Racks and Roads criteria, while described do not include evaluation methods for safety. However, residents are most concerned with safety issues as revealed in the focus group interviews. The GBCS-MF evaluation criteria include quantitative requirements rather than qualitative ones. Thus, it is necessary to improve the current certification standards by subdividing them into different sections following the proper length and width of the pedestrian road and safety levels. If the GBCS-MF evaluation criteria are developed reflecting resident points of view, residents will more frequently and appropriately use the intended GBCS-MF features.

5.2.7. Reducing Noise

The noise related criteria earned the lowest points in the surveyed GBCS-MF complexes and, correspondingly, the surveyed residents gave noise the lowest points (rated noise as being problematic). In the focus group interviews, the residents also complained about noise issues in their apartments and complexes and indicated that noise is the biggest problem living in the multi-family housing. In particular, GBCS-MF 9.3.1 Noise between Floors needs immediate modification. The criteria evaluate only the thickness of floors and walls used in units, which is not a fundamental solution. The noise related criteria need more sophisticated evaluation methods, including both quantitative and qualitative evaluation methods. To get more attention from professionals when they design and construct, the GBCS-MF needs to adapt weighting points and/or increase allocated points in the noise related criteria.

5.2.8. Feedback from Residents, POE

As revealed in the focus group interviews, most professionals such as contractors and developers think that the GBCS-MF certification is a onetime event to get a tax reduction from the Korean government and to increase sales of their apartments. In this sense, professionals seem to try to meet the GBCS-MF criteria for the GBCS-MF certification only, not particularly caring about occupants or sustainable development. The GBCS-MF is primarily directed at building characteristics relating to physical performance. Therefore, most professionals have no knowledge on how residents are living in GBCS-MF certified apartments and how they think of the GBCS-MF features because there is no opportunity for interaction or communication between professionals and residents.

Most of the building environmental assessment systems have missing links between professionals (providers) and residents (users). As Cole (1998) argues, Post-Occupancy Evaluation is important to get opinions about actual building performance from the perspective of those who use them because there are differences between anticipated performance of building design and actual performance of the certified buildings. Without residents' feedback within the evaluation process, there may be distortions in professionals' understanding of environmentally friendly buildings. The building environmental assessment systems, resident attitudes, expectations and actions are important to reduce environmental impacts achieving sustainability. My results suggest that the GBCS-MF should include POE or resident feedback processes into its own evaluation system on a regular basis.

Since there is a gap between the GBCS-MF scores and actual resident perception, the current GBCS-MF needs to be updated particularly in the categories discussed above. By doing so, the GBCS-MF will ensure sustainable developments in its certified complexes and provide residents with a higher quality living environment.

5.3. Relationships with Other Sustainable Guidelines and Prior Studies

It is important to discuss the GBCS-MF's relationship to other building environmental assessment systems since it gives a deeper understanding of the system. The GBCS-MF benchmarked LEED and BREEAM in the evaluation categories and methods. GBCS-MF is operated by the Korea Ministry of Land, Transportation and Maritime Affairs; LEED by the US Green Building Council; BREEAM by the UK Building research Establishment. These systems share one goal to reduce environmental impacts during the buildings' life cycle. The 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 cultural factors and various regulations in different countries. These systems evaluate predicted performance of buildings across a broad range of environmental considerations.

Many researchers investigated building environmental assessment systems and occupant surveys. For example, the history of POE (Preiser et al., 2002), the definition of the building environmental assessment systems (Cole, 1998) and the need for POEs (Andreu & Oreszczyn, 2004; Cole, 1998; Leaman & Bordass, 2001) were studied. They argued the needs of occupant survey and feedback. Following this lead, there have been numerous studies on the occupant survey and energy analysis (the Post-occupancy Review of Buildings and their Engineering team, 1995), occupant surveys of indoor environmental quality (the Center for Building Environment, 2006), occupant comfort and functionality (Turner, 2006; Turner & Frankel, 2008), a user survey, energy bill analysis, facility interview (the New Building Institute, 2005), POE by the Facility Performance Evaluation (2008), the Building Use Study surveys (Leaman & Bordass , 2007) and occupant comfort and satisfaction (Paul & Taylor, 2008).Based upon occupant surveys, these studies attempted to find solutions to information gaps in different building assessment systems. Their results showed that the overall occupant response is satisfactory regarding perceivable building features designed to meet the sustainable criteria.

However, there were limitations to these previous studies, which my research proposed to address with regard to a new approach to a building environmental assessment system. None of these studies used the achieved scores of the building environmental assessment systems in their analysis. None of these studies found relationships between project scores of the system and resident perception of the features related to the system. In addition, none of these studies investigated resident perception on each criterion of the system. The current study tried to find relationships between the GBCS-MF scores and resident perception of the GBCS-MF features using the resident survey and the focus group interviews on both the residents and the professionals. The resident survey was developed based on each GBCS-MF criterion. Individual perceptions of the GBCS-MF features are obviously of considerable value to professionals and residents; acquired resident experience also improves future building design and operation as well as the systems.

The existing building environmental assessment systems have contributed to an understanding of building-related environmental issues. However, the systems are only for professionals such as contractors, developers and architects. The systems do not recognize the users of the assessment results. The systems cannot communicate and/or interact with occupants about actual building performance. As my research results show, promoting a dialogue between multiple stakeholders plays an important role in developing meaningful developments for the system's future. Sustainable development cannot be achieved through divided action among different related parties; they require all parties to get involved in a building project including professionals and residents.

I suggest that future development of the systems should incorporate occupant opinions through a subsequent reassessment and feedback process, because there are differences between the potential performance of a building design and the actual building operation after construction. The building environmental assessment systems need greater communication and interaction between professionals and occupants to function more efficiently. My research also shows that it is important to have a transparency of scores. The assessment systems should open their achieved scores to the public, especially occupants. With this transparency, the systems can raise resident awareness of environmentally friendly buildings and eventually lead them to choose environmentally friendly actions while residents in such buildings.

5.4. Limitations of Research Methods

The current research has answered a call to provide post-occupancy evaluations of building environmental assessment systems and has widened and deepened the field by investigating an assessment system in a previously unstudied geographic location.

However, this study also has some limitations. One of them is the limited number of study sites. There are 359 GBCS-MF certified projects in South Korea (as of September 2012), but the number of score cards collected for this study was limited to 41, representing only 11 % of total certified projects. In addition, most of the GBCS-MF score cards are Green II (20) and Green III (20) levels. Lack of variability in the buildings might be the result of very little variation in the GBCS-MF.

The number of surveyed GBCS-MF certified apartment complexes is limited as well. I surveyed residents from 9 GBCS-MF certified apartment complexes out of the collected 41 complexes. Further, all surveyed apartment complexes are located in the capital area of Seoul, South Korea since 25 million Koreans live in this area, covering almost half of the nation's population (www.index.go.kr). Residents in other parts of Korea may show different responses. Thus, the outcomes of this study may not be generalized or applicable to other locations inside and outside of the nation. The relationships among different aspects and measures of resident perceptions of the GBCS-MF features require more rigorous studies in the future.

The fact that the scorecards were obtained through my personal contacts may result in systematic bias. This potential difference requires further attention in future research. While the researcher's resident questionnaire ensured high internal validity, resident participants were not randomly selected. This may result in perspective bias. Interviewed focus groups were limited in number and participation was voluntary. This may also result in perspective bias.

In addition, with a growing interest in post occupancy evaluations and building environmental assessment systems led by the current development paradigm, this study seeks a way to find relationships between the Korean system and resident perception ratings of the system features using the surveys and interviews. The 5-point Likert-type scale used in the survey questionnaire may not be detailed enough to evaluate the resident perceptions of a range of factors. However, it is one of the easiest methods in support of respondent understanding. It is also one of the most efficient and inexpensive methods for data collection. The translation of knowledge into sustainable behaviors of residents who live in the GBCS-MF apartment complexes was not addressed in this study, as well as comparisons between residents in GBCS-MF certified buildings and residents in non-GBCS-MF ones. Suggestions for future development imply that perspectives of different end users need to be examined from varied research angles and methodologies, including increasing the number of and diversifying research participants and buildings, such as facility management staff and non-GBCS-MF certified apartments. It is also necessary to monitor whether residents translate environmental understanding into everyday practices.

Future research should not only look at resident perceptions but also evaluate other issues on a broader scale with various types of research methods. For instance, operational building performance, environmental factors, personal control, and satisfaction can be more examined with different approaches including but not limited to behavior mapping and ethnography.

Despite these limitations, this study has supplemented the GBCS-MF and added information on building environmental assessment system literature in terms of interactions between professionals and residents. It has several implications for research, practice, and public policy as discussed above.

5.5. Closing

Sustainability is one of the important issues in the 21st century due to global climate change. The definition of “Sustainability” is not clear since the concept of sustainability is complex and the term has been applied to multidisciplinary fields. This study defines sustainability as sustainable developments that reduce environmental impacts from buildings and provide the quality of life for residents. For this purpose, there exist many building environmental assessment systems which were developed and used in different parts of the world. Numerous buildings and facilities are designed and built to meet the systems.

However, there are insufficient guarantees that the system certified buildings are working as intended since the systems only evaluate construction methods, prospective building performance and materials used without resident points of view. To address this problem, this study investigated relationships between a building environmental assessment system and resident perception of the system in Korea. This study’s results showed differences between intended GBCS-MF (providers) and resident perceptions of the GBCS-MF features (users). It also pointed out that there should be changes in the GBCS-MF to encourage interaction between professionals and occupants. Given the intended goals of the GBCS-MF, which promote sustainable development and provide residents a better living environment, investigating human factors associated with building end users is extremely important in the process of evaluating building performance. These changes can promise a brighter future for South Koreans living in multi-family units by reducing environmental impacts to the earth and improving resident quality of life.

Although this present study is not for generalization to all building environmental assessment system situations in South Korea or in the world, it accomplished its initial mission to introduce and bring attention to an aspect of the Korean building environmental system and the importance of post-occupancy evaluation. My study is meaningful as a first time exploratory look at what a building environmental assessment system is like in South Korea and how the system functions in that setting.

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APPENDIX A

RESIDENT SURVEY QUESTIONNAIRE

Survey Respondent #

This survey investigates residents' ratings of the building features constructed to meet the Green Building Certification System for Multi-Family Housing criteria and solicits information regarding the features that need to be improved.

This survey will take approximately 20 minutes to complete.

Please circle the correct answer or fill in the blank.

1. How long have you lived in your unit?
a. Less than 6 months
b. More than 6 months

2. Which floor do you live on?

____

3. What age group are you in?
a. Under 30
b. 31-40
c. 41-50
d. Above 50

4. What is your gender?
a. Male
b. Female

5. Home ownership?
a. Owned
b. Rented

6. Do you know if your apartment complex is certified by the GBCS-MF?
(YES) or (NO)

Please, circle your unit.

Please circle the number associated with your response and write comments.

<table>
<tr><td colspan="6">1.Land Development</td></tr>
<tr><td rowspan="4">1.4.1 Provision of community center and/or facilities refers to encouraging interaction among residents by providing community centers/facilities in the apartment complex.</td><td colspan="5">1.4.1 How would you rate the community center/facilities provided by your apartment complex?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">1.4.2 Creation of walkways in apartment complex means efficient pathway design and construction for residents to access their units, community centers, and facilities conveniently.</td><td colspan="5">1.4.2 How would you rate the connection between the walkways in the apartment complex?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">1.4.3 Connection of On-Site Walkways to Outside Walkways
How efficiently walkways inside the complex are connected to the outside walkways?</td><td colspan="5">1.4.3 How would you rate the connection between walkways inside and outside of your apartment complex?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td colspan="6">2. Transportation</td></tr>
<tr><td rowspan="4">2.1.1Accessibility to Public Transportation
How closely connected is the resident’s unit to public transportation stops/stations?</td><td colspan="5">2.1.1 How would you rate the access to public transportation from your unit?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">2.1.2Installation of bicycle racks and paths in the apartment complex</td><td colspan="5">2.1.2 Do you know the location of the bicycle racks and paths in your apartment complex? (Circle yes or no.)
(YES) or (NO)

If YES, how would you rate the access to the bicycle racks and paths?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">2.1.3Installation of High-Speed Internet</td><td colspan="5">2.1.3 How fast is your internet speed?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">2.1.4 Accessibility to City or Community Center
Very easy and fast access to the city center or major locations using cars or public transport?</td><td colspan="5">2.1.4 How would you rate the access to public neighborhood facilities such as banks, stores, parks, etc.?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
</table>

<table>
<tr><td colspan="6">3. Energy</td></tr>
<tr><td rowspan="4">3.1.1Annual Energy Consumption
To reduce CO2 emissions by evaluating the amount of a building’s energy consumption</td><td colspan="5">3.1.1 How efficient is the energy consumption in your unit as determined by your utility fees?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">3.2.1Use of Alternative Energy Sources
Installing on-site renewable energy systems to reduce a building’s fossil energy consumption</td><td colspan="5">3.2.1 Do you know whether any on-site renewable energy systems are installed in your apartment complex? (Circle yes or no.)
(YES) or (NO)

If YES, how would you rate the systems’ ability to reduce your utility fees?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:

If NO, do you think it is necessary to have one in your apartment complex?</td></tr>
<tr><td colspan="6">4. Materials and Resources</td></tr>
<tr><td rowspan="4">4.2.1 Built-in furniture and storage ratio per unit reduces the demand of private furniture by replacing them with built- in furniture and providing spacious storage.</td><td colspan="5">4.2.1 How would you rate the quantity and quality of built-in furniture or storage in your unit?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">4.3.1Installation of Recycling Containers</td><td colspan="5">4.3.1 How would you rate the locations and number of recycling containers?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">4.3.2 Installation of Food Waste Containers</td><td colspan="5">4.3.2 How would you rate the locations and number of food waste containers?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td colspan="6">5. Water Efficiency</td></tr>
<tr><td rowspan="4">5.1.1Water Efficient Landscaping
This is the efficiency of water flow to prevent flood.</td><td colspan="5">5.1.1 Do you know whether rainwater irrigation systems are installed in your apartment complex? (Circle yes or no.)
(YES) or (NO)

If YES, how would you rate the systems’ ability to drain surface water?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
</table>

<table>
<tr><td rowspan="4">5.2.1Water Use Reduction
This item means installation of water efficient fixtures: bathroom faucets, kitchen sink faucets, showerheads, toilets or low pressure water valves.</td><td colspan="5">5.2.1 Do you know if any water efficient fixtures are installed in your unit? (Circle yes or no.)
(YES) or (NO)

If YES, how do you rate the performance of water efficient fixtures such as faucets, showerheads, toilets, etc.?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:

If NO, do you think it is necessary to have water efficient fixtures in your unit?</td></tr>
<tr><td>5.2.2Installation of Storm Water Reuse Systems
Captured or recycled rainwater being used for landscaping and sprinkling</td><td colspan="5">5.2.2 Do you know whether storm water creates a problem in the complex? (Circle yes or no.)
(YES) or (NO)

How would you rate the complex’s ability to manage storm water?</td></tr>
<tr><td rowspan="3"></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td colspan="6">7. Maintenance</td></tr>
<tr><td rowspan="4">7.3.1Provision of an Occupant’s Operations and Maintenance Manual
Providing residents occupants’ manuals to appropriately use their units</td><td colspan="5">7.3.1 Do you have an occupant’s operations and maintenance manual? (Circle yes or no.)
(YES) or (NO)

If YES, how useful is the occupant’s manual?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:

If NO, what is the reason?</td></tr>
<tr><td colspan="6">8. Ecological Environment</td></tr>
<tr><td rowspan="4">8.1.1Consistent Green Space in the Complex and Connection to Local Green Space
How closely connected green walkways in your apartment complex are to the local green space?</td><td colspan="5">8.1.1. How do you rate the connectivity from landscaped walkways in your apartment complex to local landscaped areas?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">8.1.2 Green Space Area Ratio
How much green space do you have in your apartment complex?</td><td colspan="5">8.1.2 How would you rate the amount of green space in your apartment complex?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
</table>

<table>
<tr><th colspan="6">9. Indoor Environmental Quality</th></tr>
<tr><td rowspan="5">9.1.2 Increased Ventilation
Installation of ventilation systems and an appropriate portion of operable windows to increase indoor air ventilation in the unit</td><td colspan="5">9.1.2 How would you rate the performance of your ventilation systems such as fans, hoods, operable windows, etc.?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td colspan="5">9.2.1 Do you know if any thermal control systems are installed in your unit? (Circle yes or no.)
(YES) or (NO)

If YES, how easy is it to use the thermal control systems in your unit?</td></tr>
<tr><td rowspan="3">9.2.1 Installation and Controllability of Thermal System
Provision of the automatic thermostat designed to provide thermal comfort within the building</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Very difficult</td><td>Difficult</td><td>Neutral</td><td>Easy</td><td>Very easy</td></tr>
<tr><td colspan="5">Comments:

If NO, do you think it is necessary to have one in your apartment unit?</td></tr>
<tr><td rowspan="4">9.3.1Noise between Floors
Appropriate thickness of materials used to reduce noise transmission between floors</td><td colspan="5">9.3.1 How would you rate the acoustical insulation between floors/ceilings?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">9.3.2 Noise between Walls
Appropriate thickness materials used to reduce noise transmission between walls</td><td colspan="5">9.3.2 How would you rate i the acoustical insulation between walls?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">9.3.3 Noise from Outside the Apartment Complex
Overall noise in the whole apartment complex</td><td colspan="5">9.3.3 How would you rate the acoustical insulation between the inside and outside of your building?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">9.4.1Daylight in Your Unit
Minimum two hours of continuous daylight in your unit between the times of 9am to 3pm of the winter solstice</td><td colspan="5">9.4.1 How would you rate the quantity of sunlight that enters your unit?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
<tr><td rowspan="4">9.5.1Accessibility for The Disabled and Elderly
Provision of barrier-free design for the disabled and elderly allowing easy access and use of buildings and fixtures</td><td colspan="5">9.5.1 How would you rate the barrier-free design features installed in your apartment complex?</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Poor</td><td>Fair</td><td>Moderate</td><td>Good</td><td>Excellent</td></tr>
<tr><td colspan="5">Comments:</td></tr>
</table>

APPENDIX B

PROFESSIONAL FOCUS GROUP QUESTIONNAIRE

Professional Interview Group #
1. How many years have you worked for the GBCS-MF certified projects?
2. What is your general opinion about the GBCS-MF as a building environmental assessment system, including its advantages and/or disadvantages?

1. Land Development	
1.1.1 What aspects of ecological value of site did you consider when designing the building? What methods did you use to meet the land-use planning and zoning regulations for the GBCS-MF buildings? How do you evaluate this criterion' effectiveness in measuring ecological value of site?	1.1.1 Ecological value of site means protecting and saving the original conditions of the site from any harmful physical or social factors resulted from new development.
Criterion 1.1.2 is calculated using this formula: area of preserved existing natural resources/ site area x100%. According to the score cards, most of the chosen apartment complexes gained no scores in this criterion. What are the reasons for gaining such scores? How do you evaluate this criterion's effectiveness in preserving existing natural resources?	1.1.2 Preservation of existing natural resources refers to save habitat for animals and plants by reducing development footprint.
1.2.1 This criterion is calculated by the total square meters of a building divided by the total square meters of the lot the building is located on. FAR is used by local governments in zoning codes. Higher FARs tends to indicate more urban (dense) construction. How do you evaluate this criterion's effectiveness to reduce density for residents' quality of living environment? What methods or design features did you use to reduce the density?	1.2.1 Density This criterion is calculated using the following formula: $Y = (-X + 220) / 10$ Y: points X: FAR Moderate density (160%) gets maximum 6 points and high density (220%) gets no points.
1.2.2 What methods or design features did you use to develop the site in harmony with surrounding neighborhoods? How do you evaluate this criterion's effectiveness to encourage building the GBCS-MF complexes near or within existing communities?	1.2.2 Establishment of Urban Development
1.3.1 According to the score cards, most of the chosen apartment complexes have no score in this criterion, what are the reasons for this situation? How do you evaluate this criterion's effectiveness to give residents enough sunlight with no interruptions from neighboring buildings?	1.3.1 Interference with Daylight to Adjacent Properties It is related to the previous question about the density. And this particular one is about how much sunlight you have with no interruptions from neighboring buildings.

4. Materials and Resources	
4.1.1 What construction methods or design features did you consider about the changeability of the apartments during the buildings' life cycle? How do you evaluate this criterion's effectiveness to provide residents with variable floor plans to meet their needs for change?	4.1.1 Design Plan for Life Cycle Change This is about the changeability of the unit itself such as getting modified non-structural walls or combined two units into one unit differing circumstances or needs of the residents.
4.1.2 What environmentally friendly construction methods did you use while building your apartments? How do you evaluate this criterion's effectiveness to apply environmentally friendly construction methods for buildings?	4.1.2 Application of Environmentally Friendly Construction Methods
4.4.1 The GBCS-MF recommended buildings to use of recycled-content materials such as Good Recycled (GR) certified and environmentally preferable materials. What kinds of recycled-content materials did you use in the construction process to meet the GBCS-MF criteria? Where did you use these recycled-content materials in the apartments? How do you evaluate this criterion's effectiveness to use of recycled-content materials in buildings?	4.4.1 Use of Recycled-Content Materials Using recycled materials in building the complex? What kinds of materials? Where in the complex?
4.4.2 How do you evaluate this criterion's effectiveness to reuse structural elements for remodeling buildings? How helpful is reusing structural elements for improving sustainable developments? What kinds of structural elements do you think can be reusable in future building renovation/remodeling?	4.4.2 Reuse-Structural Elements It refers to the intent of an extending building's life cycle by reusing the existing building's structural elements (foundations, enclosing walls, columns, floors and roofs)
4.4.3 How do you evaluate this criterion's effectiveness to reuse non-structural elements for remodeling buildings? How helpful is reusing non-structural elements for improving sustainable developments? What kinds of non-structural elements do you think can be used when building renovation/remodeling?	4.4.3 Reuse-Nonstructural Elements It represents reusing the existing building's non-structural elements.
5. Water Efficiency	
5.2.3 According to the score cards, most of the chosen apartment complexes do not have gray water systems. What are the reasons to prevent their installation?	5.2.3 Installation of Gray Water Reuse Systems The gray water collection and distribution system to purify gray water generated by residents and to reuse for landscaping for sparkling
6. Atmosphere	
6.1.1 What kinds of methods or strategies did you use to reduce CO_2 emissions? What is the level of efficiency of the CO_2 reduction system?	6.1.1 Reduction of CO_2 Emissions

7. Maintenance	
7.1.1 The GBCS-MF is recommended to use ISO 14001 environmental management systems. What kinds of methods or strategies did you use to reduce construction waste management and reduction planning?	7.1.1 Construction Waste Management and Reduction Planning
7.2.1 A building manager's manual or binder includes the following items: floor plans; the product manufacture's manual for all installed equipment, fixtures, and appliances; general information on efficient use energy, water and natural resources; operations and maintenance guidance for any GBCS-MF related equipment installed in the unit. Did you provide a building manager's manual or binder? How many categories does your manual or binder include?	7.2.1 Provision of a Building Manager's Manual or Binder
8. Ecological Environment	
8.1.3 What kinds of construction methods or design features did you use to protect/improve the local ecological environment? How do you evaluate this criterion's effectiveness to apply planned landscaping for the local ecological environment toward sustainable developments?	8.1.3 Application of Planned Landscaping for Protecting or Improving the Local Ecological Environment Installation of sewage systems and to maximize landscape connected to near habitat
8.2.1 What construction methods or design features did you consider when planning/designing aquatic biotopes?	8.2.1 Creation of Aquatic Biotopes Creation of aquatic biotopes to increase the quality of landscape
8.2.2 What design features or construction methods did you consider when planning/designing terrestrial biotopes?	8.2.2 Creation of Terrestrial Biotopes Creation of terrestrial biotopes to increase the quality of landscape
8.3.1 What construction methods did you apply to reuse topsoil? What do you think of the practicality of reusing topsoil? If possible, what percentage of topsoil was reused? Did you find it helpful to reuse topsoil for sustainable development? If so, why?	8.3.1 Topsoil Reuse The reused topsoil ratio to the landscape area in the apartment complex
9. Indoor Environmental Quality	
9.1.1 What kinds of low-emitting materials did you use to build apartments to meet the GBCS-MF criteria? Where did you use these low-emitting materials in the building of apartments?	9.1.1 Use of Low-Emitting Materials Using less poisonous materials inside the house

APPENDIX C

RESIDENT FOCUS GROUP QUESTIONNAIRE

Resident Focus Group #

Based upon the survey, what is the most important criterion that affects your residence? Why?

What kinds of advantages or disadvantages do you find while living in the GBCS-MF certified apartments?
Do you find any differences between the GBCS-MF certified apartments and non-certified apartments?

1. Land Development

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

2. Transportation

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

3. Energy

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

4. Materials and Resources

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

5. Water Efficiency

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

7. Maintenance

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

8. Ecological Environment

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?

9. Indoor Environmental Quality

What is the most important feature in the Land development that affects your residence?

What factors affected your rating in the survey?

Do you have any suggestions to improve building features related to this category?