TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ACEM	Association of Consulting Engineers Malaysia
ACE	Air Change Effectiveness
AHP	Analytical Hierarchy Process
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
AP	Accredited Professional (e.g. LEED AP; BREEAM AP)
BCA	Building and Construction Authority
BEE	Building Environmental Efficiency
BEI	Building Energy Intensity
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
CI	Consistency Index
CIB	Council of Research and Innovation in Building and Construction
CR	Consistency Ratio
CVA	Completion and Certification Assessment
CO_2	Carbon Dioxide
DA	Design Assessment
EE	Energy Efficiency
DSS	Decision Support System
EAM	Environmental Assessment Method
GBCA	Green Building Council of Australia
GBI	Green Building Index
GBI-NRNC	Green Building Index Non Residential-New Construction
GSB	Greenbuildingindex Sdn Bhd

GBRS	Green Building Rating System
GNP	Gross National Product
GSA	General Services Administration
IEQ	Indoor Environmental Quality
iiSBE	International Initiative for a Sustainable Built Environment
IR	Inconsistency Ratio
JSBC	Japan Sustainable Building Consortium
LEED	Leadership in Energy and Environmental Design
MR	Material Resources
MCDM	Multi-Criteria Decision Making
MGBC	Malaysia Green Building Confederation
NR-NC	Non Residential-New Construction
PAM	Pertubuhan Akitek Malaysia (Architects Association of Malaysia)
QLASSIC	Quality Assessment System for Building Construction
RI	Random Index
SM	Sustainable Site Planning and Management
USGBC	United States Green Building Council
WE	Water Efficiency
IN	Innovation

CHAPTER 1

INTRODUCTION

Building construction worldwide consumes 3 billion tons of raw materials a year and produces 10% to 40% of solid waste stream in most countries [1]. In the United States, buildings account for 70% of electricity consumption, 39% of energy use, 30% of waste output, and 12% of all potable water consumption [2]. On the other hand, a statistics shows that in Malaysia, buildings account for about 20% of the production of greenhouse gases that comes in third after transportation (27%) and industries (21%) [3]. The energy used in buildings, which consist mainly of fossil fuels, thus displace mega-tonnes of earth during mining, consume a lot of energy [4]. For example, in every tonnes of cement, which is the most widely used building material, two tonnes of raw materials are consumed. Those materials emit nearly one tonne of CO_2 and up to 6 kg of NO_x greenhouse gases [5].

At the same time, in every country, buildings and construction contribute a large percentage of the world's gross domestic product. Therefore, to mitigate the impact throughout the life cycle of buildings, the construction industry and the related activities are the pressing issues faced by all the stakeholders in order to promote sustainable buildings [6]. Sustainability is the ability to maintain a certain status or process in existing systems. Based on bruntland report on 1987, is the development to meets the needs of the presence without compromising the ability of future generations to meet their needs. One of the thoughts about an ecologically sustainable building is that, rather than being something that lasts forever, it is something that maintains its amenity while being capable of adapting to change. Sustainable building use key resources like energy, water, materials, and land more efficiently than the building that is simply built to code [7].

The International Council of Research and Innovation in Building and Construction (CIB) working commissions identified several recommendations towards achieving sustainable buildings. One of them is to develop green building [8].

In the U.S the term of green building is widely known as a *high-performance building*. Whole performance building are considers site, energy, materials, indoor air quality, acoustics, natural resources, as well as their interrelation with one another. [9]. Green building provides financial benefits that conventional building is incapable of, which include cost savings from reduced energy, water and waste, lower practice, maintenance costs, improved occupants productivity and health [10].

Since building had more of financial benefits, private and public owners require building projects to be designed and constructed in an environmentally responsible manner and to be recognised as green buildings [11]. One of the main areas of activity in the concept of green buildings is the development of methods and tools used to assess the environmental performance of buildings [12]. This matter has led to the issue on how to assess whether the building performance fits into the "green" category. The International Sustainable Building Movement, which came in the early 1990s, on CIB task group 8 of Building Assessment, provided an "International impetus for the development and implementation of building assessment tools and guidelines" [13]. This is accomplished by requiring the construction projects to achieve certifications of green building using a third party rating system.

Environmental assessment methods of building exist for a wide range of applications [14]. There are three categories of building assessment methods including Green Building Rating System (GBRS). It is a design checklist and credit rating calculator developed to assist designers in identifying design criteria and documenting proposed design performance [15]. GBRS can be considered to have three distinct stages, which are defined as follows:

1. Classification,
2. Characterisation,
3. Valuation or also known as weighting.

Accreditation of buildings is an essential part of the international sustainable building movement in order to give new and renovated buildings a rating, which is determined by how green they are [16]. GBRS is developed to provide rating points in order to identify that the building meets the criteria needed [17]. Through criteria and sub-criteria, GBRS evaluates the performances of the building and gives rating awards [18, 19].

Nowadays, several GBRSs have been used and developed from international to local levels. The first system was established in the early 1990s from UK accreditation system named Building Research Establishment Environmental Assessment Method (BREEAM) [20]. After that, other systems such as Leadership in Energy and Environmental Design (LEED) from US, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) from Japan, and many more were developed and are currently applied widely.

The development of GBRS is dynamic and it is the reason for the pioneers of GBRS namely BREEAM and LEED, to have great influences to form the newer GBRS in other countries [17]. As a reflection of this dynamism, energy efficiency in building appears as the main criterion in most GBRS [21, 22], including Malaysia's Green Building Index (GBI). However, in the future it is hope that the newer GBRS will consider local context to improve the implementation of rating system. A green building rating does not imply to be used across multiple countries and often they have features with a significant local favour [23]. Launched in May 2009, GBI identified "Energy Efficiency" at the first priority, followed by "Indoor Environmental Quality", "Sustainable Sites", "Material and Resources", "Water Efficiency" and "Innovation" [23]. Based on the GBI launched forum [24], it have been criticize that GBI have given more emphasizes in "Energy Efficiency" without consider what is Malaysia's office building concern most. Research by Universiti Teknologi Malaysia mentioned that GBI need to identify specific criteria to improve implementation of GBI [22], thus the feedback from expert stakeholders needs to be addressed.

This research defines new weighting criteria with respect to the local conditions in Malaysia by analysing these criteria with questionnaires from various expert respondents using Analytical Hierarchy Process (AHP) method. In AHP, respondents rank the relative importance of each criterion and sub criterion in pairwise comparison, with the scale of 1 to 9 and then the criteria were weighted to meet the priority [25, 26]. Furthermore, to identify different points of the new weighting, the final analysis evaluates the “SIME office building” using the current GBI and GBI survey result as well as validation by the certified GBI facilitators.

1.1 Problem Statement

1. GBRS must represent the geographical location and climatic condition of its original country [27, 28]. Since GBI is based on educated guest, and adapt other GBRSs. Therefore, this research discusses a comparative analysis of GBI with five other GBRSs around the world to add knowledge in this particular area.

2. GBI put more emphasis in “Energy Efficiency”, concerning the implementation of GBI in Malaysia; it would be helpful to identify the fit criteria based on expert opinions.

3. A building might have different award if it assessed by different rating system (current GBI and GBI survey result).

1.2 Research Question

1. How different is GBI compare to other GBRSs?

2. How the expert will rank the criteria of GBI based on their expectation and experience in green building concept?

3. What is the result if a building is being assessed by different rating system?

1.3 Objectives

The aim of this study is to weight the criteria and sub-criteria of current GBI based on opinions of expert respondents. The aim is supported by the following objectives:

1. To identify and compare the GBI with the following GBRSs:
   - BREEAM, UK
   - LEED, US
   - CASBEE, Japan

- Green Star, Australia
- Green Mark, Singapore

2. To determine the criteria and criteria weighting of GBI, based on:
   2a. Different group of experts:
   - Engineers
   - Architects
   - GBI facilitators
   - Government officers and
   - Academics

   2b. all groups of experts
3. To evaluate "SIME office building" with the current GBI and GBI survey result, and validate the results with the certified GBI facilitators.

1.4 Research Contributions

To satisfy the research objective, this thesis highlights two main contributions:

1. The first contribution is to develop the current GBI in terms of the priority of criteria. In addition, this study also has given the feedback collection and analysis in order to improve the implementation of GBI.
2. The second contribution is to add knowledge in this particular area, where expert respondents have proposed different weighting criteria on current GBI. From the AHP questionnaires the respondents have their own perspectives in measuring the level of importance of each criterion.

1.5 Scope of Study

Some scope definitions are set to keep the research works focused and be done within the specified time.

1. The comparison of GBRS from different countries to show the similarities and differences of GBI and other GBRSs. The comparison is focused on Non Residential-New Construction building type. The GBRS covered in this study include BREEAM, LEED, CASBEE, Green Star, Green Mark and GBI.

2. AHP analysis focuses on analysing criteria and sub-criteria weighting of current GBI based on expert respondents to provide information for the formation of standard GBRS for the region in the future.

1.6 Limitations of Study

The Limitations of this study are mentioned as follows:

1. This research only studies on criteria and sub-criteria weighting, without mentioning specifically on each criterion, and only for GBI-Non Residential New Construction (GBI-NRNC) building type.
2. In this research over 300 questionnaires were sent to respondents, however only few questionnaires are returned.
3. This research was mainly based on questionnaire survey; however some respondents were interviewed for further clarification.
4. The proposed case study is only to view the different points that a building scores from similar rating system based on two different criteria weighting.

1.7 Thesis Organization

The thesis is organized as follows:

- Chapter 1 consists of the background study, objectives, scope of study and thesis outline.
- Chapter 2 discusses theoretical background to support the research objective and addresses the role of green building rating system. In addition, there are some previous studies related to the field of discussion. It discusses what other researchers have done in the field, and the issues and challenges faced.
- Chapter 3 presents useful information about GBI. The chapter also provides the details on how the system gives points to the building based on the specifications in each criterion and sub criterion.
- Chapter 4 provides research design, tools for analysis and data collection, methodology and specifications of the multi-criteria decision making software, i.e. Expert Choice-2000 version.

- Chapter 5 contains the results and discussions. It highlights the comparative analysis of GBRSs, pairwise comparison of criteria and sub-criteria in different group of experts, and justifications of the results.
- Summary of the conclusion and future works are drawn in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Sustainable Building and Construction

The World Commission on Environment and Development defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs [29]. When this concept is applied to the built environment, it can be viewed in the context of “green” or environmentally sensitive, conscious design and construction projects [30]. Ever since modern design and construction practices were introduced, the building industry has given less consideration towards improving environmental performance, resulting in less action taken [31].

Building and construction sectors contribute on average 10% of Gross National Product (GNP) and more than half of capital investment in all countries [32]. Statistics suggest that there is a strong link between building construction and urbanisation. Current human development has seen a transitional demographic shift from predominately rural based societies to urban centres [33]. By more than 50% of the global human population currently live in cities and this percentage is on the rise as the human population increases. It is predicted to peak at approximately seven billion peoples by early 2012 , and might reach eight billion by 2025–2030 [34]. This situation presents the building and construction sector with many challenges, requiring it to go beyond simply providing sufficient shelter.

Even though many of the urbanisation and human settlements issues expand beyond the scope of building and construction, there is large potential for the sustainable building and construction sector to exert its influence in these areas [33]. This sector therefore holds great importance to all human activities, as well as ecology and environmental. Sustainable design considers a building's environmental implications holistically, starting from the planning process to the building's deconstruction at the end of its useful life [35]. Proper planning during the design phase is important and must consider all of the projects environmental and their related impacts, as well as their actions taken to minimize the impacts. A building project has the potential to affect the health and well-being of the building's occupant and the surrounding community, including its open spaces, ecosystems, plants, animals, air quality and natural resources [36].

For example, studies shows that an average person spends over 90% of their time indoors [37]. Many buildings that have been built and occupied provide little exposure to natural daylight and limited outdoor views. Studies also show that people who work in buildings that do not provide outdoor views have a higher risk of running into health problem [38]. Many projects indiscriminately destroy natural areas or damage them more subtly by affecting their microclimates. For example, the ecosystem may be affected by heat generated from road surfaces and buildings, which is commonly referred to as the heat island effect [39]. The aim of sustainable building is not only to mitigate all the impacts, but also to produce buildings that exist harmoniously with their natural surroundings and bring benefits to their occupants. A sustainable building also considers how the building will affect the environment through its deconstruction [40]. For example, there are certain designs that incorporate materials and design elements that will not allow the building to be deconstructed and the materials to be reused or returned to their natural state at the end of the building useful life.

2.2 Green Building

A green building is an environmentally sustainable building, which is designed, constructed and operated to minimize environmental impacts. The "green building" has been used as a generic term to describe all the sustainability issues associated with a project. The "green building" apply in every phase which is from construction strategies, building design and orientation, landscaping, building operations and maintenance [41]. The less impact a building has on human health and the environment, the more green it is considered to be.

Based on Kibert, The “green building” refers to the quality and characteristics of the actual structure created using the principles of sustainable construction. Green building is healthy facilities designed and built in a resource-efficient way, using ecological design, ecologically sustainable design, and green design [42].

Based on the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), a green building design is one of those achieving high performances, over its full life cycle, in the following areas [43]:

1. Reduce the natural source consumption through more efficient use of non-renewable natural source;
2. Reduce emissions that negatively impact the indoor environment and atmosphere of the planet;
3. Reduce disposal of solid waste and liquid effluents and the associated infrastructure needed to hold removal;
4. Reduce negative impacts on-site ecosystems and
5. Maximize the quality of indoor environmental.

As the *environmental impact* of *buildings* becomes more apparent, one of the solutions devised was to include sustainability practices in the construction projects [44]. The added sense of urgency caused by continually rising energy costs has inspired many involved in the construction industry to resort to the green movement for solutions. However, the concept of incorporating sustainable practices into conventional design and construction procedures requires a redefinition and evaluation of the existing roles of project participants to be able to contribute effectively to the objectives of a sustainable [45].

2.2.1 Green Building Benefits

Green building is not only beneficial to the health, performance and well-being of occupants, it also leads to economic gains and incentives, as well as social aspect [46].

Environmental benefits:

- Enhance and protect biodiversity and ecosystem;
- Improvement of air and water quality;
- Reduction of solid waste by using recycled building materials, and;
- Conserve and restore natural resources.

Economic benefits:

- Reduction of operating and energy costs;
- Create, expand, and shape markets for green product and services;
- Improvement of employee productivity and satisfaction by reducing indoor building environmental characteristics that may lead to Sick Building Syndrome, and;
- Optimise the life-cycle economic performance of building.

Health and Social benefits:

- Improvement of indoor air, thermal, and acoustic environments;
- Enhance occupants' comfort and health;
- Minimize strain on local infrastructure by using less energy, water, and reducing solid waste, and;
- Improve the overall quality of life.

2.2.2 Green Building Barriers

While the benefits of green buildings continue to show promising results, there are a number of barriers affecting the realization of their full environmental, economic and social potential. At the local, national and international levels, efforts are underway to systematically identify and address limitations on the implementation of green building [47]. Economic perceptions, industry awareness, and availability of green design technical capabilities are the most significant operational barriers to green building design and construction. Knowledge and familiarity about green building practices have progressed relatively slowly across the industry. As more architects, engineers, planners and designers engage in green practices, both time and cost savings will be reduced [48].

Perception of higher costs and increased upfront capital for green buildings relative to conventional building designs can also be a barrier. In fact, contrary to general perceptions, the average premium for green buildings is slightly less than 2% or USD3-5/ft^2 of the cost of a conventional building [49]. A study conducted by California Sustainable Building Task Force, found that based on a 20 years building life, an initial increase of 2% in upfront costs yields lifecycle savings of 20% of total construction costs [50]. Building codes and incentive policies can be instrumental in facilitating green building practices and technologies. In addition, education and training programmes can minimise misperceptions regarding the economics of green buildings design and construction [51].

2.3 Green Building Rating System (GBRS)

In order to meet environmental goals, the building industry must take quantifiable and measurable actions. Measuring ensures that it can constantly evaluate and improve the operations and decrease the harmful impacts on the environment [52]. Based on [46], there is no universal agreement on calculating embodied energy. In addition, numerous academics and professionals are devising environmental labelling and accreditation schemes in the hope that it will become the industry standard [53]. The aim is to come up with a standardized set of criteria for environmental performance and provenance that will be adopted internationally and provide architects, manufacturers, designers and clients with a simple system to claim that their building product or material is environmentally friendly [54]. A number of tools have been developed to evaluate building environmental performance. A green Building Rating System (GBRS) is a design checklist and credit rating calculators developed to assist designers in identifying design criteria and documenting proposed design performance [55].

There are various building rating systems based on different parameters for measurements of performances and efficiency, but certain elements are common among those systems. Green building rating and certification systems address aspects of design, construction and operation of buildings consisting of site selection and orientation, energy efficiency, water efficiency, waste management during construction and operations, selection of environmentally preferable materials, improved indoor environmental and integrated management plans for buildings [56].

A GBRS grades buildings based on a system of credit points. Individual buildings can achieve different levels of certification by gaining a certain number of credit points. These credits can be achieved by complying with the green standards specified in the rating system. Based on the standards set out, one or more points can be allotted for every innovation or change that is made in the construction method of the building in order to gain compliance with the green standards [57].

GBRSs in general focus on the following five criteria; Site; Water; Energy; Materials, and Indoor Environment. For each criterion, a number of prerequisites and credits with a specific design and performance criteria exist [44]. The scores in each of the sections are weighted and then summed together to provide a single score that is reflected as a rating award. Through each criterion and sub-criterion, GBRS evaluates the performances of the building [58]. The rating systems incorporate a coordinated method for accomplishing, validating, and benchmarking sustainability of designed projects. As with any generalised method, each has its own limitations and may not apply directly to every project regional and other specific aspects [59].

Several green building rating systems are in use today and being developed at the international and national levels. The system originated in the early nineties from the UK accreditation system, Building Research Establishment Environmental Assessment Method [60]. It was later followed by other GBRS. The GBRS covered in this research are listed below:

1. BREEAM – Building Research Establishment Environmental Assessment Method
2. LEED - Leadership in Energy and Environmental Design
3. CASBEE - Comprehensive Assessment System for Building Environmental Efficiency
4. Green Star
5. Green Mark, and
6. Green Building Index.

2.3.1 Building Research Establishment Environmental Assessment Method (BREEAM)

BREEAM was first launched in 1990 and is currently revised annually to keep abreast with the UK Building Regulation and stay in line with current best practice. The first version of BREAAM was developed to assess the environmental performance of offices and is marked as the building environmental assessment method with the longest record of accomplishment. Since then, this rating system has been developed to cover the following types of buildings [61];

- Other Building (including leisure complexes, laboratories, community building and hotels design);
- Courts;
- The code for sustainable homes;
- Ecohomes;
- Ecohomes XB;
- Hospital or healthcare building;
- Industrial building;
- Multi-Residential
- Prisons;
- Offices;
- Retail;
- Education;
- Communities;
- Domestic Refurbishment;
- In-Use

The version discussed in this research is BREEAM for Non Residential New Construction (NRNC) or Offices building. Based on [62], in 2008, there have been more than 100,000 buildings certified by BREEAM of which 1358 are non-domestic buildings, more than 500,000 buildings registered, of which 3177 are non-domestic buildings. In addition, there are 1473 registered assessors operating within 820 licensed assessor organizations.

Licensed assessors carry out BREEAM assessments. Building Research Establishment (BRE) trains, examines and licenses organizations and individuals to help design teams (or facilities management companies) gather the appropriate data and to carry out the assessments. For each assessment, the assessor produces a report outlining the developments performance against each of the criteria, its overall score and the BREEAM rating achieved [63]. This report is sent to BRE who review the report using a strictly defined quality assurance process. Once a report has successfully passed the quality assurance process, BRE issues the client with a certificate that confirms the development's BREEAM rating. The details of the verification process are concluded in Figure 2.1.

Registration ↓	Via form accessed on extranet submitted online or by post in scheme appropriate to development.
Assessment reference number issued ↓	
Information collection ↓	Assessor collates information required to demonstrate compliance with BREEAM criteria.
Assessment by independent BREEAM assessor ↓	Assessor completes assessments of all information gathered and calculates BREEAM rating. Support is provide to assessors throughout, by BREEAM customer support team
Assessment report submitted ↓	Assessor compiles BREEAM assessment report referencing all relevant information and submits to BREEAM office
Quality assurance process ↓	Report submitted for quality assurance. There is maximum time form submission of report to certificate issues.
Certification	Upon successful quality assurance, certificate issued to client.

Figure 2.1 Certification Process of BREEAM

The BREEAM methodology calculates an environmental rating by awarding points, or credits, for meeting the requirements of series of criteria that, if complied with, would result in a reduction of the buildings negative environmental impact and an increase in its environmental benefits. Each criterion is usually worth a single credit in exception of cases where there is a large variation in the performance of buildings, which meet the requirements of the criteria. For example, criterion of "Pollution" is assigned 10 credits on the scale which runs from one credit for a building that achieves just above the minimum level required to meet UK building regulations, up 10 credits for a building which has net carbon emissions zero. The ten criteria in BREEAM have different points as seen in Table 2.1 [64].

Table 2.1 Criteria of BREEAM-NRNC

Criteria	Weighting
Management	12
Energy	19
Transport	8
Health and Well-Being	15
Water	6
Materials	12.5
Waste	7.5
Land use and Ecology	10
Pollution	10
Innovation	10
TOTAL	110

Table 2.2 BREEAM Rating Award

	TOTAL SCORE	**AWARD LEVEL**
Ratings Award	≥85	Outstanding
	≥70	Excellent
	≥55	Very Good
	≥45	Good
	≥30	Pass
	<30	Unclassified

The criteria are weighted according to the perceived importance of the environmental issues that the section aims to address. The weightings are applied to the percentage score for each issue category. The total of the weightings gives the environmental score. The BREEAM rating award is then added based on the score achieved. Table 2.2 shows the rating award within the score that is given to the building successful in the assessment [64].

2.3.2 Leadership in Energy and Environmental Design (LEED)

The LEED rating system, which was first launched in 1998, represents the U.S. Green Building Council (USGBC) effort to provide a national standard of what constitutes a "green building" [65]. LEED focuses on "market transformation". LEED has many versions on each phase, and the current version is LEED V.03. There are different types of building in use in LEED rating systems [66]:

- New construction and major renovations
- Existing buildings: operation and maintenance
- Commercial interiors
- Core and shell
- School
- Retail building
- Healthcare building
- LEED for homes
- LEED for neighborhood development

The version discussed in this research is LEED for NRNC or new construction and major renovations building. The new construction version is used throughout the design and construction phase, and the actual label (certificate) is only available once the construction is completed [46].

In LEED, the project team compiles the documentation required for the assessment. A trained assessor is therefore not required, although there is a credit available for appointing a LEED AP (Accredited Professional) as part of the design team. Once the project team has compiled all the documentation, it would be submitted to the USGBC who reviews the evidence and calculates the score.

Assessments are completed either by using an online application or submission of a hardcopy. The USGCB will then proceed to review LEED submissions through project teams. The project teams and the USGBC issue a certificate and plaque with the rating on it once they have accepted the final score. The details of the certification process are concluded in Figure 2.2:

Registration ↓	
CIR submission ↓	A compliance interpretation request is required if project includes features that do not fit with LEED criteria.
Document submission ↓	Report submitted either online or hardcopy
Receipt of PILOT review ↓	It taking review by the assessor.
Project team responses ↓	On receipt of the review, the project team has one-month time to supply information required.
Final review ↓	The USGBC (United States of Green Building Council) will process the information and submit final assessment.
Receipt of final assessment ↓	If project disagree with any assessment decision, it will appeal a cost. Receipt PILOT review.
If certified rating awarded, submitting image and project case study to USGBC	Once project team accepted the rating given the USGBC, there will be issue plaque and certificate.

Figure 2.2 Certification Process of LEED

LEED provides a complete framework using a point based-rating system for assessing building performance and meeting sustainability goals. In LEED, the new construction version is used throughout the design and construction phase. Once the construction is completed, it can be presented the scoring for award [49]. To receive a LEED certification, a building must meet the criteria of a particular type of structure in the appropriate program. Through criteria, it would evaluate the performances of the candidates' buildings and give rating award if the buildings meet the standards of

LEED. Based on [67], LEED emphasizes state of the strategies and assessments in the following criteria, as seen in Table 2.3.

Table 2.3 Criteria of LEED-NRNC

Criteria	Points
Energy	35
Water Efficiency	10
Materials and resources	14
Sustainable Sites	26
Indoor Environmental Quality	15
Innovation	6
Regional Prior	4
TOTAL	**110**

Each criterion has sub-criteria that are assigned points amounting to a possible score of up to 110. LEED then adds up the points and issues a rating award. The assessment is rated based on the total score for Certified, Silver, Gold, and Platinum. The rating award level used for NRNC building is shown in Table 2.4 [67].

Table 2.4 LEED Rating Award

	TOTAL SCORE	**AWARD LEVEL**
Ratings Award	≥80	Platinum
	60-79	Gold
	50-59	Silver
	40-49	Certified

An example of the point system is if the project earns 40 to 49 points of the score points, the building will be awarded “Certified” level. Earning points for any type of buildings is accomplished by meeting the criterion established for a particular category within the given award.

2.3.3 Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)

CASBEE was first launched in 2004 by Japan Sustainable Building Consortium (JSBC), which is the methodology used to calculate the score called BEE (Building Environmental Efficiency) that distinguishes between environmental load reduction and building quality performance [68]. This approach was first developed by iiSBE (International Initiative for a Sustainable Built Environment) in the form of a GBTool. This means that, CASBEE, compared with all other rating systems in this research, is different from the rest. CASBEE comprises a variety of assessment tools along with the design process, and include the following [69]:

- CASBEE for Pre-Design Assessment Tool which enables owners and planners to identify the basic context of the project, such as proper site selection and basic impact of the project.
- CASBEE for New Construction uses to assess building during design and construction stages.
- CASBEE for Existing Buildings for buildings that have been occupied for at least one year.
- CASBEE for renovation uses to help generate proposals for building upgrades and assess improvements

CASBEE New Construction is a complex calculation methodology. In CASBEE, the more measures available to improve environmental performance the more credits that can be developed. The system adopts an environmental efficiency approach by providing results that are based on the quality of environmental performance in relation to the environmental load, representing assessments made within and beyond the hypothetical boundary of the building concerned. Figure 2.3 concludes the verification process of CASBEE [70].

Report complied ↓	Data compiled by CASBEE assessor
Acceptance by CASBEE ↓	Verification of report template and certification costs payment.
Credit filter check ↓	Filtering of credits associated with development
Final credit appraisal ↓	Decision is taking on suitability of final credits and certification. Precise characteristics of developments agreed (with meeting client etc if appropriate)
Appraisal/report issued ↓	Report submitted and quality assured
Publication of result	Report published via CASBEE database on homepage.

Figure 2.3 Certification Process of CASBEE

BEE is a key concept of CASBEE, which is used to communicate the assessment results that can be translated into a simple ratio as shown below [71]:

$$BEE = \frac{Q}{L} = \frac{25x(Sq - 1)}{25x(5 - Slr)} \qquad (2.1)$$

where

BEE = Building Environmental Efficiency;

Q = Building Environmental Quality and Performance;

L = Building Environmental Load;

$Q = 25 \, x \, (S_Q - 1)$

$* \, Sq = S_Q$ *: Score of Q category*

$S_Q = 0.4 \, x \, S_{Q1} + 0.3 \, x \, S_{Q2} + 0.3 \, x \, S_{Q3}$

$L = 25 \, x \, (5 - Slr)$

$* \, Slr = S_{LR}$ *: Score of LR category*

$S_{LR} = 0.4 \, x \, S_{LR1} + 0.3 \, x \, S_{LR2} + 0.3 \, x \, S_{LR3}$

All the issues divided into two basic types, which are Quality measures (Q) and Load reduction (L). Once the assessment is complete and the score is calculated, it is presented as the BEE. CASBEE covers 80 sub-items in the assessment, which are re-categorized into [69]:

- Q_1 Indoor environment
- Q_2 Quality of service
- Q_3 Outdoor environment on site
- L_1 Energy
- L_2 Resources and materials
- L_3 Off-site environment

BEE values are represented in a plot by the gradients lines connecting the assessments data and the origin. A larger gradient, which possesses the higher value of Q and lower value of L, represents higher sustainability of the building [71]. In CASBEE, there are five different rating awards available, as seen in Table 2.5 below [62].

Table 2.5 CASBEE Rating Award

	TOTAL SCORE	AWARD LEVEL
Ratings Award	≥3	S
	1.5-2.99	A
	1-1.49	B^+
	0.5-0.99	B^-
	0-0.49	C

CASBEE has independent origins and a strong focus on issues, such as earthquake resistance, which are of particular importance in Japan, its country of origin. In short, CASBEE is different with other GBRS around the world. The scoring and weighting system in CASBEE is complex. There are number of credits that would only be of use in extreme cases. Therefore, the comparative analysis covered in this research will only be focused on CASBEE certification process.

2.3.4 Green Star

Green Star is another national voluntary rating system promoted by Green Building Council of Australia (GBCA), which is responsible for evaluating the environmental performance of buildings [72]. The first version of Green Star was developed in 2003 in a partnership between Sinclair Knight Merz and BRE. As BREEAM was used as the basis of the Green Star methodology, the two methods are very similar [62]. The Star certification system is also similar to the LEED system, and serves essentially as a market transformation tool demonstrating good practice rather than building performance itself. However, revisions have been made, due to the various differences between countries.

Green Star has rating for different phases of the building life cycle. Some examples of tools are for design, construction and operation, and for different building classes. These rating tools use the best regular standards to encourage the property industry to improve the environmental performance of development. There are different types of building in use for Green Star, as following [73]:

- Education v1;
- Healthcare v1;
- Industrial v1;
- Multi Unit Residential v1;
- Office v3;
- Office Interiors v1.1;
- Retail Centre v1;
- Office Design v2;
- Office As built v2;

In addition, in 2011, there is Green Star PILOT rating tools consisting of: custom PILOT, Convention Centre Design PILOT, and public building PILOT. Figure 2.4 concludes the verification process of Green Star. Green Star registered projects are permitted to use the release, which was current at the date of registration [74]. Any member of a design team or wider project team can use Green Star assessment.

Registration	Project registered via appropriate form
Inform GBCA of expected submission date	Report team must inform GBCA when the report will be submitted
CIR submission 2wk prior to submission	A compliance interpretation request is required if project includes features that do no “fit” with Green Star criteria. 2 CIRs are permitted per assessment.
Confirm submission date via from to GBCA	
Report submitted on agreed date	Late submissions are charged and will not be assessed for 6wks
Receipt of results 6wks after submission	
Inform GBCA of intent and timing of appeal	If project disagree with any assessment decisions they may appeal up to 5 credits, and it will have a flat fee per assessment.
Receipt of results submission 4wks after submission	If no appeal to be made certificate will be issued 2 wks after receipt of results
If certified rating awarded, submit image and project case study report to GBCA	

Figure 2.4 Certification Process of Green Star

As with LEED, points are awarded where a member of the design team has received Green Star training and achieved the Accredited Professional status. Although any member of a project team can carry out the assessment, no score can be publicized unless the Green Star assessment is certified.

In order to certify an assessment the GBCA commissions a third party assessment panel to validate the self-assessment rating and recommend, or oppose, a Green Star certified rating. If a project achieves a minimum score points, certification approved and released. Figure 2.5 below [74], is a process from the actual assessment tool and it summarizes the credit based approach employed.

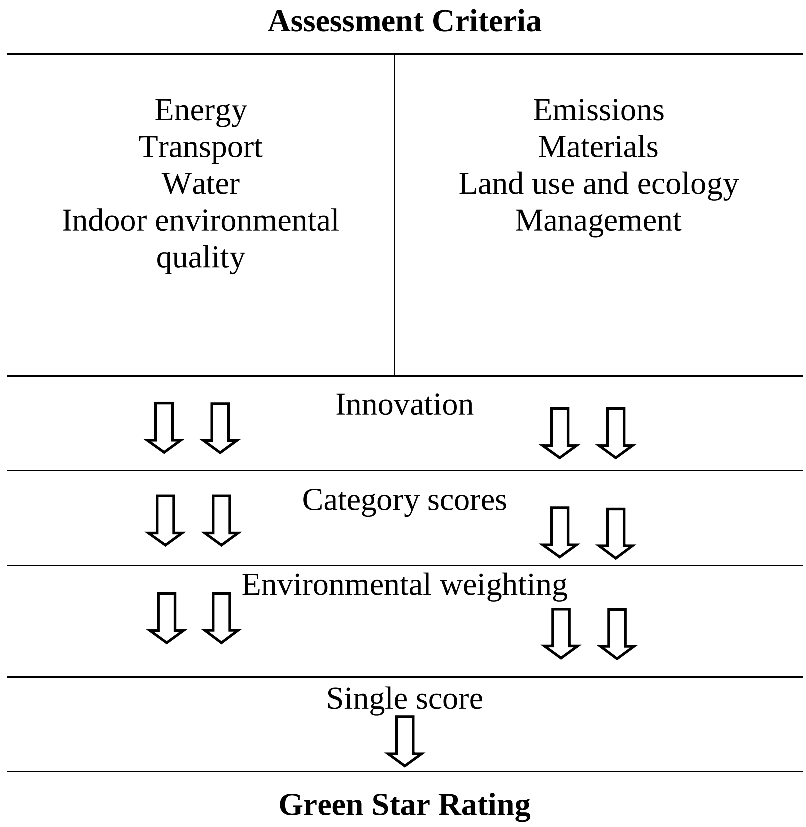


Figure 2.5 Scoring Process of Green Star

The criteria and their points are grouped into nine criteria, in which the weighting is applied to them. The Green Star criteria and total point list are shown in Table 2.6 [75]. Once all claimed credits in each criterion are assessed, a percentage score is calculated and the Green Star environmental weighting factors are then applied. The score is determined for the criteria based on the percentage of credits achieved.

An environmental weighting, derived by considering a variety of scientific and stakeholder opinions, is applied to each category score (except innovation). The overall score is then determined by adding together all the weighted criteria scores plus the innovation points (which are not weighted).

Table 2.6 Criteria of Green Star-NRNC

Criteria	Points
Management	12
Energy	29
Transport	11
Water	12
Materials	22
Land use and Ecology	8
Pollution and Emissions	19
Indoor Environmental Quality	27
Innovation (additional)	5
TOTAL	**145**

The maximum possible score for the weighted criteria is 140 with an additional 5 points available for "Innovation". The Green Star rating is determined by comparing the overall score with the rating award shown in Table 2.7 [75].

Table 2.7 Green Star Rating Award

	TOTAL SCORE	AWARD LEVEL
Ratings Award	75-100	Six Star
	60-74	Five-Star
	45-59	Four-Star

2.3.5 Green Mark

The Green Mark has been developed by BCA (Building and Construction Authority) of Singapore in January 2005 to promote environmental awareness in the construction and real estate sectors [76]. It is supported by the National Environment Agency, as a strategic program to encourage developers, building owners, designers and contractors to adopt "green building" practices right from the conceptualisation, design and construction phases for new projects, or during building management and operations for existing buildings [77]. Green mark comprises a variety of assessment tools categories and these include [76]:

- Residential building;
- Non Residential building;
- Existing building;
- Office Interior;
- Landed house;
- New and Existing parks;
- Infrastructure;
- District;
- Overseas Projects;

It is designed to promote sustainability development in the construction industry through raising environmental awareness and commitment in the sector, as well as according due recognition to those who comply with the set criteria. Under the assessment framework for new buildings, developers and design teams are encouraged to design and construct green, sustainable buildings, which can promote energy and water savings, healthier indoor environments as well as the adoption of more extensive greenery in their projects. As for existing buildings, the building owners and operators are encouraged to meet their sustainable operations goals and reduce adverse impacts of their buildings on the environment and occupants' health over the entire building life cycle. The assessment criteria cover the following key areas as shown in Table 2.8 [78].

Table 2.8 Criteria of Green Mark-NRNC

Criteria	Max Points	Minimum
Energy	116	30
Water	17	20
Sustainable Site	42	
Indoor Environmental Quality	8	
Innovation (additional)	7	
TOTAL	**190**	**50**

The assessment process involves a pre-assessment briefing to the project team for a better understanding and evaluation of BCA Green Mark requirements and the certification level sought [79]. Actual assessment would then be carried out at a later stage to verify the relevant reports and documentary evidences as well as confirmation that the building project meets the intents of the criteria and certification level. The assessment identifies the specific energy efficient and environment-friendly features as well as practices incorporated into the projects.

Points are awarded for incorporating environment-friendly features, which are better than conventional practice. The total number of points obtained will provide an indication of the environmental friendliness of the building design and operation [79]. Depending on the overall assessment and point scoring, the building will be certified to have met the BCA Green Mark Platinum, Gold Plus, Gold or Certified rating as concluded in Table 2.9 [78].

Table 2.9 Green Mark Rating Award

	TOTAL SCORE	**AWARD LEVEL**
Ratings Award	90 and above	Platinum
	85-89	Gold Plus
	75-84	Gold
	50-74	Certified

Certified Green Mark buildings are required to be re-assessed every three years to maintain the Green Mark status. New buildings that are certified will subsequently be re-assessed under the existing buildings criteria. Existing buildings will be re-assessed under the existing buildings criteria. The revised BCA Green Mark criteria for new building (Version 4.0) was take effect on 1 December 2010 [79]. All Green Mark applications for new buildings that are submitted on or after this date will be assessed and certified based on this latest version.

2.3.6 Green Building Index (GBI)

GBI is developed by Pertubuhan Akitek Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM) [80]. The rating system gives an opportunity to developers and building owners to design and construct green, buildings that can provide energy and water savings, a healthier indoor environment, better connectivity to public transport and the adoption of recycling and greenery in their projects [81]. GBI consists of six criteria with different points are concluded on Table 2.10 [82]. Of the six criteria that make up the GBI rating, emphasis is placed on energy efficiency.

Table 2.10 Criteria of GBI-NRNC

Criteria	**GBI**
Energy efficiency	35
Indoor Environmental Quality	21
Sustainable Sites	16
Materials and resources	11
Water efficiency	10
Innovation	7
TOTAL	**100**

The rating system is comprised for two building type, which are GBI Residential and GBI Non-Residential respectively. These tools are governed by the same criteria but with different emphasis for each category. The assessment process involves an assessment at the design stage leading to the award of the provisional GBI rating. There are three stages of GBI certification, which are application and registration, design assessment, and verification assessment [83].

Figure 2.6 presents the certification process of GBI. Greenbuildingindex Sdn Bhd stands as the organizer to associate the applicant with the assessor. Upon registration, GBI Terms and Conditions will be signed between the applicant and GSB. A GBI Certifier will then be appointed for the project. When the Applicant is ready, the project for GBI Design Assessment (DA) will be submitted either directly or through an appointed GBI Facilitator. Submission should be done when all key criteria of the design are finalized and preferably before the commencement of construction to enable the project to be monitored and assessed in its entirety. The GBI Certifier will then undertake Design Assessment for GSB [83].

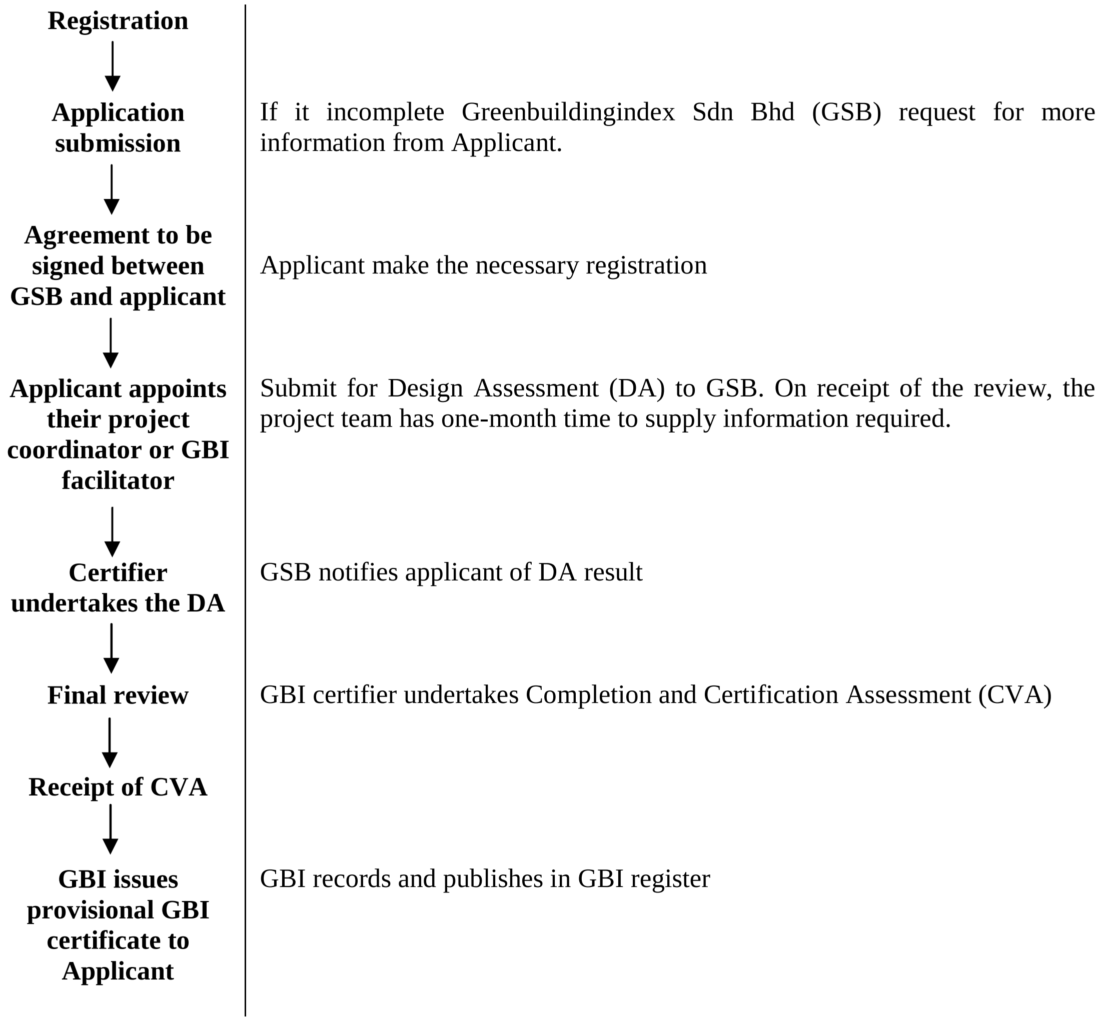


Figure 2.6 Certification Process of GBI

Upon completion of the project, the applicant should submit the Completion and Verification Assessment (CVA). GBI Accredited Professional upon completion of the CVA assessment will issue the final GBI award. Buildings will have to be re-assessed every three years in order to maintain their GBI rating to ensure that the buildings are well maintained. The final award is given one year after the building is first occupied. Buildings will also have to be reassessed every three years to maintain their GBI rating to ensure that the buildings are well-maintained. Buildings are rated on a point-scoring format and depending on their score, they can be awarded GBI Platinum, Gold, Silver and Certified ratings [84]. The rating level system for GBI is shown in Table 2.11.

Table 2.11 GBI Rating Award

	TOTAL SCORE	AWARD LEVEL
Ratings Award	≥86	Platinum
	76-85	Gold
	66-75	Silver
	50-65	Certified

2.4 Previous Studies

The availability of accessible and user-friendly GBRS has been instrumental to the widespread growth of green building practices. Since the creation of BREEAM, several methods have been developed across the world that provide more targeted guidelines that apply to region specific building practices and conditions [17]. In some locations, these efforts can be seen through adaptation of existing system to reflect local guidelines, such as South Africa's plans to launch a national version of Green Star [18]. Given these facts, many previous studies have investigated the formation process, differences and similarities of each system. The followings are previous studies and similar to what has been covered in this research.

2.4.1 Comparative Analysis among Green Building Rating Systems

1. **Comparative Analysis between the LEED and Green Globes Systems** [85]:

   The focal comparison of the study centres on LEED version 2.2 and Green Globes. Both systems pursue a common goal of greening the building in the U.S. From a process perspective, Green Globes simpler methodology, which employs a user-friendly interactive guide for assessing and integrating green design principles for buildings, continues to be a point of differentiation to LEED is more complex and primarily paper based system. LEED introduced an online-based system; it remains more extensive and requires experts' knowledge in various areas.

Any team member with general knowledge of the building's parameters can complete Green Globes web based self-assessment tool, and it provides both PILOT (after assessing the schematic design) and final ratings during the assessment. In contrast, LEED tends to be more rigid, time-intensive, and expensive to administer. Overall, the two systems are quite comparable, and it is estimated that nearly 80% of available points in the Green Globes system are addressed in LEED 2.2 while over 85% of the points specified in LEED 2.2 are addressed in the Green Globes system. It is found that the study is not a comprehensive assessment of every criterion, sub-criteria, and methodological underpinning associated with each system. The result suggested in further research is required to determine whether potentially improvements across more categories can improve overall building performances.

2. **Comparative Analysis among BREEAM, LEED, Green Globes, CASBEE and GB Tool** [17]:

The study was prepared to provide information on sustainable building rating systems for U.S General Services Administration (GSA). Five rating system were reviewed in detail based on Federal and GSA drivers which are; BREEAM, LEED, Green Globes, CASBEE and GB Tool. GSA has identified that the ratings systems need to address the following elements:

- A system that is applicable to the large scale and complexity of federal building projects.
- A stable rating system such that the evaluation of building performance is not subject to drastic change
- A system that tracks quantifiable achievements in sustainable design and is verified by a third party qualified assessor.
- A system used in the current market with practitioner awareness.

The study does not provide a recommendation for GSA but a summary of comparative details on each rating systems using the review criteria developed by GSA and other Federal services.

3. **A comparative analysis of two building rating systems : UK BREEAM and LEED Canada** [86]**:**

The study compares the two most widely adopted schemes, the UK BREEAM and LEED, as implemented by the Canada Green Building Council. The aim of the paper is to determine the effectiveness of commonly used building rating systems and to propose improvements to these systems. The results show that BREEAM and LEED Canada have enabled the building industry to evaluate construction projects in an accessible manner, although both systems bear lack of consistency. However, assessment consistency is not vital to the overall success of the operation-the desired market transformation is being observed despite the apparent limitation. Furthermore, the effect of building users' actions on the structure's performance should be incorporated into BREEAM and LEED Canada in the near future.

Despite the rapid growth of building assessment over the last 15 years, the construction industry is still undergoing a cultural shift towards the widespread use of such tools. While BREEAM and LEED Canada have been instrumental in fostering this change, both systems must continue to evolve in order to maintain the momentum developed thus far while expanding to include construction sectors and markets not currently undergoing assessment at the same time.

4. **Comparative Analysis of GBRS among BREEAM, LEED, CASBEE, and Green Star** [62]:

The environmental assessment methodologies covered in the report include BREEAM, LEED, CASBEE, and Green Star. The study looks at the most commonly used schemes and how all international GBRS compared to the local UK benchmark, called BREEAM. The results show that Green Star version 2.0 is almost identical to BREEAM 2002 as that is the version it was based on. At the time of development, there were credits that could not be applied to Australia, such as change in ecological value and proximity to public transport, as these issues reflect regional norms. The compliance requirements and benchmark of these credits were therefore changed significantly. Since that initial work, the main change has been in progress, which is now more akin to LEED. On the other hand, CASBEE takes on a very different approach. In fact, more than half the credits in CASBEE do not have a BREEAM equivalent. It is therefore much more difficult to compare the rating bands of the two systems.

The comparison shows that it is tougher to meet the highest rating in BREEAM than it is to meet the requirements of the alternative schemes when building in the UK. If a building is designed to meet the highest LEED or Green Star rating, it is only likely to achieve a BREEAM rating of “Very Good” or “Good” which are the second and third highest ratings respectively. The results from CASBEE are difficult to compare, as more than 50% of the criteria included in CASBEE are not relevant to a country that does not have a major risk of severe earthquakes or typhoons. The future directions stated in the study suggested developing a set of underpinning standards that exclude as much “home territory regulatory effects” as possible to facilitate comparisons.

Justification

Many existing GBRSs vary enormously both in their complexity and in their application. Although there has been an attempt to design rating system applicable to multiple countries, however this effort is considered futile and often ends with GBRS of a significant local favor. This explains why comparisons between the GBRS are necessary. Therefore, this research carried out a comparative analysis of GBI with other GBRS around the world to add knowledge in this particular area. The difference with previous study is this research covered six GBRSs, which are BREEAM, LEED, CASBEE, Green Star, Green Mark and Green Building Index. The comparative analysis is based on the certification process, criteria, and rating award.

2.4.2 Analytical Hierarchy Process in Selecting Criteria

1. **Developing a green building assessment tool for developing countries – Case of Jordan** [87]:

   The aim of this study is to provide a framework model for developing an effective GBRS for Jordan. The outcome is a green building (residential type) assessment tool for Jordan called SABA GBRS. It is recommended that this system is a powerful GBRS for Jordan because it is based on scientific research and technical knowledge, has participated in multi-stakeholders knowledge and experiences in collaborative process. In the proposed system (SABA) seven categories were addressed that include; site, energy efficiency, water efficiency, material and resources, waste and pollution, indoor environmental quality, and economics.

   Some other criteria, sub-criteria and parameters were suggested by stakeholders, which had significant value on the weighting system (AHP system) and were considered in the system. Although there are similarities on the criteria level between SABA and other GBRS, there are differences in the weighting of each criterion. The study suggests number of recommendations to develop a green building assessment tool in general:

   - First, development of assessment tools should be based on scientific research and technical knowledge.
   - Multi-stakeholders should participate in developing such an approach, as it requires participating and collaborative processes. Experts, designers, government officers, working groups, agency players, and others should be introduced as key participants in the process.
   - Sustainability strategies and goals should be addressed as a major aim
   - The assessment framework should suit the local context of the country; depending on its culture, issues, players, practices and institutions. It will be essential for each country to design its own indicators in its own way to achieve its shared goals.
   - Countries can learn from each other’s work and ideas. Hence, they should use the work of experts as inputs in their discussions.

2. **Adapting aspects of GB Tool 2005: case study in Taiwan** [88]:

GB Tool is the software implementation of the Green Building Challenge assessment method, which has been under development since 1996 by International Initiative for a Sustainable Built Environment and participating teams from more than 20 countries. The method also places emphasis on the ability of local users to adjust the system to suit regional technical and cultural issues.

This study seeks to explore regional customization of the GB Tool 2005. It will utilize the AHP method to investigate the priority of the criteria and sub-criteria of the GB Tool 2005, by compiling and completing an expert's questionnaire. The expert's opinions, which are based on the recent situation and the domestic environment, can provide a suitable guide for the GB Tool 2005 adaptation in Taiwan.

It outlines the priority of the criteria, which are: "Environmental Loadings", "Energy and Resources Consumption", and "Indoor Environmental Quality". This study declared that AHP can be a useful tool for systematically analyzing the opinions of experts from diverse fields in GBRS studies. It is hoped that the results will be advantageously employed in SB assessment studies in future for developing countries.

Justification

In Jordan case, the purpose of AHP method is to develop an effective GBRS for residential unit in Jordanian. The criteria was made and built by the respondents. The AHP questionnaires carried out 60 respondents, where 50% of them were experts of sustainable development. The respondents came from project managers, field engineers, design engineers, students, and academics.

In Taiwan case, the research focuses in adapting the GB Tool 2005 by iiSBE. The criteria were based on the elements of GB Tool 2005. The numbers of experts are 36 respondents, which are from architects, government officers, academics and professors.

This thesis focuses on criteria weighting of the current GBI. The criteria and sub-criteria came from the existing one (GBI-NRNC). The current GBI criteria weighting is derived from other GBRS comparison and “educated guess” fact-finding, where “Energy Efficiency” criterion has the highest points than other criteria. GBI has its own limit and may not apply directly to every project in the country, where other specific criteria need to be considered. Therefore, for implementation of GBI, the criteria weighting should be based on suitable criteria that suits the Malaysian context. This research will analyse the criteria weighting based on expert opinion (the professionals involved in green building) with the use of pairwise comparison by Analytical Hierarchy Process (AHP) method. The expert respondents are come from engineers, architects, government officers, academics, and GBI facilitators.

CHAPTER 3

GREEN BUILDING INDEX MALAYSIA

3.1 Green Building Rating System in Malaysia

Buildings and construction industry is a key sector for sustainable development as they are amongst the biggest threat to the ecological systems. In Malaysia, the building industry produces about 20% of green house gasses (GHG). According to United Nation Development programmes, Human Development Report 2007/2008, instead of reusing by 5% as committed in the Kyoto Protocol, Malaysia’s GHG emissions was more than double the amount in 1990. According to the report, Malaysia ranked as the world’s 26th largest emitter [89]. In Malaysia there is increasing public awareness and interest in how buildings affect the environment, workers productivity and public health. As a result, both the public and private sector are beginning to demand buildings that optimize energy use, promote resources efficiency and improve indoor environmental quality. Developers, owners, operators, insurers and the public at large are beginning to value and market the benefits of sustainable building [90].

In 2009, Malaysia has developed its rating system for new office building, i.e. GBI-NRNC. The green building in Malaysia so far, only address “Energy Efficiency” (EE) measures, which is only one part of the entire sustainable building assessment criteria. The GBRS rating system is an adaptation of LEED, modified to Malaysian construction requirements. Various aspects appropriate to the needs and its pertinence were considered when developing the ratings system [91]. GBI was at first only a tool used for Non Residential-New Construction building. The present GBI has rating systems for Residential building, Non Residential building, Township, and Industrial building [82]. This research focuses on GBI for Non Residential-New Construction building (GBI-NRNC).

The GBI-NRNC rating system evaluates the sustainability of newly constructed buildings that are commercial, institutional and industrial in nature. These include factories, offices, hospitals, universities, colleges, hotels and shopping complexes. Of six criteria, current GBI-NRNC emphasises "EE" with maximum 35 points. The six criteria are divided into 19 sub-criteria. Each sub-criterion has pre-requisite, totalling 52 pre-requisites in all [84].

Each criterion was assigned a weighting factor, used to translate credits into points. Some criteria are more heavily weighted than others are, meaning credit for some criteria is more important than in others. For example, the 'energy and carbon dioxide' are heavily weighted, whereas credits in the 'materials' category has a low weighting. In order to achieve a particular rating, all mandatory standards relating to a rating must be achieved.

3.2 Green Building Index

This chapter illustrates how GBI works, and briefly examines the sub-criteria and pre-requisites of each for NRNC building type. Each criterion is further sub-divided into prerequisite. The classification of measuring all the pre-requisites can be found in Appendix F.

3.2.1 Energy Efficiency (EE)

A building project utilizes energy during both construction and ongoing operations. Therefore, it is increasingly important to focus on the energy use of buildings. For example, community health is best served by using sunlight and natural ventilation for ambient lighting and temperature modulation. By making buildings more energy efficient, energy consumption and costs are reduced along with the pollution associated with the burning of fossil fuels.

The GBI-NRNC "EE" criterion addresses the issue of energy use in high-performing buildings. It also covers issues that connect building systems to environmental impacts on air and the atmosphere [84]. The goals are to reduce total energy consumption and lower electrical demand during peak times. This could lead to reduction in air pollution; lower contributions to global warming and ozone depletion caused by energy production; slower depletion of fossil fuel reserves and savings on energy cost due to upgrades in infrastructures [30]. This criterion has three sub-criteria with a total of 35 points. Each pre-requisite has a different point value. Table 3.1 present the breakdown of points for "EE" criterion.

Table 3.1 Sub-Criteria of EE (GBI-NRNC)

EE Sub-Criteria	Max Points
Design	
EE1	1
EE2	3
EE3	1
EE4	5
EE5	15
Commissioning	
EE6	3
EE7	2
Verification and Commissioning	
EE8	2
EE9	3
TOTAL	**35**

3.2.1.1 EE Design

This sub-criterion holds 25 points, with nine pre-requisites [84] are as follows:

1. EE1 (Minimum EE performance): One point is granted if the building is designed to meet the mandatory provisions of Energy Management Control systems and follows the minimum "EE" requirements as stipulated in MS 1525:2007:
   - OTTV $\leq$ 50, RTTV $\leq$ 25. Submit calculations using the BEIT software or other GBI approved software(s), and
   - Provision of Energy Management Control system where Air-conditioned space $\geq$ 4000m^2
2. EE2 (Lighting Zone): Three points are granted if the building provides lighting controls, auto-sensor controlled lighting, or motion sensors.

3. EE3 (Electrical Sub-Metering and Tenant Sub-Metering): One point is granted to buildings that provide sub-metering for all energy uses.
4. EE4 (Renewable Energy): Two to five points are given if the use of renewable energy is encouraged. Higher points are granted if the total electricity consumption is generated by renewable energy of certain standards.
5. EE5 (Advanced EE Performance): Buildings receive two to fifteen points if the Building Energy Intensity (BEI) is achieved ≤ 150 kWh/m^2/year as defined under GBI reference.

3.2.1.2 EE Commissioning

The “commissioning” sub-criterion is worth five points, which are divided into two pre-requisites, as follows [84]:

1. EE6 (Enhanced Commissioning): Three points are added if a building’s energy related systems are designed and installed to achieve proper commissioning, so as to realize their full potential..
2. EE7 (Post Occupancy Commissioning): The remaining two points are given if a building carries out post occupancy commissioning for all tenancy areas after fit-out changes are completed.

3.2.1.3 EE Verification and Maintenance

1. EE8 (Verification): Building is given another two points if there is verifiable predicted energy use of key building services.

2. EE9 (Sustainable Maintenance): Three points are possible if the building’s performance in energy related systems is ensured to continue to perform as intended beyond 12 months after construction.

3.2.2 Indoor Environmental Quality (IEQ)

Research has shown that buildings with daylight, fresh air, and occupant control are consistently rated as more comfortable and contribute to occupants' performance and productivity [92]. Evidence suggests that day lighting can enhance the rate of learning for elementary students and lead to higher test scores. The benefits of good indoor environmental quality extend to the performance and productivity of occupants.

Table 3.2 Sub-Criteria of IEQ (GBI-NRNC)

IEQ Sub-Criteria	Max Points
Air Quality	
IEQ1	1
IEQ2	1
IEQ3	1
IEQ4	2
IEQ5	1
Thermal comfort	
IEQ6	2
IEQ7	1
Lighting, Visual and Acoustic Comfort	
IEQ8	2
IEQ9	1
IEQ10	1
IEQ11	1
IEQ12	2
IEQ13	1
Verification	
IEQ14	2
IEQ15	2
TOTAL	**21**

The goal is to monitor and avoid indoor air quality problems during renovation, demolition, and construction activities; provide occupants with operational control of lighting and HVAC systems whenever possible; provide environments that enhance human comfort, well-being, performance and productivity [30]. Indoor Environmental Quality (IEQ) has four sub-criteria that allow a maximum of 21 points. Table 3.2 shows an overview of the "IEQ" structure in the current GBI-NRNC.

3.2.2.1 IEQ Air Quality

The ‘air quality’ is worth six points from five pre-requisites, as follows [84]:

1. IEQ1 (Minimum Indoor Air Quality Performance): One point is granted if a minimal level of indoor air quality performance is demonstrable by meeting the requirements of ASHRAE 62.1:2007 or the local building code, whichever is most stringent..
2. IEQ2 (Environmental Tobacco Smoke ‘ETS’ Control): One point is given for satisfying two standards of compliance: prohibiting indoor smoking and designating external smoking areas at least 10 m away from entries and having operable windows and outdoor air intakes.
3. IEQ3 (Carbon Dioxide Monitoring and Control): One point is awarded if the building has a carbon dioxide (CO_2) monitoring and control system. Systems must have at least one CO_2 sensor at all main return points on each floor to facilitate continual monitoring and adjustment of outside air ventilation rates to each floor, and must ensure independent control of ventilation rates to maintain CO_2 level $\leq$ 1.000ppm.
4. IEQ4 (Indoor Air Pollutants): Two points are given for reducing the VOC’s emitted by building materials. First, low uses of VOC paint, carpet or flooring thorough out the building are necessary. Second, product with no added urea formaldehyde must be used.
5. IEQ5 (Mould Prevention): One point is granted for maintaining a relative humidity below 70% RH. Programs to reduce the risk of mould growth and its associated detrimental impact on occupant health must be implemented. To earn this point, building must also have earned credits during the Design, Construction and Operation stages.

3.2.2.2 IEQ Thermal Comfort

Building designs must show the intent to provide a thermally comfortable environment, supporting the productivity and well-being of its occupants. Thermal comfort is an important component of IEQ and the building can acquire three points for demonstrating that the sub-criteria for this measure have been met [84]. The two pre-requisites are as follows:

1. IEQ6 (Thermal Comfort: Design and Controllability of Systems): Two points are earned if the project meets the requirements of ASHRAE 55 in conjunction with the relevant localized parameters, as listed in MS1525:2007.
2. IEQ7 (Air Change Effectiveness): One point is granted for a mechanically ventilated building, with ventilation systems designed to result in ACE greater than or equal to 0.95 according to ASHRAE 129-1997.

3.2.2.3 IEQ Lighting, Visual and Acoustic Comfort

The ability of building occupants to control lighting conditions, views of the outside and acoustic comfort have emerged as important issues in providing a high-quality indoor environment. This sub-criterion has six pre-requisites, and a total of eight points.

1. IEQ8 (Day lighting): Two points are achieved if the design provides a good level of day lighting for building occupants. The design must allow 30% or 50% of the occupants to adjust the lighting for their tasks and preferences.
2. IEQ9 (Daylight Glare Control): One point is given if there is reduced discomfort of glare from natural light.
3. IEQ10 ((Electric Lighting Levels): One point is granted if a building demonstrates an office lighting design that maintains a luminance level according to MS1525:2007.
4. IEQ11 (High Frequency Ballasts): Installation of high frequency ballasts in fluoresces luminaries over minimum of 90% of NLA results in one point
5. IEQ12 (External Views): Two points are given for a reduction in eyestrain for building occupants by allowing long distance views and a provision of visual connection to the outdoors.
6. IEQ13 (Internal Noise Levels): One point is given if through out of the entire baseline building general office, space noise from the building services does not

exceed 40dBAq, or within the baseline building office space, the sound level does not exceed 45dBAeq for open plan and not exceed 40dBAeq for closed offices.

3.2.2.4 IEQ Verification

1. IEQ14 (IAQ Before and During Occupancy): A developed and implemented IAQ management plan for the Pre-Occupancy phase results in two points being granted. In addition, a permanent air flushing system of at least 10 airchanges/hour operations needs to be installed for use during the occupancy phase.
2. IEQ15 (Post Occupancy Comfort Survey: Verification): Two points are given if a post-occupancy *comfort* survey to confirm occupant comfort is provided.

3.2.3 Sustainable Site Planning and Management (SM)

Building projects affect the environment and transform the land in both obvious and subtle ways. Traditionally, project sites were defined in terms of metes and bounds, setbacks and height limits, points of entry and egress, fire lanes and utility connections etc. While these definitions are useful and necessary, sustainability requires a broader set of issues to be included that incorporate community health and welfare; economy in terms of resource utilization during and after development and environmental impacts with regard to local and regional microclimates as well as biodiversity [30].

Sustainable site planning identifies ecological, infrastructural and cultural characteristics of the site to assist designers in their efforts to integrate the building and the site. The goals are to maintain and enhance the biodiversity of natural systems and/or the existing character of the site; respond to microclimates and natural conditions; reduce energy use for transportation and site related activities and contribute to the cohesiveness of the existing area.

The Sustainable Site criterion has four sub-criteria with a maximum of 16 points. The structure of the Sustainable Site Planning and Management of GBI NRNC building assessment system are as follows, including an overview of the credits and points on Table 3.3:

Table 3.3 Sub-Criteria of SM (GBI-NRNC)

SS Sub-Criteria	Max Points
Site Planning	
SM1	1
SM2	1
SM3	2
SM4	2
Construction Management	
SM5	1
SM6	1
SM7	1
Transportation	
SM8	1
SM9	1
SM10	1
Design	
SM11	1
SM12	2
SM13	1
TOTAL	**16**

3.2.3.1 SM Site Planning

The "Site Planning" aims to channel development to urban areas with existing infrastructure and preserve habitat and natural resources. It has four prerequisites with a maximum six points [84].

1. SM1 (Site Selection): One point is given if the selection of a site is based on minimal environmental or ecological system impact, a very important feature of a high performance green building. This credit requires that buildings, road and parking area on a site or part of a site have the standards of GBI-NRNC.
2. SM2 (Brownfield Redevelopment): If the land has already been impacted by human activities (developed site), one point is granted. This is preferable for building project rather than "undeveloped land."

Although "Brownfields" are generally urban sites with access to excellent infrastructure, there are numerous issues with respect to remediating or cleaning up these properties. This is a complex and potentially costly process; hence, it applies to only a very small number of building projects. A site can be designated as "Brownfield" via an Environmental Site Assessment or by a federal, state, or local government agency.

3. SM3 (Development Density and Community Connectivity): There are two preferences for earning two points. First, construct a new building or renovate an existing building on a previously developed site and in a community with a minimum density of 20,300m^2 per hectare net. Second, construct a new building or renovate an existing building on a previously developed site and within 1 km of a residential zone or neighborhood.
4. SM4 (Environment Management): The key to earning the two points associated with this pre-requisite are conserving existing natural areas and restoring damaged areas to provide habitats and promote biodiversity, and to maximize open space by providing a high ratio of open space to the development's footprint to promote biodiversity.

3.2.3.2 SM Construction Management

The overall points of the "'construction management', allowing for three points, are as follows [84]:

1. SM5 (Earthworks-Construction Activity Pollution Control): The purpose of this prerequisite is to minimize the environmental impact of erosion on the environment. The primary requirement, earning one point, is having a design and implementing an Erosion and Sedimentation Control plan that prevents soil loss via water or wind and sedimentation of storm water infrastructure and receiving bodies of water.
2. SM6 (Quality Assessment System for Building Construction Work-QLASSIC): One point is given if there is intent to achieve quality workmanship in construction work, based on CIDB's CIS 7: QLASSIC. In order to earn these points, a score of 70% is necessary.

3. SM7 (Workers Site Amenities): Reducing pollution from construction activities by controlling pollution from waste and rubbish from workers is given one point. In addition, creating and implementing a Site Amenities Plan for all construction workers associated with the project is required.

3.2.3.3 SM Transportation

For building to be truly green, it should be in allocation where there is ready access to reach. The "transportation" sub criterion has total maximum three points, with three prerequisites [84] as follows:

1. SM8 (Public Transportation Access): Earning one point requires the building project to be within 1km of an existing, or planned and funded, commuter rail, light rail or subway station, or within 500m of at least one bus stop.
2. SM9 (Green Vehicle Priority-Low Emitting and Fuel Efficient Vehicles): Another approach to reducing the impacts associated with occupants having to travel to and from the building is to facilitate the use of alternative-fuel vehicles. This credit can be achieved by providing low-emitting and fuel-efficient vehicles for 5% of Full-Time Equivalent occupants and providing preferred parking for these vehicles. One point can be earned by reaching these requirements
3. SM10 (Parking Capacity): One point is granted for the reduction of parking capacity for automobiles to the bare minimum needed to meet local zoning requirements. To earn this point, non-residential project parking capacities must be sized to meet, but not exceed minimum local zoning requirements and provide preferred parking for carpools or vanpools capable of serving 5% of the total provided parking spaces.

3.2.3.4 SM Design

This sub-criterion has a maximum of four points that can be achieved by three pre-requisites, as follows [84]:

1. SM11 (Storm water Design-Quantity and Quality Control): One point is given if storm water management is required because of the significant reduction in pervious surfaces caused by buildings and their associated parking and paving. The goal of this credit is to ensure that the imperviousness of the building site does not increase. In cases where there is significant imperviousness, it should be decreased. This credit requires that if existing imperviousness is less than or equal to 50%, a storm water management plan must be implemented that prevents the post development peak discharge rate and quantity from exceeding the predevelopment peak discharge rate and quantity in conformance to the Storm Water Management Manual for Malaysia (MASMA). If existing imperviousness is greater than 50%, storm water management must be implemented that results in a 25% decreases in the volume of storm water runoff required under MASMA.
2. SM12 (Greenery-Roof): Two points are granted for this pre-requisite. The air temperature in urban areas can be higher than in the surrounding countryside, a consequence in solar energy absorption and reradiation by components of the built environment, particularly dark, non-reflective surfaces used for paving and roofing. This increase in air temperature means that significantly more energy is needed for cooling and even that distinct microclimates are created in the affected areas. Reducing the heat islands effect can markedly reduce energy use. To earn the point associated with this credit, at least 50% of the site hardscape must be shaded within 5 years of occupancy, paving materials must have a Solar Reflectance Index (SRI) of at least 29, or an open grid pavement system can be used. Roofing materials must have an SRI equal to or greater than 78 (for low-sloped roof < 2:12) or 29 (for steep-sloped roof > 2:12). Optionally, a vegetated roof covering at least 50% of the roof area can satisfy the requirements for this credit. A combination of high-albedo roof and vegetated roof can also meet the requirements.
3. SM13 (Building User Manual): One point is given for providing a building user manual, documenting green building design features and strategies for user information and serving as a guide to sustain performance during occupancy.

3.2.4 Material and Resources (MR)

The building industry consumes three billion tons of raw materials annually, forty percent of the total material flow in the global economy. Construction materials are ‘reorganized matter’ and this reorganization process creates significant environmental and social impacts. From a sustainability perspective, the best building materials are those that are long-lived, least disruptive to harvest, ship and install, and are also easiest and safest to maintain and reuse.

The goals are to reduce consumption and depletion of material resources, especially non-renewable resources; minimize the life cycle impact of materials on the environment; enhance indoor environmental quality; encourage better management of waste [30]. The material provisions of GBI-NRNC with respect to credits and points in MR criteria are listed in Table 4.4 [84].

Table 3.4 Sub-Criteria of MR (GBI-NRNC)

MR Sub-Criteria	Max Points
Reused and Recycled Materials	
MR1	2
MR2	2
Sustainable Resources	
MR3	1
MR4	1
Waste Management	
MR5	1
MR6	2
Green Product	
MR7	2
TOTAL	**11**

3.2.4.1 MR Reused and Recycled Materials

1. MR1 (Materials Reuse and Selection): Two points are granted for reducing materials used in building. Reusing components of an existing building has the greatest benefit in lowering the overall materials impacts. Reusing building

materials and products can result in the project's receiving up to two points. One point is achievable if reused products or materials constitutes ≥ 2% of the project's total material cost value, or two points will be add if it ≥ 5%.   .

2. MR2 (Recycled Content Materials): The use of recycled content building materials provides up to two points in the GBI-NRNC building assessment process. One point is achieved if the total recycled content value of the building materials (calculated as the percentage of postconsumer recycled content plus half of the percentage of pre consumer recycled content) is ≥ 10%. Two points are achievable, if the total recycled content value is at least 30%.

3.2.4.2 MR Sustainable Resources

The 'sustainable resources' sub-criterion addresses the issues of materials in two prerequisites with a total of two points [84]:

1. MR3 (Regional Matters): If an emphasis is placed on local or regional materials, a point is granted. This reduces the transportation impacts associated with the life cycle assessment of the materials. If ≥ 20% of the value of the materials and products in the projects were extracted, harvested, and manufactured within 500 km of the project site, one point is awardable.
2. MR4 (Sustainable Timber): One point is granted if a minimum of 50% of the wood-based materials and products in the project are certified (Compliance with Forest Stewardship Council and Malaysian Timber Certification Council Requirements). In the context of GBI-NRNC, wood-based products include, but are not limited to, structural framing, dimensional framing, flooring, sub-flooring, wood doors and finishes.

3.2.4.3 MR Waste Management

1. MR5 (Storage and Collection of Recyclables): One point is given to project that provide areas and storage for collection of non-hazardous materials for recycling. During building occupancy, there must be permanent recycle bins.

2. MR6 (Construction Waste Management): Reducing construction waste is a critical part of construction operations for the production of green buildings; GBI-NRNC provides a maximum of two points for construction waste diversion: one point if diversion rate of 50% and two points if the diversion rate is75% (volume of non-hazardous construction debris).

3.2.4.4 MR Green Product

1. MR7 (Refrigerant and Clean Agents): Two points are obtained if the project used environmentally friendly refrigerants and clean agents exceeding Malaysia's commitment to the Montreal and Kyoto protocols.

3.2.5 Water Efficiency (WE)

Sustainable design dictates that water and its relationship to building design, development and operation are managed carefully. The community requires adequate potable water in the times of drought, and planning should provide for protection from storm waters and flood. At the same time, the biodiversity of each region is dependent on water for maintaining appropriate habitat conditions. The principles of sustainable building seek to increase the value from the water resources by designing and operating the structures more efficiently. The "Water Efficiency" criteria of GBI-NRNC cover water harvesting and efficiency. A maximum of 10 points are available in the WE category, as summarized in Table 3.5 [84].

Table 3.5 Sub-Criteria of WE (GBI-NRNC)

WE Sub-Criteria	Max Points
Water Harvesting and Recycling	
WE1	2
WE2	2
Increased Efficiency	
WE3	2
WE4	2
WE5	2
TOTAL	**10**

3.2.5.1 Water Harvesting and Recycling

1. WE1 (Rainwater Harvesting): Two points are granted for rainwater harvesting. One point is given for rainwater harvesting that leads to ≥ 15% reduction in potable water consumption. Both points are granted if rainwater harvesting leads to ≥ 30%.
2. WE2 (Water Recycling): Two points are earned if water recycling leads to a reduction in potable water consumption. One point is achievable, if a building treats and recycles ≥ 10% of wastewater leading to reduction in potable water consumption. Two points are given if a building treats and recycles ≥ 30%.

3.2.5.2 Increased Efficiency

1. WE3 (Irrigation/Landscaping): Two points are granted for thoughtful irrigation and landscaping. The intention of these credits is to reduce the use of potable water or natural surface waters or natural groundwater for outdoor irrigation. Potable water is water that is assumed acceptable for human consumption. In GBI-NRNC, reduce potable water consumption for landscape irrigation by ≥ 50% will gain one point. Two points are achieved for not using any potable water.
2. WE4 (Water Efficiency Fittings): Two points are awarded for encouraging a reduction in potable water consumption through use of efficient devices: a reduction in annual potable water consumption by ≥ 30% is given one point. Alternatively, reducing annual potable water consumption by ≥ 50% earns two points.
3. WE5 (Metering and leak Detection System): Project are given one point for using sub-meters to monitor and manage major water usage for cooling towers, irrigation, kitchens and tenancy use. Another one point is given for linking all water sub-meters to MES to facilitate early detection of water leakage.

3.2.6 Innovation (IN)

Currently, projects pursuing GBI certification have the opportunity to earn up seven points from two pre-requisites in “IN”, as summarized in Table 3.6 [84]:

3.2.6.1 IN1 Innovation in Design and Environmental Design Initiatives

The purpose of IN is to reward design teams and projects for innovative performance in green building categories not covered by GBI rating system and/or exceptional performance beyond the GBI requirements. Six points can be obtained [84].

3.2.6.2 IN2 GBI Accredited Facilitator

At least one principal participant of the project team must successfully complete GBI accredited professional (facilitator) for credit achievement [84]. Only one point is awarded regardless of how many GBI Facilitator are on the team.

Table 3.6 Sub-Criteria of IN (GBI-NRNC)

IN Sub-Criteria	Max Points
IN1 Water Harvesting and Recycling	6
IN2 GBI Accredited Facilitator	1
TOTAL	**7**

3.3 Summary

From the review above, it can be concluded that each criterion has a unique role in green building certification. “EE” refers to using a minimum amount of energy to provide the same level of service and to reduce the impact of energy generation on the environment. “IEQ” refers to the building’s indoor environmental quality, which consists of thermal quality, heating, ventilating, and air conditioning (HVAC) and lighting elements. “SM” is concerned with site selection, planning, assessment of surrounding areas and landscaping, construction methods, environmental management of the site and planning for sustainability.

“MR”, promotes the use of environmentally-friendly materials sustainably sourced. WE refers to accomplishing a water usage minimum and utilising technologies that deliver equal or better service with less water. “IN” is introducing or creating new concepts to further “green” building strategies. Currently among all the criteria, “EE” stands as the main criteria with a maximum of 35 points, followed by “IEQ”, “SS”, “MR” and “IN”. The current GBI for NRNC give more emphasizes in “EE”.

Large number of building assessment tools are in use around the world. Those GBRSs have their own weighting and criteria, some give emphasizes in “Energy”, some in “Environmental”. Most GBRS have emphasizes in Energy Efficiency, since office building most used lot of energy in their daily operation. As might be expected, energy receives the most emphasis in LEED, Green Star, and especially Green Mark as well as in GBI. While BREEAM and CASBEE have the priority in both, which are energy and environmental.

A BCI survey in 2007 acknowledged that commercial buildings in Malaysia [93], relied heavily on mechanical air conditioning throughout the day. GBI-NRNC so far, emphasises energy efficiency measures, which is only one part of the entire sustainable building assessment criteria. Based on Kibert [13], office building should consider the natural air system in the building, where it might the most important human-related issues of green building, as it directly affects the health of the building occupants. While using natural air system, less energy used.

With regards with this issue, Malaysia should consider what the main priority is when it comes to the implementation of green building concepts. However, a green building rating system by its nature is very dependent on the local environment, including climate, resources and current state of development. As Malaysia differs markedly in these areas with other countries, the rating criteria must be customized accordingly.

According to the forum of GBI on 29th May 2009, GBI-NRNC V.01 was based on “educated guess”. Critical issues have been recognised by professionals of the construction industry and they are as follows:

- More research is needed on the GBI rating system in order to increase the effectiveness of the rating system, since it was based on educated guesses.
- Feedback from the user and the stakeholder needs to be addressed.

- Concentrated research related to the local culture and climatic conditions is necessary
- GBI criteria need to be evaluated from all perspectives to continuously improve the quality of green building design and orientation guidelines.

A research concerning implementation of GBI [94], mentions that:

- GBI has only been implemented for one year. Therefore, feedback collection and analysis are the most effective and important tasks in order to improve GBI.
- Universities should identify specific areas of improvement for GBI.
- GBI promotes efficient energy savings. It would be helpful if a study can be conducted to look into the construction of buildings from many aspects of environmental concern.

Achieving sustainable development requires collaboration among sectors and institutions, and the participation of all stakeholders and individuals. This research adopts a multi criteria decision making, AHP approach which is a method to analyze and select the appropriate criteria of GBI based on different group of experts. The expert opinions which are based on the recent situation and the domestic environment can provide a suitable guide for current GBI. In the next chapter it will be shown the methodology of the research.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter begins with comparative analysis of GBRSs, either used locally or globally. The comparative analysis of rating system was conducted to find the similarities and differences between GBI and other rating systems. This analysis mainly consists of literature review and critical review of commonly used GBRS. The result will become factor of consideration to proceed further analysis. Multi Criteria Decision Making (MCDM) is then described in terms of method and justification on the decision to use the AHP for this research. Next, this chapter reviews the basic concept of the Decision Support System (DSS) and explains why Expert Choice software was chosen as the DSS tool for research analysis.

Multiple Criteria Decision Making (MCDM) approach is utilized to solve the selection problem, considering the capability of this method in solving multi-criteria problem with mutual conflict. A quantitative and qualitative approach includes in AHP method. Qualitative used to calculate weight of each criterion. Furthermore, matrix pairwise comparison algorithm is then utilized to convert preference of experts into, consecutively, probability assignment, total probability assignment and preference degree eventually. Quantitative criteria are also converted into preference degree and entropy methods are used to weighting and rank the criteria. A suggested criteria weighting was developed from questionnaires eliciting expert opinions.

This chapter also describes data collection of the pilot survey, the questionnaires survey, expert respondents who involved in the research and the process involve in the questionnaires analysis. For validation purpose, the last phase present a case study on the evaluation of “SIME office building” with the current GBI and GBI survey result. The results are then validated by the certified GBI Facilitators. This research methodology has three phases as presented in Figure 4.1.

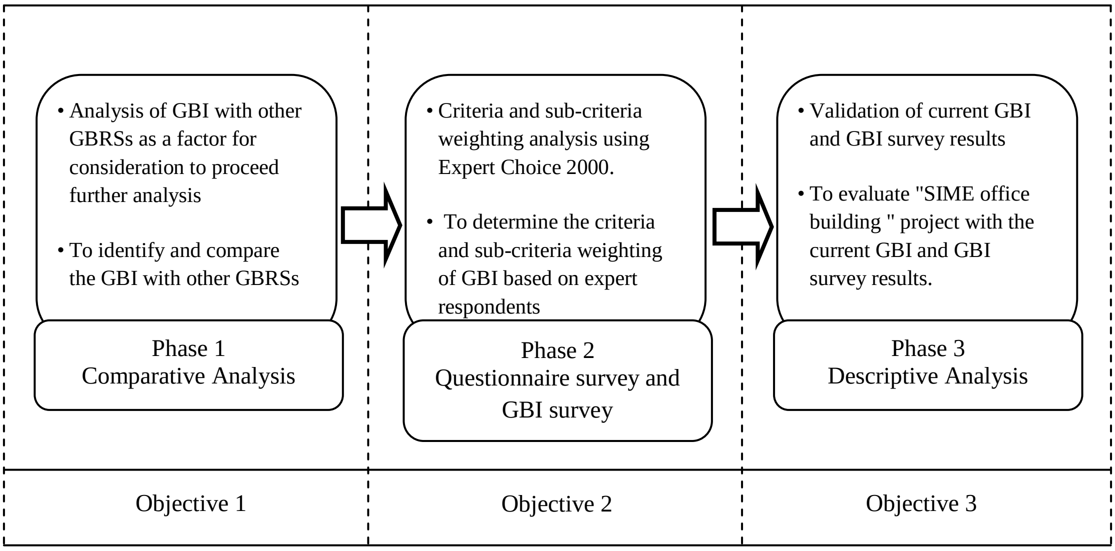


Figure 4.1 Research Methodology Process Flow

4.2 Comparative Analysis

Lee in his social science knowledge reported with following description [95]:

"Comparative methods are used for both quantitative and qualitative studies. Three strategies are used in comparative methodologies: illustrative comparison, complete or universe comparison, and sampled-based comparisons".

Illustrative comparison is the most common form of comparative analysis and has been employed extensively by theorists from diverse group items are chosen based on illustrative value, and were not selected to be statistically representative. This research used illustrative comparison to benchmark GBI with other rating systems as follows:

- BREEAM
- LEED
- CASBEE
- Green Star
- Green Mark

The comparisons are based on the process of certification, and the criteria and sub-criteria used for each rating system. This research focuses on comparative analysis of GBRS in NRNC building type only.

4.3 Multi Criteria Decision Making (MCDM)

MCDM is part of a general area of research called Multi Criteria Decision Aid [96]. The descriptive approach in MCDM aims to help decision makers understand the problems and guide them in identifying a preferred course of action. The typical MCDM problem evaluates a set of alternatives for criteria, helping to determine the best alternatives. It is important to assess characteristics of a problem when choosing a MCDM method. The characteristics of the problem in this research involve [97]:

- Type of problem – Identifying the most important criteria and sub-criteria used in the current GBI, to determine what constitutes green building.
- Decision Maker – Stakeholders in Malaysia are those in the construction industry and have good knowledge of GBI.
- Type of Data – Goals, criteria, and sub-criteria are determined before applying the decision method. It also involves quantitative and qualitative information
- Output – Improving the decision-making process by creating a structured selection process, with criteria and sub-criteria ranked based on experts' opinions.

Therefore, based on these expected outcomes, a MCDM approach is required. The single criterion synthesis approach matches the expected outcome of the research. This allows decision makers to clearly visualise goals and criteria having influence on the selection process. Several methods of MCDM are in use today, i.e. Analytical hierarchy process (AHP), Analytic network process (ANP), Weighted Sum Model, etc. The choice of which model is most appropriate depends on the research problem and may be to some extent dependent on which model the decision maker (expert respondents) is most comfortable with. This thesis aim to weight the criteria based on expert opinions. The AHP method was selected over other methods due to the following reasons:

- It has a more effective decision making process. The hierarchical structure used in formulating the AHP model enables the respondent to select the pairwise comparison process for criteria and sub-criteria.
- It has the capability to compare both qualitative and quantitative criteria by using informed judgment to derive weights and priorities.
- The AHP pairwise comparison scale makes it easy to create a pairwise comparison matrix. It also has the capability to measure inconsistency in opinions or judgments.
- Decision Support System (DSS), called Expert Choice software is based on the AHP theory makes it user friendly.

4.4 Decision Support System (DSS)

DSS is based on an assumption about the role of computers in supporting decision making [98, 99]:

- DSS should require human intervention. It should support the decision maker but not replace his/her judgement. It should therefore neither provide answers nor impose a predefined sequence of analysis.
- DSS is particularly effective for semi-structured and unstructured problems, but the computer systemizes the analysis, and gives an optional for the user to control the process.
- Effective problem solving is interactive and enhanced by dialogue between the user and system.

The most suitable DSS for this research based on the same method of AHP's is Expert Choice. Some of the features of this software are [100, 101]:

- It offers user-friendly displays that make the decision model straightforward and simple.
- It works by examining judgments made by the decision maker and measures the consistency of those judgments.
- It does not require numerical judgments from the decision maker; rather, pairwise comparisons may be performed numerically, verbally or graphically.

This is because the software converts subjective judgments into a one to nine scale then into meaningful priority vector.

- It allows for re-examination and revision of judgments for all levels of the hierarchy. It shows where the inconsistencies to suggest ways to minimise them in order to improve the decision.

In short, Expert Choice asks the user how much more important, or preferred, X is compared to Y with respect to some property. A judgment is made using the AHP verbal or graphical scale or the equivalent 1 to 9 numerical scale. Expert Choice determines if the comparisons are logical and consistent and if not assists the user to improve consistency through its "inconsistency measure". Expert Choice does not make a choice in some mysterious way, or assume that the answer is hidden in the method of the underlying mathematics, but helps make an informed choice based on knowledge, experience and preferences.

4.5 Pilot Survey

A pilot survey was conducted involving seven professionals in green building and sustainable construction in Malaysia. These seven experts were selected from Malaysia Green Building forum. The purpose of conducting a preliminary survey was to choose the best methods and estimate research costs. The most important part of this research is to have a suggested criteria weighting of GBI from expert respondents, without disregarding the current GBI. The judgment is based on the experts' knowledge, experiences and intuitions. The expert respondents were carefully selected so that they could provide the researcher with the required knowledge and cooperation.

In the pilot survey, interviews with seven respondents were carried out after all returned questionnaires are analyzed. Each interview lasted approximately 15 minutes. It was decided to use semi-structured interview to encourage in depth discussions and greater interaction and at the same time maintained a level of comparability between respondents. The objectives of the interview were to define and justify which stakeholders/parties, are relevant to the research project.

Stakeholders Analysis

Stakeholder analysis is fundamental in situation analysis. It identifies all primary and secondary stakeholders who have a stake with the project concerned [102]. A stakeholder is defined as any person, group or institution that positively or negatively affects or is affected by a particular issue, goal, undertaking or outcome. An alternative way of conducting stakeholder analysis is to identify all parties, and then determine what each supply delivers or receives from the others. Determining parties who want to be involved is the first step. Following is a table of stakeholders identified based on respondents' feedback in the pilot survey.

Table 4.1 Stakeholders

	Parties
Government	Government officer
Researchers	Academics (Lecturer/Assoc.Prof./Prof.), Student
Professional (technical)	Designer, Planner, Electrical Engineer, Architect, Environmental Engineer, Project Manager
Others	Society member, building owner, GBI facilitator

A group of expert respondents was selected from stakeholders who have expertise in GBI and construction in Malaysia. From Table 4.1, stakeholder mapping is then performed under the influence and importance as shown in Table 4.2. Based on the stakeholder analysis, it was concluded that experts who should be involved in this research are as follows:

1. Government officers;
2. Academics;
3. Architects;
4. GBI facilitators and

5. Engineers (Inclusive of environmentalists, planners, electrical engineers, project managers and developers)

All expert respondents were identified from seminars, meeting projects, conferences, GBI launches and social communities, where all parties involved are concerned with green building construction.

Table 4.2 Stakeholders Influence

Influence of Stakeholders	Little/ No importance	Some importance	Moderate importance	Very importance	Critical player
Little/ No Influence					
Some influence		-Student -Society member			
Moderate influence			Building owner		
Significant influence					
Highly influence				-Designer -Electrical Eng. -Environmental Eng. -Planner -Architect -GBI facilitator	- Government officer - Lecturer - Professor

4.6 Questionnaire Survey

Questionnaire surveys were used in this study to capture the experts' knowledge. These surveys helped to establish an analytical hierarchy of the selection process. A questionnaire can be defined as a "list or grouping of written questions which a respondent answers", also known as a "manual expert driven system" or "expert self report" [103]. The questionnaire used the self-reported data collection method. The questionnaires were collected using mail survey through postal services, internet surveys through the web, email and fax.

Type of Questionnaire

The questionnaire was designed for data collection and the format was synthesized with references to the AHP pairwise comparison based on Saaty [26]. The survey was conducted in direct and indirect setting, as all respondents were notified of the background and objectives of the survey beforehand. They were then given instructions on how to complete the questionnaire. In order to ensure a common understanding of the decision-maker and criteria to be weighted by the respondents, key terms used in the questionnaire were clearly explained and the respondents were allowed to ask questions to avoid any ambiguities. This is an indispensable process used to guarantee consistent interpretations of the terminology and to ensure results can be analysed in a meaningful way.

Questionnaire Design

To facilitate the feedback, a structured format was used. *Appendix* A presents the parts of *questionnaire*. The questionnaire was designed in four parts:

1. The introduction/cover letter.
2. Particulars of the respondent.
3. An input matrix of pairwise comparison for priority ordering. The respondent had to choose the intensity of importance between two different criteria as well as sub-criteria.
4. Open-ended questions were also included in the questionnaire to capture certain knowledge that needs further explanations or reviews. Appendix A shows a copy of the questionnaire.

Sampling of Questionnaire

The questionnaires were sent to 300 respondents, comprising engineers, architects, GBI facilitators, government officers and academics. The targeted respondents were chosen as the basic sampling of pilot survey, where in pilot survey, 30 questionnaires were sent out and have received seven respondents. Based on the AHP recommendation, stakeholder analysis was conducted to analyse an expert's influence in green building construction. Selective sampling method is being used to choose the respondent, when there are a limited number of experts in a particular area. All respondent have been identified from the Malaysia Green Building Confederation (MGBC) members, ACEM members, PAM members, Green Building forum, sustainable building conferences, seminars, meetings project, GBI launches and social community, where all parties are players in green building construction. A total of 44 respondents completed the questionnaires.

4.7 Analytical Hierarchy Process (AHP)

AHP is based on the MCDM approach developed by Saaty in 1970 [26]. Fundamentally, the AHP works by developing a multi level hierarchy structure of goals, criteria, sub-criteria and their alternatives [104]. Saaty described the AHP as a decision making approach based on the innate human ability to make sound judgments about small problems. Desirable characteristics of such an approach include simplicity, usefulness for both individuals and groups, accommodative of intuition, compromise, consensus building and without prejudice towards specialised skills or knowledge [105].

Saaty suggested AHP as a process that requires structuring of the decision problem to demonstrate key elements and relationships. This process elicits judgments reflecting feelings or emotions, and assigns judgments meaningful numbers represented by ratios. These numerical representatives can be used to generate weights that represent the relative importance of the criteria. Finally, alternatives can be compared to an absolute standard, so comparison results can be synthesized into single statistics. Each value represents an alternative that can be further analyzed for sensitivity to changes. However, this research uses an analysis concerned with priorities of the criteria and sub-criteria only, without needing alternative suggestions.

The power of AHP lies in its variants, and the use of pair wise comparisons in decision-making [26]. The hierarchical structure used in formulating the AHP model enables respondents to visualize problems systematically in terms of relevant criteria and sub-criteria. Furthermore, by using the AHP, respondents can systematically compare the priorities of criteria and sub-criteria. AHP involves the following basic steps: model building, pairwise comparisons, consistency ratios, weightings and an evaluation [106, 107].

4.7.1 Structuring Issues into a Hierarchy

The structure of AHP consists of a hierarchy of criteria and sub-criteria cascading from a decision objective or goal [26]. This research involves formulating an appropriate AHP model consisting of a goal, level 1 and level 2. The current GBI has six main criteria, classified as level 1. Each criterion has corresponding sub-criteria, comprising level 2.

Figure 4.2 presents the current 6 criteria and 19 sub-criteria of GBI, including the currently assigned point values. The "EE" criterion and 'design EE' sub-criterion are regarded as the main priorities. This model facilitates selection, comparison and prioritisation of each criterion and sub-criterion, based on respondents' knowledge.

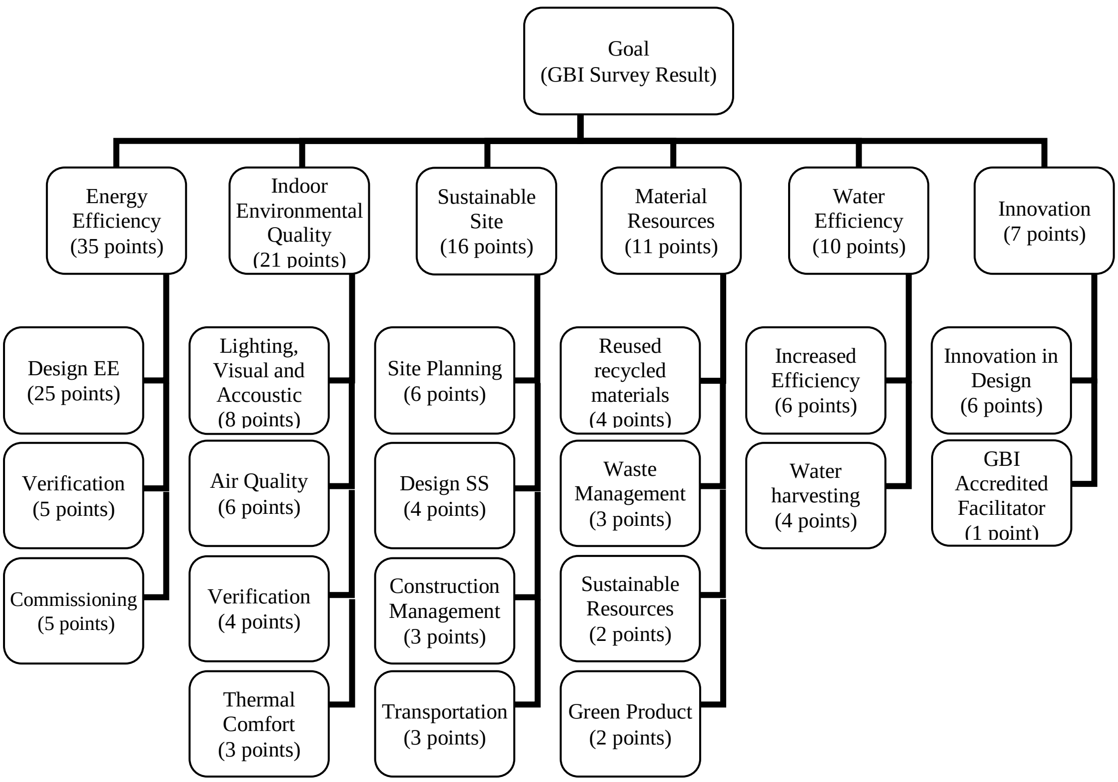


Figure 4.2 Criteria and Sub-criteria of GBI-NRNC

The top level of the hierarchy represents the objective of the goal; in this case, the suggested GBI model is addressed. The set of choices for selection is made from the first level of the hierarchy. The problem formulated in Figure 4.2 is selection of criteria and sub-criteria for the GBI which best fit the Malaysian construction Industry. The decisions are based on the respondent's knowledge of GBI and construction projects in Malaysia. The criteria and sub-criteria with the highest total weighting, obtained through a synthesis process, are eventually selected as the main criterion/sub-criterion.

4.7.2 Pairwise Comparison

A pairwise comparison of elements allows priority weights to be derived. Pairwise comparisons at each level of the hierarchy help respondents develop relative weights, called priorities, to differentiate the importance of the criteria [108]. The scale recommended by Saaty is one to nine, with one meaning compared criteria are of the same importance, and 9 meaning one criterion is extremely more important than the other, with increasing degrees of importance in between[109]. Respondents scaled each pairwise comparison of the criteria and sub-criteria in the questionnaire. Table 4.3 shows the level of importance of each criterion based on the AHP scale.

Table 4.3 The Fundamental Scale of AHP by Saaty

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the property.
2	Weak or slight	
3	Moderate importance of one over another	Experience and judgment slightly favour one element over another.
4	Moderate plus	
5	Essential or strong importance	Experience and judgment slightly strongly favour one element over another.
6	Strong plus	
7	Very strong importance	An element is strongly favourable and its dominance is demonstrated in practice.
8	Very, very strong	
9	Extreme importance	The evidence of favouring one element over another is of the highest possible order of affirmation.

The importance of one element in respect to another is represented by the reciprocal value. Values are assigned in the following manner, using X and Y as compared elements [26]:

a. 1 if X and Y are equally important
b. 3 if X is weakly more important than Y
c. 5 if X is strongly more important than Y
d. 7 if X is very strongly more important than Y
e. 9 if X is absolutely more important than Y
f. Reciprocal values are used when X and Y are interchanged

The respondent will be asked to scale the level of importance of each criterion and sub-criterion. For example, comparing the criterion between "EE" and IEQ", as to choose which criterion is more important, is done as follow:

Energy Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indoor Environmental Quality

Respondent chose 3 which mean that "EE" is moderate importance than "IEQ". Process pairwise comparison is used for making judgments regarding the relative importance of the elements in each level with respect to the higher level of the hierarchy, using the AHP pair wise comparison scale, as given in Table 4.3.

AHP calculations are then required in solving the eigenvalue problem by involving a reciprocal matrix of comparisons. Expert choice software carries out the scale above; it is also makes approximating solutions relatively simple. The spreadsheet software used involves only computations of normalised values if conditions are met [108].

4.7.3 Consistency Ratio

Several issues in the AHP process deserve special attention. The first is its ability to analyse consistency of judgments. As Saaty described [26], the method involves redundant comparisons to improve validity, recognizing that participants may be uncertain or make poor judgments in some of the comparisons. This redundancy results in multiple comparisons that may lead to numerical inconsistencies. For example, if criterion A is just as important as criterion B, the pairwise judgments for A and B to any other criterion should be identical. In the event this does not happen, inconsistencies are accounted for. Consistency ratios (CR) are calculated and compared to indexes derived from random judgments. As long as the CR $\leq$ 0.10, analysis of results can be done. Saaty also emphasizes that greater consistency does not imply greater accuracy and judgments should be altered only if they are compatible with one's understanding. Otherwise, more information may be necessary or the hierarchy may need re-examination.

Saaty shows that to maintain reasonable consistency when deriving priorities from paired comparisons, the number of factors being considered must be less or equal to nine. AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. The consistency of the judgmental matrix can be determined by Consistency Ratio (CR), defined as:

$$\textit{Consistency Ratio, (CR) or Inconsistency Ratio, (IR)} = CI/RI \quad (3.1)$$

Here, CI is the Consistency Index and RI is the Random Index. Furthermore, Saaty [26] provided average consistencies (RI values) of randomly generated matrices as conclude in Table 3.2. CI matrix for a matrix of order *n* is defined as [25]:

$$CI = (\chi_{max} - n) / (n-1) \quad (3.2)$$

n = *matrix size*

χ_{max} = *eigenvalue max*

Random Index *(RI)* is a simulation of a large number of randomly generated pairwise comparisons for different sizes of matrices, carried out by Saaty, with regard to calculation of the average CI. The significance of RI is the ratio of the CI to the RI, in a particular set of judgements in the same size of matrix. The values of standard RI are given in Table 4.4

Table 4.4 The Average Consistencies of Random Matrixes (RI values)

Size	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

4.7.4 Weighting

A relative weight is assigned to each criterion, based on its reported level of importance. The sum of all the criteria belonging to a common direct parent criterion in the same hierarchy level must be equal to 100% or 1 [110]. A global priority is computed to quantify the relative importance of a criterion within the overall decision model. AHP scores each criterion in a hierarchy, accounting for all levels and computes an overall score. Finally, rankings are used to compare the criteria and select the one that best fits the goal.

4.7.5 Evaluation

Evaluation has been conducted to evaluate the feedback from the respondent. As discussed before, in the questionnaire, the respondents will scale each pair wise comparison of the criteria and sub-criteria, by the number of 1 to 9. To analyse the questionnaire, the judgment matrixes were computed via the use of Expert Choice 2000 software, and the CR must be ≤ 0.10. A higher CR (greater than 0.10) at any level or in the final synthesis revealed that the judgments are inconsistent [111].

Although not invalidating the entire model, inconsistencies suggest that an expert's opinion should be investigated to determine the cause. If the modification of judgments fails to lead to an improvement of the CR, it is likely that the problem needs to be restricted by grouping the elements that are interrelated by common characteristics. In this research, questionnaires with a CR score greater than 0.10 was investigated. The process is illustrated in Figure 4.3.

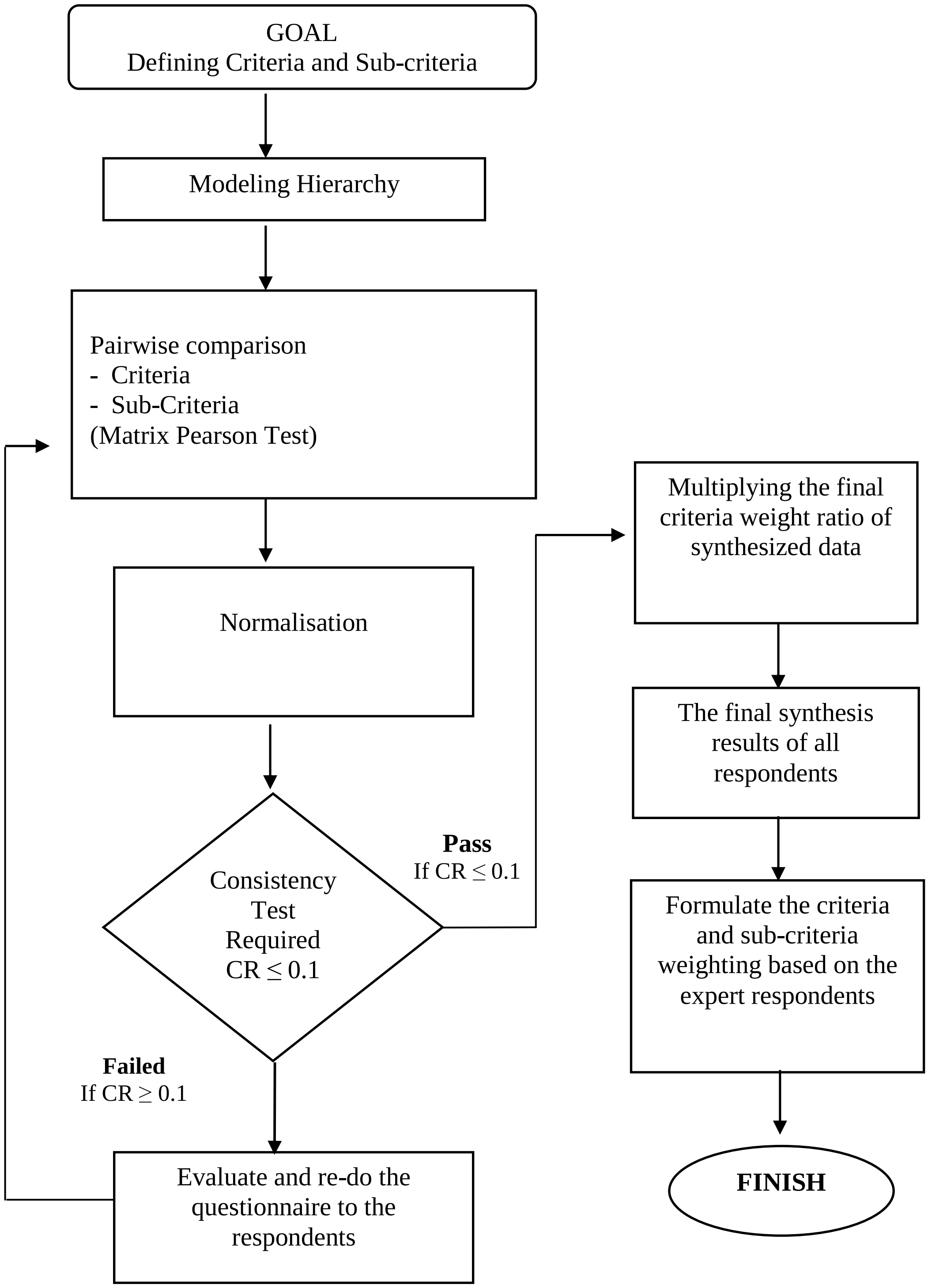


Figure 4.3 AHP Flowchart

4.8 Validation by the Certified GBI Facilitator

The final phase will be evaluation one of new building construction projects in Malaysia, the “SIME office building”. The aim is to validate the workability of the GBI survey result and its scoring differences with the current GBI. “SIME office building” was chosen because it was designed and constructed to fulfil LEED silver rating certification. The result of this building assessment will be then validated by the certified GBI facilitators.

4.9 Summary of Methodology

The comparative analysis was an initial step in analysing the criteria and sub-criteria of GBI. The result of the comparative analysis was combined with literature reviews that are critical to GBI. The main focus of the study is to determine if experts would rate the criteria of GBI differently than the existing weighting currently in use. AHP was selected apart from other MCDM methods because of its ability to overcome the problems characteristic of this type of research. In order to choose the criteria based on expert opinions, this thesis applied the analytical hierarchy process, developed by Saaty (1980), which decomposes the decisional process in a hierarchy of criteria and sub criteria through a set of weights that reflect the relative importance. The AHP has become a significant methodology due to its capability for facilitating multi-criteria decision-making.

In AHP, Expert Choice Software, was used as a DSS tool to assist in structuring the hierarchy and in synthesizing judgments. This software eliminated tedious calculations. The details of research design are explained in Figure 4.4. In the next chapter, results of the comparative analysis of international rating system with GBI, in order to find the similarities and differences are further discussed. The aim is to find out whether GBI closely resembles (to be alike or similar) other GBRSs in term of certification process, criteria and rating award. This will be followed by analysis of the criteria and sub-criteria weighting of GBI based on expert respondents. Respondent will scale and choose the criteria and sub-criteria which according to their expertise and experience is the most suitable in the Malaysian local context.

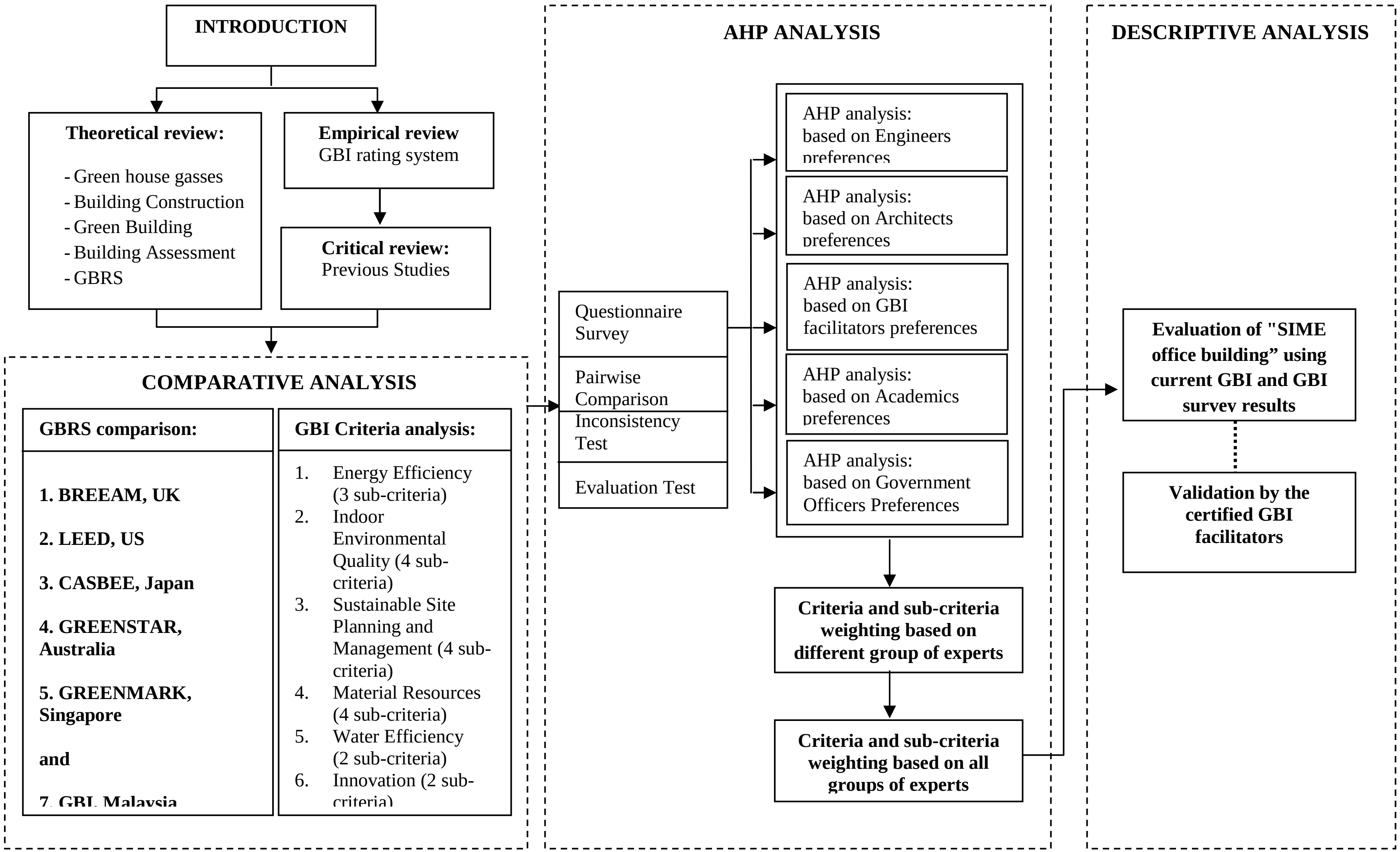


Figure 4.4 Design of Research Methodology

CHAPTER 5

RESULT AND DISCUSSION

5.1 Introduction

There are large numbers of environmental rating systems internationally, but only several have gained significant market acceptance and widely in use. The two that have achieved the greatest prominence within their respective market sectors are LEED in the US, and BREEAM in the UK. In other parts of the world, efforts are being made to adapt existing systems to reflect local guidelines. For example, South Africa is planning to launch a national version of *Green Star* in the near future. Many similarities exist among the different systems; each is based on the levels of rating award as well as criteria use. However, significant questions remain in which content and process differences among the systems, significantly influence environmental performance outcomes.

This chapter attempts to address the content and priorities specific to GBI when it is compared to the other five GBRSs, as well as the process related to implementing the systems. Therefore, issues associated with credibility (certification process), flexibility (applicability and rigidity of point systems), and the criteria chosen by six rating systems, form a life cycle perspective underline much of the discussion. As mentioned in Chapter 3, GBI was based on a combination of “educated guess” as well as an adaptation of LEED. Thus, it will be interesting to systematically evaluate weighting of criteria and sub-criteria of GBI based on the opinions of expert respondents. Finally, a “SIME office building” is chosen as a case study to be evaluated with the current GBI and GBI survey result. The results were then validated by certified GBI facilitators.

5.2 Comparative Analysis

The purpose of this comparison is to identify similarities and differences between the GBI and other GBRSs. This comparison includes BREEAM, LEED, Green Star, Green Mark and CASBEE. The comparisons are based on the building type, the certification process, the criteria and sub-criteria weighting, as well as the rating of each of GBRS. This study aims to establish the theoretical background in order to prepare for further analysis in the next phase of studies.

5.2.1 General Comparison

In general, all GBRSs have a similar aim; to address the sustainability of buildings in specific locations. Benchmarking schemes are used to assess best practices in design and construction in terms of sustainability. All GBRSs have differences, as each one is unique to the environment of its intended use. A general summary comparing GBI and other GBRSs is shown in Table 5.1.

The process in which GBI is formed greatly differs from other GBRSs. BREEAM, LEED, Green Star, and Green Mark were developed by Green Building Council (GBC) in their respective countries based on local needs and requirements. However, GBI was created by a group local architects and engineers, namely the members of Malaysia Association of Architects (PAM) and the Association of Consulting Engineers Malaysia (ACEM). CASBEE was first developed by the iiSBE in the form of a GB Tool. This system is unique and the most different among other GBRSs.

In term of projects certification, BREEAM and Green Mark are the only systems that are compulsory in their countries of origin. In the UK, BREEAM certification is required. Government departments utilise BREEAM for non-domestic buildings and apply the code to most sustainable homes for domestic buildings. The Singaporean government has encouraged obtaining Green Mark approval, requiring certification in some cases, in an effort to promote environmental awareness in the construction and real estate sectors. In Malaysia, GBI certification for building projects is still on voluntary. This is also applied for Green Star, LEED and CASBEE.

Table 5.1 General Comparison of GBRS

	BREEAM	**LEED**	**Green Star**	**Green Mark**	**CASBEE**	**GBI**
Establish	1990	1998	2003	2005	2004	2009
Country of Origin	UK	US	Australia	Singapore	Japan	Malaysia
Status	Compulsory	Voluntary	Voluntary	Compulsory	Voluntary	Voluntary
Local/ Global	National/ Multi National	National/ Multi National	National/ Multi National	National/ Multi National	National	National
Third party validation	Building Research Establishment	United States green Buildings Council	Green Building Council Australia	Building and Construction Authority (BCA)	Japan Sustainable Building Consortium	Pertubuhan Akitek Malaysia and Association of Consulting Engineers Malaysia
Assessor	Trained Assessors	USGBC	Accredited Professionals	BCA assessment team	Design/ Management Team of JSBC	GBI Accreditation Panel
Update Process	Annual	As required	-	As required	-	Per three years

BREEAM, LEED, Green Star and Green Mark were systems intended to be used both locally and globally. Green Star was initially intended to be used only in Australia but later is also used in New Zealand and Indonesia. CASBEE is used only in Japan, and on a voluntary basis. As for GBI, the implementation is only in Malaysia.

There are no required deadlines to renew certification with either LEED or Green Mark. Requirements for BREEAM vary depending on characteristics of use; "assets," are required to be updated every three years, while management and organizational policies need to be updated every year. CASBEE certifications are valid for three years upon completion of construction of a new house. CASBEE certifications for existing buildings or urban development are valid for five years and valid for three years for renovation projects. Green Star currently has no required renewal date, but is expected to have one in the future. GBI's legal period of certification is three years.

In these ways and others, GBRS systems vary in characteristics. The most distinct differences of GBI, compared to other GBRSs, are the certification renewal requirements and “third-party support”.

5.2.2 Building Type and Certification Process

Each rating system is used during different stages of building, and on different types of buildings. Some GBRSs’ have very detailed categories of building type. BRE was a government funded research body when BREEAM was conceived in 1990. BREEAM’s mission was to provide relevant research and information to the building industry regarding the best methods to support environmental protection and sustainable development. Because of this, BREEAM has the most detailed categories of building types, totalling 15. BREEAM’s rating system is considered to be the most valuable because of the detailed requirements of each building type. BREEAM uses various assessment tools to determine a building’s category. Each building type’s unique specifications are continually identified by BREEAM, and accounted for by updated versions, such as the new BREEAM 2011.

Currently, LEED is known as the leading rating system in the global market. Since its inception in 1998, LEED has changed the construction industry by using a consensus approach. It has also adopted a commercial approach to marketing, attracting paying members and bringing in US$24 million a year. LEED is a registered trade mark and a brand name. A total of nine building types have been covered by LEED thus far. In order to be more widely accepted, LEED intends to update its processes. The most current version is LEED 3.0, which includes an upgrade for the 2009 rating system. LEED for New Construction 2009 is adapted from the Green Building Design and Construction Reference Guide.

Table 5.2 Building Type and Certification Process of GBRS

	Building Types Covered	Certification Process
BREEAM	1. Other Building (including leisure complexes, laboratories, community building and hotels design); 2. Courts 3. The code for sustainable homes; 4. Ecohomes; 5. Ecohomes XB; 6. Hospital or healthcare building; 7. Industrial building; 8. Multi-Residential 9. Prisons; 10. Offices; 11. Retail; 12. Education; 13. Communities; 14. Domestic Refurbishment; 15. In-Use	There are several licensed assessment organizations mainly in UK. For each assessment, the assessor produces a report outlining the development's performance against each of the criteria, its overall score and the BREEAM rating achieved.
LEED	1. New construction and major renovations 2. Existing buildings: operation and maintenance 3. Commercial interiors 4. Core and shell 5. School 6. Retail building 7. Healthcare building 8. LEED for homes 9. LEED for neighborhood development	USGBC conduct third party verification prior to awarding a certification Cost of certification depending on member status, building type and size. Significant documentation required for submittal. Accredited professional is recommended but not required to be part of design team.
Green Star	1. Education v1; 2. Healthcare v1; 3. Industrial v1; 4. Multi Unit Residential v1; 5. Office v3; 6. Office Interiors v1.1; 7. Retail Centre v1; 8. Office Design v2; 9. Office As built v2;	In Australia, GBCA validates the project's achievement through a formal assessment. The GBCA encourage users of the schemes to give feedback. Unlike BREEAM assessment, Green Star can be carried out by any member of project team.
CASBEE	1. CASBEE for Pre-Design Assessment Tool 2. CASBEE for New Construction 3. CASBEE for Existing Buildings 4. CASBEE for renovation	CASBEE is sold primarily as a "self assessment check system" to permit users to raise the environmental performance of buildings under consideration.

	Building Types Covered	Certification Process
Green Mark	1. Residential building; 2. Non Residential building; 3. Existing building; 4. Office Interior; 5. Landed house; 6. New and Existing parks; 7. Infrastructure; 8. District; 9. Overseas Projects;	The assessment will include design and documentary reviews as well as site verification. Documentary evidences are to be submitted at the end of the assessment. Upon completion of the assessment, a letter of award showing the certification level of the projects will be sent to the team
GBI	1. Residential 2. Non-Residential : New Construction and Existing Building 3. Township 4. Industrial	Application & Registration, The Registration Fee will be set depending on the size of the project Design Assessment (DA), The GBI Certifier will then undertake the Design Assessment for GSB Completion & Verification Assessment (CVA), The final GBI award will be issued by the GBIAP upon completion of this CVA assessment.

Green Star is known for frequently updating building assessment tools. Early formed, Green Star adapted BREEAM. Through time, Green Star developed its own rating system. The new system took into account every aspect of building in Australia. CASBEE involves complex calculation methodologies. Although utilising only four types of buildings, the system is sufficiently detailed. Green Mark's systems have been improved since becoming a compulsory assessment for building by the Singaporean government. GBI currently has only three different types of building assessments. All GBRSs have a third-party verification process, where assessors verify all projects and estimate costs. The comparison of building type and the certification process is shown in Table 5.2.

5.2.3 Criteria

All GBRSs use point systems, and have minimum requirements for projects to receive certification. The necessary criteria impacts building designs and also influence development of construction methods. Points scored may be as simple as having a design feature or may call for a detailed analysis to verify the building's performance.

With CASBEE, it is impossible to calculate the value of each criterion, as values are dependent on the final scores. CASBEE has unique criteria for point scoring; it is a complex calculation based on the Building Environmental Efficiency equation. The efficiency of the point system continues to develop as more measures of environmental impact are created. However, this has not necessarily shown a direct correlation with levels of environmental impact.

BREEAM uses a different system to evaluate environmental impact. Their system calculates the criteria by weighting the scores. After all characteristics have been examined, a score is determined. This process gives a final environmental score. The BREEAM rating is then added based on the score achieved. BREEAM also is unique because it has 10 different criterions.

LEED, Green Star and Green Mark use similar scoring assessment procedures. These systems calculate all the criteria, and assign points. No weighting is used for either criteria or sub-criteria. Buildings earn points which accumulate to earn an approval rating.

Green Star uses similar criteria to BREEAM. These criteria were developed by BREEAM, and adopted later by Green Star. Green Star continually evolves based on the local needs in order to remain applicable to current standards. Green Mark differs from GBI most greatly because Singapore emphasises low energy consumption. The system currently most similar to GBI is LEED, which utilises the same six criteria for scoring.

Points earned for each criteria:

- BREEAM has 9 criteria, plus one additional criterion. The main criterion is “Energy” receiving 19 points. BREEAM point value for “Water Efficiency” is the lowest of all the criteria.
- LEED utilises 6 criteria, plus one additional, totalling 110 points. The main priority is “Energy Efficiency”, which is valued at 35 points. The least priority is “Innovation”, valued at only 6 points.

- Green Star's rating system consists of 7 criteria and one additional item. Green Star emphasizes "Energy", with a value of 29 points. The least priority is "Land use and ecology", scoring 8 points.
- Green Mark's emphasis is on "Energy" assigning 116 points to this category.
- GBI, similar to LEED, assigns "Innovation" the lowest point value. Innovation is considered only a minor influence in a building's environmental impact. "Energy Efficiency" is the most significant criteria, holding 35 points, similar to LEED.

Table 5.3 shows the classification of the comparison of criteria in each GBRS. GBI and LEED are very similar in terms of criteria and its points, although the two systems are used in different geographical zones under different climatic conditions. Priority ranking of these criteria is also comparable. The criteria for both GBRSs are energy efficiency, water, materials, land use, sustainable sites, indoor environmental quality and innovation.

Table 5.3 Comparison of GBRS in Criteria and Points

Criteria	**BREEAM**	**LEED**	**Green Star**	**Green Mark**	**GBI**
Management	12		12		-
Energy	19	35	29	116 (min30)	35
Transport	8		11		-
Health and Well Being	15				-
Water Efficiency	6	10	12	17	10
Materials	12.5	14	22		11
Waste	7.5				
Land use and Ecology	10		8		-
Pollution and Emissions	10		19		-
Sustainable Sites		26		42	16
Indoor Environmental Quality		15	27	8	21
Innovation	10 (add)	6	5 (add)	7	7
Regional Prior		4 (add)			
Building environmental management					
TOTAL	**110**	**110**	**145**	**190**	**100**

5.2.4 Rating Award

Each GBRS has its own approach to scoring. A percentage of each criterion is calculated and a rating awarded after scores are determined. A rating award is a certification given to buildings determined environmentally friendly or “green”.

BREEAM has four rating awards. The highest scores are giving a rating of “excellent” if the total score is 70 points. The lowest rating awarded is labeled “passing” with 25 points to 39 points scored. The maximum points achievable are 70 points. Green Star has three certified ratings available. “Four stars”, is awarded for utilising best practices, “Five stars” represents Australian excellence, and “Six stars” represents the world leadership accomplishment. Total points possible for Green Star is over 140 points, since points for innovation are added.

CASBEE has five rating awards. “S” means the building’s environmental quality is excellent. “C” is a poor rating. Scores and ratings are assigned in a variety of ways, leading to confusion for many who are not familiar with the rating system. Even though Green Mark has a maximum of 190 points, the highest ranking requires a minimum of only 90 points.

As concluded in Table 5.4, LEED and GBI have very similar ratings. Both awards award ratings from “Platinum” to the lowest level labeled “Certified”. Difference lies in the “Certified” level, since LEED assigns scores between 40 and 49 points, while GBI assigns between 50 and 65 points. The “Platinum” level, for GBI requires 86 points and LEED requires a total of 80.

Table 5.4 Comparison of GBRS in Rating Award

	BREEAM	**LEED**	**Green Star**	**CASBEE**	**Green Mark**	**GBI**
Rating Award	Outstanding: ≥85 Excellent : ≥70 Very Good: ≥55 Good≥45 Pass: ≥30 Unclassified: ≥30	Platinum: ≥80 Gold: 60-79 Silver: 50-59 Certified: 40-49	Six Star: 75-100 Five-Star: 60-74 Four-Star: 45-59	S : ≥3 A: 1.5-2.99 B^+ : 1-1.49 B^- : 0.5-0.99 C : 0-0.49	Platinum : >89 Gold Plus: 85-89 Gold : 75-84 Certified: 50-74	Platinum : ≥86 Gold: 76-85 Silver: 66-75 Certified: 50-65

5.2.5 Summary

It has been found that GBI is very similar to one of the GBRS. Of all GBRSs, LEED and GBI are the most similar, even though the systems were developed for use in a totally different climate. Comparative analysis shows that GBI closely adopted LEED's rating system. It is important each GBRS shows consideration for locality of its intended use. Therefore, next analysis will show how experts respondents judge the criteria used in GBI in terms of knowledge specific to the construction industry in Malaysia. Each respondent will evaluate each criterion and sub-criterion, corresponding to the overall weighting of GBI.

5.3 AHP Analysis of the GBI Survey

This analysis presents experts' opinions of the criteria and sub-criteria used for GBI, and its suitability for use in Malaysia specifically. This analysis is divided into four sections: pilot survey, questionnaire survey, analysis on different groups of expert respondents and an analysis of all groups of respondents.

5.3.1 Pilot Survey Result

The aim of the pilot survey was to give an overview, to ensure the evaluation covered relevant areas of focus. The survey involved seven respondents, professionals in green building and sustainable construction in Malaysia. Respondents were an architect, an engineer, a project manager, an environmental engineer, a design engineer, a GBI facilitator and an academic. Seventy-two percents of respondents have five to nine years of experience in green building. Remaining respondents had two to four, or over fifteen years of experience. A pilot survey was conducted to gather feedback from experts. A total of 50 questionnaires were sent, 10 were returned, and seven included usable responses. The criteria and sub-criteria were weighted by the pairwise comparison method, requiring respondents to choose a level of importance, on a scale from one to nine, in two different issues, as shown in the Instructions section of Appendix A.

The feedback from respondents was converted into a geometric mean. Later, the total value of the geometric mean for each criterion was compared to other criterion and calculated through Expert Choice software. The weighting of criteria and sub-criteria was determined by geometric means. Expert Choice software weighs criteria and compares to one another. The value of the CR, as shown in Appendix B: Figure B1 and B2, is 0.05 and 0.02 respectively. It is less than 1, which is consistent. It was concluded that the respondents clearly understood of pairwise comparison method and found its use acceptable. Respondents' opinions were analyzed through the pair wise comparison method of AHP to determine weighting. Appendix B shows the weighting process for each criteria and sub-criteria, which the results are as follows:

1. Indoor Environmental Quality "IEQ" (0.281),
2. Energy Efficiency "EE" (0.252),
3. Water Efficiency "WE" (0.151),
4. Sustainable Site Planning and Management "SM" (0.120),
5. Material and Resources "MR" (0.099) and
6. Innovation "IN" (0.097).

<u>Discussion</u>

As shown in Table 5.5, ranks of criteria and sub-criteria revealed that the pilot survey weighted results differently than the current GBI. A summary of the survey findings are as follows:

- 'IEQ' was perceived as the most important core criterion in green building assessment. Respondents considered 'air quality' more important than 'lighting and visual' in the sub-criteria of this category.
- "EE" was considered the second most important criteria. Respondents' reported that all sub-criteria in this category are of equal importance.
- Current GBI rates "WE" in the fifth rank, but the pilot survey ranked it third. According to feedback 'water harvesting' was more important than 'increased efficiency' in this category's sub-criteria.
- "SM" was rated the fourth most important criteria. Respondents stated that the best locations to build projects were near mass transportation areas. For this criterion, both systems (current GBI and pilot survey result) weight the sub-criteria, as all equally important.

- “MR” was rated fifth. All sub-criteria were weighted of almost equal importance.
- The pilot survey rates “IN” the least important.

Table 5.5 Share Points in Criteria and Sub-Criteria (Pilot Survey Result)

Item	Points of Criteria (pilot survey)	Points of Sub-criteria (pilot survey)	Points in Current GBI
Energy Efficiency			
Design EE	25	8.4	25
Commissioning		8.4	5
Verification n Maintenance		8.4	5
Total		25.2	35
Indoor Environmental Quality			
Air quality	28	11	6
Thermal comfort		8	3
Lighting, visual, & acoustic		5	8
Verification		4	4
Total		28	21
Sustainable Site Planning And Management			
Site planning	12	4	6
Construction management		2.5	3
Transportation		2.5	3
Design SM		3	4
Total		12	16
Material Resources			
Reused, recycled materials	10	2.5	4
Sustainable resources		3	2
Waste management		2	3
Green Product		2.5	2
Total		10	
Water Environment			
Water harvesting & recycling	15	10	4
Increased Efficiency		5	6
Total		15	10
Innovation			
Innovation in design	10	8	6
GBI accredited facilitator		2	1
Total		10	7
TOTAL	**100**	**100**	**100**

GBI is typically point based and involve assigning ratings to building projects in order to classify them as environmentally sustainable. The pilot survey showed that "IEQ" is the main priority of GBI rating system.

5.3.2 Questionnaires Survey Result

The questionnaire was designed based on the AHP method, allowing respondents to compare each criterion and sub-criteria. Appendix A shows the questionnaire sent to the expert respondents. Most questions allowed for respondents to give additional information. Some open-ended questions were included to allow for unforeseen expert opinion and advice.

GBI was launched May 2009, a month before this study began in June. At that time, only a few people were acquainted with GBI and green building construction in Malaysia. Targeted respondents were contacted by telephone, email and fax to encourage participation and confirm mailing addresses. Phone interviews were also conducted to determine which respondents made decisions related to GBI issues.

Based on the stakeholder analysis in chapter 3, five parties had high influence in GBI decision making. Architects, engineers, GBI facilitators, government officers and academics were among the experts involved. The survey, consist of a questionnaire sent to 300 respondents that were selected from members of ACEM, MGBC and PAM, GBI facilitators and government officers involved in green building. A total of 69 questionnaires were returned as shown in Table 5.6. In addition, there are 25 questionnaires un-useable, where the CR is more than 0.1, which means the respondents are not consistent or understand with the subject matter. Appendix C shows the CR for each criterion and sub-criterion.

Table 5.6 Responses from the Questionnaire Survey

	Total
Number of questionnaire sent	300
Number of replies received	69
Number of useable replies	44

The surveys indicate five groups of respondents, based on profile backgrounds. The biggest group was the ‘engineers’ category, representing 16 respondents, followed by ‘academics” with 11 respondents, ‘GBI facilitators’ with 10 respondents, ‘architects’ with 5 respondents, and ‘government officers’ with 2 respondents. The percentage of each group is shown in Figure 5.1.

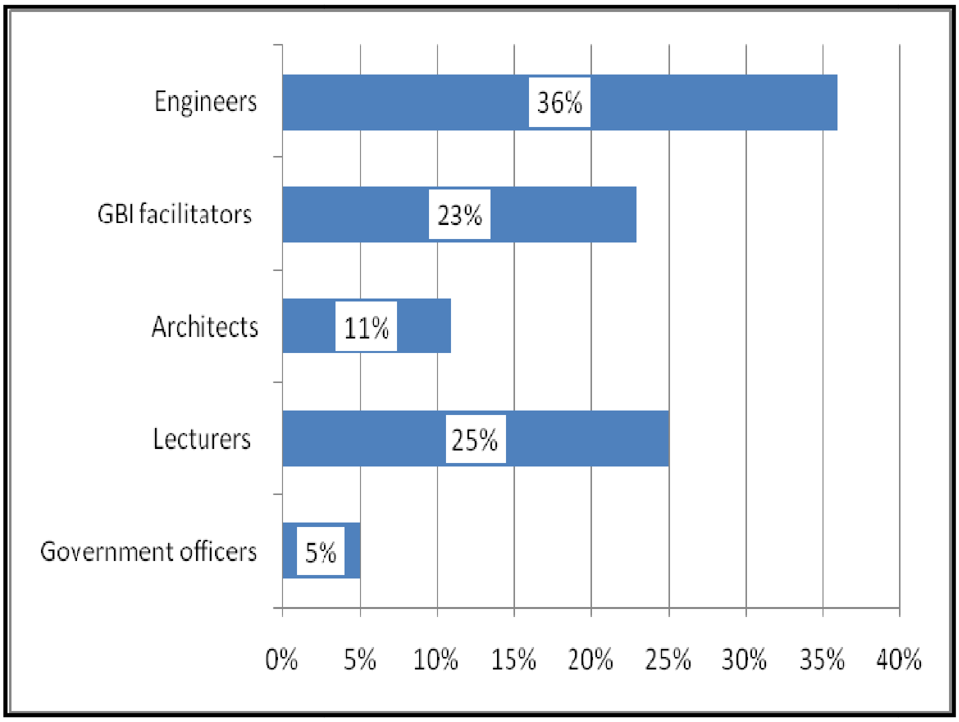


Figure 5.1 Groups of Respondents (%)

Respondents with experience between five and nine years in green building made up the largest group, constituting 41% of the total respondents. Twenty-seven percent of respondents had between two and four years of experience. Twenty-one percent had between 10-15 years of experience, while 9% had less than two years of experience. The smallest group of respondents had a total of 15 years of experience or more, comprising 2%. Figure 5.2 shows the breakdown of respondent’s experience.

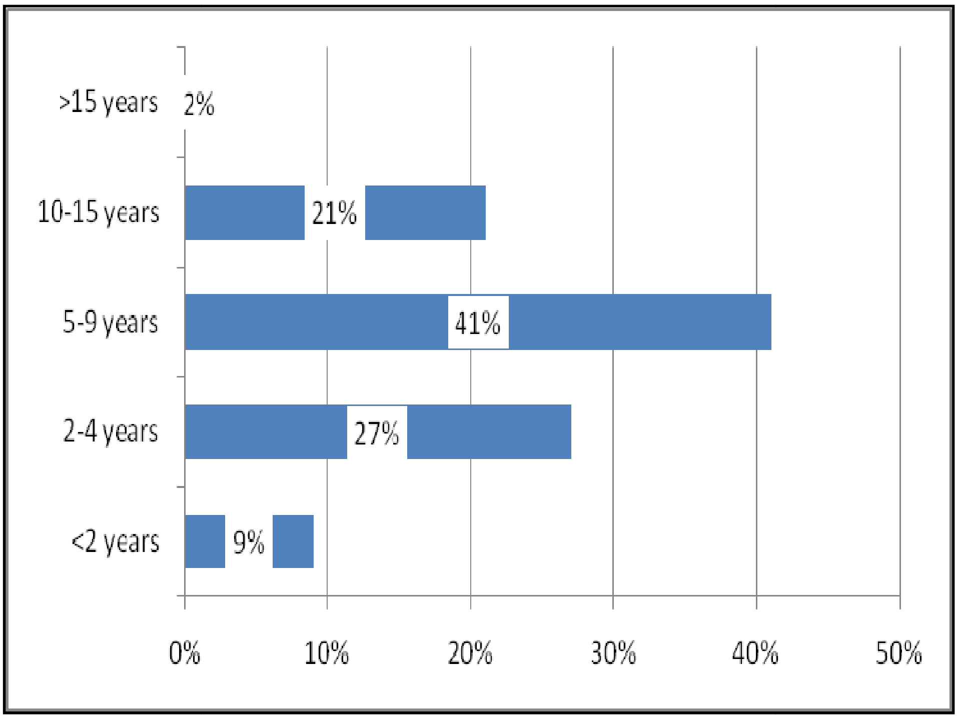


Figure 5.2 Respondent Years of Experience (%)

Summary

The method adopted for this survey proved appropriate when a high response rate was achieved. The 44 responses from the survey also proved to be from person's very knowledgeable in green building practices, lending a Consistency Ratio of less than 0.1.

5.3.3 AHP based on Different Group of Experts

Forty-four questionnaires were analyzed for the AHP. Demographic information revealed that all respondents were highly involved in green building construction. This survey included 16 engineers, 5 architects, 10 GBI facilitators, 2 government officers and 11 academics.

The current GBI has six criteria, rating "EE" of most importance, followed by "IEQ", "SM", "MR", "WE" and "IN". Pilot survey results showed "IEQ" to be the first priority of experts in this field. However, opinions of different groups of experts may lead to different results.

5.3.3.1 Engineers

Total Sixteen respondents were engineers. Results show the opinions of experts on practical aspects of green building during a recent time period. Figure 5.3 shows the AHP analysis results based on engineers' feedback. Importance of criteria was weighted as follows; "EE" (29.5 points), "IEQ" (24.8 points), "SM" (12.4 points), "WE" (12.1 points), "MR" (11.2 points), and "IN" (10 points).

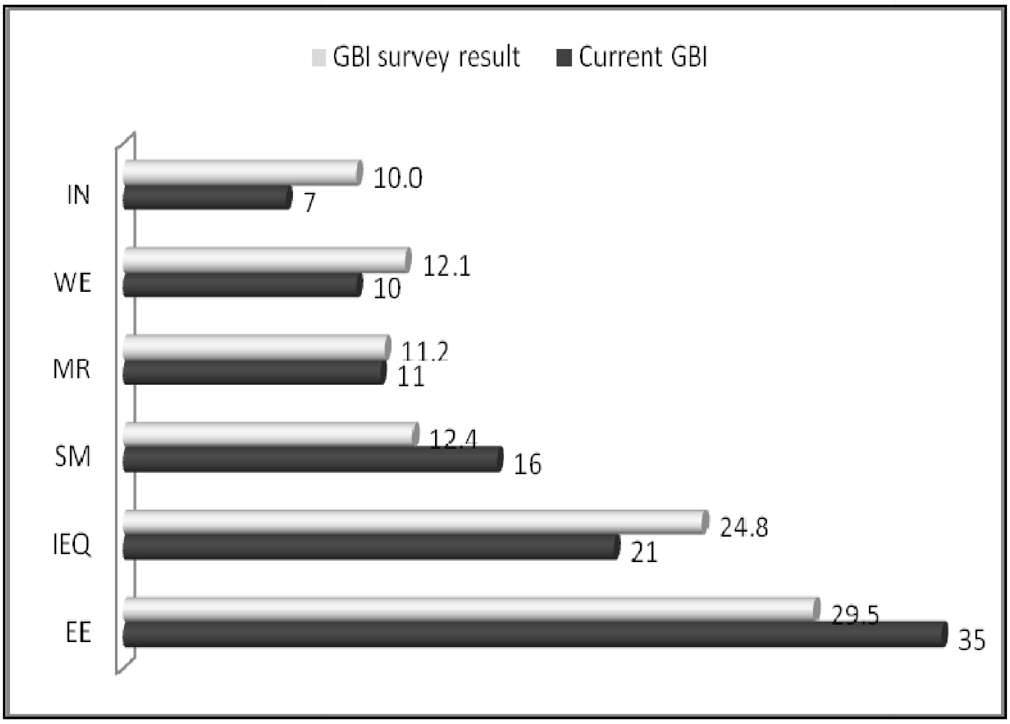


Figure 5.3 Share Point of Criteria based on Engineers

5.3.3.2 Architects

The five respondents who were architects reported different viewpoints from the engineers. The criterion of highest importance was "IEQ", but "IN" was reported as the next criteria of importance in designing buildings. The other criteria in order of importance were: "WE", "EE", "MR" and "SM". Figure 5.4 shows points given to each criterion.

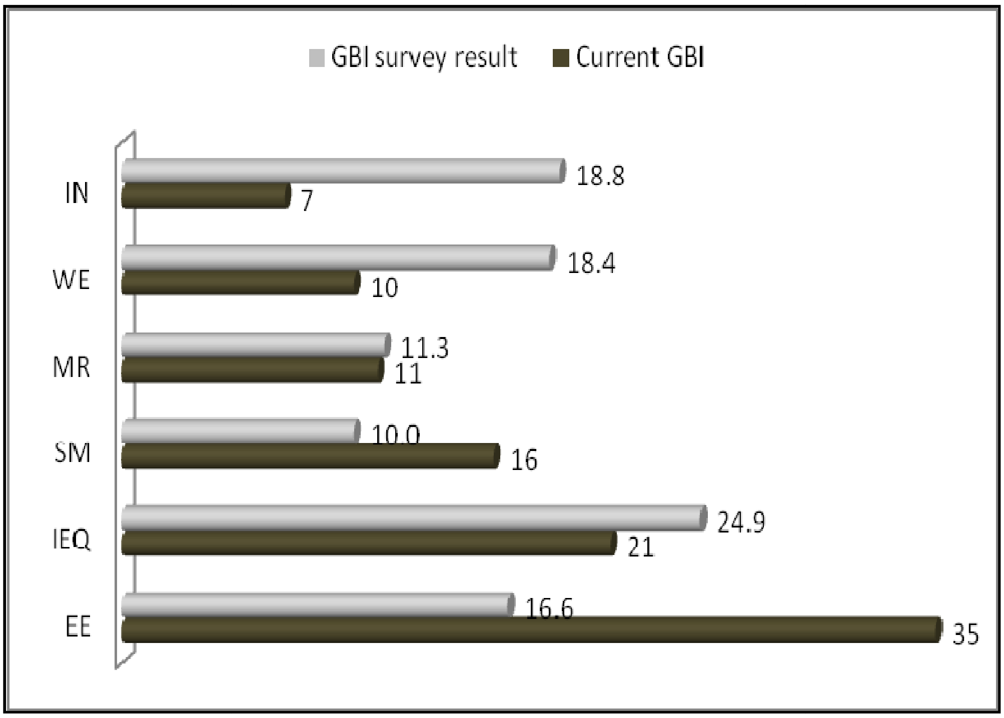


Figure 5.4 Share Point of Criteria based on Architects

5.3.3.3 GBI facilitators

The 10 respondents who were GBI facilitators reported having the most experience in green building. The survey results were similar to results from the engineers' group. The only difference was the first and second ranks. The criteria were rated in this order of importance: "IEQ", "EE", "SM", "WE", "MR" and "IN". Figure 5.5 shows point totals for each criterion.

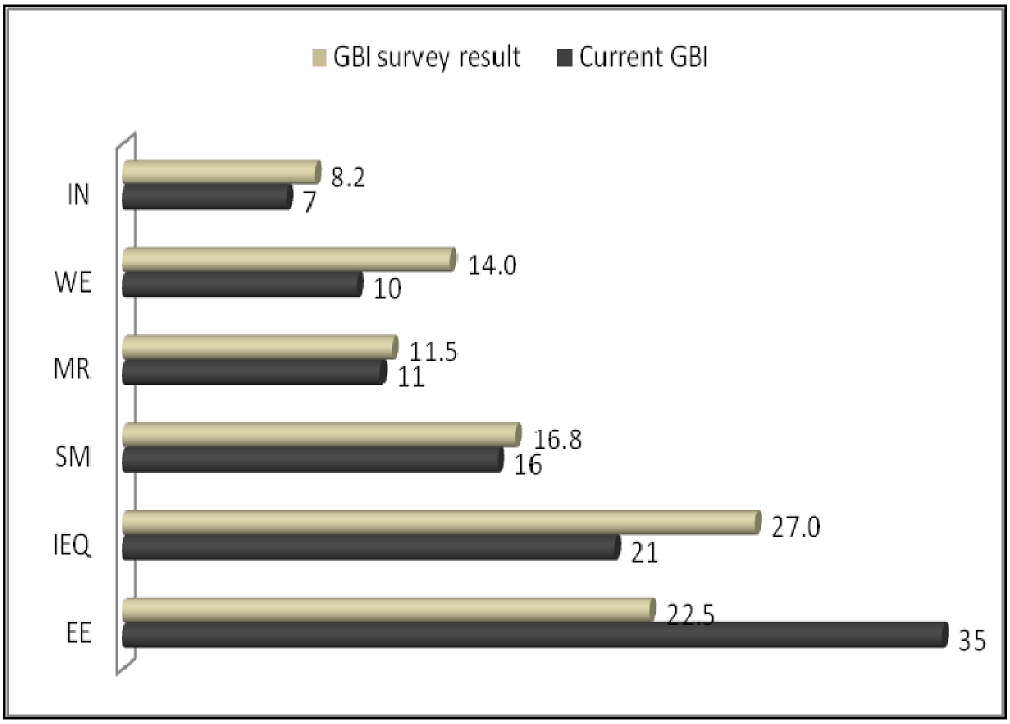


Figure 5.5 Share Point of Criteria based on GBI Facilitators

5.3.3.4 Government Officers

The Malaysian Government is serious in its long term commitment to promoting green technology. Thus, this research involved government officers. Two respondents formed this group. The analysis shows "IEQ" as the highest ranking criteria. Other criteria were ranked in the following order of importance: "EE", "SM", "MR", "IN" and "WE". Figure 5.6 shows points given to each criterion by this group of respondents.

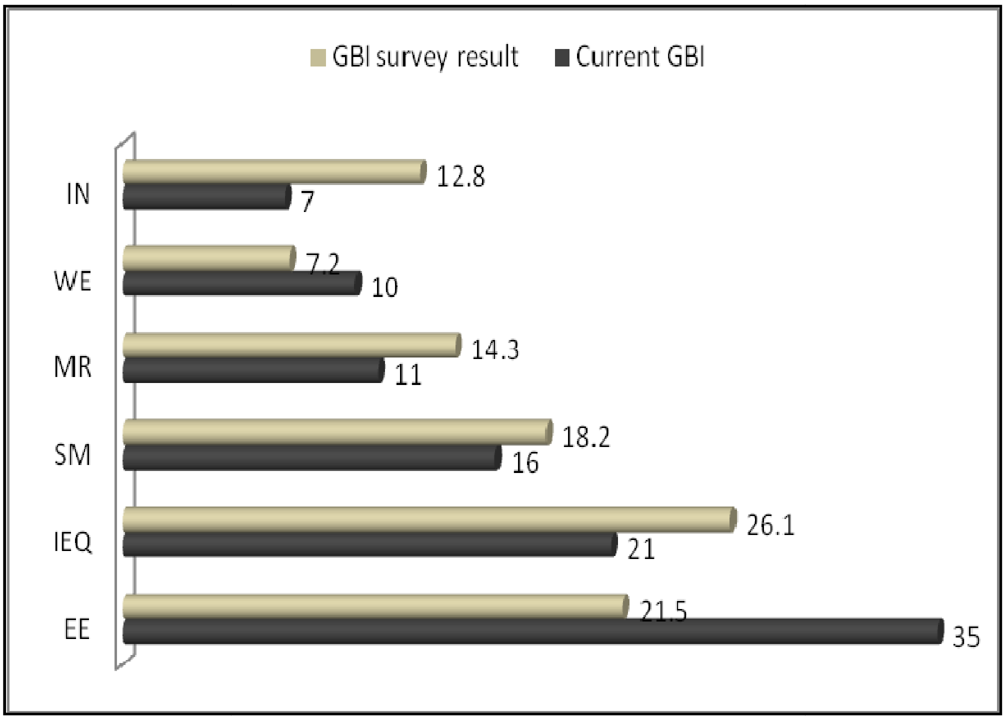


Figure 5.6 Share Point of Criteria based on Government Officers

5.3.3.5 Academics

Academics are considered experts in this field due to the large volume of research done in this field of study. The group of academics consists of 11 respondents. The findings show "IEQ" and "EE" are the most important criteria in green building assessment, both holding 21.1 points.

In comparing results of the current GBI and the survey, it is seem that both assign the highest rank to "IEQ". Other criteria, in order of importance, are: "MR" with 16.1 points, "WE" with 15.7 points, "SM" with 14 points and "IN" with 12 points. A comparison of criteria rankings between the current GBI and Academics surveyed is shown in Figure 5.7.

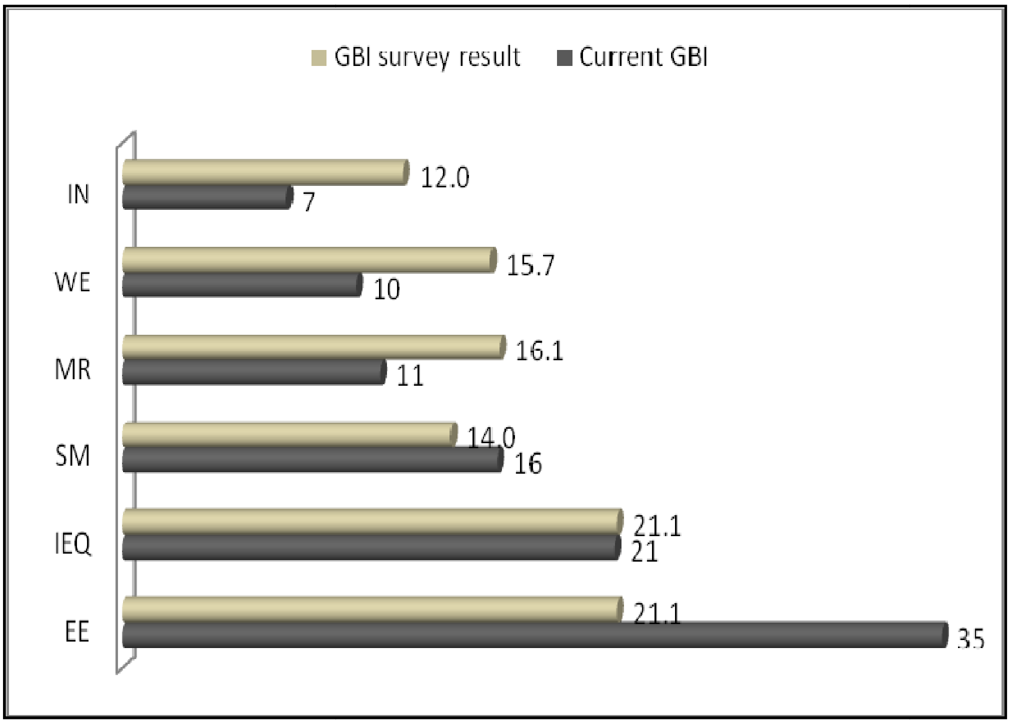


Figure 5.7 Share Point of Criteria based on Academics

Discussion

Engineers' feedback shows that "IN" is not presently a concern in green building. Technology is presently more advanced than current technical standards in this part of the world. Architects' disagree, concluding that innovation yields a significant impact on building design. "IEQ" and "IN" both constitute large part in green building assessment, since both influence energy use.

Academics were under the opinion that "IEQ" and "EE" has the largest part in green building assessment because it affects the health of occupants. They also stated that failure of proper environmental quality in a local hospital in Malaysia is linked to the use of GBI.

GBI facilitators comment that the high priority of "IEQ" is due to bylaws. IEQ needs to be addressed to get basic building approval. "EE" is important to lower energy consumption. Government officers also rate "IEQ" as a high priority because designs related to air quality, day lighting, and air conditioner usage can lower energy needs. Table 5.7 shows the differences of criteria points in each group.

Table 5.7 Comparison of Criteria Priority by Different Group of Experts

	EE	IEQ	SM	MR	WE	IN	Priority
Current GBI	**35**	21	16	11	10	**7**	1. EE 2. IE 3. SM 4. MR 5. WE 6. IN
Expert Group Respondents							
Engineers	**29.5**	24.8	12.4	11.2	12.1	**10**	1. EE 2. IEQ 3. SM 4. WE 5. MR 6. IN
Architects	16.6	**24.9**	**10**	11.3	18.4	18.8	1. IEQ 2. IN 3. WE 4. EE 5. MR 6. SM
GBI facilitators	22.5	**27**	16.8	11.5	14	**8.2**	1. IEQ 2. EE 3. SM 4. WE 5. MR 6. IN
Government Officers	21.5	**26.1**	18.2	14.3	**7.2**	12.8	1. IEQ 2. EE 3. SM 4. MR 5. IN 6. WE
Academics	**21.1**	**21.1**	14	16.1	15.7	**12**	1. IEQ 2. EE 3. MR 4. WE 5. SM 6. IN

5.3.3.6 Summary

From the analysis above, it can be concluded that every group of experts has a unique perspective related to GBI criteria weighting. In term of the framework, the groups with the most similar opinions are engineers and GBI facilitators. While not agreeing on the top two most important criteria, their priority on the rest of criteria is very similar. In term of the first priority in criteria, three groups showed similar result, which ranked "IEQ" as the main top criteria. These groups are aarchitects, GBI facilitators, government officers and academics. As for academics, they chose "IEQ" and "EE" as main criteria. Surprisingly, engineers' survey result is similar with current GBI, where "EE" is the main criteria. Appendix C shows the details of AHP analysis which covered five different expert groups. The value of CR in each group is less than 0.10; thus, the data and result are acceptable. It is indicated that the respondents are consistent and understand of the subject matter. Appendix C shows the criteria and sub-criteria weighting process for each group.

5.3.4 AHP based on All Experts Group

This survey shows the results of all groups of respondents' feedback. A total of 44 questionnaires were reviewed to complete this analysis. Further analysis was then conducted to structure criteria into a hierarchy to distinguish the most important criteria from the least important ones. Three levels were marked, labeled as: goal as objective, level 1 as criteria and level 2 as sub-criteria. Appendix D shows the details of AHP calculation in terms of criteria and sub-criteria based on all group of experts.

5.3.4.1 Level 1: Criteria Weighting

Pairwise comparison judgements were made with respect to the attributes of one level of the hierarchy. Table 5.8 shows the judgments matrix from 44 respondents. Each respondent chose which criteria they believed the most important to compare with other criteria. The feedback helped construct scale and weight for each criterion. In this level, the value of CR is 0.00, meaning it is consistent; respondents understand and give good responses on the issues. Table 5.8 shows respondents' of results where

”IEQ” have the highest weight of all criteria; holding value of 0.247. Other criteria are in the following order: “EE”, “MR”, “SM”, “WE” and “IN”.

Table 5.8 Pairwise Comparison Matrix and Relative Weight of Level 1

	EE	IEQ	SM	MR	WE	IN	Weighted	Rank
EE		1.12	1.54	1.61	1.68	1.76	0.239	2nd
IEQ			1.82	1.95	1.58	1.71	0.247	1st
SM				1.12	1.02	1.15	0.138	4th
MR					1.1	1.22	0.139	3rd
WE						1.34	0.127	5th
IN							0.11	6th
	Incon:0.00							

5.3.4.2 Level 2: Sub-Criteria Weighting

Level 2 consists of sub-criteria, allowing each criterion to be broken into relevant categories. In this level, each respondent chose the most important sub-criteria of each criterion. Nineteen sub-criteria were used. Table 5.9 shows the Eigen value of the sub-criteria of “EE”, which contains 3 sub-criteria. The table shows ‘design EE’ was rated of highest priority, earning a weighting of 0.486. The smallest weighting was assigned to ‘ccommissioning’ at 0.218.

Table 5.9 Pairwise Comparison Matrix and Relative Weight of Level 2 (Sub-criteria of Energy Efficiency)

	Design EE	Commissioning	Verification and Maintenance	Weighted	Rank
Design EE		2.25	1.62	0.486	1st
Commissioning			1.33	0.218	3rd
Verification and Maintenance				0.296	2nd
	Incon:0.00				

“IEQ” was divided into 4 sub-criteria. Based on respondents’ feedback, the highest priority was ‘air quality’, weighted at 0.415. The smallest weighting was assigned to ‘verification’, with 0.125. Other priority weightings are shown in Table 5.10.

Table 5.10 Pairwise Comparison Matrix and Relative Weight of Level 2 (Sub-criteria of Indoor Environmental Quality)

	Air quality	Thermal comfort	Lighting VA	Verification	Weighted	Rank
Air quality		1.58	2.19	3.2	0.415	1st
Thermal comfort			1.48	2.14	0.271	2nd
Lighting VA				1.58	0.189	3rd
Verification					0.125	4th
	Incon:0.00					

“SM” was also divided into 4 sub-criteria. The pairwise comparison matrix of the four point rating scale is shown in Table 5.10. Using Expert Choice software, the relative weights of ‘site planning’, ‘construction management’, ‘transportation’ and ‘design SM’ were calculated, equalling 0.309, 0.198, 0.151 and 0.342, respectively. Table 5.11 also shows all sub-criteria of “SM”. Respondents rated ‘design SM’ as the most important sub-criteria of GBI-NRNC.

Table 5.11 Pairwise Comparison Matrix and Relative Weight of Level 2 (Sub-criteria of Sustainable Site)

	Site Planning	Construction Management	Transportation	Design SM	Weighted	Rank
Site Planning		1.56	2	1	0.309	2nd
Construction Management			1.35	1.79	0.198	3rd
Transportation				2.2	0.151	4th
Design SM					0.342	1st
	Incon:0.00					

Table 5.12 shows the pairwise comparison matrix of the “MR” sub-criteria. Four sub-criteria were weighted. Respondents were asked to assign the four sub-criteria a rating, which were then converted into a corresponding relative weight, shown in Table 7. After normalising the total scores, ‘green product’, was shown as the

preferred sub-criteria, receiving the highest weight of 0.279, follow with ‘reused and recycled materials’ at 0.276.

Table 5.12 Pairwise Comparison Matrix and Relative Weight of Level 2 (Sub-criteria of Material Resources)

	Reused Recycled Materials	Sustainable Resources	Waste Management	Green Product	Weighted	Rank
Reused Recycled Materials		1	1.47	1	0.276	2nd
Sustainable Resources			1.28	1	0.252	3rd
Waste Management				1.43	0.193	4th
Green Product					0.279	1st
	Incon:0.00					

“WE” was divided into two sub-criteria. Based on respondents feedback, the highest weighting was given to ‘water harvesting’, with a weight of 0.514. Table 5.13 shows the weighting of the two sub-criteria of “WE”. “IN” was also separated into two sub-criteria. Table 5.14 shows ‘innovation and design’ rated as a higher priority than ‘GBI accredited facilitator’.

Table 5.13 Pairwise Comparison Matrix and Relative Weight of Level 2 (Sub-criteria of Water Efficiency)

	Water harvesting	Increased Efficiency	Weighted	Rank
Water harvesting		1.05	0.514	1st
Increased Efficiency			0.486	2nd
	Incon:0.00			

Table 5.14 Pairwise Comparison Matrix and Relative Weight of Level 2 (Sub-criteria of Innovation)

	Innovation in Design	GBI Acc. Facilitator	Weighted	Rank
Innovation in Design		2.63	0.725	1st
GBI Facilitator			0.275	2nd
	Incon:0.00			

Rankings of all sub-criteria are shown in Figure 5.8. The most important sub-criterion was 'air quality' receiving a weighting of 0.104. The least important was 'GBI accredited Facilitator' receiving a score of 0.018.

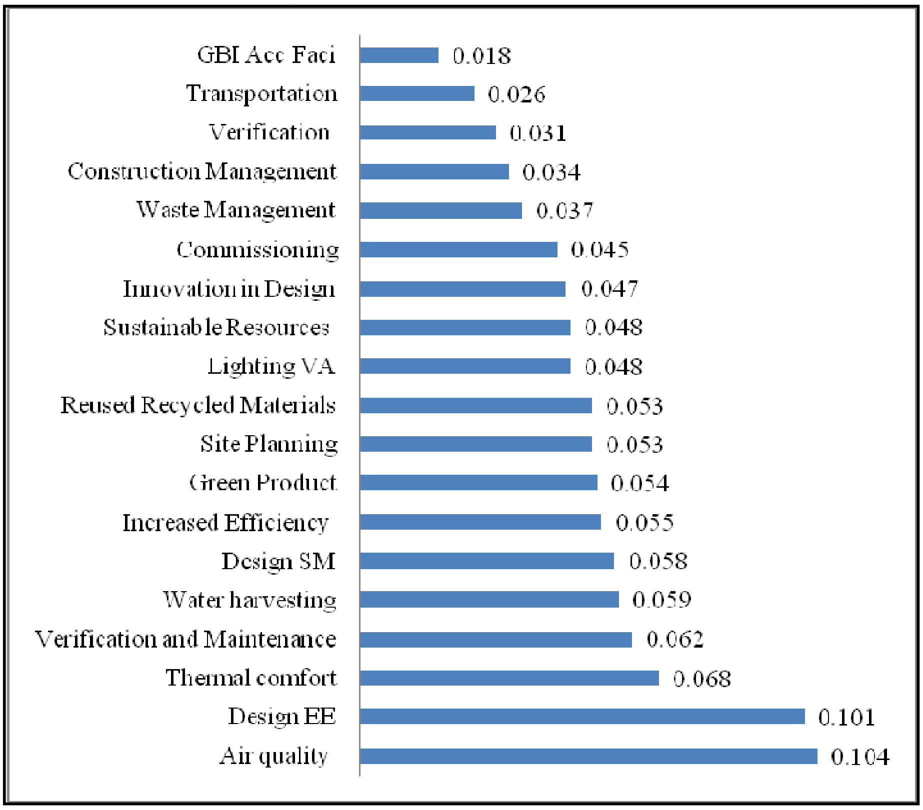


Figure 5.8 Sub-Criteria Weighting

Discussion

1. Ranking

Results show that the current GBI weightings of importance are different from expert opinion, derived from the survey results. Decision maker did a pairwise comparison based on their knowledge of green building practice. The aim was to develop a criteria weighting suitable to Malaysia specifically. These results do not indicate that the current GBI is of no good, but gives collective feedback from experts in this field on improving the implementation of GBI. As mentioned in chapter 2 and 4, GBRSs should continually evolve to meet the changing needs of the intended country of use.

Respondents' opinions were analyzed through pair wise comparison to AHP, assigning weightings to the criteria. The results were very similar to the preliminary survey, where "IEQ" stood as the main criterion. Criteria, in order of importance, are:

1. Indoor Environmental Quality (0.247)
2. Energy Efficiency (0.239)
3. Water Efficiency (0.139)
4. Sustainable Sites (0.138)
5. Material (0.127) and
6. Innovation (0.110).

As seen in Table 5.15, "EE" was the second most important criteria. "IEQ" was the first priority of GBI-NRNC. "MR" was the 3rd priority, although it's rated of fourth priority in the current GBI. The fourth was "SM", which is rated third in the GBI. The rest of the criteria have the same priority rankings

Majority of the experts agreed "IEQ" was the first priority because it is the only criteria that directly affect occupants' health. Most engineers and architect respondents commented on the wide use of air conditioners and lighting in Malaysian office buildings. In "IEQ", considerations are itemised for day-lighting, reducing the need for lighting fixtures during daytime, thereby reducing daytime peak cooling loads and justifying a reduction in the size of mechanical cooling systems. This results in lower energy costs over a building's life span.

Table 5.15 Comparison of Current GBI and Survey Result in Criteria Ranking

	Ranking of Current GBI	Ranking of GBI Survey Result
Energy Efficiency	1^{st}	2^{nd}
Indoor Environmental Quality	2^{nd}	1^{st}
Sustainable Site	3^{rd}	4^{th}
Material Resources	4^{th}	3^{rd}
Water Efficiency	5^{th}	5^{th}
Innovation	6^{th}	6^{th}

Consistently, as seen in Figure 5.8 majority respondents rated 'air quality' as the most important sub-criteria of "IEQ". The most exciting and under-utilised resource for creating high-performance green buildings are natural systems (day lighting and air quality). Natural systems can shade and cool buildings, yet allow sunlight through for heating during appropriate seasons. The ultimate green building features a deep integration of ecosystems and structures and allows for an exchange of matter-energy between human systems and natural systems, benefiting both entities.

2. Share Point

Table 5.16 shows the scoring of the current GBI and GBI survey results. The current GBI assigns 35 points to "EE" and 21 points to "IEQ", a 14 point difference. As mentioned before, "IEQ" is the first priority of the expert respondents. In terms of scoring, only small differences were shown between the first and second criteria. "IEQ" was assigned 25 points and "EE" was assigned 24 points. Similar scores results obtained mainly because these criteria are related one another. Based on respondents' feedback, office buildings in Malaysia used energy in much different ways than Malaysian households. Most energy used in office buildings is for lighting, heating, and cooling. Typically, this energy comes in the form of electricity, the highest-cost fuel. Consequently, the primary targets for energy saving were cooling and lighting. Appliances are also a major opportunity to save electricity. Recently, a program was initiated in Malaysia for the consumers to purchase Energy Star labeled computers and peripherals.

Table 5.16 Comparison of Current GBI and Survey Result in Scoring

Sub-criteria of EE	Current GBI	GBI survey result
Design EE	25	12
Commissioning	5	5
Verification and Maintenance	5	7
	35	24
Sub-criteria of IEQ	Current GBI	GBI survey result
Air Quality	6	10
Thermal Comfort	3	6
Lighting, Visual and Acoustic Comfort	8	6
Verification	4	3
	21	25
Sub-criteria of SM	Current GBI	GBI survey result
Site Planning	6	4
Construction Management	3	3
Transportation	3	3
Design SM	4	4
	16	14
Sub-criteria of MR	Current GBI	GBI survey result
Reused and Recycled Materials	4	3
Sustuinable Resources	2	3
Waste Management	3	2
Green Products	2	4
	11	12
Sub-criteria of WE	Current GBI	GBI survey result
Water Harvesting and Recycling	4	7
Increased Efficiency	6	7
	10	14
Sub-criteria of IN	Current GBI	GBI survey result
Innovation in Design and environmental design initiatives	6	8
Green building index facilitator	1	3
	7	11
TOTAL	**100**	**100**

The four sub-criteria of "EE" share 25 points in the current GBI. 'Design EE', is allocated only 12 points in the survey results. 'Commissioning' was given the same amount of points by both. Survey results gave more points to 'verification' than the current system. Respondents felt that continually monitoring energy use would result in a "green" status over a long period, giving the building a high value throughout its lifespan.

"IEQ" survey results attributed high points to 'air quality'. Ten points were allocated by the survey, while the current GBI gave it only six points. 'Thermal comfort' and 'lighting' both received six points from the survey, while the current system gave three and eight points respectively. There was no large difference in points assigned to 'verification'.

The survey result of "SM" shows that 'design' and 'site planning' share the same point values, which are four points. The same is shown by 'construction management' and 'transportation', each receiving three points. The current GBI allows six points for 'site planning'. The rest were rated the same. Expert respondents mentioned that both 'design' and 'site planning' were the simplest sub-criteria to achieve in GBI-NRNC, relative to 'transportation'.

In the category "MR", the current GBI assigned the largest point value to 'reused and recycled materials', a value of four points. The survey results has 'green product' deserved an equal value. 'Sustainable resources' was assigned three points according to survey results, with an equal amount of points going to 'reused and recycled materials'. The current GBI assigns two and three points respectively.

In the category "WE", the current GBI gives 'water harvesting' and 'increased efficiency' four and six points each. The survey results give the same weighting to both sub-criteria, each holding seven points.

The last criteria, "IN", consists of 'innovation in design' and "GBI accredited facilitator'. The current GBI and the survey results rate both of the same priority. Summary of points assigned are listed in Table 5.16 as well as in Appendix E.

5.3.5 Summary

GBRSs are expected to continually evolve, in order to adapt to the countries of its intended use. This analysis shows that there are rooms for improvement in term of the criteria weighting, since expert respondents gave different weightings to most criteria and sub-criteria. GBI survey results show “IEQ” and “EE”, having the 1st and 2nd priority. In fact, the survey results gave more points to “IEQ” than “EE”. This analysis shows the opinion of expert respondents, that ”IEQ” has a larger influence in building design than “EE”, especially for NRNC building type.

Pilot survey and four groups of respondents have also demonstrated that “IEQ” is the top priority for building assessment in this building type. The fact that Malaysian office buildings depends more on air conditioning and artificial lighting throughout day, made the use of energy higher. The survey results conclude that to build a new office building in Malaysia, stakeholders need to consider the use of natural system, so that the use of energy will be more efficient throughout the building life-span. Moreover, office buildings with daylight, fresh air and occupant control are consistently rated as more comfortable and contribute to occupants’ performance and productivity.

The aim of sustainable building based on respondents’ feedback is also to produce office buildings that exist harmoniously with their natural surroundings and bring benefits to their occupants. For environmental benefits, it can preserve and restore natural resources and improve outdoor air quality; where in term of economic impact, there will be reduction of operating and energy costs. There will also be improvement of employee productivity and satisfaction by reducing indoor building environmental characteristics that may lead to Sick Building Syndrome (SBS); in term of health and social aspect: it can enhance occupants’ comfort and health.

However, today’s green building designers make only a minimal effort to use natural systems for anything other than amenities. In the future, it is hoped that more comprehensive knowledge of ecology and ecological systems used in GBI will result in nature being incorporated into building design.

5.4 Evaluation of SIME Office Building: Case Study

Case studies bring understanding to complex issues and enrich literature review of what is already known through previous research. To further explore the differences between the current GBI and survey result, a case study has been conducted. Evaluation is made by using current GBI and GBI survey results on the same building, i.e. “SIME office building” for the final analysis.

SIME building is an office building owned by Sime Darby Bhd. It is under construction in Subang Jaya within the local authorities of Majlis Perbandaran Ampang Jaya territory. The building consists of five blocks, with buildings ranging from five to thirteen storeys. These buildings comprise of cafeterias, grocery stores, day care centers and an auditorium. The construction began in June 2009, and is expected to be completed on 30th November 2011. The main contractor for this project is Brunsfield Construction Sdn. Bhd.

This project was chosen because it was initially constructed under LEED guidelines, as shown in Appendix G. Based on LEED assessment, the project tentatively obtains LEED “silver certification”, with a total of 57 points. The expected results will be different set of scores when rated by the current GBI and the GBI survey results. The assessment of this project was conducted in duration of one month.

5.4.1 Current GBI Weighting

The current GBI has six criteria, listed in sequence:

1. Energy Efficiency (35 points)
2. Indoor Environmental Quality (21 points)
3. Sustainable Site Planning and Management (16 points)
4. Material and Resources (11 points)
5. Water Efficiency (10 points)
6. Innovation (7 points)

The total point achievable is 100 points. Buildings earn GBI classifications based on the following point values:

1. Platinum : >86 points
2. Gold : 76 to 85 points
3. Silver : 66 to 75 points

4. Certified : 50 to 65 points

The “SIME office building” project was assessed with the current GBI, based on Appendix F, and received a tentative total score of 61 points. The building achieved a GBI rating of “Certified”. As listed in Table 5.16, “SIME office building” obtained 14 points for “EE” criterion, 16 points in “IEQ”, 13 points in “SM”, 5 points for “MR” and “IN”, and 8 points for “WE”.

In sequence, “SIME office building” gain more points in “IEQ”, followed by “EE”, “SM”, “WE”, “IN” and “MR”. Table 5.17 shows point awarded brake down by criteria and sub-criteria.

Table 5.17 SIME Office Building Assessment based on Current GBI

Assessment Criteria Over All Points Score	
ITEM	**Current GBI**
Energy Efficiency : 1. Design : 7/25 2. Commissioning : 5/5 3. Verification and maintenance : 2/5	14/35
Indoor Environmental Quality: 1. Air quality : 4/6 2. Thermal comfort: 2/3 3. Lighting : 6/8 4. Verification : 4/4	16/21
Sustainable Site Planning & Management: 1. Site Planning : 4/6 2. Construction management : 2/3 3. Transportation : 3/3 4. Design : 4/4	13/16
Material & Resources: 1. Reused, recycled materials : 3/4 2. Sustainable Resources : 0/2 3. Waste management : 1/3 4. Green Product : 1/2	5/11
Water Efficiency: 1. Water harvesting : 4/4 2. Increased Efficiency : 4/6	8/10
Innovation: 1. Innovation in Design : 5/6 2. GBI facilitator : 0/1	5/7
TOTAL SCORE	**61/100**

5.4.2 GBI Survey Result Weighting

GBI survey results provide a rating system based on expert respondents' opinions, valuing "IEQ" and "EE" as the most important criteria.

1. Indoor Environmental Quality (25 points)
2. Energy Efficiency (24 points)
3. Sustainable Site Planning and Management (14 points)
4. Water Efficiency (14 points)
5. Material and Resources (12 points)
6. Innovation (11 points)

Table 5.18 SIME Office Building Assessment based on GBI Survey Result

ASSESSMENT CRITERIA OVER ALL POINTS SCORE	
ITEM	**GBI survey result**
Energy Efficiency : 1. Design : 5/12 2. Commissioning : 5/5 3. Verification and maintenance : 3/7	13/24
Indoor Environmental Quality: 1. Air quality : 8/10 2. Thermal comfort: 4/6 3. Lighting : 5/6 4. Verification : 3/3	20/25
Sustainable Site Planning & Management: 1. Site Planning : 3/4 2. Construction management : 2/3 3. Transportation : 3/3 4. Design : 4/4	12/14
Material & Resources: 1. Reused, recycled materials : 3/3 2. Sustainable Resources : 0/3 3. Waste management : 1/2 4. Green Product : 2/4	6/12
Water Efficiency: 1. Water harvesting : 7/7 2. Increased Efficiency : 5/7	12/14
Innovation: 1. Innovation in Design : 7/8 2. GBI facilitator : 0/3	7/11
TOTAL SCORE	**70/100**

Rating awards based on survey results were similar to the current GBI results. As shown in Table 5.18, the project was granted 70 points. Based on GBI survey result, the building gain more points in “IEQ” as much as 20 points, followed by “EE” with 13 points, “SM” and “WE” with 12 points, “IN” with 7 points, and last “MR” with 6 points. Thus, the building achieved a GBI “Silver” certification.

Discussion

The aim of the AHP analysis was to create a weighting based on experts’ opinions of the criteria and sub-criteria. Respondent’s feedback were systematically analysed by pairwise comparison, tapping into their knowledge of green building practices in Malaysia. The survey result shows the weightings suggested by the respondents. Appendix F illustrates the “SIME office building” assessment using current GBI and GBI survey result. The results indicate the workability of GBI survey results. In fact, it is right to say that with more emphasis put on “IEQ”, more points are score able in GBI survey results as compared to current GBI.

The differences for current GBI and GBI survey result, both ratings, are show in their pre-requisites. Pre-requisites are the area of assessment that stands for each sub-criterion. Some pre-requisites of sub-criteria in current GBI are no longer valid in GBI survey result. This is because of how respondents weighted the criteria and in some cases, there are no sufficient points cover all the pre-requisites.

According to survey results, there are four pre-requisites for ‘renewable energy’, but for current GBI only has three pre-requisites. This may be because it is hard to achieve the first and second pre-requisites in Malaysia, leading respondents to suggest combining both pre-requisites. Opinion on BEI was also similar. Details are concluded in Table 5.19.

Table 5.19 SIME Building Assessment (Sub-Criteria of EE)

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
Design							
EE4	Renewable Energy						
	Where 0.5 % or 5 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy, ***OR***	2	5	5	1	3	3
	Where 1.0 % or 10 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy, ***OR***	3					
	Where 1.5 % or 20 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy, ***OR***	4			2		
	Where 2.0 % or 40 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy	5			3		
EE5	Advanced EE Performance – BEI						
	Exceed Energy Efficiency (EE) performance better than the baseline minimum to reduce energy consumption in the building. Achieve Building Energy Intensity (BEI) ≤ 150 kWh/m2yr as defined under GBI reference (using BEIT Software or other GBI approved software(s)), ***OR***	2	15	0	1	4	0
	BEI ≤ 140, ***OR***	3			2		
	BEI ≤ 130, ***OR***	5					
	BEI ≤ 120, ***OR***	8			3		
	BEI ≤ 110, ***OR***	10					
	BEI ≤ 100, ***OR***	12			4		
	BEI ≤ 90	15					

The current GBI has a pre-requisite of day lighting for "IEQ", dividing it into two sub-criteria. GBI survey results suggest combining them into one pre-requisite. Similar was found for external views. Details are shown in Table 5.20.

Table 5.20 SIME Building Assessment (Sub-Criteria of IEQ)

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
Lighting, visual & Acoustic comfort							
IEQ8	Daylighting						
	Demonstrate that ≥ 30% of the NLA has a daylight factor in the range of 1.0 – 3.5% as measured at the working plane, 800mm from floor level, OR	1	2	0	1	1	0
	Demonstrate that ≥ 50% of the NLA has a daylight factor in the range of 1.0 – 3.5% as measured at the working plane, 800mm from floor level	2					
IEQ12	External Views						
	Demonstrate that ≥ 60% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from	1	2	2	1	1	1
	Demonstrate that ≥ 75% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from floor level.	2					

The current GBI has two pre-requisites for “SM”, development density & community connectivity. GBI survey results suggested combining these as one pre-requisite. The reason for this is difficulty in finding locations to build a new building near community services in Malaysia. ‘Environment management’ has a similar case. Details are shown in Table 5.21.

Table 5.21 SIME Building Assessment (Sub-Criteria of SM)

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
SM3	Development Density & Community Connectivity						
	A) Development Density	1	2	2	1	1	1
	B) Community Connectivity	1					
SM4	Environment Management						
	A) conservation	1	2	1	1	1	1
	B) Open Space:	1					

Two pre-requisites are mandated under the current GBI for ‘waste management’. The GBI survey results suggested combining both into one pre-requisite. The respondents shared an opinion that developing and implementing a construction waste management system would be difficult. Details are shown in Table 5.21.

Table 5.22 SIME Building Assessment (Sub-Criteria of MR)

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
Waste management							
MR6	Construction waste management						
	Recycle and/or salvage ≥ 50% volume of non-hazardous construction debris, OR	1	2	0	1	1	0
	Recycle and/or salvage ≥ 75% volume of non-hazardous construction debris.	2					

5.4.3 Summary

Although the advantages of green buildings practice persist to demonstrate promising results, there are a number of barriers identified and limitations to be addressed on the implementation of green building. Economic perceptions, industry awareness and availability of green design technical capacities are the most significant operational barriers to green building construction. Perceptions of higher cost and difficulties in implementing green building practices have spread relatively across the industry. As the *environmental impact* of *buildings* becomes more apparent, thus one of the solutions devised was to develop a more user-friendly rating system, in order to increase the effectiveness of the rating system.

The criteria and sub-criteria of current GBI were systematically weighted using AHP method by 44 expert respondents. The purpose is to show the different weighting based on respondent knowledge that suit Malaysian building and construction needs and requirements. As current GBI promote energy saving criterion, it is hoped that more revise look into how to make building assessment friendlier to implement through other criteria.

As more architects, engineers, designers, researchers, academics and government officers engage in green practices, there are more calls now for a simple approach in promoting sustainable building. Based on "SIME office building" assessment conducted, it can be concluded that GBI survey result is workable and easier to comply points. In current GBI, "SIME office building" obtained only 61 points while in GBI survey result, the same building achieved 70 points. In term of the sub-criteria weighting and points, there are some pre-requisites in GBI survey result that have been eliminated in order to make it user-friendly and more points are score able.

For example, Table 5.18 shows the pre-requisites that have been combined which are 'renewable energy' (EE4) and 'EE performance' (EE5), since both consume higher cost to be implemented. GBI survey result suggested 'EE4' to be reduced from five to three points, as for 'EE5' from 15 to 4 points only. The remaining credit point will go to other pre-requisites which are more score able.

GBI has been implemented for almost two years now, and it’s still on voluntarily basis. In order to improve the implementation of GBI, the survey results will encourage more stakeholders to take a part in green building practices due to its practicality. Moreover, this research attempts to develop the framework of current GBI so that it is more users friendly, and more points are score able to encourage participants from the stakeholders.

5.5. Validation of GBI Survey Result by Certified GBI Facilitators

The GBI survey results were validated by two certified GBI facilitators:

Name : Ar. Menaha Ramanath (GBIF 0016)
Gender : Female
Age : (40-50)
Degree : Bachelor of Architecture
Profession : Architect/ GBI facilitator
Company : Menaha Architect
Experience in Construction Industry: 10 years
Experience in GBI: 2 years

Remark about survey results:

1. The current GBI ratings and weightings are based on what is suitable for Malaysia, especially regarding resources and technology availability, but still need to be evolved from time to time. GBI survey results are based on respondents’ opinions about current needs and requirements in Malaysia.
2. LEED and other rating systems are based on resources availability and the practicality, in its country of origin. The current GBI will need continual re-evaluation based on Malaysia local context.
3. Point values are not important, but using common sense regarding the practicality of achieving green and sustainable buildings is. Such practical thinking must be put in place during the concept stage of design.

4. Support from the government is needed to control waste and mandate, waste recycling in policies for urban and utility maintenance. Otherwise, all efforts to create green buildings are useless.

Name : Ahmad Ridha Abd Razak (GBIF 0052 / MGBC 0096)
Gender : Male
Age : (20-30)
Degree : Bachelor of Architecture
Profession : Project Architect / GBI facilitator
Company : AbRAZ arkitek/ Green Earth Design Solution (GEDS Sdn Bhd)
Experience in GBI: 3-5 years

Remarks on the GBI:

1. It would be interesting for research to focus on the challenges of implementing the GBI benchmarking tool. Also, identification of other types of tools, possibly useful for Malaysians in the future, should be of consideration. Tip: Commercial Interiors, Infrastructure tools etc.
2. Making comparisons between Indonesia and Malaysia is useful because of similar climatic conditions. Many projects in Indonesia currently use Green Star. Recommendations as to whether the GBI tools would be suitable in Indonesia in areas other than Jakarta would be valuable.
3. The establishment of the Green Building Index by PAM and ACEM is awaited by many young professionals. The establishment of GBI is a step above other green rating systems since the rating system tackles not only the shell and core, but also the continuous operations of the buildings, as opposed to LEED and Green Star.
4. Addressing the question as to whether the GBIM will influence Malaysia's building industry in the future. This shall create awareness of the importance of a green building industry.
5. The effectiveness of GBI is dependent on acceptance by the developers, home owners and purchasers. While having been proven effective in other countries, GBI will be a step forward, not only as a benchmark to green building, but to promote a maintenance mentality in the industry. With the participation of

developers, it is hoped that the construction industry will soon reduce energy consumption, slowing Malaysia from becoming a net-energy importer in the near future.

Remarks regarding survey results:

1. Main priority was given to "IEQ" because of by laws. "IEQ" needs to be addressed to receive basic building approval.
2. "EE" is important to lower energy consumption.
3. Site Management is a trend among developers and contractors, addressed in ISO 9001, 14001 and 18001.
4. Water is the next best method in saving energy.
5. Material points are low, as not many recycling haulers exist and materials are difficult to source, making these criteria difficult to achieve.
6. Innovation causes high expenses in building, and is perceived as an optional add-on.

<u>Summary</u>

As a review from both certified GBI facilitators, it can be concluded that implementation of GBI needs to consider:

- Practicality: As Ar. Menaha mentioned that actually rating system is not only about the points, but the common sense practically to achieve green and be sustainable. This is shown in GBI survey result, where few pre-requisite are combined and credits to other pre-requisites which is easier to be achieved, in order to score more points. Since it will need a lot of cost and investment in saving and renewable energy, GBI survey result suggested reduction of points in "EE" criterion from 35 to 24 points. While the "IEQ" increases from 21 to 24 points.
- Bylaws: According to Mr.Ahmad Ridha, "IEQ" is picked as main top criteria because of bylaws and it also need to be addressed to get basic building approval. Also, IEQ could affect the health and well being of the users as well as their performances. This is where building quality is actually felt and easily measurable.

- Future versions of GBI should consider increasing the importance of “IEQ”. In order to cover the full array of issues, quality of lighting also should receive additional consideration in term of weighting and points.
- Government and stakeholders support: Both facilitators believe support from government and all of stakeholders are required in building construction to improve the quality of GBI. The effectiveness of GBI shall be dependent of the acceptance of the stakeholders inclusive the public. GBI survey results demonstrated participation from all stakeholders in GBI criteria and sub-criteria weighting analysis.

CHAPTER 6

CONCLUSIONS

6.1 Conclusion

A large number of GBRS exist internationally, but only several are widely used. LEED in the US and BREEAM in the UK have achieved the greatest prominence within their respective market sectors. Many similarities exist between the systems, which are based on the levels of rating award or along performance criteria. However, significant questions remain as to the degree in which content and process differences will influence environmental performance outcomes. Therefore, comparative analysis based on certification process, criteria and sub-criteria and rating award by six rating systems form a perspective.

achieved the greatest prominence within their respective market sectors. Many similarities exist between the systems, which are based on the levels of rating award or along performance criteria. However, significant questions remain as to the degree in which content and process differences will influence environmental performance outcomes. Therefore, comparative analysis based on certification process, criteria and sub-criteria and rating award by six rating systems form a perspective that underlies the thrusts of this research.

The purpose of the comparison was to understand the differences and similarities between the GBI and other GBRSs. Based on literature review, a green rating system should be designed according to individual country's needs and requirements. This is because parameters of each system should be considerate of local issues. As the GBI has been implemented for two years to date, further studies and feedback from users are timely.

GBI was based on “educated guess”, where major adaptation of LEED’s system is made. Thus, systematic analysis of the weighting of criteria and sub-criteria is necessary. The three objectives of the study have been reached as follows:

1. A comparison analysis of GBI with the other five GBRSs.

   The comparative analysis covered common international GBRS (BREEAM, LEED, CASBEE, Green Star), as well as Green Mark and GBI. The results indicate that GBI is very much similar to LEED, in term of the criteria and rating award, although both intended for use in different countries, with different geographical and climatic conditio[illegible]e next objective was to create a new weighting for criteria based on expert opinions.

2. Determination of criteria and sub-criteria weighting of GBI using AHP, based on:

   a. Different group of experts:

   There are five different groups involved in this analysis, namely are engineers, architects, GBI facilitators, government officers and academics. The results concluded that each group of experts had different preferences regarding the weighting of GBI criteria. Three groups (architects, GBI facilitators, and Government Officers) chose “IEQ” as a first priority. Only engineers group show similarity with the current one, where “EE” is the top priority of criteria. Meanwhile, academics group have “EE” and “IEQ” as a main priority.

   b. All group experts:

   This analysis covered 44 respondents, a total from all group of experts. The results show that there is a significance differences, the main priority goes to “IEQ”, and the scores increased from 21 to 25 points. As for “EE”, it is ranked as second criterion, with scores decreasing from 35 to 24 points only. The survey results conclude that to build a new office building in Malaysia, one has to consider the use of natural system, so that the use of energy will be more efficient throughout the building life-span. It is hoped that a more comprehensive knowledge of ecology and ecological systems will lead to a better green building design in the near future.

3. Evaluation of “SIME office building” with current GBI and GBI survey result, and validation by certified GBI facilitators.

   Some of the difficult sub-criteria points like ‘EE4’ and ‘EE5’ need high investment, hence both have been combined. GBI survey result suggested “EE4” to be reduced from five to three points, as for “EE5” from 15 to four points only. The remaining credit point is transferred to other pre-requisites that are more score able. As for this case study, on the current GBI, the building was awarded with 61 points, achieving a GBI “Certified” certification. When GBI survey results is used, the building received 70 points and achieved GBI “Silver” certification. As a conclusion GBI survey result translate into a better rating system, in term of practicality more points and can be scored.

6.2 Recommendation for Future Research

- A further study of the GBI rating system for different building types, especially on the effectiveness of the rating system specifically in Malaysia should be made.
- Further evaluation of indoor environmental quality criteria should be carried out, regarding the continuous improvement of guidelines for green building design and orientation.
- Since the current system heavily promotes energy efficiency, a study of the other criteria is highly recommended.
- Further study may include the expert’s respondents from developers, investors, contractors.
- Another method of analysis can be carried out, i.e Delphi analysis to tackle low respondent.

REFERENCES

[1] C. J. Kibert, "Policy Instruments for Sustainable Built Environment," *Journal of Land Use and Environmental Law*, vol. 17:2, pp. 379-394 2001-2002.

[2] Y. Sanchez, "Strategic & Standardization Cmgt-564 : U.S. Green Building & Standards 189," Catholic University of America, 2008, p. Page 6.

[3] M. H. A. Samad, A. M. A. Rahman, and F. Ibrahim, "Green Performance Ratings for Malaysian Buildings With Particular Reference to Hotels," in *International Conference on ENvironmental Research and Technology* Penang, Malaysia: School of Industrial Technology, Universiti Sains Malaysia, 2008, pp. 313-317.

[4] A. K. Chatterje, "Sustainable Construction and Green Buildings on The Foundation of Building Ecology," *The Indian Concrete Journal*, pp. 27-30, May 2009.

[5] H. Van, "Minerals and Metals: Cement." vol. 1, Geology, Ed. Washington: US Government Printing Office, 1999, pp. 16.1-16.13.

[6] F. Moavenzadeh, "Construction Industry in Developing Countries," *World Development*, vol. 6, pp. 97-116, 1978.

[7] CU.S Dept. of Agriculture, "Sustaining the People's Lands: recommendations for stewardship of the national forests and grassland into the next century," Dept. of Agriculture., US Government., Washington, D.C, March 1999. Accessed on: http://www.fs.fed.us/news/news_archived/science/cosfrnt.pdf

[8] C. A. Boyle, "Sustainable Buildings," *Proceedings of the Instittuion of Civil Engineers* vol. Engineering Sustainability: 158, pp. 41-48, March 2005.

[9] R. E. Frechette and R. Gilchrist, "Towards Zero Energy : A Case Study of the Pearl River Tower, Guangzhou, China," in *CTBUH 8th World Congress - Tall*

& Green: Typology for a Sustainable Urban Future, Dubai 2008.

[10] R. O. Salami and M. K. Olaniyan, "Towards a Sustainable Built Environment: The Green Building Concept," *Continental J. Sustainable Development*, vol. 1, 45 - 50 2010.

[11] T. E. Glavinich. (2007, July). *What to Bid: Requirements in bidding green building projects.* [Online]. Accessed on: http://www.ecmag.com/index.cfm?fa=article&articleID=7835.

[12] Q. Shi, "Strategies of Implementing a Green Building Assessment System in Mainland China," *Journal of Sustainable Development*, vol. Vol 1: No.2, 2008.

[13] C. J. Kibert, *Sustainable Construction : Green Building Design and Delivery*, 2nd ed. Hoboken: N.J. : Wiley, 2007.

[14] R. J. Cole, "Building environmental assessment methods: clarifying intentions," *Building Research and Information*, vol. 27: 2, pp. 230 - 246, 1999.

[15] P. Watson, D. Jones, and P. Mitchell, "Sustainability Measures for Decision-Support: Redefining Life Cycle for A Building Sustainability Assessment Framework," in *Fourth Australian Life Cycle Assessment Conference* Sydney, Australia 2005, pp. 1-12.

[16] C. Y. Leong, "Integrating Green Initiatives into Existing Commerical Buildings," in *Faculty of Civil Engineering*. vol. Master of Science (Construction management): Universiti of Teknologi Malaysia, 2010, p. 88.

[17] K. M. Fowler and E. M. Rauch, "Sustainable Building Rating Systems Summary," Pacific Northwest National Laboratory July 2006.

[18] D. Castro-Lacouture, J. A. Sefair, L. Flórez, and A. L. Medaglia, "Optimization model for the selection of materials using a LEED-based green building rating system in Colombia," *Building and Environment*, vol. 44, pp. 1162-1170, 2009.

[19] K. R. Bunz, G. P. Henze, and D. K. Tiller, "Survey of Sustainable Building Design Practices in North America, Europe, and Asia," *Journal of*

Architectural Engineering vol. Vol. 12. No. 1, pp. 33-62, March 2006.

[20] K. Elgendy. (2010, April 10th). *Comparing Estidama's Pearls Rating System to LEED and BREEAM.* [Online]. Accessed on: http://www.carboun.com/sustainable-development/sustainable-design/comparing-estidama%E2%80%99s-pearls-rating-method-to-leed-and-breeam/

[21] Sweden Green Building council, "*For Future, Sustainable Building*", Stockholm 2010.

[22] F. Shafii, "Status of Sustainable Building In South-East Asia," Institute Sultan Iskandar of Urban Habitat & Highrise (Universiti Teknologi Malaysia) 2008.

[23] Oxford Business Group, "*The Report: Malaysia 2010"*, Oxford, 2010. ISBN: 9781907065200.

[24] ACEM. (2009). *Malaysia's Green Building Index.* Kuala Lumpur,. [Online]. Accessed on: http://www.acem.com.my/index.php?option=com_content&task=view&id=58&Itemid=1.

[25] T. L. Saaty and L. G. Vargas, *Decision making in economic, political, social, and technological environments with the analytic hierarchy process*: RWS Publications, 1994.

[26] T. L. Saaty and L. G. Vargas, *Models, methods, concepts & applications of the analytic hierarchy process*: Kluwer Academic Publishers, 2000.

[27] A. J. Nelson, O. Rakau, and P. Dorrenberg, "Green Buildings: A niche becomes mainstream," Deutsche Bank Research, Frankfurt April 12 2010.

[28] T. E. Glavinich, *Contractor's guide to green building construction : management, project delivery, documentation, and risk reduction*: John Wiley, 2008.

[29] World Commission on Environment and Development (1987), *What is sustainable development?*. Brundtland Report, pp. 43. [Online]. Accessed on: http://www.3mfuture.com/sustainability/definition_sustainable_development.htm

[30] M. Montoya, *Green building fundamentals: practical guide to understanding and applying fundamental sustainable construction practices and the LEED system*: Prentice Hall, 2010.

[31] S. M. Sabry Elattar, "Towards a Global Vision for Building Technology Future " *European Journal of Scientific Research.* vol. 30.No.3, pp. pp.495-504 2009

[32] E. Durmisevic, "Transformable Building Structures : Design for disassembly as a way to introduce sustainable engenieering to building design & construction," in *Architects*. vol. ter verkrijging van de graad van doctor Delft: Delft University of Technology, 2006, p. 306.

[33] D. Beyer, "Sustainable Building and Construction Implementing Green Building in Western Australia," in *Sustainable Development*. vol. Degree of Bachelor of Science (Honours): Institute for Sustainability and Technology Policy (ISTP), Murdoch University, 2002, p. 99.

[34] Population Reference Bureau. (2009). *2009 World Population Data Sheet.* Washington. [Online]. Accessed on: http://www.prb.org/pdf09/09wpds_eng.pdf.

[35] L. Bragança, R. Mateus, and H. Koukkari, "Building Sustainability Assessment," *Journal Sustainability,* vol. 2, pp. 2011-2023, 2010.

[36] J. W. Thompson and K. Sorvig, *Sustainable Landscape Construction : A Guide to Green Building Outdoors* Washington, D.C.: Island Press, 2000.

[37] S. M. Hays, R. V. Gobbell, and N. R. Ganick, *Indoor air quality: solutions and strategies*: McGraw-Hill, 1995.

[38] J. Bergs, "The Effect of Healthy Workplaces on the Well-being and Productivity of Office Workers," plants-in-buildings.com, pp. 1-12.

[39] K. A. Gray and M. E. Finster, "The Urban Heat Island, Photochemical Smog, and Chicago: Local Features of the Problem and Solution," Atmospheric Pollution Prevention Division. U.S. Environmental Protection Agency, June 2010.

[40] P. Graham, *Building Ecology : First Principles for a Sustainable Built Environment*, 1st ed. Oxford: Blackwell Science, 2003.

[41] J. C. Sailor, H. A. Naik, and C. Rakes. (2010). *Green Building Concept: Eco-Friendly & Indirect method of Energy Conservation* [Online]. Accessed on: http://www.scribd.com/doc/35910007/Green-Building-Concept.

[42] C. J. Kibert, *Sustainable Construction: Green Building Design and Delivery*, 1st ed.: Wiley, 2005.

[43] American Society of Heating, Refrigerating Air-Conditioning, Engineers, "ASHRAE green guide: the design, construction, and operation of sustainable buildings: American Society of Heating, Refrigerating, and Air-conditioning Engineers," ASHRAE publisher, 2006.

[44] S. Kubba, *LEED Practices, Certification, and Accreditation Handbook*: Butterworth-Heinemann, 2009.

[45] L. Y. Shen, S. C. Song, J. L. Hao, and V. W. Y. Tam, "Collaboration Among Project Participants Towards Sustainable Construction – A Hong Kong Study," *The Open Construction and Building Technology Journal*, vol. 2, pp. 59-68, 2008.

[46] T. Wooley, S. Kimmins, P. Harrison, and R. Harrison, *Green building handbook : a guide to building products and their impact on the environment, Volume 1*. London: E & FN Spon, 1997.

[47] J. Yudelson, *Green building through integrated design*: McGraw-Hill, 2008.

[48] J. Yudelson, *Greening Existing Buildings*: McGraw-Hill, 2009.

[49] G. H. Kats, "Green Building Costs and Financial Benefits," USA: Massachusetts Technology Collaborative @ Copyright, 2003.

[50] G. Kats and C. E "The Costs and Financial Benefits of Green Buildings : A Report to California’s Sustainable Building Task Force," Sustainable Building Task Force October 2003

[51] M. Bauer, P. MÃ¶sle, and M. Schwarz, *Green Building: Guidebook for Sustainable Architecture*: Springer, 2009.

[52] M. Heying, "Buildings/Facilities Energy Management & Water Conservation Plan ": Department of The Interior, 2006.

[53] The European Environmental Bureau. (2004, April 14). *NGO Stakeholder Recommendations on The Communication: towards a Thematic Strategy On The Urban Environment* [Online]. Accessed on: http://ec.europa.eu/environment/urban/pdf/stakeholder_consultation/ngo2.pdf.

[54] F. Ali-Toudert, "Towards urban sustainability: Trends and challenges of building environmental assessment methods," in *International Conference Portugal SB07. Sustainable Construction, Materials and Practices - Challenge of the Industry for the New Millennium*, Portugal, 2007, pp. 702-709.

[55] K. Moskow, *Sustainable Facilities : green design, construction, and operations*. New York: Mc-Graw-Hill Companies, Inc. , 2008.

[56] L. Reeder, *Guide to green building rating systems: understanding LEED, Green Globes, Energy Star, the National Green Building Standard, and more*: John Wiley & Sons, 2010.

[57] R. K. Bose, *Energy efficient cities: assessment tools and benchmarking practices*: World Bank, 2010.

[58] G. Baird, "Incorporating User Performance Criteria into Building Sustainability Rating Tools (BSRTs) for Buildings in Operation," *Journal of Sustainability*, vol. 1, pp. 1069-1086, 2009.

[59] W. B. Trusty and S. Horst, "Integrating LCA Tools in Green Building Rating Systems."

[60] K. Stubbins, *Sustainable Design of Research Laboratories: Planning, Design, and Operation*: John Wiley & Sons, 2010.

[61] BREEAM. (2011). *BREEAM Schemes from starter homes to opera houses.* [Online]. Accessed on: http://www.breeam.org/page.jsp?id=122.

[62] T. Saunder. (2008). *A Discussion Document Comparing International Environmental Assessment Methods For Buildings.* [Online]. Accessed on: http://www.dgbc.nl/images/uploads/rapport_vergelijking.pdf. [63] J. J. Prior,

Breeam/New Offices, Version 1/93: Environmental Assessment for New Office Designs: Building Research Establishment, 1993.

[64] BREEAM, "BREEAM Offices," © Copyright BRE Global Ltd, 2011.

[65] L. Haselbach, *The engineering guide to LEED-new construction: sustainable construction for engineers*: McGraw-Hill, 2008.

[66] U.S. Green Building Council. (2011). *LEED Rating System* [Online]. Accessed on: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222.

[67] U.S. Green Building Council. (2011). *LEED for New Construction* [Online]. Accessed on: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220.

[68] P. Brandon and P. Lombardi, *Evaluating Sustainable Development in the Built Environment*: John Wiley & Sons, 2010.

[69] Japan Sustainable Building Consortium. (2006). St*ructure of CASBEE-NC Tool* [Online]. Accessed on: http://www.ibec.or.jp/CASBEE/english/method2E.htm.

[70] Japan Sustainable Building Consortium. (2006). *An overview of CASBEE* [Online]. Accessed on: http://www.ibec.or.jp/CASBEE/english/overviewE.htm.

[71] Japan Sustainable Building Consortium. (2006). Two Categories of Assessment: Q and L [Online]. Accessed on: http://www.ibec.or.jp/CASBEE/english/method2E.htm.

[72] R. Guenther and G. Vittori, *Sustainable healthcare architecture*: John Wiley & Sons, 2008.

[73] Green Building Council of Australia. (2010, Oct.).*Green Star Rating Tools* [Online]. Accessed on: http://www.gbca.org.au/green-star/rating-tools/.

[74] Green Building Council of Australia. (2010, May). *Certification* [Online]. Accessed on: http://www.gbca.org.au/green-star/certification/.

[75] Green Building Council of Australia. (2011, Feb.). *Green Star-Office v3* [Online]. Accessed on: http://www.gbca.org.au/green-star/rating-tools/green-star-office-v3/1710.htm.

[76] Singapore Building & Construction Authority. (2006). *About BCA Green Mark Scheme.* [Online]. Accessed on: http://www.bca.gov.sg/greenmark/green_mark_buildings.html.

[77] T. Yao, *Zero-carbon Energy Kyoto 2010: Proceedings of the Second International Symposium of Global Coe Program "Energy Science in the Age of Global Warming--toward Co2 Zero-emission Energy*: Springer, 2011.

[78] Singapore Building & Construction Authority. (2006). *BCA Green Mark for New Non-Residential Buildings Version NRB/4.0* [Online]. Accessed on: http://bca.gov.sg/GreenMark/others/gm_nonresi_v4.pdf.

[79] Singapore Building & Construction Authority. (2006). *BCA Green Mark Assessment Criteria and Application Forms* [Online]. Accessed on: http://bca.gov.sg/GreenMark/green_mark_criteria.html.

[80] L. S. Yin. (2009). *GBI Forum & GBI [MS1525] Seminar* [Online]. Accessed on: http://pamsabah.com/archives/3177. [81] D. Chandranayagam, "Malaysia's Green Building Index For Tropical Structures," © The CSR Digest, 2008-2010.

[81] D. Chandranayagam. (2010, Feb. 25). *Malaysia's Green Building Index for Tropical Structures* [Online]. Accessed on: http://www.csrdigest.com/2010/02/malaysias-green-building-index-for-tropical-structures/.

[82] Greenbuildingindex. (2009). *The GBI Rating System* [Online]. Accessed on: http://www.greenbuildingindex.org/how-GBI-works2.html#RatingTools.

[83] Greenbuildingindex. (2009). *The GBI Assessment Process* [Online]. Accessed on: http://www.greenbuildingindex.org/how-GBI-works.html.

[84] Greenbuildingindex. (2009). *Green Building Index Assessment Criteria For NRNC* [Online]. Accessed on: http://www.greenbuildingindex.org/Resources/GBI%20Tools/GBI%20NRNC%20Non-Residential%20Tool%20V1.0.pdf.

[85] T. M. Smith, M. Fischlein, S. Suh, and P. Huelman, "Green Building Rating Systems: A Comparison of The LEED and Green Globes Systems in The US,"

University of Minnesota September 2006.

[86] R. A. Fenner and T. Ryce, "A comparative analysis of two building rating systems Part 1: Evaluation," *Proceedings of the ICE - Engineering Sustainability,* vol. 161, pp. 55-63, 2008.

[87] H. H. Ali and S. F. Al Nsairat, "Developing a green building assessment tool for developing countries - Case of Jordan," *Building and Environment,* vol. 44, pp. 1053-1064, 2009.

[88] K.-F. Chang, C.-M. Chiang, and P.-C. Chou, "Adapting aspects of GBTool 2005--searching for suitability in Taiwan," *Building and Environment,* vol. 42, pp. 310-316, 2007.

[89] M. H. A. Samad, A. M. A. Rahman, and F. Ibrahim, "Green Performance Ratings for Malaysian Buildings with Particular Reference to Hotels," in *International Conference on Environmental Research and Technology* 2008, pp. 313-317.

[90] F. Shafii and M. Z. Othman, "Sustainable Building in Malaysian Context," pp. 601- 606.

[91] F. Shafii, "Status of Sustainable Building in South – East Asia," in *World Sustainable Building Conference - SB08* Melbourne, 2008.

[92] H. Levin, "Indoor Environment And Sustainable Buildings " in *Sustainable Buildings 2005* Tokyo, 2005, pp. 1-8

[93] Goethe-Institut. (2010). *Green ARC–Urban Social Housing 2010* [Online]. Accessed on: http://www.goethe.de/ins/my/kua/kue/arc/enindex.htm.

[94] A. H. Yau "The Implementation of Green Building Index in Malaysia," in *Faculty of Civil Engineering* vol. Bachelor of Civil Engineering Universiti Teknologi Malaysia 2010.

[95] R. Lee, "Social Science Knowledge: A Report on Institutionalization," in *Gulbenkian Commission on the Restructuring of the Social Sciences* Lisbon, 1994.

[96] J. S. Dye R, P. C. Fishburn, R. E. Steuer, J. Wallenius, and S. Zionts, "Multiple Criteria Decision Making, Multiattribute Utility Theory: The

Next Ten Years," *Management Science,* vol. 38, pp. 645-654, May, 1992 1992.

[97] C. Zopounidis *et al., Multiple-Criteria Decision Making* [Online]. Accessed on: http://www.referenceforbusiness.com/management/Mar-No/Multiple-Criteria-Decision-Making.html.

[98] A. Bascetin, "A decision support system using analytical hierarchy process (AHP) for the optimal environmental reclamation of an open-pit mine," *Environmental Geology,* vol. 52, pp. 663-672, 2007.

[99] S. H. Ghodsypour and C. O'Brien, "A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming," *International Journal of Production Economics,* vol. 56-57, pp. 199-212, 1998.

[100] W. Ossadnik and O. Lange, "AHP-based evaluation of AHP-Software," *European Journal of Operational Research,* vol. 118, pp. 578-588, 1999.

[101] E. W. T. Ngai and E. W. C. Chan, "Evaluation of knowledge management tools using AHP," *Expert Systems with Applications,* vol. 29, pp. 889-899, 2005.

[102] B. Golder and M. Gawler, "Stakeholder Analysis," WWF October 2005 2005.

[103] N. C. Schaeffer, J. Dykema, K. Elver, and J. Stevenson, *Survey Fundamentals : A Guide to Designing and Implementing Surveys*: University of Wisconsin System Board of Regents, 2010.

[104] T. L. Saaty, *Mathematical Methods of Operations Research*. New York: Dover Publications, 2004.

[105] D. Bouyssou, *Evaluation and decision models: a critical perspective*: Kluwer Academic Publishers, 2000.

[106] G. IsIklar and G. Büyüközkan, "Using a multi-criteria decision making approach to evaluate mobile phone alternatives," *Computer Standards & Interfaces,* vol. 29, pp. 265-274, 2007.

[107] A. Montazar and E. Zadbagher, "An Analytical Hierarchy Model for Assessing Global Water Productivity of Irrigation Networks in Iran," *Water*

Resources Management, vol. 24, pp. 2817-2832, September 2010 2010.

[108] J. R. Grandzol, "Improving the Faculty Selection Process in Higher Education: A Case for the Analytic Hierarchy Process." vol. 6: IR Applications, 2005.

[109] T. Saaty. *The Analytic Hierarchy Process (AHP) for Decision Making* [Online]. Accessed on: http://cashflow88.com/decisiones/saaty1.pdf.

[110] R. Handfield, S. V. Walton, R. Sroufe, and S. A. Melnyk, "Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process," *European Journal of Operational Research*, vol. 141, pp. 70-87, 2002.

[111] O. S. Vaidya and S. Kumar, "Analytic hierarchy process: An overview of applications," *European Journal of Operational Research*, vol. 169, pp. 1-29, 2006.

APPENDIX A

QUESTIONNAIRE

Appendixes A consist of a questionnaire that has been distributed to 300 respondents. Number of questionnaires received by 44, all obtained via email, mail, interview and fax.

UNIVERSITI TEKNOLOGI PETRONAS

CIVIL ENGINEERING

Research Questionnaire of Criteria Weighting of Green Building Index Malaysia

INTRODUCTION

Dear respective respondent,

The purpose of the questionnaire is to support a research on of green building criteria weighting. This research is a master's thesis study, which concern on Green Building Index (GBI) Criteria and Sub Criteria. This research gives a better understanding in the concept of green building rating systems and its role for achieving sustainable development through an effective green building rating system. This research also focused on Green Building Index Non Residential-New Construction building (GBI-NRNC) in Malaysia, the GBI-NRNC tool evaluates the sustainable aspects of buildings that are commercial, institutional and industrial in nature. This includes factories, offices, hospitals, universities, colleges, hotels and shopping complexes

Recently a number of Green Building Rating System (GBRS) have been introduced around the world namely Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) from Japan, Leadership in Energy and Environmental Design (LEED) from US, Green Star from Australia, Building Research Establishment Environmental Assessment Method (BREEAM) from UK, or Green Mark form Singapore. Developing such system is becoming necessary in developing world because of the considerable environmental, social and economical problems. Malaysia has launched the GBI in 2009 and adopted LEED as well. Both systems have same criteria and priority, yet they have different climate and location.

Therefore, this research studied comparison of GBI with others GBRS. Then, it will define new criteria of GBI which gives priority respecting the local conditions of Malaysia by discussing it with various respondents having expertise in sustainable/green building. After the assessment criteria selection, they are weighted using the Analytical Hierarchy Process (AHP) method using expert choice 2000 software. The outcome of the research is a green building assessment criteria based on expert respondents that suits the Malaysia context in terms of environmental, social, and economic.

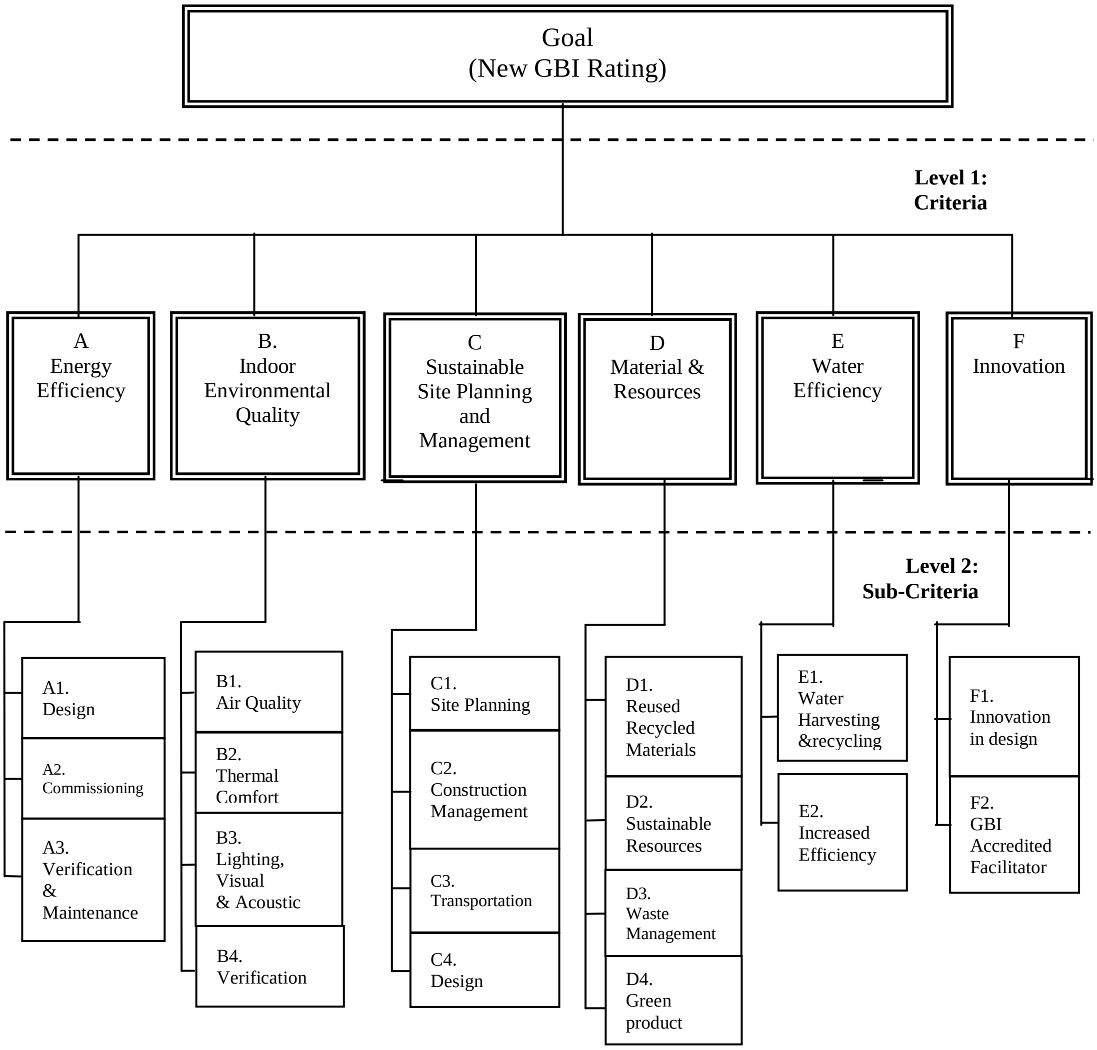
As a part of the AHP, questionnaires are needed to be distributed to the person who concerns on Green Building. In the questionnaires, a respondent need to rank and give a priority on each of criterion and sub criterion. The feedback will be use to weighting the criteria and sub criteria of GBI. The questionnaire consists of three sections as explain above. The name of respondent will not be used in any reports of the research and their rights will be protected. The respondent's answers will be reported and aggregated with other respondents.

Thank you for your willingness to answer this survey, which focuses on your experiences with and opinions concerning green building index. We appreciate your time and participation. If you have any questions regarding this survey procedure or wish to make suggestions, please do not hesitate to contact the researcher. Once again, thank you for your cooperation.

Researcher:
Retno Rahardjati
MSc Student of Civil Engineering
University Technology PETRONAS
Tronoh, Perak, Malaysia
Ph: +60195455109
E-mail: enoq46@gmail.com
retno_rahardjati@ymail.com

Supervisor:
Dr. Mohd Faris Khamidi
Lecturer of Civil Engineering
University Technology Petronas
Tronoh, Perak, Malaysia

Green Building Index Hierarchy of Analytical Hierarchy Process (AHP)



INSTRUCTIONS

The purpose of this questionnaire is to rank the relative importance of evaluation factors as shown in the table below by utilizing the AHP method. The question ask you to:
(1) rank evaluation factors (criteria),
(2) compare two factors of them as a pair, and
(3) repeat such pairwise comparison for all combinations.
The question starts from level 1 for Criteria and level 2 for Sub-Criteria.

Table A1. Analytical Hierarchical Process Scale of Judgments by Saaty 1990

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the property.
2	Weak or slight	
3	Moderate importance of one over another	Experience and judgment slightly favour one element over another.
4	Moderate plus	
5	Essential or strong importance	Experience and judgment slightly strongly favour one element over another.
6	Strong plus	
7	Very strong importance	An element is strongly favourable and its dominance is demonstrated in practice.
8	Very, very strong	
9	Extreme importance	The evidence of favouring one element over another is of the highest possible order of affirmation.

Referring to the ranking that you have above, please compare two factors in each table below as a pair, select one that is more important than the other and **<u>Bold/Underline</u>** the coresponding box. If you think from two criteria, A is moderate important other than B, please leave boxes in the A row number labelled **"3".**

Example:
If "Energy Efficiency" is **moderate importance** than "Indoor EQ", then the **Intensity of Importance** is **3**, afterward number **3** had to be **<u>Bold/Underline</u>** in Energy Efficiency row number.

Energy Efficiency	9	8	7	6	5	4	**<u>3</u>**	2	1	2	3	4	5	6	7	8	9	Indoor EQ

If "Energy Efficiency" is **equal importance** than "Indoor EQ", then the **Intensity of Importance** is **1**, afterward number **1** had to be **<u>Bold/Underline</u>**.

Energy Efficiency	9	8	7	6	5	4	3	2	**<u>1</u>**	2	3	4	5	6	7	8	9	Indoor EQ

RESPONDENT PROFILE

Name : ....

Gender : Male/Female *

Age : (20-30) / (31-40) / (41-50) / (>50) years *

Degree : Bachelor/Master/Doctorate//Other.................. *

Profession : ....

Organisation/Institution/: ....
Company

Experience in Green Building : <2 / 3-5 / 6-10 / 11-15 / >15 years *

Date : ....

***<u>Bold/Underline</u>**

SECTION A: LEVEL 1 - CRITERIA

Referring to the instructions on page 3, please compare two Criteria/Sub-Criteria and judge the relative importance in each pair in the table below (i.e. how much more important one of paired factors is than the other) by using the judgement scale of AHP method. **Bold/Underline** the number in one box corresponding to your judgement on the side of the more important criteria than the other. If two criteria are equally important, **bold/underline** the number of "equally=1" in the centre of the scale.

Please rank the followong six criteria's in order of importance, and indicate an appropriate number in the bracket on the left of each factor. If you think two or more factors are equally important, please assign the same number to them.

A. **Energy Efficiency (EE):**
The Energy efficiency criterion encourages a wide variety of energy strategies in building.

B. **Indoor Environmental Quality (IEQ):**
Monitoring and controlling of tobacco smoke, CO2, and other indoor air pollutants.

C. **Sustainable Site Planning & Management (SM):**
Choosing a building's site and managing that site during construction are important considerations for a project's sustainability.

D. **Material Resources (MR):**
This credit category encourages the selection of sustainably grown, harvested, produced and transported products and materials. It promotes the reduction of waste as well as reuse and recycling, and it takes into account the reduction of waste at a product's source.

E. **Water Efficiency (WE):**
The goal of the Water Efficiency credit category is to encourage smarter use of water, inside and out.

F. **Innovation (IN):**
The Innovation in Design credit category provides bonus points for projects that use new and innovative technologies and strategies to improve a building's performance.

A	Energy Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IEQ	**B**
A	Energy Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainable Site	**C**
A	Energy Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Material Resources	**D**
A	Energy Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Efficiency	**E**
A	Energy Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation	**F**

B	IEQ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainable Site	**C**
B	IEQ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Material Resources	**D**
B	IEQ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Efficiency	**E**
B	IEQ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation	**F**

C	Sustainable Site	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Material Resources	**D**
C	Sustainable Site	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Efficiency	**E**
C	Sustainable Site	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation	**F**

D	Material Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Efficiency	**E**
D	Material Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation	**F**

E	Water Efficiency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Innovation	**F**

SECTION B: LEVEL 2 – SUB CRITERIA

Please rank the followong Sub Criteria in order of importance concerning Green Building Index Malaysia, and indicate an appropriate number in the bracket on the left of each factor. If you think two or more factors are equally important, please assign the same number to them.

A. Sub-Criteria of Energy Efficiency.

Please repeat ranking and pair wise comparisons of the following three sub criteria's of energy efficiency:

A1. Design: provide flexible design to optimize energy savings.
A2. Commissioning : enhanced and post occupancy of building energy systems
A3. Verification : sustainable maintenance of building

A1	Design	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Commissioning	**A2**
A1	Design	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Verification & Maintenance	**A3**
A2	Commissioning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Verification & Maintenance	**A3**

B. Sub-Criteria of Indoor Environmental Quality.

Please repeat ranking and pair wise comparisons of the following four sub criteria's of indoor environmental quality:

B1. Air Quality: establish minimum IAQ performance to enhance IAQ in building.
B2. Thermal Comfort: provide effective delivery of clean air.
B3. Lighting, visual and acoustic: provide good levels on day lighting, noise, external views in building.
B4. Verification: provide for the assessment of comfort of the building occupants.

B1	Air Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Thermal Comfort	**B2**
B1	Air Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lighting, visual, & acoustic	**B3**
B1	Air Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Verification	**B4**
B2	Thermal Comfort	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Lighting, visual, & acoustic	**B3**
B2	Thermal Comfort	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Verification	**B4**
B3	Lighting, visual, & acoustic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Verification	**B4**

C. Sub-Criteria of Sustainable Site Planning & Management.

Please repeat ranking and pair wise comparisons of the following four sub criteria's of Sustainable Site Planning & Management:

C1. Site planning: reduce pressure on undeveloped land by rehabilitating damaged sites.
C2. Construction management: assessment system for building construction.
C3. Transportation: access of public transportation, green vehicle priority, and park capacity.
C4. Design : building design futures and strategies

C1	Site Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Construction Management	**C2**
C1	Site Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation	**C3**
C1	Site Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Design	**C4**
C2	Construction Management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Transportation	**C3**
C2	Construction Management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Design	**C4**
C3	Transportation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Design	**C4**

D. Sub-Criteria of Material Resources.

Please repeat ranking and pair wise comparisons of the following four sub criteria's of Material Resources:

D1. Reused and recycled materials: reuse and recycled building materials to reduce creation of waste.
D2. Sustainable resources: use building materials manufactured within the region.
D3. Waste management: facilitate reduction of waste during construction.
D4. Green products: use environmentally friendly refrigerants and clean agents.

D1	Reused Recycled Materials	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainable Resources	**D2**
D1	Reused Recycled Materials	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Waste Management	**D3**
D1	Reused Recycled Materials	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Green Products	**D4**
D2	Sustainable Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Waste Management	**D3**
D2	Sustainable Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Green Products	**D4**
D3	Waste Management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Green Products	**D4**

E. Sub-Criteria of Water Efficiency.

Please repeat ranking and pair wise comparisons of the following two sub criteria's of Water Efficiency:

E1. Water harvesting: encourage rainwater harvesting and water recycling.
E2. Increased efficiency: encourage the design system that monitors water consumption.

E1	Water Harvesting & Recycling	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increased Efficiency	**E2**

F. Sub-Criteria of Innovation.

Please repeat ranking and pair wise comparisons of the following two sub criteria's of Innovation:

F1. Innovation in design and environmental design initiatives.
F2. Green building index accredited facilitator.

F1	Innovation in design	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	GBI accredited	**F2**

SECTION C: General Questions

[1] What is your opinion about Malaysia Green Building Index (GBI)?

……

[2] Does the GBI will influence the Malaysia's building and construction industry in the future?

……

[3] How much do you think GBI effectiveness for Malaysia's building especially in against the global warming?

………

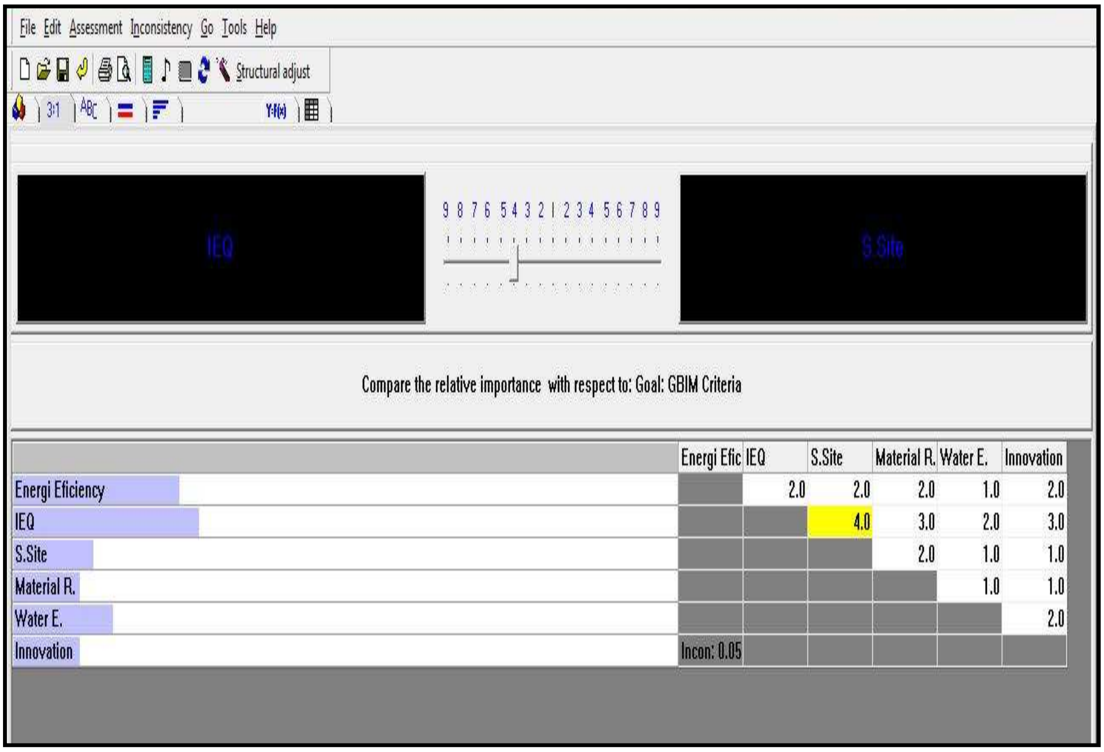
 # thank you for your cooperation and greatly appreciates for your time and early response#

APPENDIX B

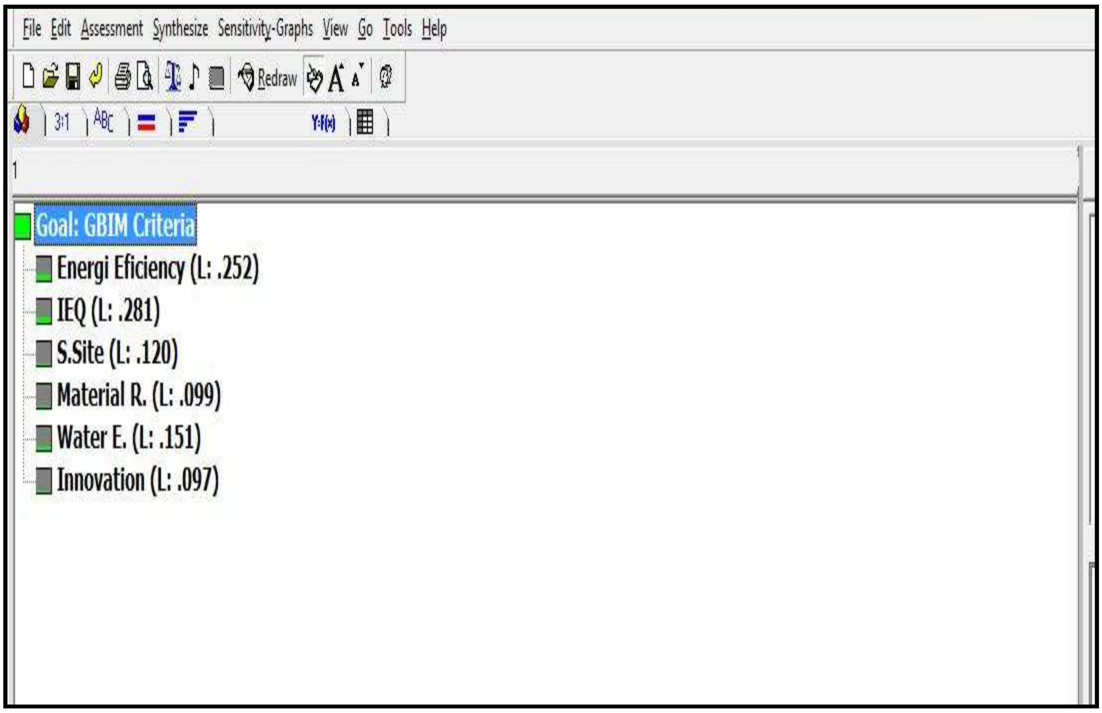
PILOT SURVEY RESULTS

Appendix B shows the pilot survey results from seven expert respondents. They are come from various backgrounds of professionals. The results shows Indoor Environmental Quality have first priority among other criterion.

B1. Pairwise matrix for criteria



B2. Ranking of criteria



B3. Pairwise matrix for sub-criteria

	Design	Commisior	Verification
Design		1.0	1.0
Commisioning			1.0
Verification and Maintenance	Incon: 0.00		

	Air Quality	Thermal Cc	Lighting,Vi	Verification
Air Quality		2.0	2.0	2.0
Thermal Comfort			2.0	2.0
Lighting,Visual & Acoustic				2.0
Verification	Incon: 0.05			

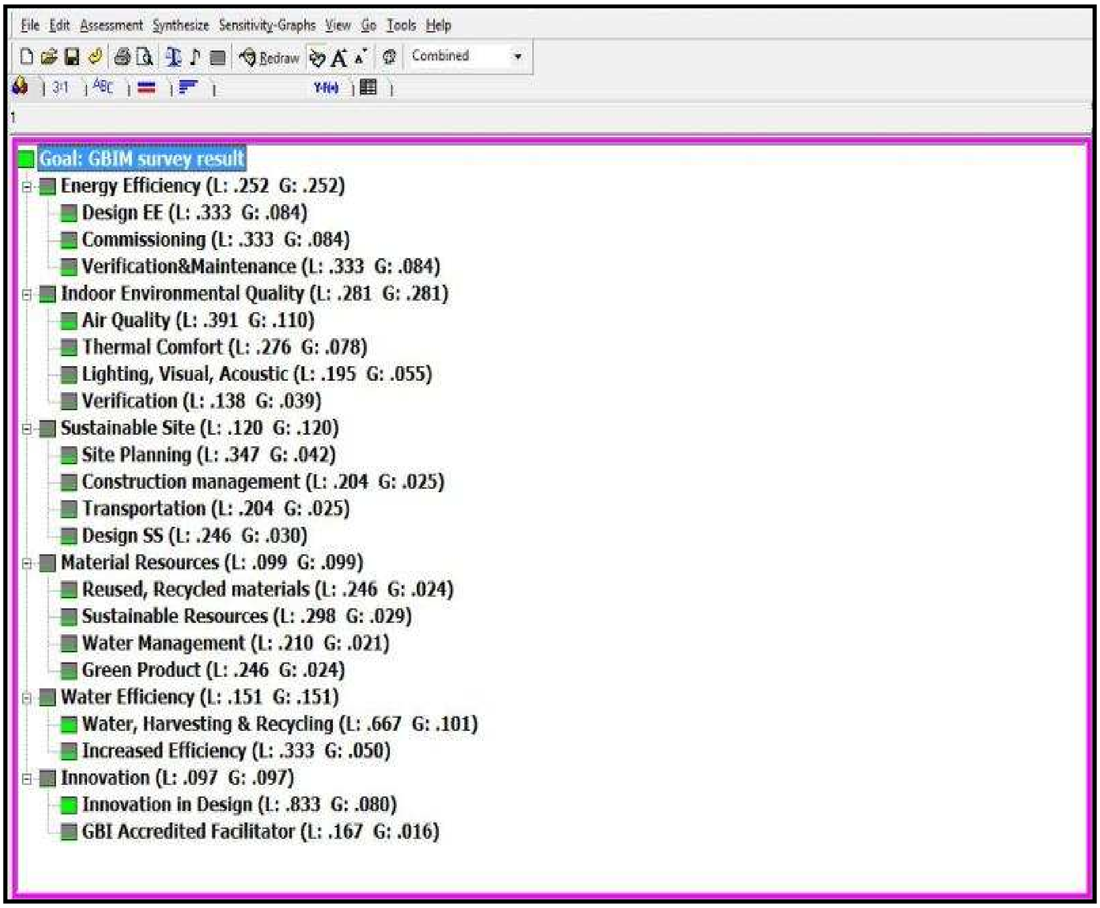
	Site Planni	Constructic	Transporta	Design
Site Planning		2.0	2.0	1.0
Construction Management			1.0	1.0
Transportation				1.0
Design	Incon: 0.02			

	Reused,rec	Sustainabl	Waste mar	Green Proc
Reused,recycled materials		1.0	1.0	1.0
Sustainable Resources			2.0	1.0
Waste management				1.0
Green Product	Incon: 0.02			

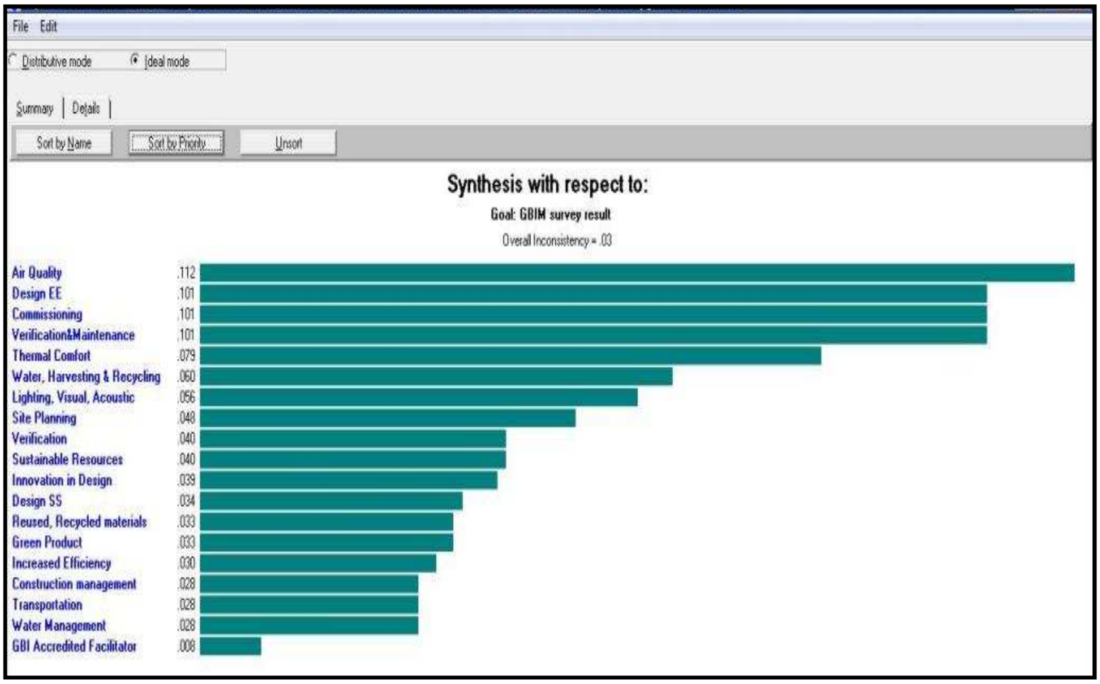
	Water harv	Increased
Water harvesting & recycling		2.0
Increased Efficiency	Incon: 0.00	

	Innovation	GBI accred
Innovation in design		5.0
GBI accredited facilitator	Incon: 0.00	

B4. Ranking of criteria and sub-criteria (local and global)



B5. Priority of all sub-criteria respect to the goal



B6. Convert eigenvalue to points (refer to local)

Item	weighting value of sub-criteria		points of criteria	points of sub-criteria
ENERGY EFFICIENCY				
Design EE	0.333	8.3916	25	8.4
Commissioning	0.333	8.3916		8.4
Verification n Maintenance	0.333	8.3916		8.4
Total	0.999	25.1748		25.2
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.391	10.9871	28	11
Thermal comfort	0.276	7.7556		8
Lighting, visual, & acoustic	0.195	5.4795		5
Verification	0.138	3.8778		4
Total	1	28.1		28
SUSTAINABLE SITE				
Site planning	0.347	4.164	12	4
Construction management	0.204	2.448		2.5
Transportation	0.204	2.448		2.5
Design SM	0.246	2.952		3
Total	1.001	12.012		12
MATERIAL RESOURCES				
Reused, recycled materials	0.246	2.4354	10	2.5
Sustainable resources	0.298	2.9502		3
Waste management	0.21	2.079		2
Green Product	0.246	2.4354		2.5
Total	1	9.9		10
WATER ENVIRONMENT				
Water harvesting & recycling	0.667	10.0717	15	10
Increased Efficiency	0.333	5.0283		5
Total	1	15.1		15
INNOVATION				
Innovation in design	0.833	8.0801	10	8
GBI accredited facilitator	0.167	1.6199		2
Total	1	9.7		10
TOTAL			100	100.2

B7. Comparison of current GBI and pilot survey (in criteria)

Criteria	current GBI	Pilot Survey
innovation	7	10
water efficiency	10	15
material and resources	11	10
sustainable sites	18	12
indoor environmental quality	21	28
energy efficiency	35	25
TOTAL	100	100

APPENDIX C

SURVEY RESULT (DIFFERENT GROUP)

Appendix C is the result of a survey which covered 5 different groups of respondents consisting of several experts, as follows:

C1. Engineers

C2. Architects

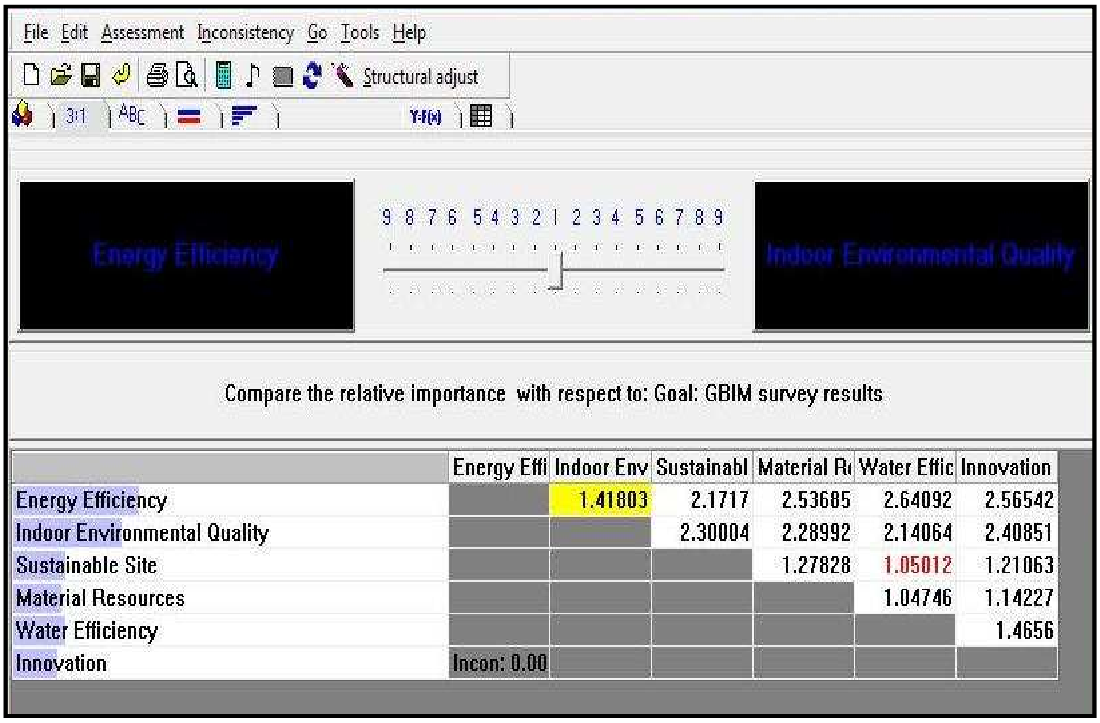
C3. GBI facilitators

C4. Government officers

C5. Academics

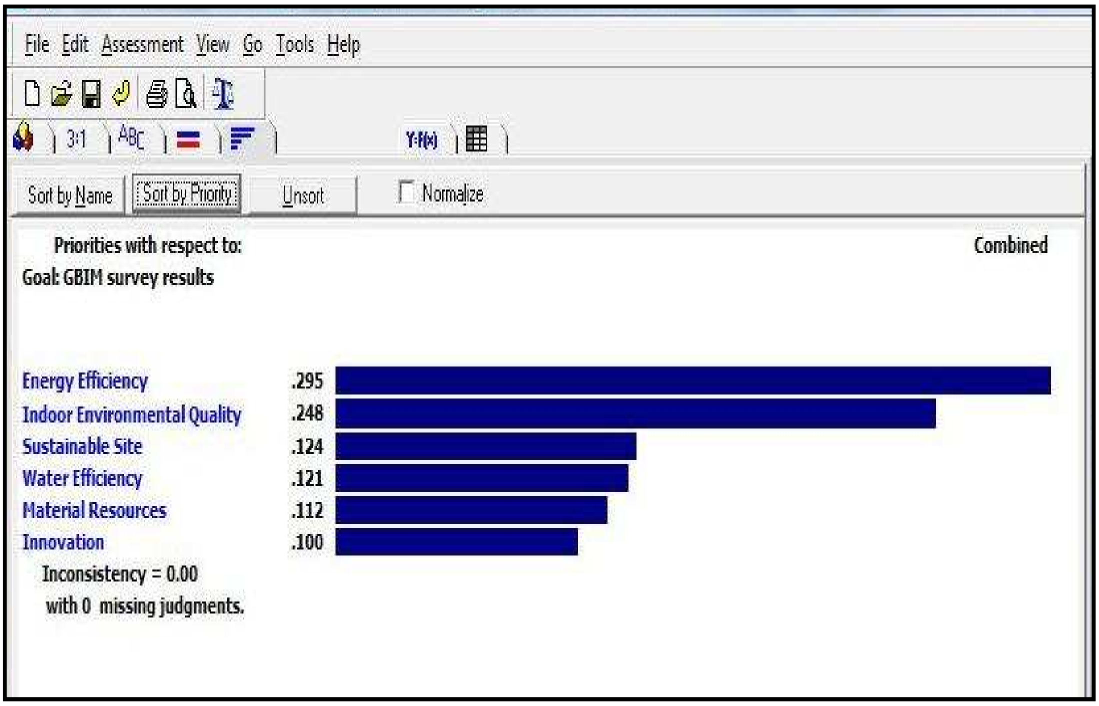
C1. Engineers (16 respondents)

C1.1 Pairwise matrix for criteria:

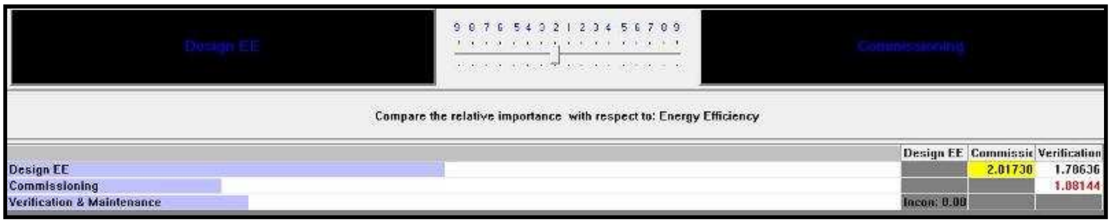


	Energy Effi	Indoor Env	Sustainabl	Material R	Water Effic	Innovation
Energy Efficiency		1.41803	2.1717	2.53685	2.64092	2.56542
Indoor Environmental Quality			2.30004	2.28992	2.14064	2.40851
Sustainable Site				1.27828	1.05012	1.21063
Material Resources					1.04746	1.14227
Water Efficiency						1.4656
Innovation	Incon: 0.00					

C1.2 Priority of criteria respect to Goal:

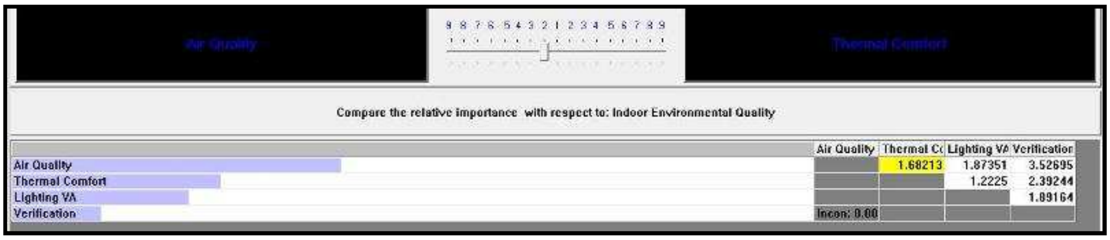


C1.3 Pairwise matrix for sub-criteria:



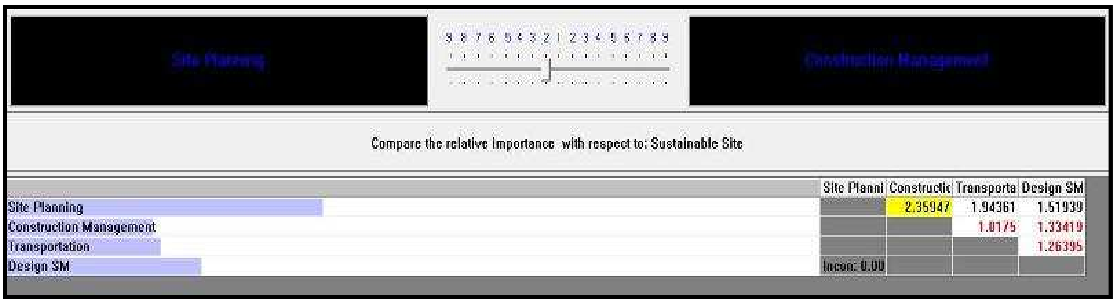
Compare the relative importance with respect to: Energy Efficiency

	Design EE	Commissic	Verification
Design EE		2.01730	1.70636
Commissioning			1.08144
Verification & Maintenance	Incon: 0.00		



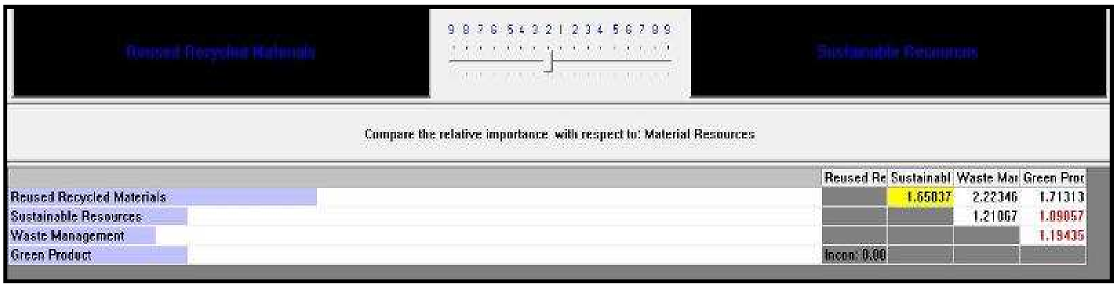
Compare the relative importance with respect to: Indoor Environmental Quality

	Air Quality	Thermal Cc	Lighting VA	Verification
Air Quality		1.68213	1.87351	3.52695
Thermal Comfort			1.2225	2.39244
Lighting VA				1.89164
Verification	Incon: 0.00			



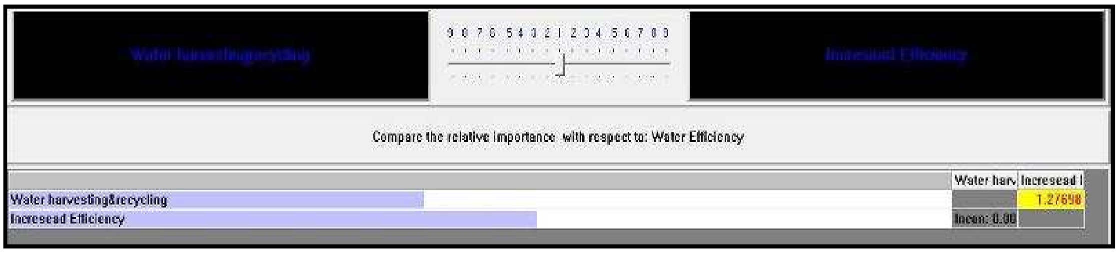
Compare the relative importance with respect to: Sustainable Site

	Site Planni	Constructic	Transporta	Design SM
Site Planning		2.35947	1.94361	1.51939
Construction Management			1.0175	1.33419
Transportation				1.26395
Design SM	Incon: 0.00			



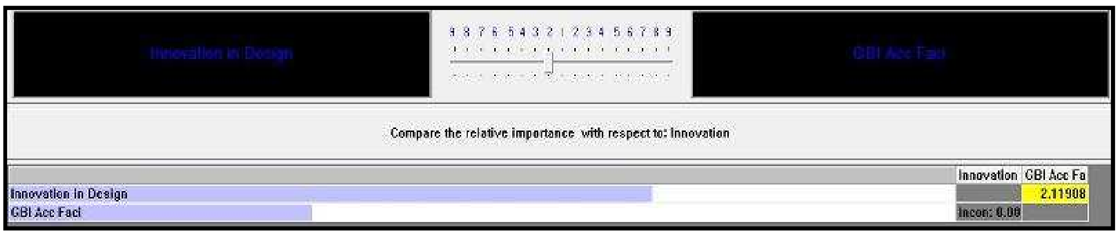
Compare the relative importance with respect to: Material Resources

	Reused Re	Sustainabl	Waste Mar	Green Proc
Reused Recycled Materials		1.65037	2.22346	1.71313
Sustainable Resources			1.21067	1.09057
Waste Management				1.19435
Green Product	Incon: 0.00			



Compare the relative importance with respect to: Water Efficiency

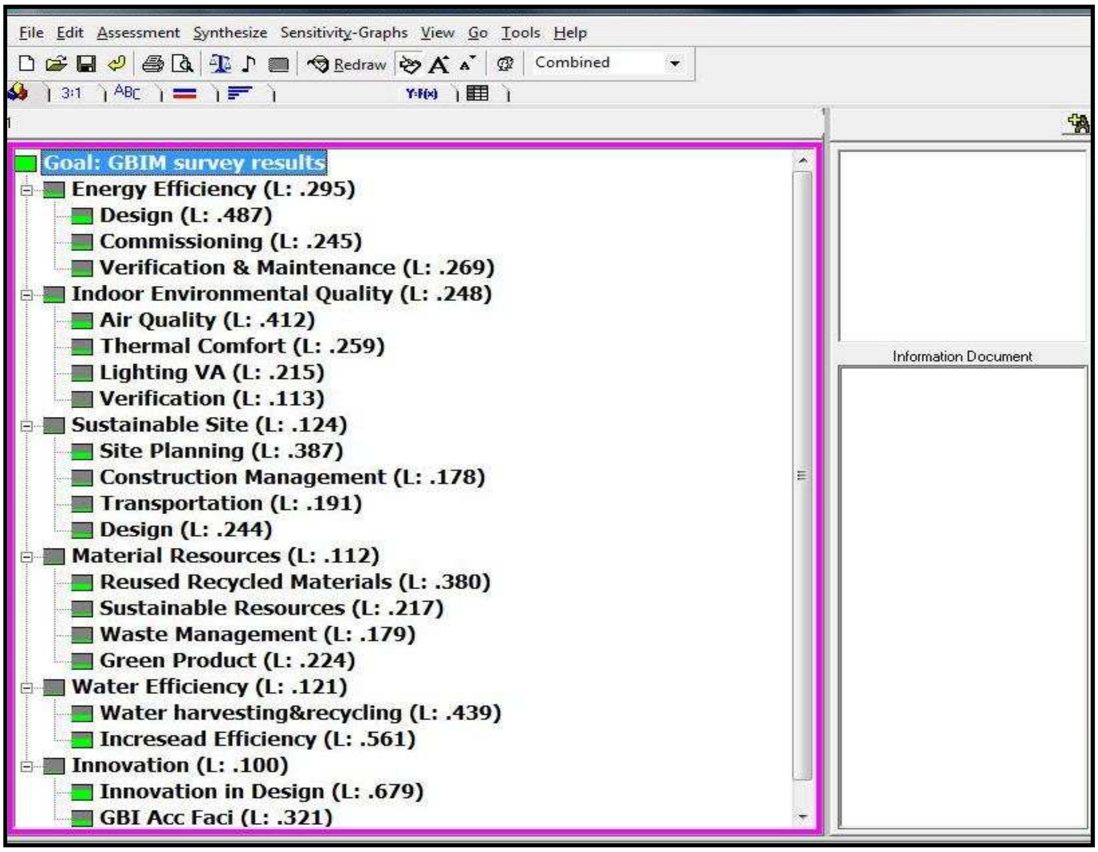
	Water harv	Incresead I
Water harvesting&recycling		1.27698
Incresead Efficiency	Incon: 0.00	



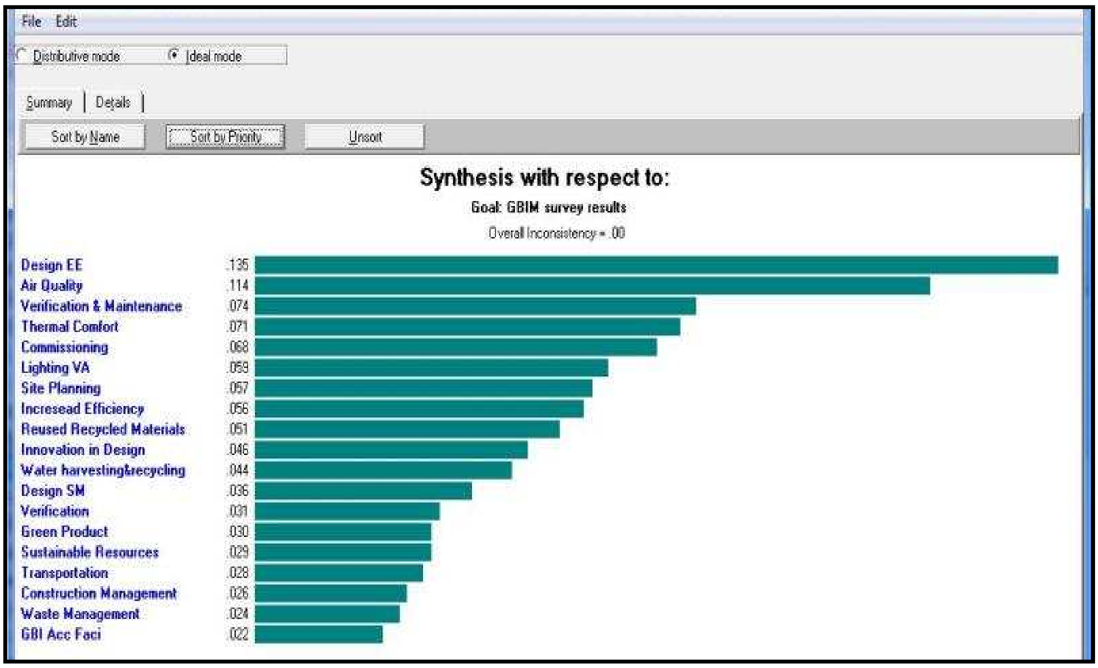
Compare the relative importance with respect to: Innovation

	Innovation	GBI Acc Fa
Innovation in Design		2.11908
GBI Acc Fact	Incon: 0.00	

C1.4 Ranking of criteria and sub-criteria:



C1.5 Priority of all sub-criteria respect to the goal:



C1.6 Convert eigenvalue to points:

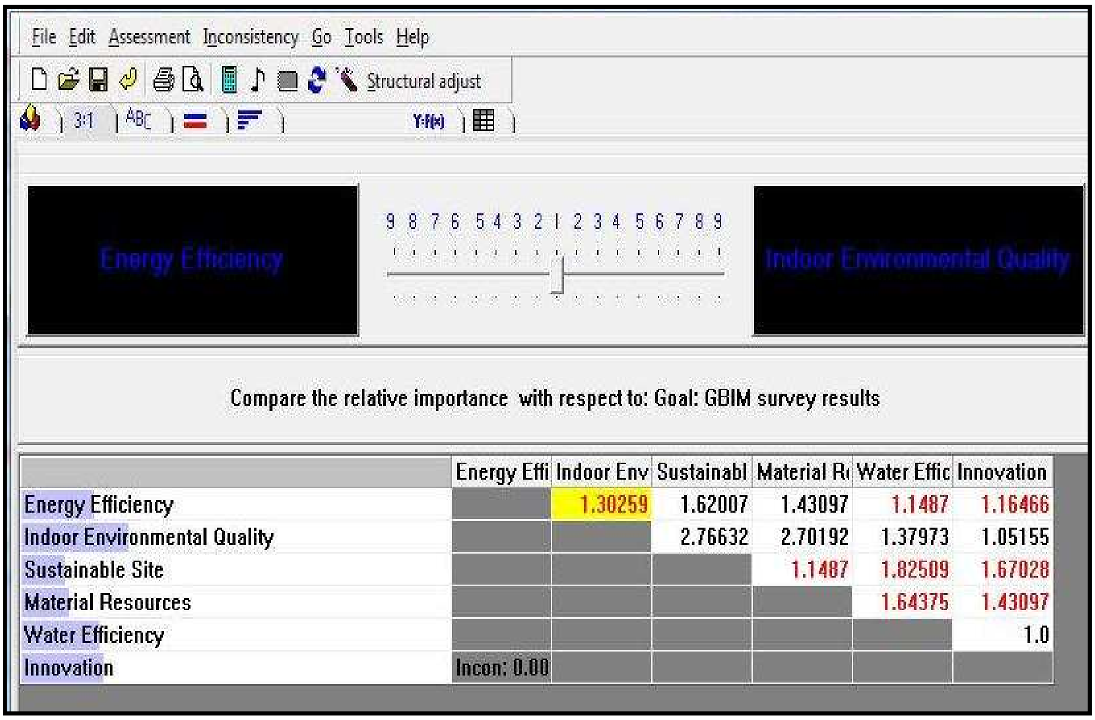
Item	**weighting value of sub criteria**		**points of criteria**	**points of sub-criteria**
ENERGY EFFICIENCY				
Design EE	0.487	14.3665	29.5295	14.3665
Commissioning	0.245	7.2275		7.2275
Verification n Maintenance	0.269	7.9355		7.9355
Total	1.001	29.5295		29.5295
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.412	10.2176	24.7752	10.2176
Thermal comfort	0.259	6.4232		6.4232
Lighting, visual, & acoustic	0.215	5.332		5.332
Verification	0.113	2.8024		2.8024
Total	0.999	24.7752		24.7752
SUSTAINABLE SITE				
Site planning	0.387	4.7988	12.4	4.7988
Construction management	0.178	2.2072		2.2072
Transportation	0.191	2.3684		2.3684
Design SM	0.244	3.0256		3.0256
Total	1	12.4		12.4
MATERIAL RESOURCES				
Reused, recycled materials	0.38	4.256	11.2	4.256
Sustainable resources	0.217	2.4304		2.4304
Waste management	0.179	2.0048		2.0048
Green Product	0.224	2.5088		2.5088
Total	1	11.2		11.2
WATER ENVIRONMENT				
Water harvesting & recycling	0.439	5.3119	12.1	5.3119
Increased Efficiency	0.561	6.7881		6.7881
Total	1	12.1		12.1
INNOVATION				
Innovation in design	0.679	6.79	10	6.79
GBI accredited facilitator	0.321	3.21		3.21
Total	1	10		10
			100.0047	100.0047

C1.7 Comparison of current GBI and GBI based on engineers (in criteria):

CRITERIA	Current GBI	GBI based on engineers
Energy Efficiency	35	29.5
Indoor Environmental Quality	21	24.8
Sustainable Site Planning & Management	16	12.4
Material & Resources	11	11.2
Water Efficiency	10	12.1
Innovation	7	10.0
TOTAL	100	100

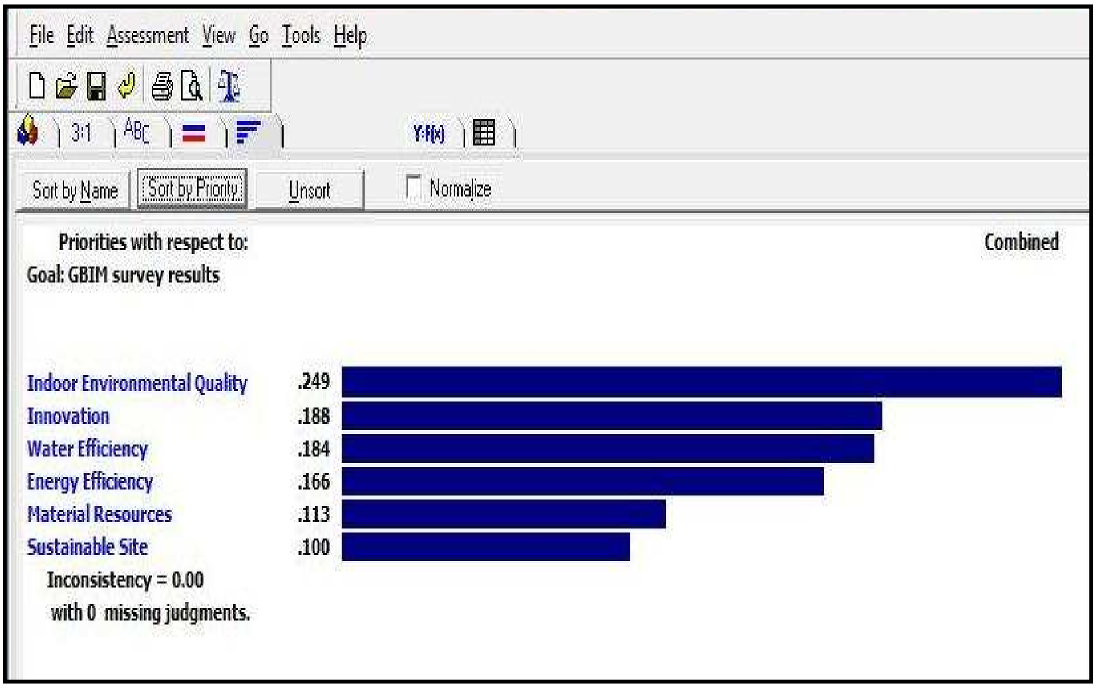
C2. Architects (5 respondents)

C2.1 Pairwise matrix for criteria:

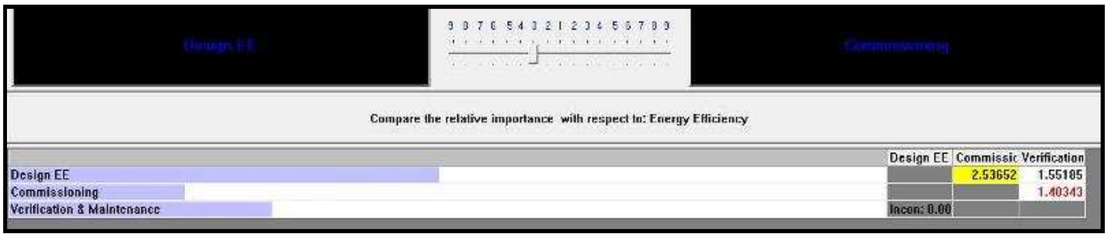


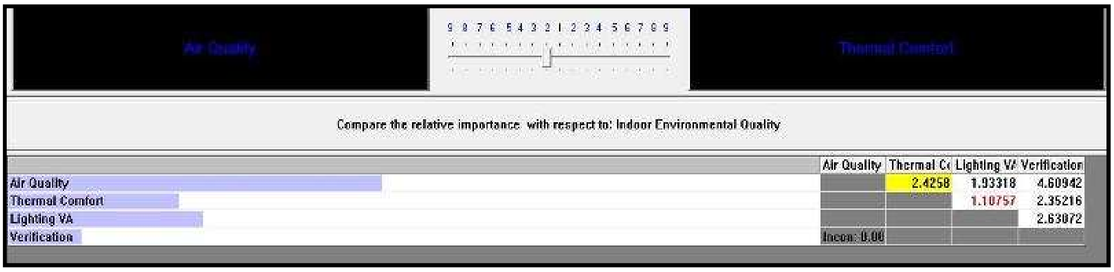
	Energy Effi	Indoor Env	Sustainabl	Material R	Water Effic	Innovation
Energy Efficiency		1.30259	1.62007	1.43097	1.1487	1.16466
Indoor Environmental Quality			2.76632	2.70192	1.37973	1.05155
Sustainable Site				1.1487	1.82509	1.67028
Material Resources					1.64375	1.43097
Water Efficiency						1.0
Innovation	Incon: 0.00					

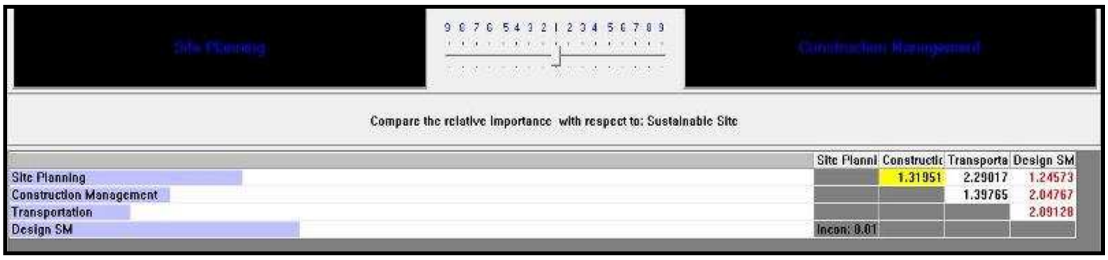
C2.2 Priority of criteria respect to goal:

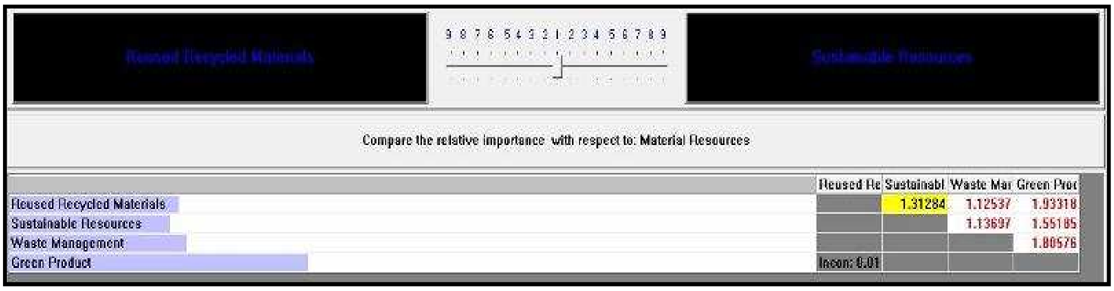


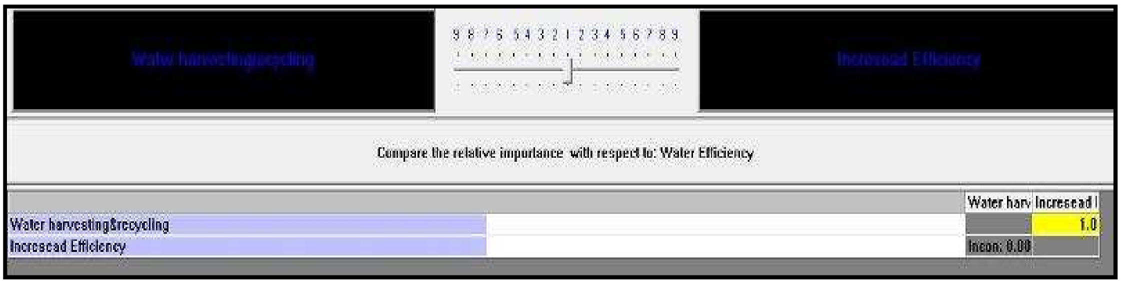
C2.3 Pairwise matrix for sub-criteria:

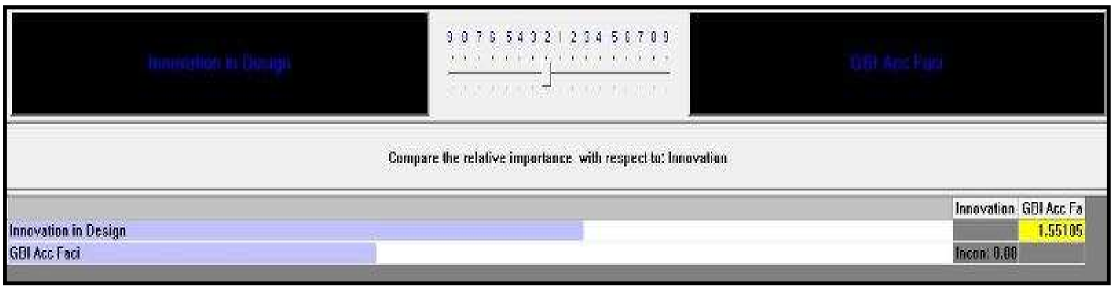




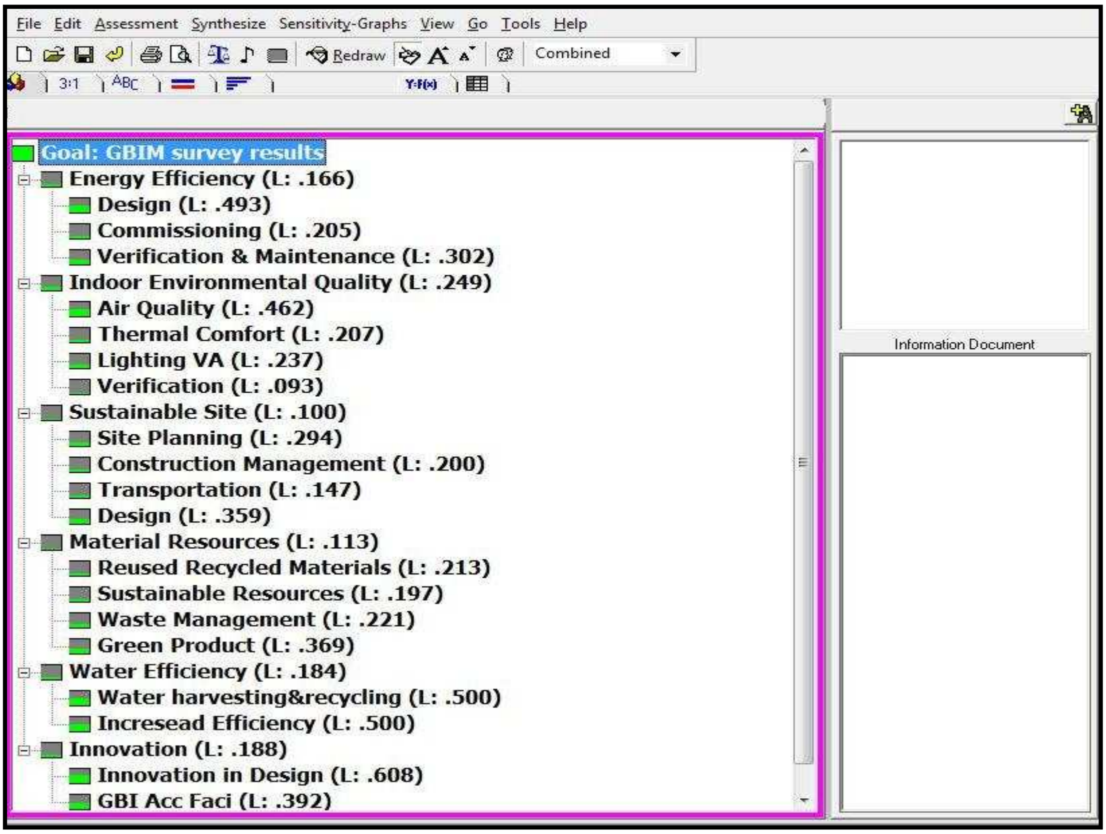




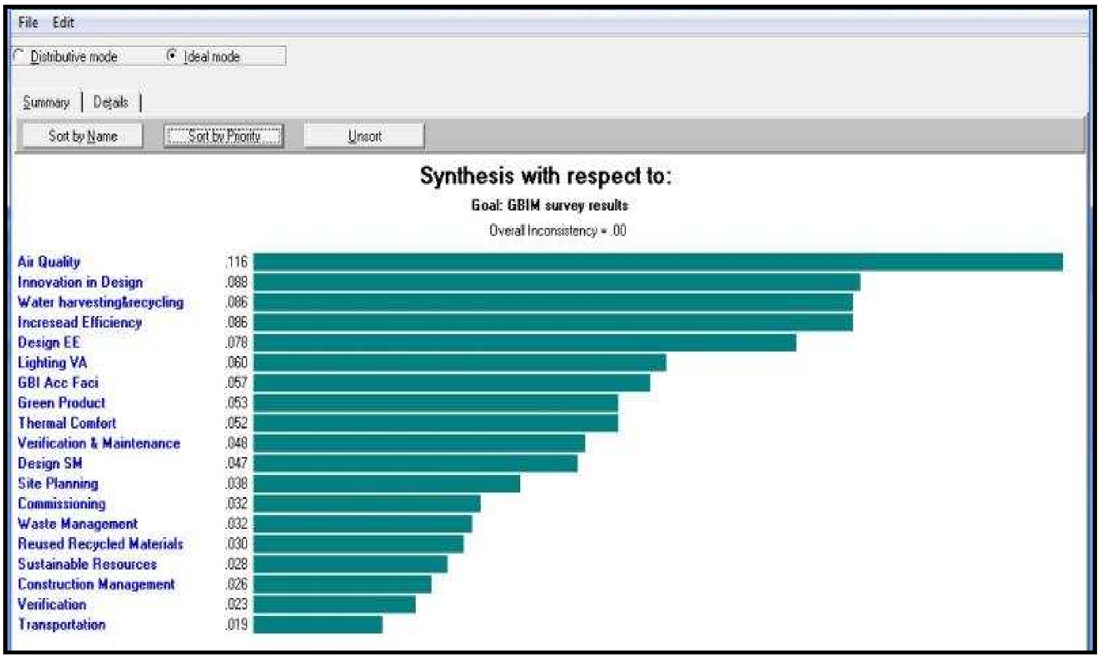




C2.4 Ranking of criteria and sub-criteria:



C2.5 Priority of all sub criteria respect to the goal:



C2.6 Convert eigenvalue to points:

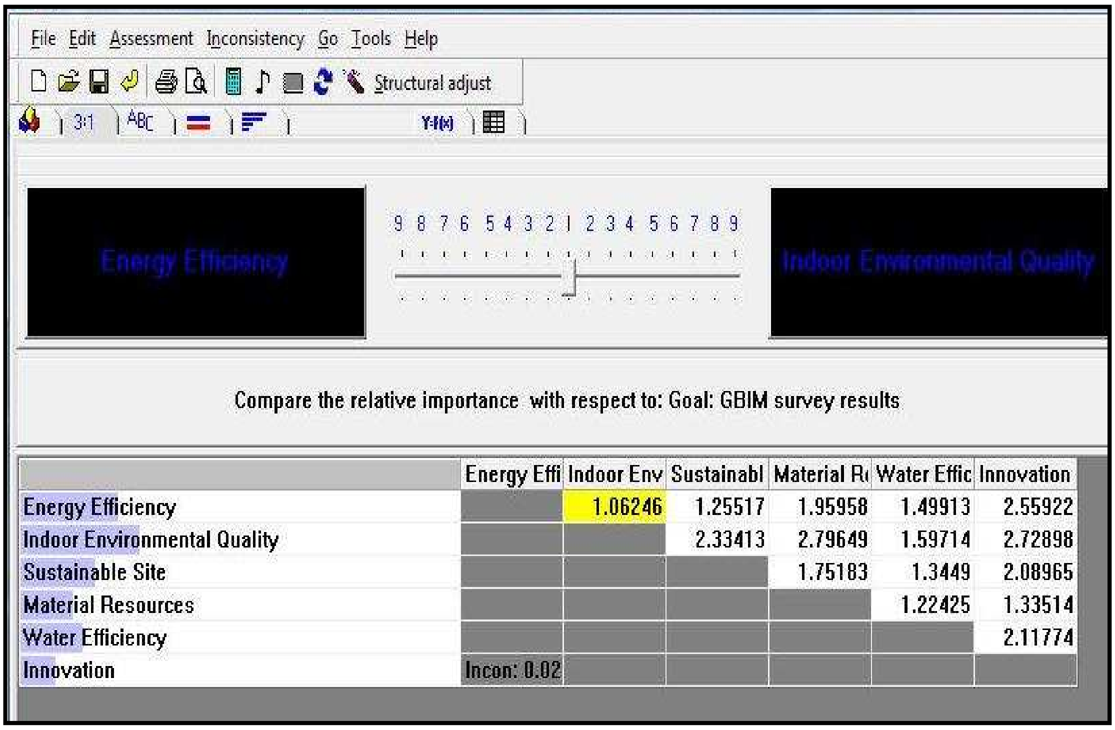
Item	weighting value of sub-criteria		points of criteria	points of sub-criteria
ENERGY EFFICIENCY				
Design EE	0.493	8.1838	16.6	8.1838
Commissioning	0.205	3.403		3.403
Verification n Maintenance	0.302	5.0132		5.0132
Total	1	16.6		16.6
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.462	11.5038	24.8751	11.5038
Thermal comfort	0.207	5.1543		5.1543
Lighting, visual, & acoustic	0.237	5.9013		5.9013
Verification	0.093	2.3157		2.3157
Total	0.999	24.8751		24.8751
SUSTAINABLE SITE				
Site planning	0.294	2.94	10	2.94
Construction management	0.2	2		2
Transportation	0.147	1.47		1.47
Design SM	0.359	3.59		3.59
Total	1	10		10
MATERIAL RESOURCES				
Reused, recycled materials	0.213	2.4069	11.3	2.4069
Sustainable resources	0.197	2.2261		2.2261
Waste management	0.221	2.4973		2.4973
Green Product	0.369	4.1697		4.1697
Total	1	11.3		11.3
WATER ENVIRONMENT				
Water harvesting & recycling	0.5	9.2	18.4	9.2
Increased Efficiency	0.5	9.2		9.2
Total	1	18.4		18.4
INNOVATION				
Innovation in design	0.608	11.4304	18.8	11.4304
GBI accredited facilitator	0.392	7.3696		7.3696
Total	1	18.8		18.8
			100.0	100.0

C2.7 Comparison of current GBI and GBI based on architects (in criteria):

CRITERIA	Current GBI	GBI based on Architects
Energy Efficiency	35	16.6
Indoor Environmental Quality	21	24.9
Sustainable Site Planning & Management	16	10.0
Material & Resources	11	11.3
Water Efficiency	10	18.4
Innovation	7	18.8
TOTAL	100	100

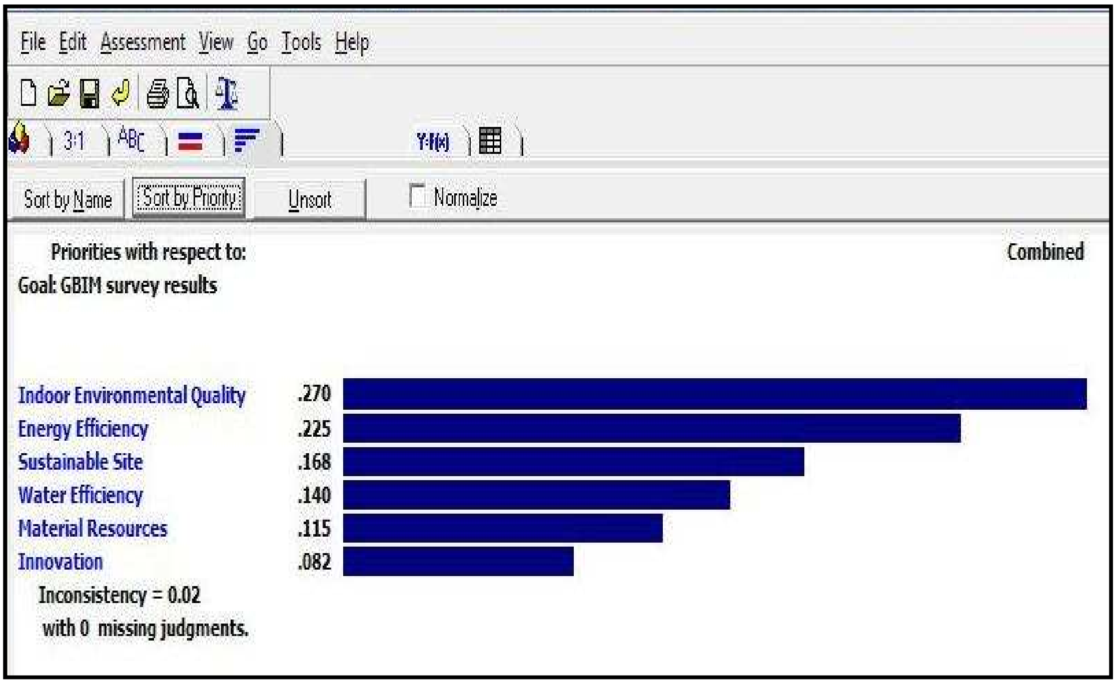
C3. GBI facilitators (10 respondents)

C3.1 Pairwise matrix for criteria:

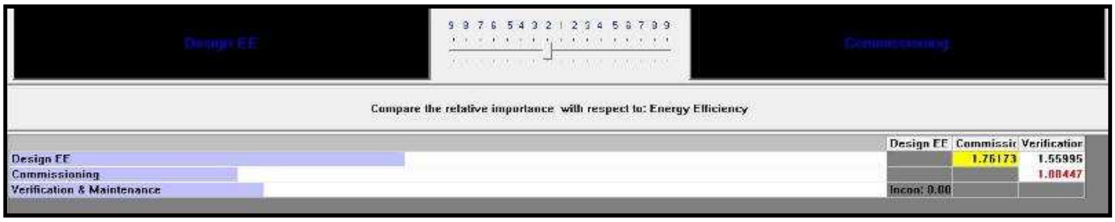


	Energy Effi	Indoor Env	Sustainabl	Material Re	Water Effic	Innovation
Energy Efficiency		1.06246	1.25517	1.95958	1.49913	2.55922
Indoor Environmental Quality			2.33413	2.79649	1.59714	2.72898
Sustainable Site				1.75183	1.3449	2.08965
Material Resources					1.22425	1.33514
Water Efficiency						2.11774
Innovation	Incon: 0.02					

C3.2 Priority of criteria respect to goal:



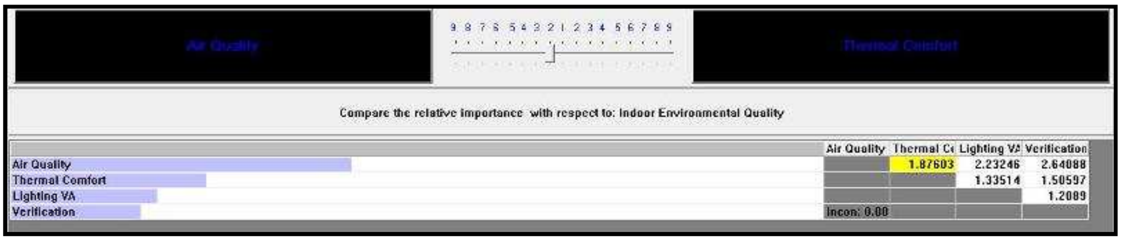
C3.3 Pairwise matrix for sub-criteria:



Design EE — Commissioning

Compare the relative importance with respect to: Energy Efficiency

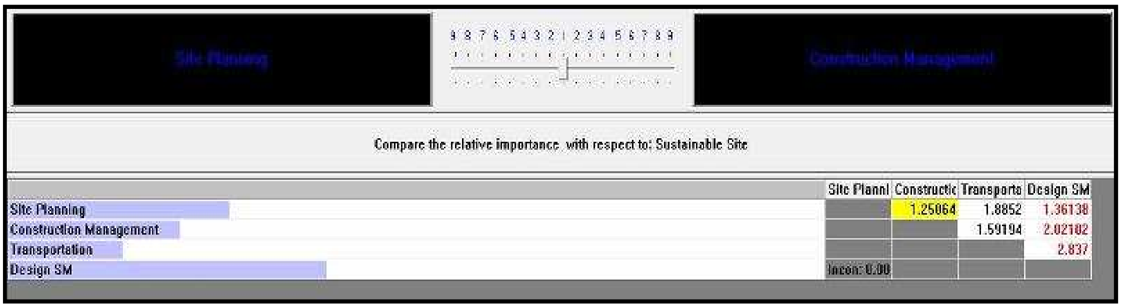
	Design EE	Commissioning	Verification
Design EE		1.76173	1.55995
Commissioning			1.00447
Verification & Maintenance	Incon: 0.00		



Air Quality — Thermal Comfort

Compare the relative importance with respect to: Indoor Environmental Quality

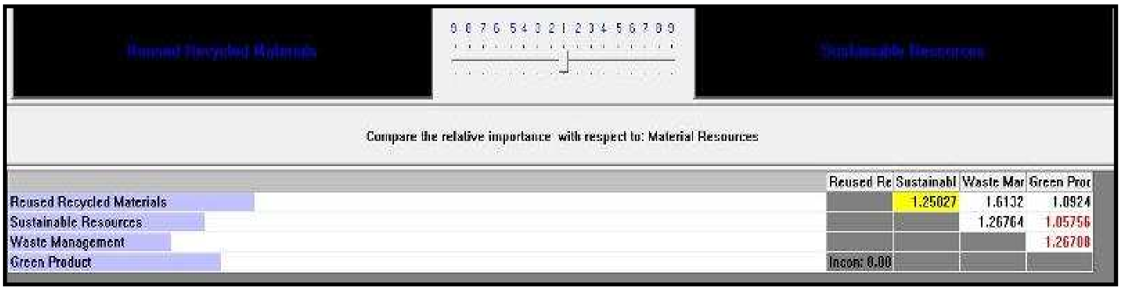
	Air Quality	Thermal Co	Lighting VA	Verification
Air Quality		1.87603	2.23246	2.64088
Thermal Comfort			1.33514	1.50597
Lighting VA				1.2089
Verification	Incon: 0.00			



Site Planning — Construction Management

Compare the relative importance with respect to: Sustainable Site

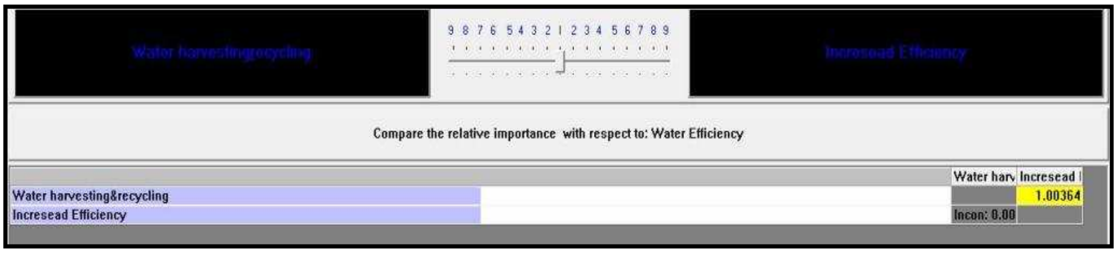
	Site Planni	Constructio	Transporta	Design SM
Site Planning		1.25064	1.8852	1.36138
Construction Management			1.59194	2.02182
Transportation				2.837
Design SM	Incon: 0.00			



Reused Recycled Materials — Sustainable Resources

Compare the relative importance with respect to: Material Resources

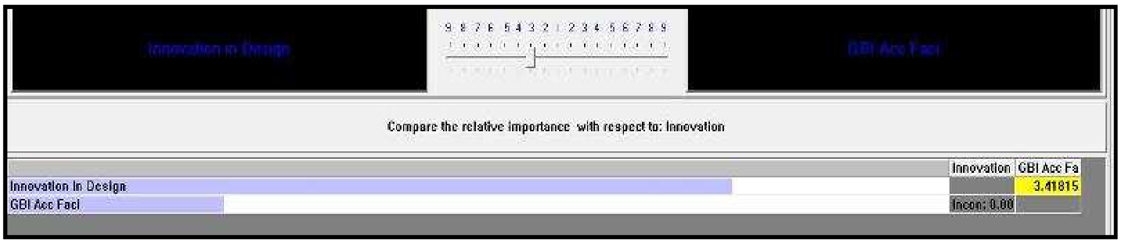
	Reused Re	Sustainabl	Waste Mar	Green Proc
Reused Recycled Materials		1.25027	1.6132	1.0924
Sustainable Resources			1.26764	1.05756
Waste Management				1.26708
Green Product	Incon: 0.00			



Water harvesting&recycling — Incresead Efficiency

Compare the relative importance with respect to: Water Efficiency

	Water harv	Incresead I
Water harvesting&recycling		1.00364
Incresead Efficiency	Incon: 0.00	

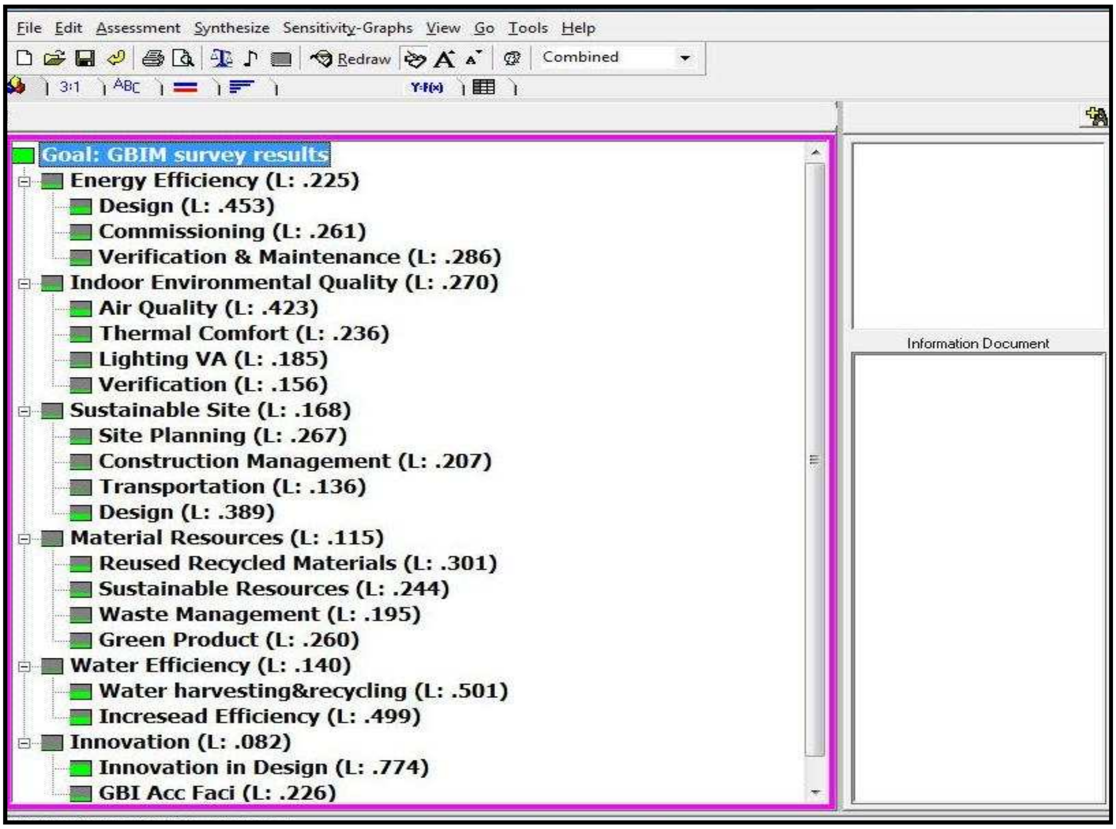


Innovation in Design — GBI Acc Faci

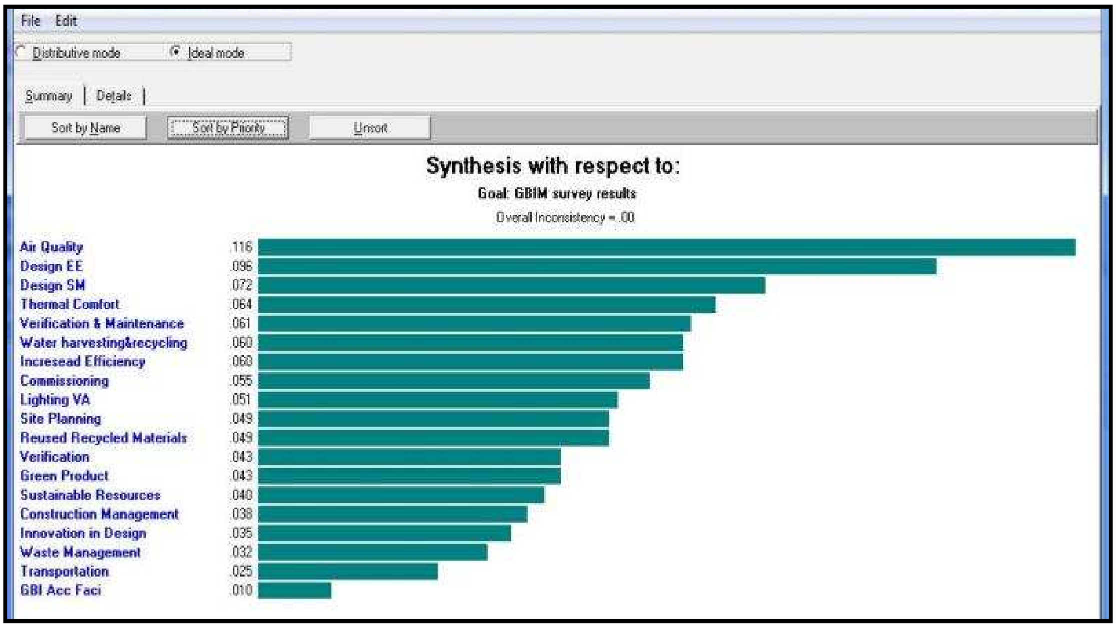
Compare the relative importance with respect to: Innovation

	Innovation	GBI Acc Fa
Innovation In Design		3.41815
GBI Acc Faci	Incon: 0.00	

C3.4 Ranking of criteria and sub-criteria:



C3.5 Priority of all sub-criteria respect to the goal:



C3.6 Convert eigenvalue to points:

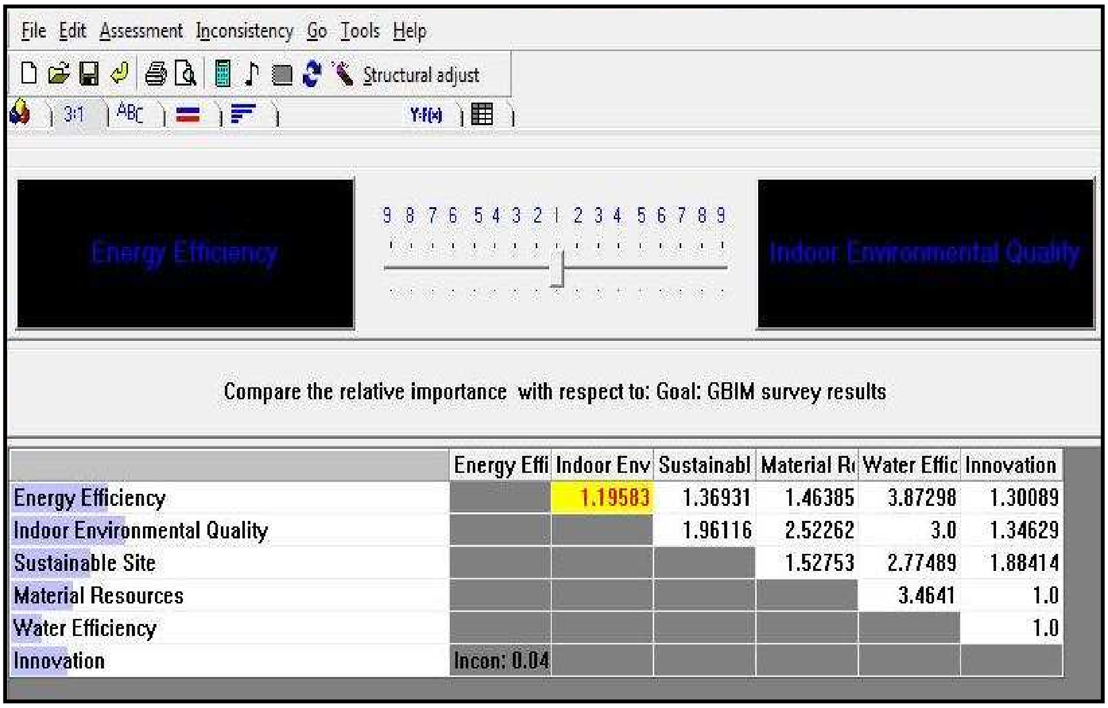
Item	**weighting value of sub-criteria**		**points of criteria**	**points of sub-criteria**
ENERGY EFFICIENCY				
Design EE	0.453	10.1925	22.5	10.1925
Commissioning	0.261	5.8725		5.8725
Verification n Maintenance	0.286	6.435		6.435
Total	1	22.5		22.5
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.423	11.421	27	11.421
Thermal comfort	0.236	6.372		6.372
Lighting, visual, & acoustic	0.185	4.995		4.995
Verification	0.156	4.212		4.212
Total	1	27		27
SUSTAINABLE SITE				
Site planning	0.267	4.4856	16.7832	4.4856
Construction management	0.207	3.4776		3.4776
Transportation	0.136	2.2848		2.2848
Design SM	0.389	6.5352		6.5352
Total	0.999	16.7832		16.7832
MATERIAL RESOURCES				
Reused, recycled materials	0.301	3.4615	11.5	3.4615
Sustainable resources	0.244	2.806		2.806
Waste management	0.195	2.2425		2.2425
Green Product	0.26	2.99		2.99
Total	1	11.5		11.5
WATER ENVIRONMENT				
Water harvesting & recycling	0.501	7.014	14	7.014
Increased Efficiency	0.499	6.986		6.986
Total	1	14		14
INNOVATION				
Innovation in design	0.774	6.3468	8.2	6.3468
GBI accredited facilitator	0.226	1.8532		1.8532
Total	1	8.2		8.2
			100.0	100.0

C3.7 Comparison of current GBI and GBI based on GBI facilitators (in Criteria):

CRITERIA	**Current GBI**	**GBI based on GBI facilitators**
Energy Efficiency	35	22.5
Indoor Environmental Quality	21	27.0
Sustainable Site Planning & Management	16	16.8
Material & Resources	11	11.5
Water Efficiency	10	14.0
Innovation	7	8.2
TOTAL	100	100

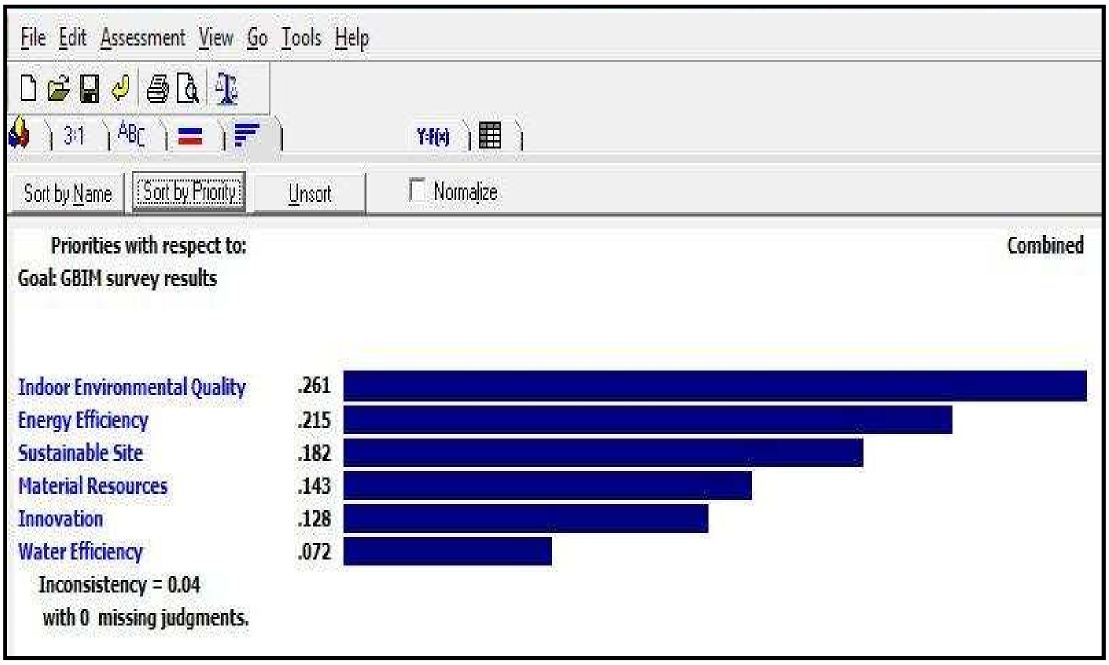
C4. Government Officers (2 respondents)

C4.1 Pairwise matrix for criteria:

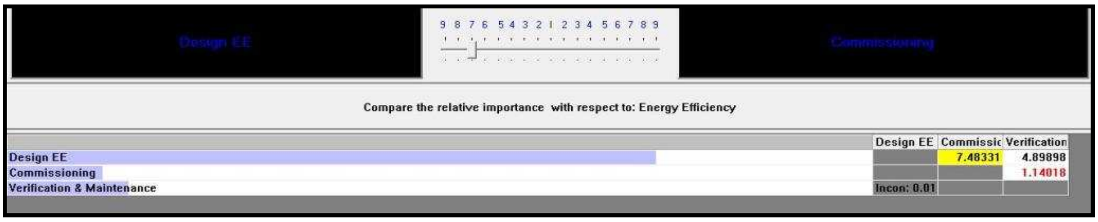


	Energy Effi	Indoor Env	Sustainabl	Material R	Water Effic	Innovation
Energy Efficiency		1.19583	1.36931	1.46385	3.87298	1.30089
Indoor Environmental Quality			1.96116	2.52262	3.0	1.34629
Sustainable Site				1.52753	2.77489	1.88414
Material Resources					3.4641	1.0
Water Efficiency						1.0
Innovation	Incon: 0.04					

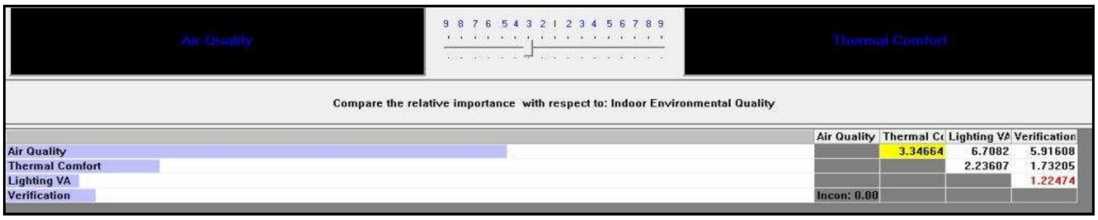
C4.2 Priority of criteria respect to goal:



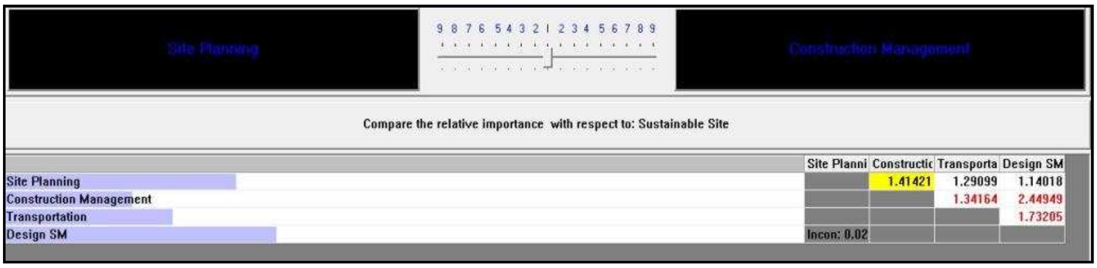
C4.3 Pairwise matrix for sub-criteria:



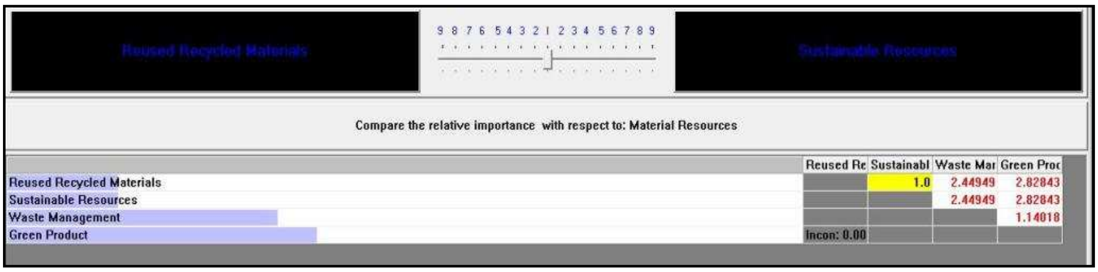
	Design EE	Commissic	Verification
Design EE		7.48331	4.89898
Commissioning			1.14018
Verification & Maintenance	Incon: 0.01		



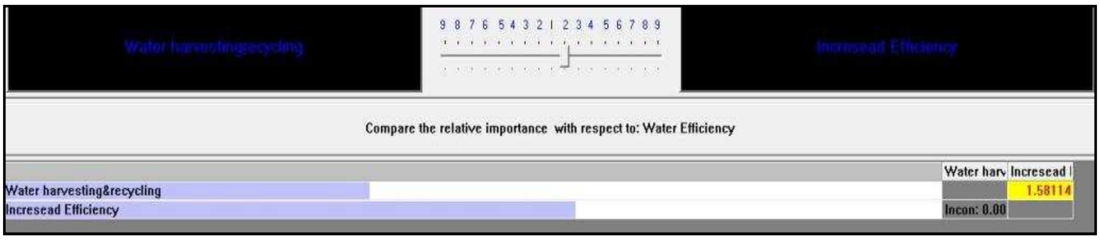
	Air Quality	Thermal Cc	Lighting VA	Verification
Air Quality		3.34664	6.7082	5.91608
Thermal Comfort			2.23607	1.73205
Lighting VA				1.22474
Verification	Incon: 0.00			



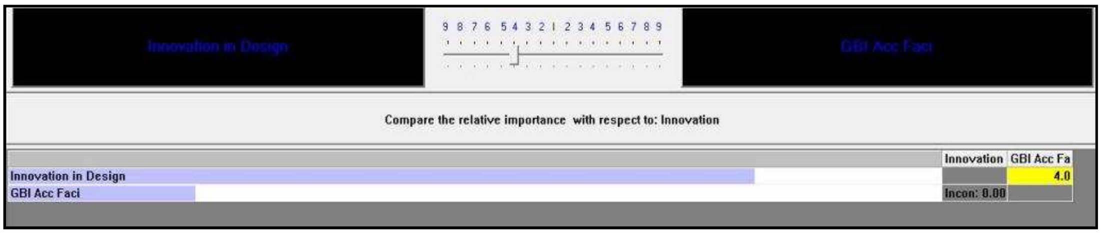
	Site Planni	Constructic	Transporta	Design SM
Site Planning		1.41421	1.29099	1.14018
Construction Management			1.34164	2.44949
Transportation				1.73205
Design SM	Incon: 0.02			



	Reused Re	Sustainabl	Waste Mar	Green Proc
Reused Recycled Materials		1.0	2.44949	2.82843
Sustainable Resources			2.44949	2.82843
Waste Management				1.14018
Green Product	Incon: 0.00			

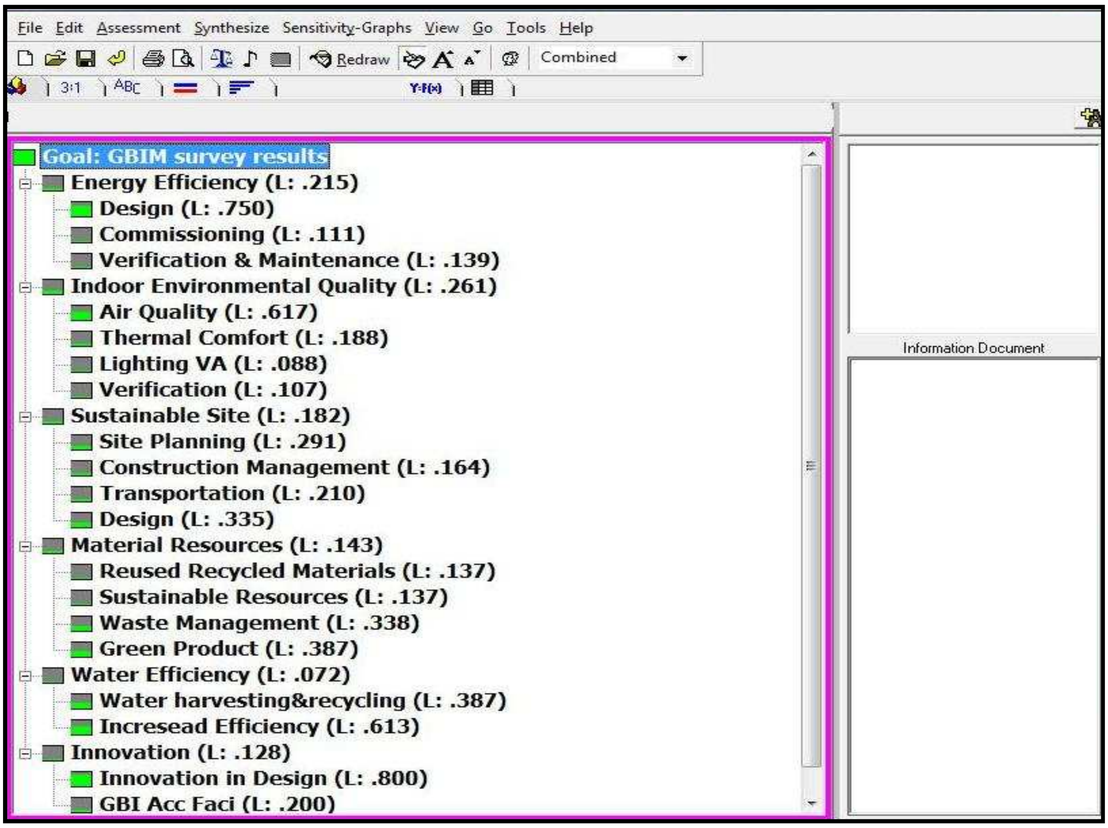


	Water harv	Incresead I
Water harvesting&recycling		1.58114
Incresead Efficiency	Incon: 0.00	

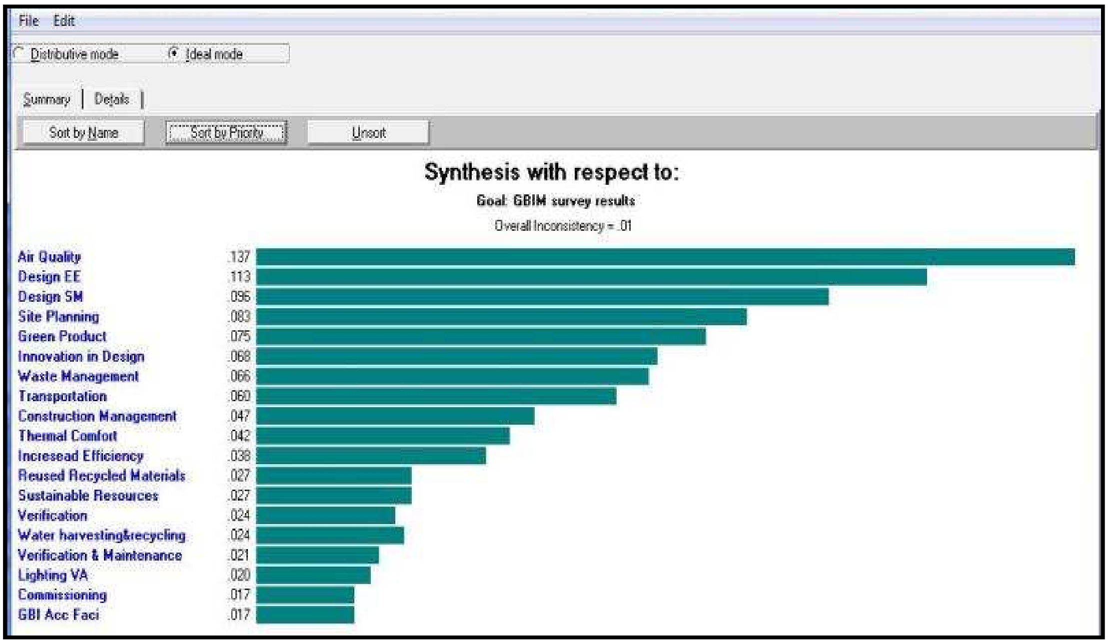


	Innovation	GBI Acc Fa
Innovation in Design		4.0
GBI Acc Faci	Incon: 0.00	

C4.4 Ranking of criteria and sub-criteria:



C4.5 Priority of all sub criteria respect to the goal:



C4.6 Convert eigenvalue to points:

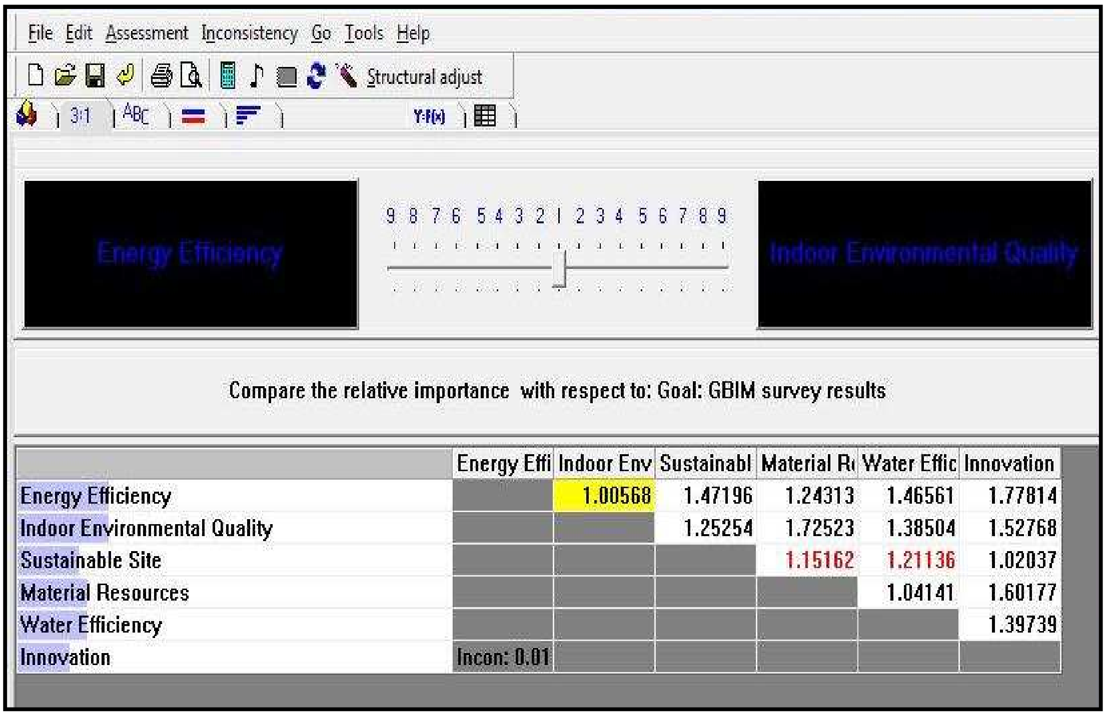
Item	weighting value of sub-criteria		points of criteria	points of sub-criteria
ENERGY EFFICIENCY				
Design EE	0.75	16.125	21.5	16.125
Commissioning	0.111	2.3865		2.3865
Verification n Maintenance	0.139	2.9885		2.9885
Total	1	21.5		21.5
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.617	16.1037	26.1	16.1037
Thermal comfort	0.188	4.9068		4.9068
Lighting, visual, & acoustic	0.088	2.2968		2.2968
Verification	0.107	2.7927		2.7927
Total	1	26.1		26.1
SUSTAINABLE SITE				
Site planning	0.291	5.2962	18.2	5.2962
Construction management	0.164	2.9848		2.9848
Transportation	0.21	3.822		3.822
Design SM	0.335	6.097		6.097
Total	1	18.2		18.2
MATERIAL RESOURCES				
Reused, recycled materials	0.137	1.9591	14.2857	1.9591
Sustainable resources	0.137	1.9591		1.9591
Waste management	0.338	4.8334		4.8334
Green Product	0.387	5.5341		5.5341
Total	0.999	14.2857		14.2857
WATER ENVIRONMENT				
Water harvesting & recycling	0.387	2.7864	7.2	2.7864
Increased Efficiency	0.613	4.4136		4.4136
Total	1	7.2		7.2
INNOVATION				
Innovation in design	0.8	10.24	12.8	10.24
GBI accredited facilitator	0.2	2.56		2.56
Total	1	12.8		12.8
			100.1	100.1

C4.7 Comparison of current GBI and GBI based on government officers (in criteria):

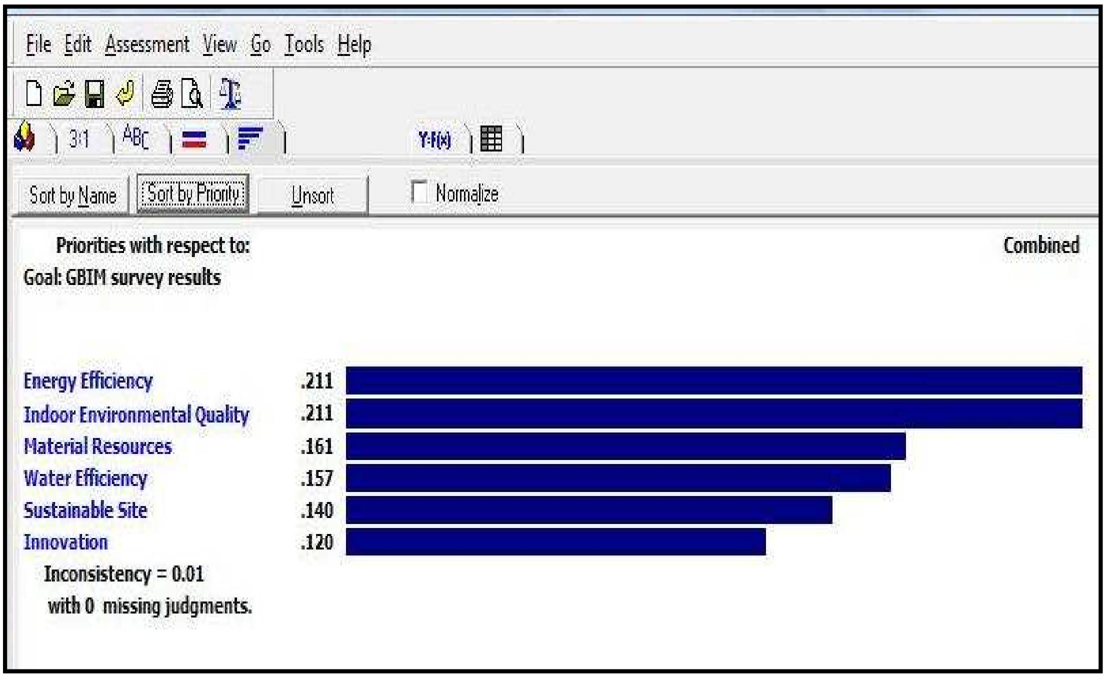
CRITERIA	Current GBI	GBI based on government officers
Energy Efficiency	35	21.5
Indoor Environmental Quality	21	26.1
Sustainable Site Planning & Management	16	18.2
Material & Resources	11	14.3
Water Efficiency	10	7.2
Innovation	7	12.8
TOTAL	100	100

C5. Academics (11 respondents)

C5.1 Pairwise matrix for criteria:



C5.2 Priority of criteria respect to goal:



C5.3 Pairwise matrix for sub-criteria:

Compare the relative importance with respect to: Energy Efficiency

	Design EE	Commissic	Verification
Design EE		2.52089	1.21488
Commissioning			2.21104
Verification & Maintenance	Incon: 0.00		

Compare the relative importance with respect to: Indoor Environmental Quality

	Air Quality	Thermal Cc	Lighting VA	Verification
Air Quality		1.12165	2.36285	2.52298
Thermal Comfort			2.53681	2.53171
Lighting VA				1.39312
Verification	Incon: 0.00			

Compare the relative importance with respect to: Sustainable Site

Extreme
Very Strong
Strong
Moderate
Equal
Moderate
Strong
Very Strong
Extreme

	Site Planni	Constructic	Transporta	Design SM
Site Planning		1.16821	2.27498	1.79866
Construction Management			2.17652	2.19713
Transportation				4.24897
Design SM	Incon: 0.00			

Compare the relative importance with respect to: Material Resources

	Reused Re	Sustainabl	Waste Mar	Green Proc
Reused Recycled Materials		2.03037	1.18823	1.65827
Sustainable Resources			2.07744	1.22967
Waste Management				1.96431
Green Product	Incon: 0.00			

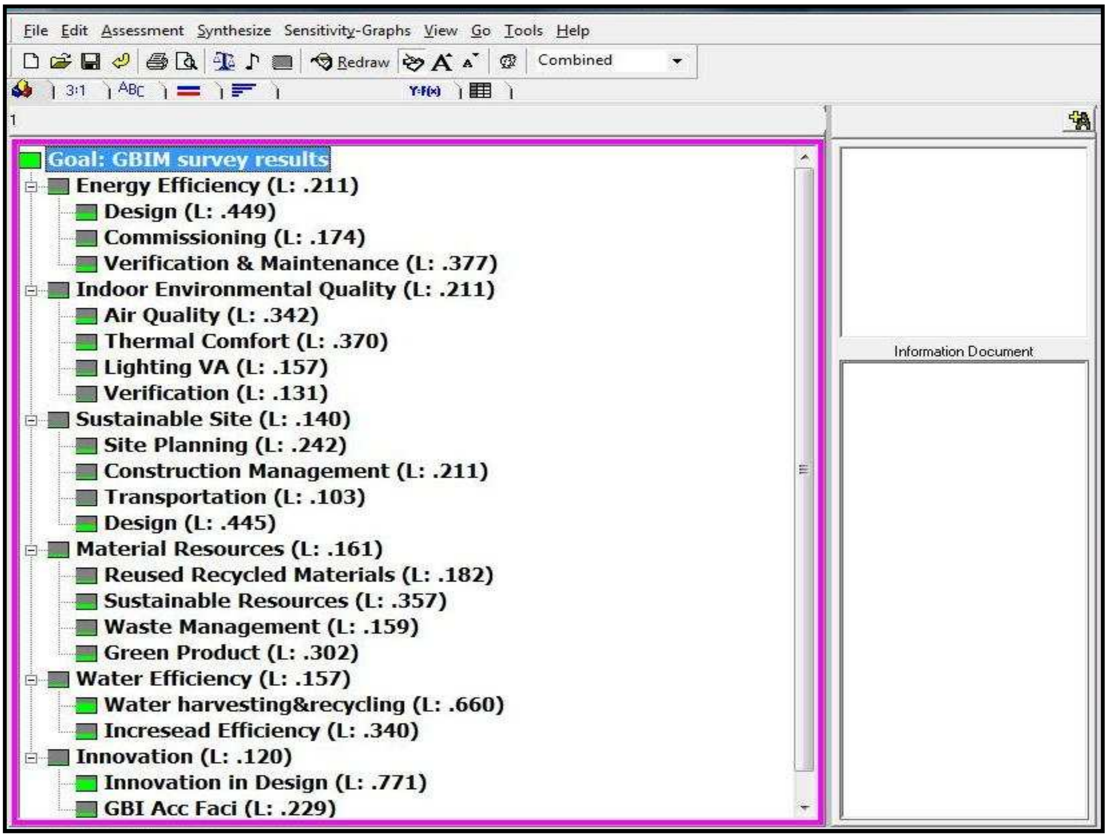
Compare the relative importance with respect to: Water Efficiency

	Water harv	Increscead I
Water harvesting&recycling		1.93697
Increscead Efficiency	Incon: 0.00	

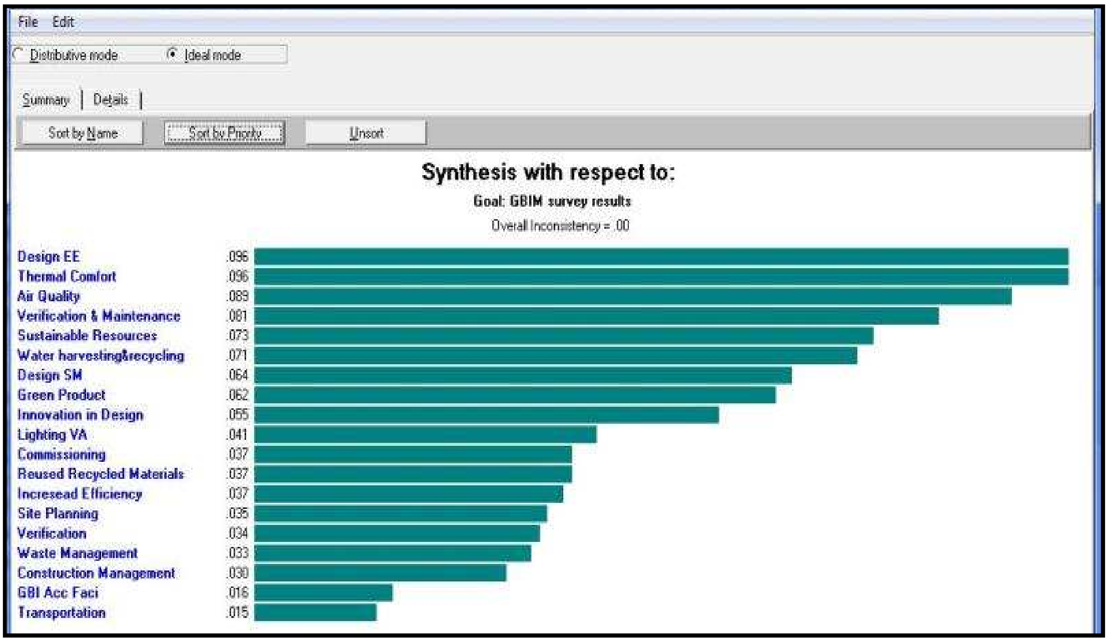
Compare the relative importance with respect to: Innovation

	Innovation	GBI Acc Fa
Innovation in Design		3.35808
GBI Acc Faci	Incon: 0.00	

C5.4 Ranking of criteria and sub-criteria:



C5.5 Priority of all sub-criteria respect to the goal:



C5.6 Convert eigenvalue to points:

Item	weighting value of sub-criteria		points of criteria	points of sub-criteria
ENERGY EFFICIENCY				
Design EE	0.449	9.4739	21.1	9.4739
Commissioning	0.174	3.6714		3.6714
Verification n Maintenance	0.377	7.9547		7.9547
Total	1	21.1		21.1
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.342	7.2162	21.1	7.2162
Thermal comfort	0.37	7.807		7.807
Lighting, visual, & acoustic	0.157	3.3127		3.3127
Verification	0.131	2.7641		2.7641
Total	1	21.1		21.1
SUSTAINABLE SITE				
Site planning	0.242	3.388	14.014	3.388
Construction management	0.211	2.954		2.954
Transportation	0.103	1.442		1.442
Design SM	0.445	6.23		6.23
Total	1.001	14.014		14.014
MATERIAL RESOURCES				
Reused, recycled materials	0.182	2.9302	16.1	2.9302
Sustainable resources	0.357	5.7477		5.7477
Waste management	0.159	2.5599		2.5599
Green Product	0.302	4.8622		4.8622
Total	1	16.1		16.1
WATER ENVIRONMENT				
Water harvesting & recycling	0.66	10.362	15.7	10.362
Increased Efficiency	0.34	5.338		5.338
Total	1	15.7		15.7
INNOVATION				
Innovation in design	0.771	9.252	12	9.252
GBI accredited facilitator	0.229	2.748		2.748
Total	1	12		12
			100.014	100.014

C5.7 Comparison of current GBI and GBI based on academics (in criteria)

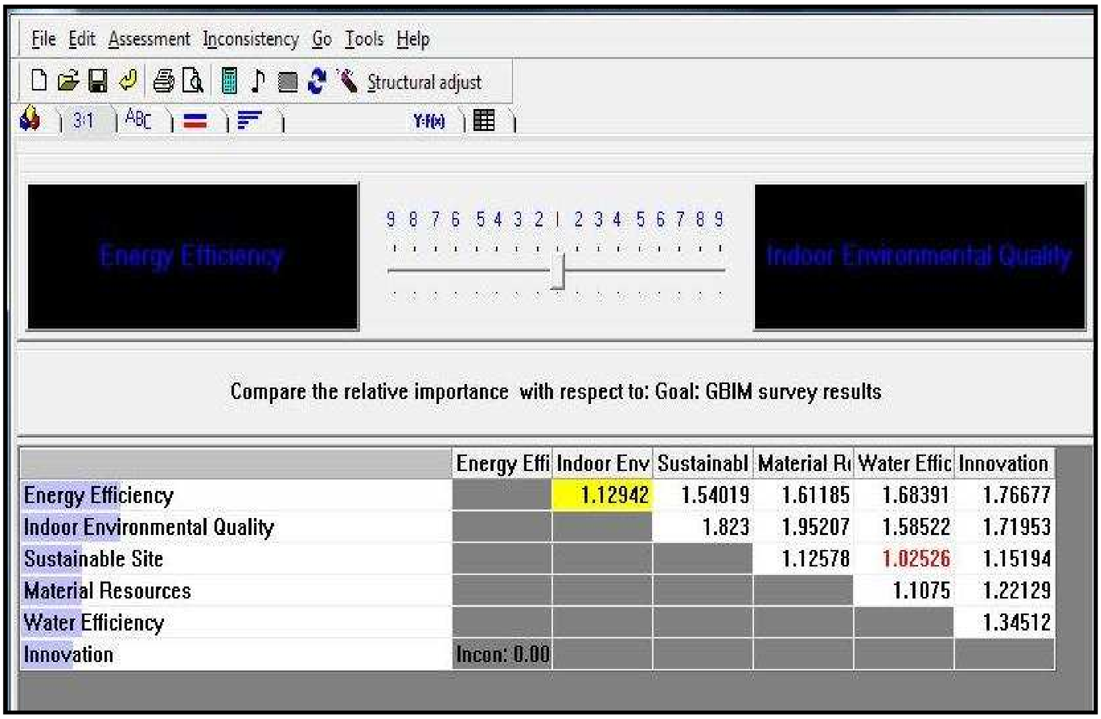
CRITERIA	Current GBI	GBI based on academics
Energy Efficiency	35	21.1
Indoor Environmental Quality	21	21.1
Sustainable Site Planning & Management	16	14.0
Material & Resources	11	16.1
Water Efficiency	10	15.7
Innovation	7	12.0
TOTAL	100	100

APPENDIX D

SURVEY RESULT (ALL EXPERTS GROUP)

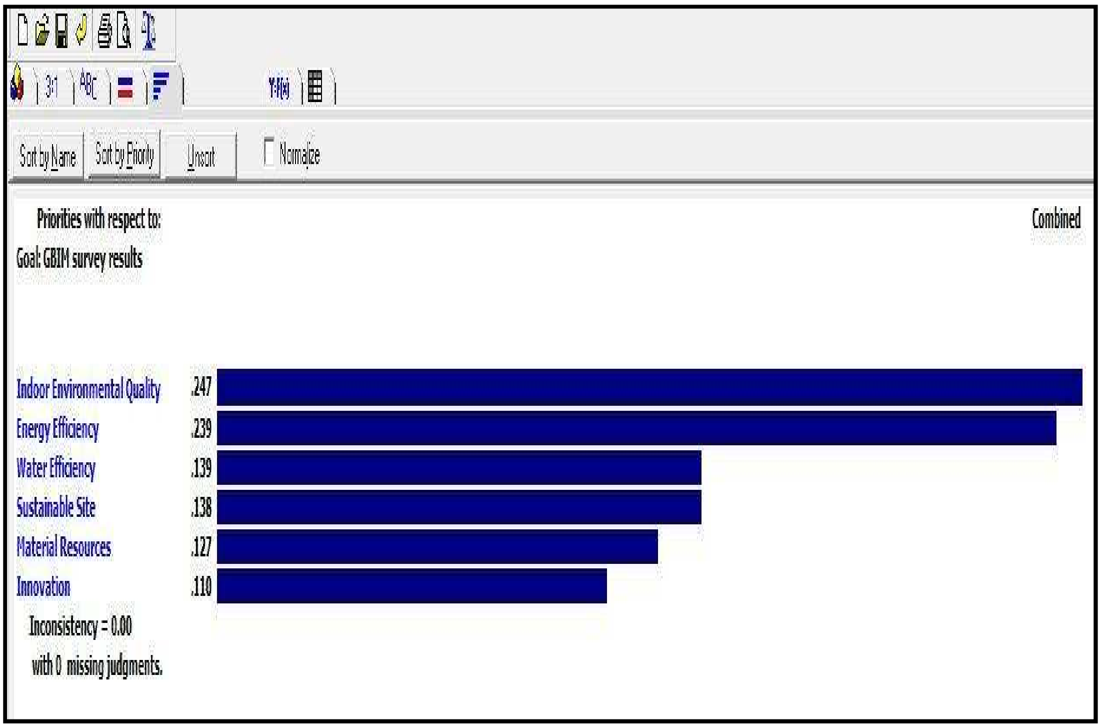
Appendix D is the result of a survey which covered by 44 respondents from different kind of background. They are all expert in green building constructions. The result is similar with pilot survey, where "IEQ" hold the large points and being the first priority among other criteria.

D1. Pairwise matrix for criteria:

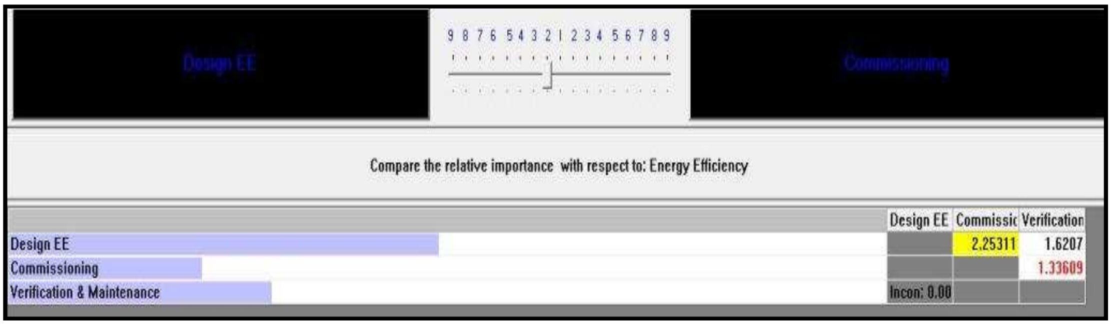


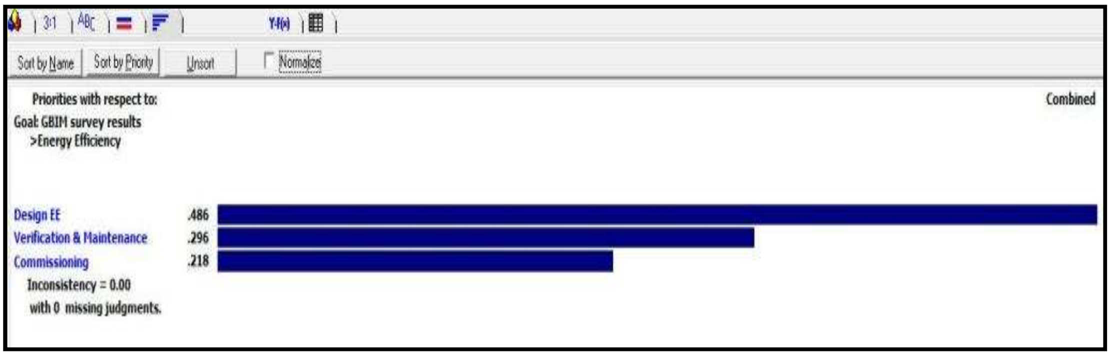
	Energy Effi	Indoor Env	Sustainabl	Material R	Water Effic	Innovation
Energy Efficiency		1.12942	1.54019	1.61185	1.68391	1.76677
Indoor Environmental Quality			1.823	1.95207	1.58522	1.71953
Sustainable Site				1.12578	1.02526	1.15194
Material Resources					1.1075	1.22129
Water Efficiency						1.34512
Innovation	Incon: 0.00					

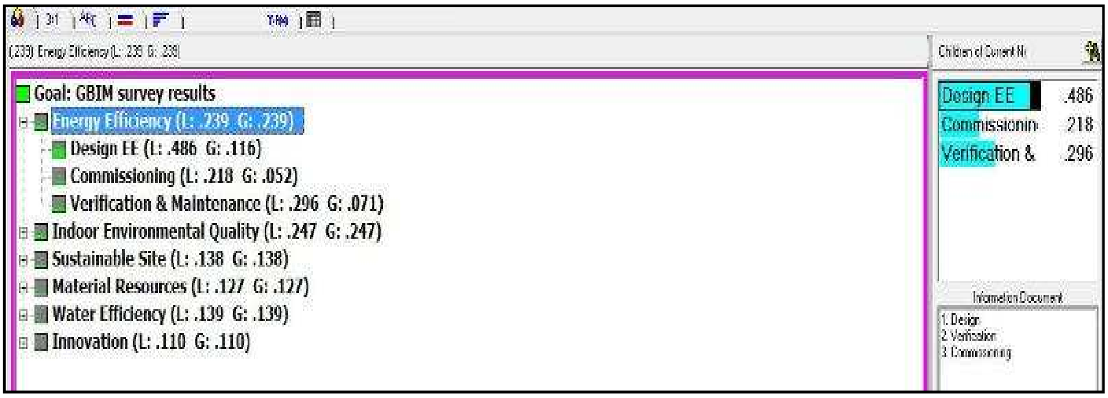
D2. Priority of criteria respect to goal:



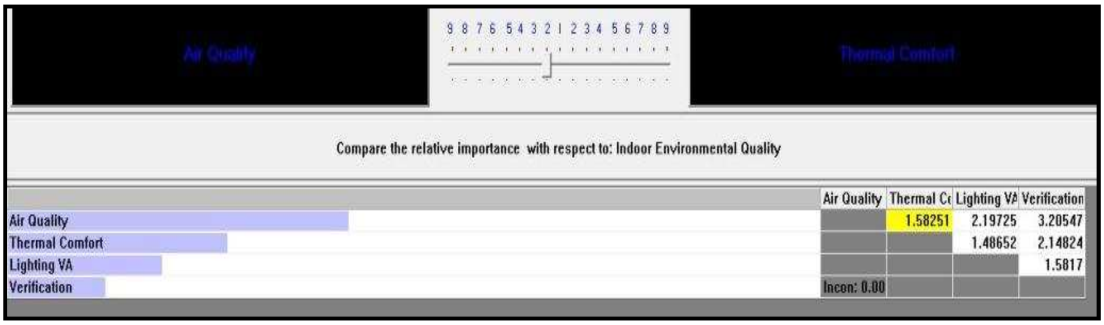
D3. Sub-criteria of energy efficiency:

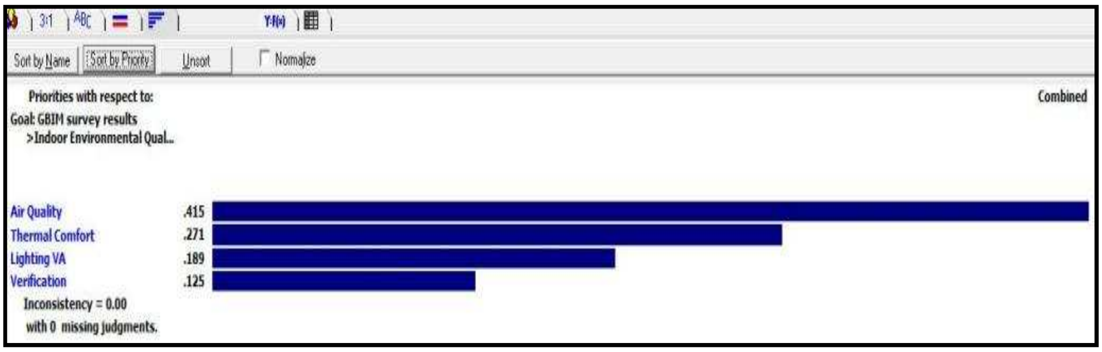


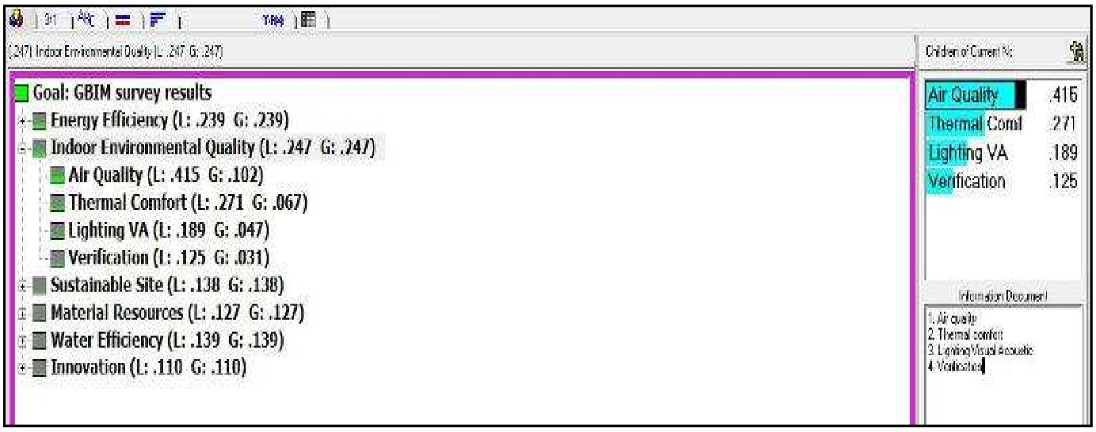




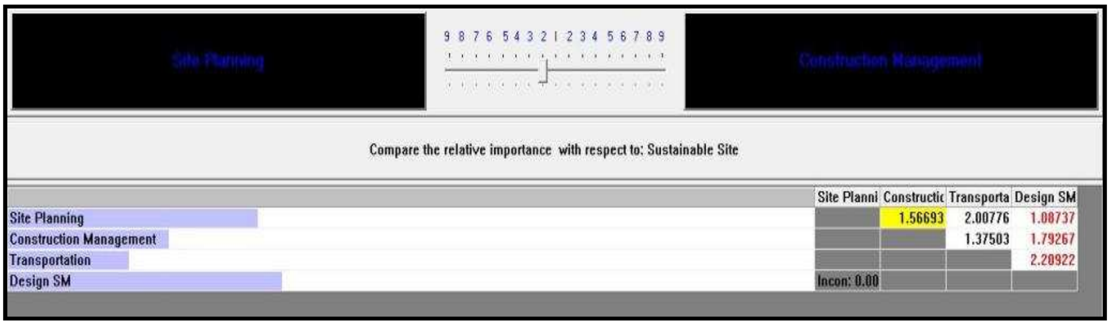
D4. Sub-Criteria of Indoor Environmental Quality:

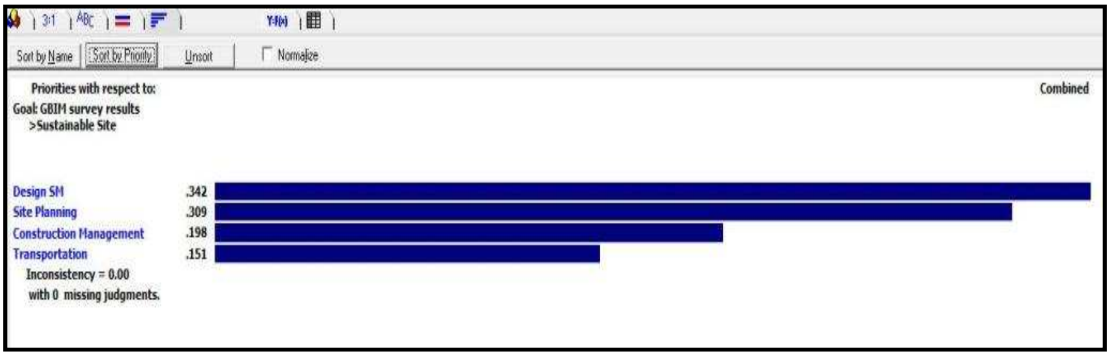


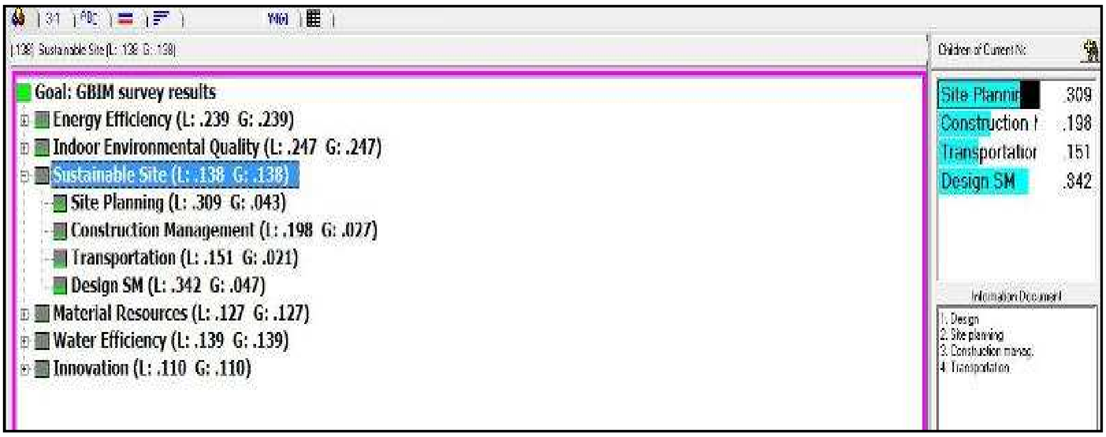




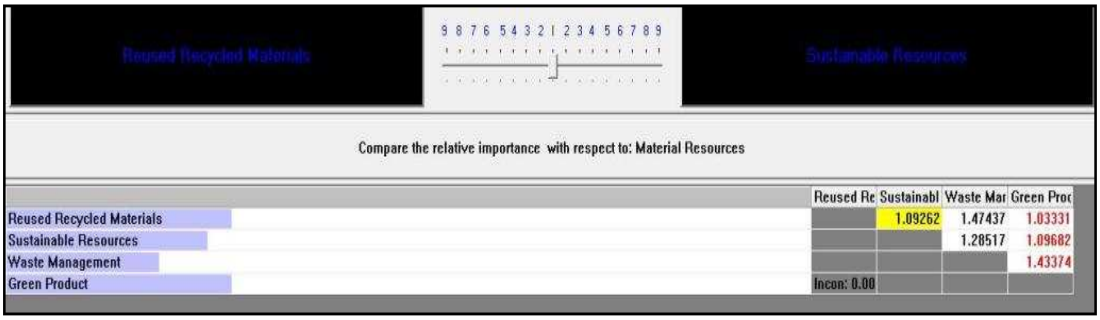
D5. Sub-Criteria of Sustainable Site:

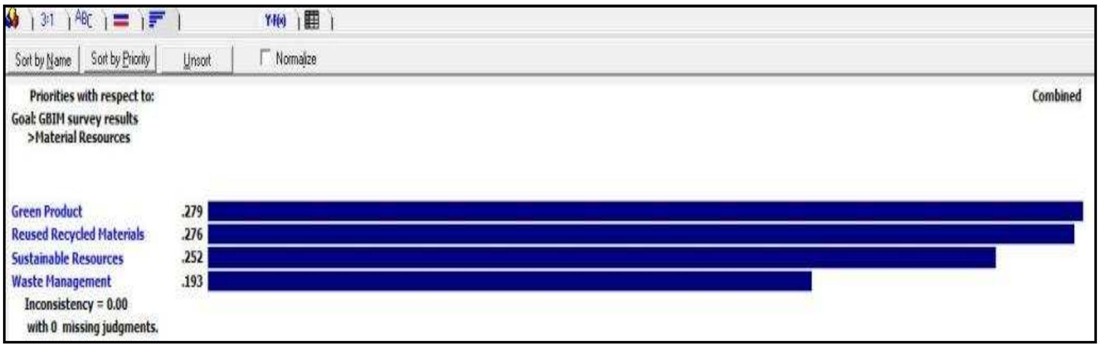


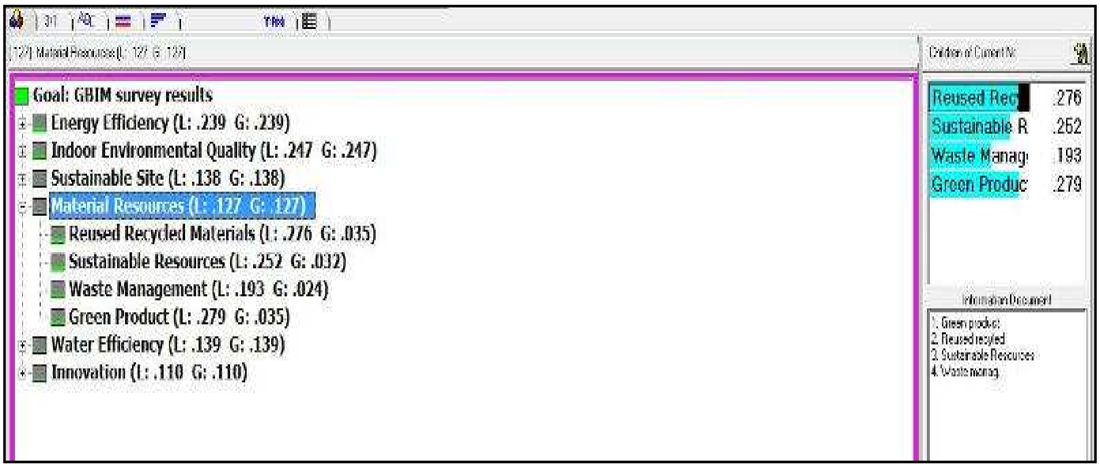




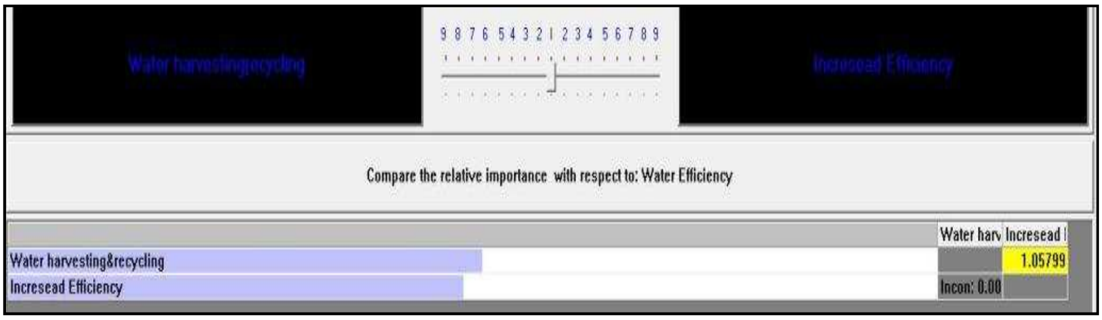
D6. Sub-Criteria of Material Resources:

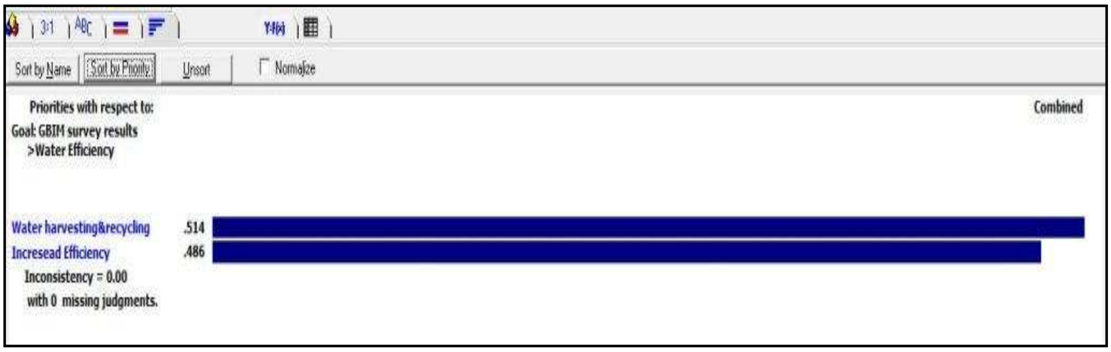


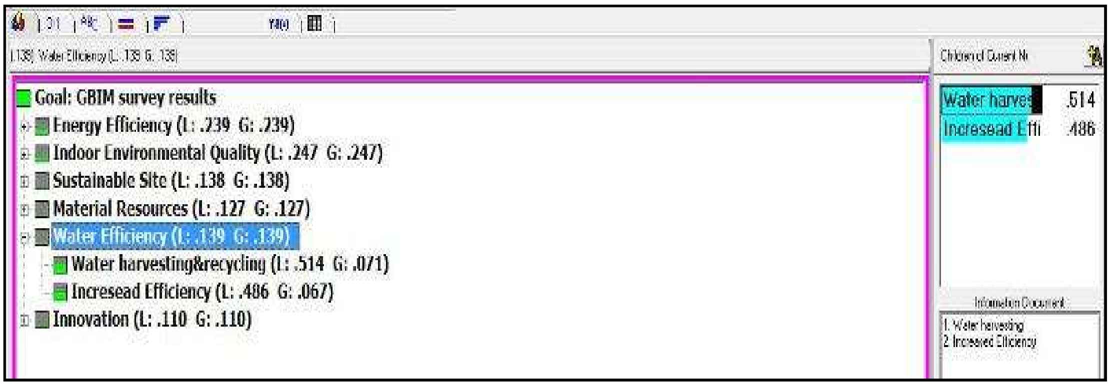




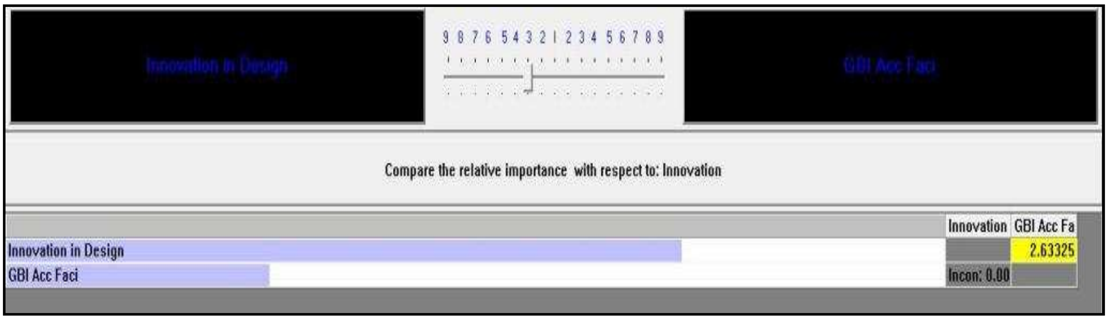
D7. Sub-Criteria of Water Efficiency:

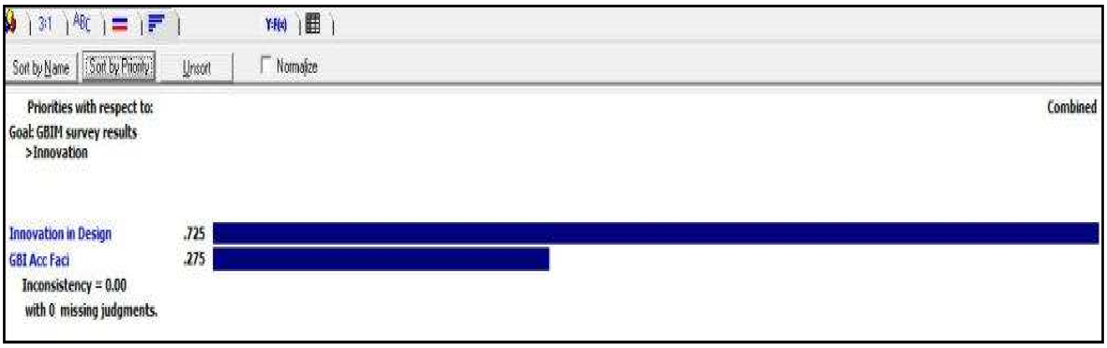


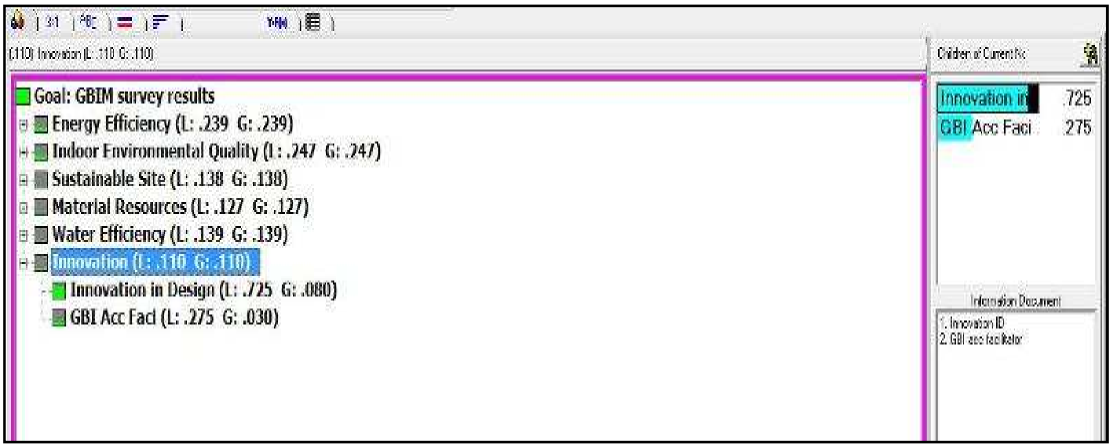




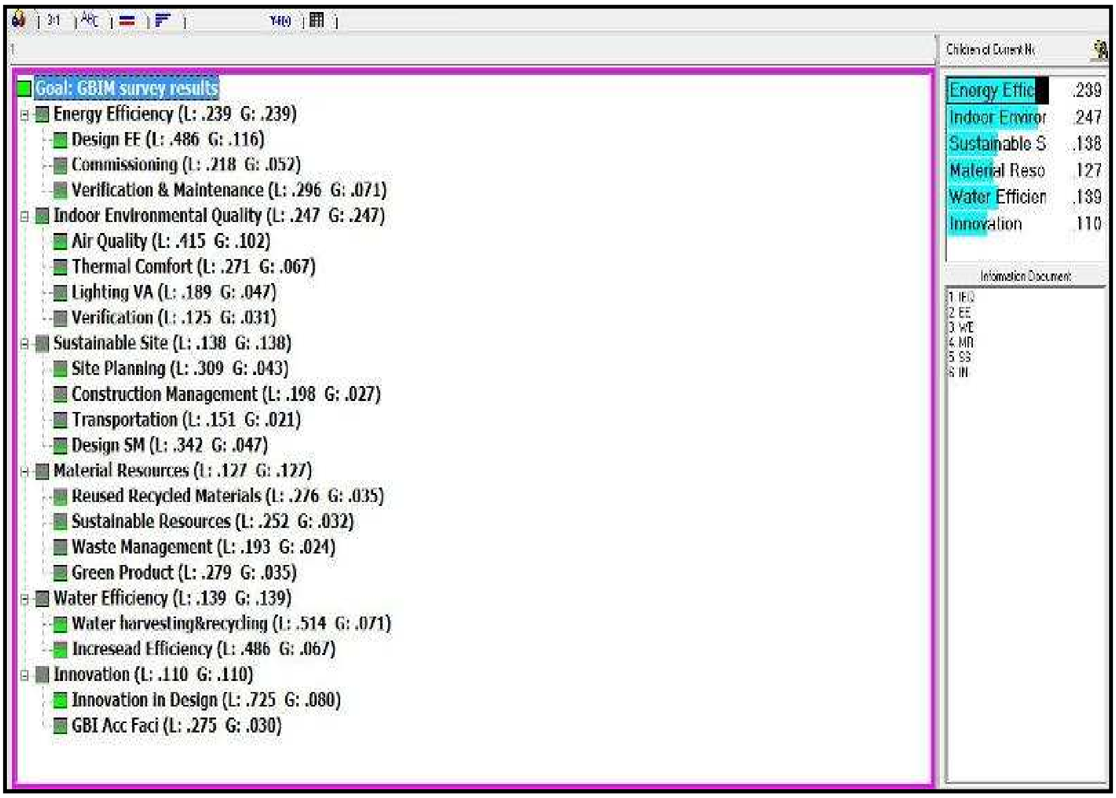
D8. Sub-Criteria of Innovation:



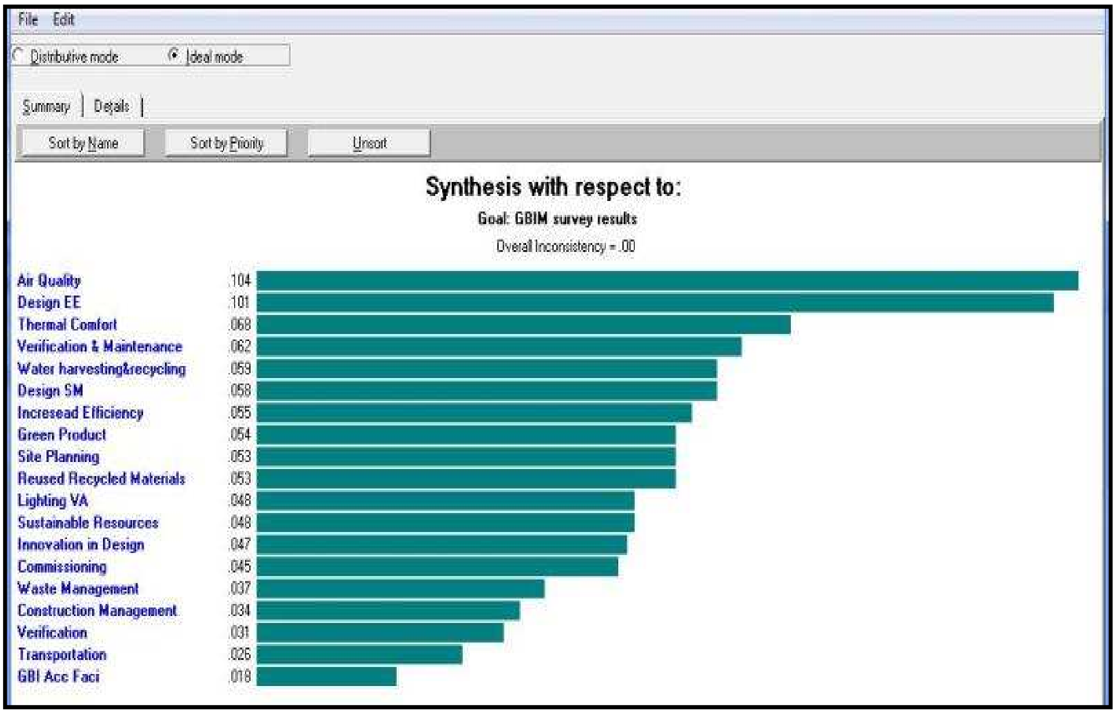




D9. Ranking of criteria and sub-criteria



D10. Priority of all sub-criteria respect to the goal:



D11. Convert eigenvalue to points (based on local weighting):

Item	weighting value of sub-criteria		points of criteria	points of sub-criteria
ENERGY EFFICIENCY				
Design EE	0.486	11.6154	23.9	12
Commissioning	0.218	5.2102		5
Verification n Maintenance	0.296	7.0744		7
Total	1	23.9		24
INDOOR ENVIRONMENTAL QUALITY				
Air quality	0.415	10.2505	24.7	10
Thermal comfort	0.271	6.6937		6
Lighting, visual, & acoustic	0.189	4.6683		6
Verification	0.125	3.0875		3
Total	1	24.7		25
SUSTAINABLE SITE				
Site planning	0.309	4.2642	13.8	4
Construction management	0.198	2.7324		3
Transportation	0.151	2.0838		3
Design SM	0.342	4.7196		4
Total	1	13.8		14
MATERIAL RESOURCES				
Reused, recycled materials	0.276	3.5052	12.7	3
Sustainable resources	0.252	3.2004		3
Waste management	0.193	2.4511		2
Green Product	0.279	3.5433		4
Total	1	12.7		12
WATER ENVIRONMENT				
Water harvesting & recycling	0.514	7.1446	13.9	7
Increased Efficiency	0.486	6.7554		7
Total	1	13.9		14
INNOVATION				
Innovation in design	0.725	7.975	11	8
GBI accredited facilitator	0.275	3.025		3
Total	1	11		11
TOTAL			100	100

D12. Comparison of current GBI and GBI based on all experts group (in criteria):

CRITERIA	Current GBI	GBI based on all experts group
Energy Efficiency	35	24
Indoor Environmental Quality	21	25
Sustainable Site Planning & Management	16	14
Material & Resources	11	12
Water Efficiency	10	14
Innovation	7	11
TOTAL	100	100

D13. Comparison of current GBI and GBI based on all respondents (in sub-criteria):

Sub Criteria of EE	Current GBI	GBI survey result
Design EE	25	12
Commissioning	5	5
Verification and Maintenance	5	7
Sub Criteria of IEQ	Current GBI	GBI survey result
Air Quality	6	10
Thermal Comfort	3	6
Lighting, Visual and Acoustic Comfort	8	6
Verification	4	3
Sub Criteria of SM	Current GBI	GBI survey result
Site Planning	6	4
Construction Management	3	3
Transportation	3	3
Design SM	4	4
Sub Criteria of MR	Current GBI	GBI survey result
Reused and Recycled Materials	4	3
Sustuinable Resources	2	3
Waste Management	3	2
Green Products	2	4
Sub Criteria of WE	Current GBI	GBI survey result
Water Harvesting and Recycling	4	7
Increased Efficiency	6	7
Sub Criteria of IN	Current GBI	GBI survey result
Innovation in Design and environmental design initiatives	6	8
Green building index accredited facilitator	1	3
TOTAL	**100**	**100**

APPENDIX E

CURRENT GBI AND GBI SURVEY RESULT

E1. Scoring:

ASSESSMENT CRITERIA OVER ALL POINTS SCORE		
ITEM	**Current GBI**	**GBI survey result**
Energy Efficiency	35	24
Indoor Environmental Quality	21	25
Sustainable Site Planning & Management	16	14
Material & Resources	11	12
Water Efficiency	10	14
Innovation	7	11
TOTAL SCORE	**100**	**100**

E2. Assessment criteria (score summary):

Part	Criteria	Item	Current GBI		GBI Survey	
			Points	Total	Points	Total
	Energy Efficiency					
	Design					
	EE1	Minimum EE Performance	1		1	
	EE2	Lighting Zoning	3		3	
	EE3	Electrical Sub-metering	1		1	
	EE4	Renewable Energy	5		3	
	EE5	Advanced EE Performance - BEI	15		4	
	commissioning			**35**		**24**
	EE6	Enhanced Commissioning	3		3	
1	EE7	Post Occupancy Commissioning	2		2	
	verification & maintenance					
	EE8	EE Verification	2		3	
	EE9	Sustainable Maintenance	3		4	
	Indoor Environmental Quality					
	Air Quality					
	EQ1	Minimum IAQ Performance	1		2	
	EQ2	Environmental Tobacco Smoke (ETS) Control	1		2	
	EQ3	Carbon Dioxide Monitoring and Control	1		2	
	EQ4	Indoor Air Pollutants	2		3	
	EQ5	Mould Prevention	1		1	
	thermal comfort					
	EQ6	Thermal Comfort: Design & Controllability of Systems	2		2	
	EQ7	Air Change Effectiveness	1		1	
	Lighting, visual & Acoustic comfort			**21**		**25**
	EQ8	Daylighting	2		1	
	EQ9	Daylight Glare Control	1		1	
	EQ10	Electric Lighting Levels	1		1	
	EQ11	High Frequency Ballasts	1		1	
2	EQ12	External Views	2		1	
	EQ13	Internal Noise Levels	1		1	
	verification					
	EQ14	IAQ Before & During Occupancy	2		2	
	EQ15	Post Occupancy Comfort Survey: Verification	2		1	

Part	Criteria	Item	Current GBI		GBI Survey	
			Points	Total	Points	Total
3	Sustainable Site Planning & Management					
	site planning			16		14
	SM1	Site Selection	1		1	
	SM2	Brownfield Redevelopment	1		1	
	SM3	Development Density & Community Connectivity	2		1	
	SM4	Environment Management	2		1	
	construction management					
	SM5	Earthworks - Construction Activity Pollution Control	1		1	
	SM6	QLASSIC	1		1	
	SM7	Workers' Site Amenities	1		1	
	transportation					
	SM8	Public Transportation Access	1		1	
	SM9	Green Vehicle Priority	1		1	
	SM10	Parking Capacity	1		1	
	Design					
	SM11	Stormwater Design – Quantity & Quality Control	1		1	
	SM12	Greenery & Roof	2		2	
	SM13	Building User Manual	1		1	
4	Materials & Resources					
	reused & recycled materials			11		12
	MR1	Materials reuse and selection	2		1	
	MR2	Recycled content materials	2		2	
	sustainable resources					
	MR3	Regional Materials	1		2	
	MR4	Sustainable Timber	1		1	
	Waste management					
	MR5	Storage & Collection of recyclables	1		1	
	MR6	Construction waste management	2		1	
	Green products					
	MR7	Refrigerants & Clean Agents	2		4	
5	Water Efficiency					
	Water Harvesting & recycling			10		14
	WE1	Rainwater Harvesting	2		3	
	WE2	Water Recycling	2		4	
	Increased efficiency					
	WE3	Water Efficient - Irrigation/Landscaping	2		3	
	WE4	Water Efficient Fittings	2		2	
	WE5	Metering & Leak Detection System	2		2	
6	Innovation					
	IN1	Innovation in Design & Environmental Design Initiatives	6	7	8	11
	IN2	Green Building Index Accredited Facilitator	1		3	
TOTAL POINTS				**100**		**100**

APPENDIX F

SIME PROJECT: CASE STUDY

Appendix F is the final result of this research, which is implementation of current GBI and GBI survey result to “SIME office building”.

F1. Energy Efficiency Assessment:

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
EE	**ENERGY EFFICIENCY**						
Design			**25**			**12**	
EE1	Minimum EE Performance						
	Establish minimum energy efficiency performance to reduce energy consumption in buildings, thus reducing CO_2 emission to the atmosphere. Meet the following minimum EE requirements as stipulated in MS 1525:2007: 1) OTTV ≤ 50, RTTV ≤ 25. Submit calculations using the BEIT software or other GBI approved software(s), ***AND*** 2) Provision of Energy Management Control system where Air-conditioned space ≥ $4000m^2$	1	1	0	1	1	0
EE2	Lighting Zoning						
	Provide flexible lighting controls to optimise energy savings:						
	All individual or enclosed spaces to be individually switched; and the size of individually switched lighting zones shall not exceed 100m² for 90% of the NLA; with switching clearly labelled and easily accessible by building occupants.	1	3	1	1	3	1
	Provide auto-sensor controlled lighting in conjunction with day lighting strategy for all perimeter zones and day lit areas, if any.	1			1		
	Provide motion sensors or equivalent to complement lighting zoning for at least 25% NLA.	**1**			**1**		
EE3	Electrical Sub-metering						
	Monitor energy consumption of key building services as well as all tenancy areas: Provide sub-metering for all energy uses of ≥ 100kVA; with separate sub-metering for lighting and separately for power at each floor or tenancy, whichever is smaller.	1	1	1	1	1	1
EE4	Renewable Energy						
	Encourage use of renewable energy:						
	Where 0.5 % or 5 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy, ***OR***	**2**	**5**	5	**1**	**3**	3
	Where 1.0 % or 10 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy, ***OR***	**3**					
	Where 1.5 % or 20 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy, ***OR***	**4**			**2**		
	Where 2.0 % or 40 kWp whichever is the greater, of the total electricity consumption is generated by renewable energy	**5**			**3**		
EE5	Advanced EE Performance - BEI						
	Exceed Energy Efficiency (EE) performance better than the baseline minimum to reduce energy consumption in the building. Achieve Building Energy Intensity (BEI) ≤ 150 kWh/m2yr as defined under GBI reference (using BEIT Software or other GBI approved software(s)), ***OR***	**2**	**15**	0	**1**	**4**	0
	BEI ≤ 140, ***OR***	**3**			**2**		
	BEI ≤ 130, ***OR***	**5**					
	BEI ≤ 120, ***OR***	**8**			**3**		
	BEI ≤ 110, ***OR***	**10**					
	BEI ≤ 100, ***OR***	**12**			**4**		
	BEI ≤ 90	**15**					

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	**Max points**	**Score**	**Detail points**	**Max points**	**Score**
commissioning		**5**			**5**		
EE6	Enhanced Commissioning						
	Ensure building's energy related systems are designed and installed to achieve proper commissioning so as to realise their full potential and intent. Appoint an independent GBI recognised Commissioning Specialist (CxS) at the onset of the design process to verify that comprehensive pre-commissioning and commissioning is performed for all the building's energy related systems in accordance with ASHRAE Commissioning Guideline or other GBI approved equivalent standard/s by: 1. Conducting at least one commissioning design review during the detail design stage and back-check the review comments during the tender documentation stage. 2. Developing and incorporating commissioning requirements into the tender documents. 3. Developing and implementing a commissioning plan. 4. Verifying the installation and performance of the systems to be commissioned. 5. Reviewing contractor submittals applicable to systems being commissioned for compliance. 6. Developing a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems. 7. Verifying that the requirements for training operating personnel and building occupants are completed.	3	3	3	3	3	3
EE7	Post Occupancy Commissioning						
	Carry out post occupancy commissioning for all tenancy areas after fit-out changes are completed:						
	1) Design engineer shall review all tenancy fit-out plans to ensure original design intent is not compromised and upon completion of the fit-out works, verify and fine-tune the installations to suit.	1	2	2	1	2	2
	2) Within 12 months of practical completion (or earlier if there is at least 50% occupancy), the CxS shall carry out a full post/re-commissioning of the building's energy related systems to verify that their performance is sustained in conjunction with the completed tenancy fit-outs.	1			1		
verification & maintenance		**5**			**7**		
EE8	EE Verification						
	Verify predicted energy use of key building services: 1) Use Energy Management System to monitor and analyse energy consumption including reading of sub- meters, AND 2) Fully commission EMS including Maximum Demand Limiting programme within 12 months of practical completion (or earlier if there is at least 50% occupancy).	2	2	2	3	3	3
EE9	Sustainable Maintenance						
	Ensure the building's energy related systems will continue to perform as intended beyond the 12 months						
	1) At least 50% of permanent building maintenance team to be on-board one (1) to three (3) months before practical completion and to fully participate (to be specified in contract conditions) in the Testing & Commissioning of all building energy services.	1	3	0	1	4	0
	2) Provide for a designated building maintenance office that is fully equipped with facilities (including tools and instrumentation) and inventory storage. 3) Provide evidence of documented plan for at least 3-year facility maintenance and preventive maintenance budget (inclusive of staffing and outsourced contracts).	2			3		
TOTAL		**35**		**14**	**24**		**13**

F2. Indoor Environmental Quality Assessment:

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
IEQ	**INDOOR ENVIRONMENTAL QUALITY**						
Air Quality		**6**			**10**		
IEQ1	Minimum IAQ Performance						
	Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in building, thus contributing to the comfort and well-being of the occupants: Meet the minimum requirements of ventilation rate in ASHRAE 62.1:2007 or the local building code whichever is the more stringent.	1	1	1	**2**	2	2
IEQ2	Environmental Tobacco Smoke (ETS) Control						
	Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to Environmental Tobacco Smoke (ETS): Prohibit smoking in the building, AND Locate any exterior designated smoking areas at least 10m away from entries, outdoor air intakes and operable windows	1	1	1	2	2	2
IEQ3	Carbon Dioxide Monitoring and Control						
	Provide response monitoring of carbon dioxide levels to ensure delivery of minimum outside air requirements: Install carbon dioxide (CO_2) monitoring and control system with at least one (1) CO_2 sensor at all main return points on each floor to facilitate continuous monitoring and adjustment of outside air ventilation rates to each floor, and ensure independent control of ventilation rates to maintain CO_2 level $\leq$ 1,000ppm	1	1	1	2	2	2
IEQ4	Indoor Air Pollutants						
	Reduce detrimental impact on occupant health from finishes that emit internal air pollutants:						
	Use low VOC paint and coating throughout the building. Paints and Coatings to comply with requirements specified in international labelling schemes recognized by GBI, AND Use low VOC carpet or flooring throughout the building. Carpets to comply with requirements specified in international labelling schemes recognized by GBI. Other types of flooring to comply with requirements under FloorScore developed by Science Certification System or equivalent, AND Use low VOC adhesive and sealant or no adhesive or sealant used.	**1**	2	1	**2**	3	2
	Use products with no added urea formaldehyde. These include: 1) Composite wood and agrifiber products defined as: particleboard, medium density fiberboard (MDF), plywood, wheatboard, strawboard, panel substrates and door cores, AND 2) Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies, AND 3) Insulation foam, AND 4) Draperies	1			1		
IEQ5	Mould Prevention						
	Design system(s) which reduce the risk of mould growth and its associated detrimental impact on occupant health: Where it is demonstrated that the mechanical air-conditioned ventilation system will maintain a positive indoor air pressure relative to the exterior and can actively control indoor air humidity to be no more than 70% RH without the use of active control that will consume additional energy. Ensure that excessive moisture in building is controlled during the Design, Construction and Operation stages by the consideration and the control of the following: 1) Rainwater leakage through roof and walls 2) Infiltration of moist air 3) Diffusion of moisture through walls, roof and floors 4) Groundwater intrusion into basements and crawl spaces through walls and floors 5) Leaking or burst pipes 6) Indoor moisture sources 7) Construction moisture OR The building is fully naturally ventilated	1	1	0	1	1	0

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
thermal comfort			**3**			**6**	
IEQ6	Thermal Comfort: Design & Controllability of Systems						
	Provide a high level of thermal comfort system control by individual occupants or by specific groups in multi- occupant spaces to promote the productivity, comfort and well-being of building occupants:						
	Design to ASHRAE 55 in conjunction with the relevant localised parameters as listed in MS1525:2007.	1	2	**2**	**2**	4	4
	Provide individual comfort controls for ≥ 50% of the building occupants to enable adjustments to suit individual task needs and preferences. AND Provide comfort system controls for all shared multi-occupant spaces to enable adjustments to suit group needs and preferences. Conditions for thermal comfort include the primary factors of air temperature, radiant temperature, air speed and humidity. Comfort system control for this purpose is defined as the provision of control over at least one of these primary factors in the occupants' local environment.	1			**2**		
IEQ7	Air Change Effectiveness						
	Provide effective delivery of clean air through reduced mixing with indoor pollutants in order to promote a healthy indoor environment. Demonstrate that the Air Change Effectiveness (ACE) meets the following criteria for at least 90% of the NLA: The ventilation systems are designed to achieve an ACE of ≥ 0.95 when measured in accordance with ASHRAE 129-1997: Measuring air change effectiveness where ACE is to be measured in the breathing zone (nominally 1.0m from finished floor level)	1	1	0	2	2	0
Lighting, visual & Acoustic comfort			**8**			**6**	
IEQ8	Day lighting						
	Provide good levels of day lighting for building occupants:						
	Demonstrate that ≥ 30% of the NLA has a daylight factor in the range of 1.0 – 3.5% as measured at the working plane, 800mm from floor level, OR	**1**	2	0	1	1	0
	Demonstrate that ≥ 50% of the NLA has a daylight factor in the range of 1.0 – 3.5% as measured at the working plane, 800mm from floor level	**2**					
IEQ9	Daylight Glare Control						
	Reduce discomfort of glare from natural light. Where blinds or screens are fitted on all glazing and atrium as a base building, incorporate provisions to meet the following criteria: 1) Eliminate glare from all direct sun penetration and keep horizontal workspace lux level below 2,000; 2) Eliminate glare from diffuse sky radiation for occupant workspace at viewing angles of 15° to 60° from the horizontal at eye level (typically 1.2m from floor level) 3) Control with an automatic monitoring system (for atrium and windows with incident direct sun light only - not applicable for fixed blinds/screens); AND 4) Equip with a manual override function accessible by occupants (not applicable for fixed blinds/screens)	1	1	1	1	1	1
IEQ10	Electric Lighting Levels						
	Baseline building office lighting not to be over designed: Demonstrate that office lighting design maintains a luminance level of no more than specified in MS1525:2007 for 90% of NLA as measured at the working plane (800mm above the floor level).	1	1	1	1	1	1
IEQ11	High Frequency Ballasts						
	Increase workplace amenity by avoiding low frequency flicker that may be associated with fluorescent lighting: Install high frequency ballasts in fluorescent luminaries over a minimum of 90% of NLA.	1	1	1	1	1	1
IEQ12	External Views						
	Reduce eyestrain for building occupants by allowing long distance views and provision of visual connection to the outdoor.						
	Demonstrate that ≥ 60% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from	**1**	2	2	1	1	1
	Demonstrate that ≥ 75% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from floor level.	**2**					
IEQ13	Internal Noise Levels						
	Maintain internal noise levels at an appropriate level. Demonstrate that 90% of the NLA do not exceed the following ambient internal noise levels: Within the entire baseline building general office, space noise from the building services does not exceed 40dBAeq. OR Within the baseline building office space, the sound level does not exceed 45dBAeq for open plan and not exceed 40dBAeq for closed offices	1	1	1	1	1	1

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
verification		**4**			**3**		
IEQ14	IAQ Before & During Occupancy						
	Reduce indoor air quality problems resulting from the construction process in order to help sustain the comfort and well-being of building occupants. Develop and implement an Indoor Air Quality (IAQ) Management Plan for the Pre-Occupancy phase as follows: 1) Perform a building flush out by supplying outdoor air to provide not less than 10 air changes/hour for at least 30 minutes operation before occupancy and continuous minimum 1 ACH during the initial 14 days occupancy of the completed building OR 2) If low VOC materials and low formaldehyde composite wood are used, then building flush out can be performed by supplying outdoor air to provide not less than 10 airchanges/hour for at least 15 minutes operation or not less than 6 airchanges/hour for at least 30 minutes operation and continuous 1ACH during the initial 7 days occupancy of the completed building OR 3) Within 12 months of occupancy, conduct IAQ testing to demonstrate maximum concentrations for pollutants are not exceeded according to the Indoor Air Quality Code of Malaysia.	1	2	**2**	1	2	2
	During Occupancy Stage: Where a permanent air flushing system of at least 10 airchanges/hour operation is installed for use during occupancy stage	1			1		
IEQ15	Post Occupancy Comfort Survey: Verification						
	Provide for the assessment of comfort of the building occupants: Conduct a post-occupancy comfort survey of building occupants within 12 months after occupancy/ building completion. This survey should collect anonymous responses about thermal comfort, visual comfort and acoustic comfort in a building. It should include an assessment of overall satisfaction with thermal, visual and acoustic performance and identification of thermal-related, visual-related and acoustic-related problems. AND Develop a plan for corrective action if the survey results indicate that more than 20% of occupants are dissatisfied with the overall comfort in the building. This plan should include measurement of relevant environmental variables in problem areas. The relevant environmental variables include 1) Temperature, relative humidity, air speed and mean radiant temperature, 2) Lighting level and glare problem, 3) Background noise level, 4) Odour problem, CO2 level, VOCs, and particulate concentration	2	2	2	1	1	1
TOTAL		**21**		**16**	**25**		**20**

F3. Sustainable Site and Planning and Management Assessment:

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
SM	**SUSTAINABLE SITE AND PLANNING AND MANAGEMENT**						
site planning		**6**			**4**		
SM1	Site Selection						
	Do not develop building, hardscape, road or parking area on a site or part of a site that meet any one of the following criteria: 1. Prime farmland as defined by the Structure Plan of the area or the National Physical Plan ; 2. Forest reserve or State Environmental Protection Zones that is specifically identified as habitat for any species found on the endangered lists ; 3. Within 30m of any wetlands as defined by the Structure Plan of the area OR within setback distances from wetlands prescribed in state or local regulations, as defined by local or state rule or law, whichever is more stringent ; 4. Previously undeveloped land that is within 30m of Mean High Water Spring (MHWS) sea level which supports or could support wildlife or recreational use, or statutory requirements whichever is the more stringent ; 5. Previously undeveloped land that is within 20m of lake, river, stream and tributary which support or could support wildlife or recreational use ; 6. Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is provided.	1	1	1	1	1	1
SM2	Brownfield Redevelopment						
	Reduce pressure on undeveloped land by rehabilitating damaged sites where development is complicated by environmental contamination, thereby reducing pressure on undeveloped land. This would typically involve old rubbish tips, former mining land, old factory sites, etc.	1	1	0	1	1	0

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
SM3	Development Density & Community Connectivity						
	Channel development to urban area with existing infrastructure, protect greenfield and preserve habitat and natural resources:						
	A) Development Density Construct a new building or renovate an existing building on a previously developed site AND in a community with a minimum density of 20,300m2 per hectare net (87,000 sqft per acre net)	**1**	**2**	2	**1**	**1**	1
	B) community connectivity Construct a new building or renovate an existing building on a previously developed site AND within 1km of a residential zone or neighbourhood with an average density of 25 units per hectare net (10 units per acre net) AND within 1km of at least 10 Basic Services AND with pedestrian access between the building and the services. Basic Services include, but are not limited to: 1) Bank; 2) Place of Worship; 3) Convenience / Grocery; 4) Day Care; 5) Police Station; 6) Fire Station; 7) Beauty; 8) Hardware; 9) Laundry; 10) Library; 11) Medical / Dental; 12) Senior Care Facility; 13) Park; 14) Pharmacy; 15) Post Office; 16) Restaurant; 17) School; 18) Supermarket; 19) Theatre; 20) Community Centre; 21) Fitness Centre. Proximity is determined by drawing a 1km radius around the main building entrance on a site map and counting the services found within that radius.	**1**					
SM4	Environment Management						
	A) Conserve existing natural area and restore damaged area to provide habitat and promote biodiversity						
	A) Conservation On previously developed or graded site, restore or protect a minimum of 50% of the site area (excluding the building footprint) with native or adaptive vegetation. Native or adaptive plants are plants indigenous to a locality or cultivars of native plants that are adapted to the local climate and are not considered invasive species or noxious weeds. Applicable also to landscaping on rooftops and roof gardens so long as the plants meet the definition of native or adaptive vegetation. OR On greenfield sites, limit all site disturbance to within 12m beyond the building perimeter; 3m beyond surface walkway, patio, surface parking and utilities less than 300mm in diameter; 4.5m beyond primary roadway curb and main utility branch trench; and 7.5m beyond constructed area with permeable surface (such as pervious paving area, storm water detention facility and playing field) that require additional staging area in order to limit compaction in the constructed area.	**1**	**2**	1	**1**	**1**	1
	B) Open Space: Reduce by 25%, the development footprint (defined as the total area of the building footprint, hardscape, access road and parking) and/or provide vegetated open space within the project boundary to exceed the local zoning's open space requirement for the site by 25%. OR for areas with no local zoning requirement (e.g. university campus, military bases), provide vegetated open space adjacent to the building whose area is equal to that of the building footprint. OR Where a zoning ordinance exists, but there is no requirement for open space (zero), provide vegetated open space equal to 20% of the project's site area.	**1**					
construction management			**3**			**3**	
SM5	Earthworks - Construction Activity Pollution Control						
	Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. Create and implement an Erosion and Sedimentation Control (ESC) Plan for all construction activities associated with the project. The ESC Plan shall conform to the erosion and sedimentation requirements of the approved Earthworks Plans OR Local erosion and sedimentation control standards and codes, whichever is the more stringent. The plan shall describe the measures implemented to accomplish the following objectives: 1. Prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse; 2. Prevent sedimentation of storm sewer or receiving stream. 3. Prevent polluting the air with dust and particulate matter.	1	1	1	1	1	1
SM6	QLASSIC						
	Achieve quality of workmanship in construction works: Subscribe to independent method to assess and evaluate quality of workmanship of building project based on CIDB's CIS 7: Quality Assessment System for Building Construction Work (QLASSIC). Must achieve a minimum score of 70%	1	1	0	1	1	0
SM7	Workers' Site Amenities						
	Reduce pollution from construction activities by controlling pollution from waste and rubbish from workers. Create and implement a Site Amenities Plan for all construction workers associated with the project. The plan shall describe the measures implemented to accomplish the following objectives: 1. Proper accommodation for construction workers at the site or at temporary rented accommodation nearby; 2. Prevent pollution of storm sewer or receiving stream by having proper septic tank; 3. Prevent polluting the surrounding area from open burning and proper disposal of domestic waste; 4. Provide adequate health and hygiene facilities for workers on site.	1	1	1	1	1	1

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
Transportation		**3**			**3**		
SM8	Public Transportation Access						
	Reduce pollution and land development impacts from automobile use: Locate project within 1km of an existing, or planned and funded, commuter rail, light rail or subway station. Or, locate project within 500m of at least one bus stop.	1	1	1	1	1	1
SM9	Green Vehicle Priority						
	Encourage use of green vehicles: Provide low-emitting and fuel-efficient vehicles for 5% of Full-Time Equivalent (FTE) occupants AND provide preferred parking for these vehicles. "Preferred parking" refers to the parking spots that are closest to the main entrance of the project (exclusive of spaces designated for handicapped or parking passes provided at a discounted price).	1	1	1	1	1	1
SM10	Parking Capacity						
	Discourage over-provision of car parking capacity: Size parking capacity to meet, but not to exceed the minimum local zoning requirements, AND provide preferred parking for carpools or vanpools for 5% of the total provided parking spaces.	1	1	1	1	1	1
Design		**4**			**4**		
SM11	Stormwater Design – Quantity & Quality Control						
	Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, and managing storm water runoff. Reduce or eliminate water pollution by reducing impervious cover, increasing onsite infiltration, eliminating sources of contaminants, and removing pollutants from storm water runoff: Condition 1: IF Existing Imperviousness IS ≤ 50%: Implement a storm water management plan that prevents the post development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity in conformance to the Storm Water Management Manual for Malaysia (MASMA). Condition 2: IF Existing Imperviousness IS > 50%: Implement a storm water management plan that results in a 25% decrease in the volume of storm water runoff required under MASMA. For either condition, implement a storm water management plan that reduces impervious cover, promotes infiltration, and captures and treats the storm water runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs).	1	1	1	1	1	1
SM12	Greenery & Roof						
	Reduce heat island (thermal gradient difference between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat:						
	A) hard cape & Greenery Application Provide any combination of the following strategies for 50% of the site hardscape (including sidewalks, courtyards, plazas and parking lots): 1) Shade (within 5 years of occupancy); 2) Paving materials with a Solar Reflectance Index (SRI) of at least 29; 3) Open grid pavement system;	1	2	2	1	2	2
	B) ROOF Application 1) Use roofing material with a Solar Reflectance Index (SRI) equal to or greater than the value in the table below for a minimum of 75% of the roof surface; OR 2) Install a vegetated roof for at least 50% of the roof area; OR 3) Install high albedo and vegetated roof surfaces that, in combination, meet the following criteria: (Area of SRI Roof / 0.75) + (Area of vegetated roof / 0.5) ≥ Total Roof Area Roof Type Slope SRI Low-Sloped Roof < 2:12 78 Steep-Sloped Roof > 2:12 29	1			1		
SM13	Building User Manual						
	Document Green building design features and strategies for user information and guide to sustain performance during occupancy: Provide a Building User Manual which documents passive and active features that should not be downgraded.	1	1	1	1	1	1
TOTAL		**16**		**13**	**14**		**12**

F4. Material and Resources Assessment:

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
MR	**MATERIALS AND RESOURCES**						
reused & recycled materials			**4**			3	
MR1	Materials reuse and selection						
	Reuse building materials and products to reduce demand for virgin materials and reduce creation of waste. This serves to reduce environmental impact associated with extraction and processing of virgin resources. Integrate building design and its build ability with selection of reused building materials, taking into account their embodied energy, durability, carbon content and life cycle costs:						
	Where reused products/materials constitutes ≥ 2% of the project's total material cost value, OR	**1**	**2**	1	**1**	**1**	1
	Where reused products/materials constitutes ≥ 5% of the project's total material cost value	**2**					
MR2	Recycled content materials						
	Increase demand for building products that incorporate recycled content materials in their production: (Recycled content shall be defined in accordance with the International Organization of Standards Document)						
	Where use of materials with recycled content is such that the sum of post-consumer recycled plus one-half of the pre-consumer content constitutes ≥ 10% (based on cost) of the total value of the materials in the project, OR	1	2	2	1	2	2
	Where use of materials with recycled content is such that the sum of post-consumer recycled plus one-half of the pre-consumer content constitutes at least 30% (based on cost) of the total value of the materials in the project.	2			2		
sustainable resources			**2**			**3**	
MR3	Regional Materials						
	Use building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation: Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500km of the project site for ≥ 20% (based on cost) of the total material value. Mechanical, electrical and plumbing components shall not be included. Only include materials permanently installed in the project.	1	1	0	2	2	0
MR4	Sustainable Timber						
	Encourage environmentally responsible forest management: Where ≥ 50% of wood-based materials and products used are certified. These components include, but are not limited to, structural framing and general dimensional framing, flooring, sub-flooring, wood doors and finishes. To include wood materials permanently installed and also temporarily purchased for the project. Compliance with Forest Stewardship Council and Malaysian Timber Certification Council requirements.	1	1	**0**	1	1	0
Waste management			**3**			**2**	
MR5	Storage & Collection of recyclables						
	Facilitate reduction of waste generated during construction and during building occupancy that is hauled and disposed of in landfills: During Construction, provide dedicated area/s and storage for collection of non-hazardous materials for recycling, AND During Building Occupancy, provide permanent recycle bins.	1	1	1	1	1	1
MR6	Construction waste management						
	Develop and implement a construction waste management plan that, as a minimum identifies the materials to be diverted from disposal regardless of whether the materials will be sorted on site or co-mingled. Quantify by measuring total truck loads of waste sent for disposal:						
	Recycle and/or salvage ≥ 50% volume of non-hazardous construction debris, OR	**1**	**2**	0	**1**	**1**	0
	Recycle and/or salvage ≥ 75% volume of non-hazardous construction debris .	**2**					

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
Green products		2			4		
MR7	Refrigerants & Clean Agents						
	Use environmentally-friendly Refrigerants and Clean Agents exceeding Malaysia's commitment to the Montreal & Kyoto protocols:						
	Use zero Ozone Depleting Potential (ODP) products: non-CFC and non-HCFC refrigerants/clean agents;	1	2	1	2	4	2
	Use non-synthetic (natural) refrigerants/clean agents with zero ODP and negligible Global Warming Potential.	1			2		
TOTAL		**11**		**5**	**12**		**6**

F5. Water Efficiency Assessment:

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
WE	**WATER EFFICIENCY**						
Water Harvesting & recycling		4			7		
WE1	Rainwater Harvesting						
	Encourage rainwater harvesting that will lead to reduction in potable water consumption:						
	Rainwater harvesting that leads to ≥ 15% reduction in potable water consumption, OR	1	2	2	1	3	3
	Rainwater harvesting that leads to ≥ 30% reduction in potable water consumption	2			3		
WE2	Water Recycling						
	Encourage water recycling that will lead to reduction in potable water consumption:						
	Treat and recycle ≥ 10% wastewater leading to reduction in potable water consumption, OR	1	2	2	2	4	4
	Treat and recycle ≥ 30% wastewater leading to reduction in potable water consumption	2			4		
Increased efficiency		6			7		
WE3	Water Efficient - Irrigation/Landscaping						
	Encourage the design of system that does not require the use of potable water supply from the local water authority:						
	Reduce potable water consumption for landscape irrigation by ≥ 50% (e.g. through use of native or adaptive plants to reduce or eliminate irrigation requirement, OR	1	2	1	2	3.0	2.0
	Do not use potable water at all for landscape irrigation	2			3		
WE4	Water Efficient Fittings						
	Encourage reduction in potable water consumption through use of efficient devices:						
	Reduce annual potable water consumption by ≥ 30%, OR	1	2	2	1	2.0	2.0
	Reduce annual potable water consumption by ≥ 50%	2			2		
WE5	Metering & Leak Detection System						
	Encourage the design of systems that monitors and manages water consumption:						
	Use of sub-meters to monitor and manage major water usage for cooling towers, irrigation, kitchens and tenancy use	1	2	1	1	2.0	1
	Link all water sub-meters to EMS to facilitate early detection of water leakage	2			2		
TOTAL		**10**		**8**	**14**		**12**

F6. Innovation Assessment:

Item	Area of Assessment	Current GBI			GBI Survey Result		
		Detail points	Max points	Score	Detail points	Max points	Score
Innovation		7			11		
IN1	Innovation in Design & Environmental Design Initiatives						
	Provide design team and project the opportunity to be awarded points for exceptional performance above the requirements set by GBI rating system: 1 point for each approved innovation and environmental design initiative up to a maximum of 6 points, such as: Condensate water recovery (accounting for at least 50% of total AHUs/FCUs) for use as cooling tower make-up water etc; Co-generation / Tri-generation system; Thermal / PCM / Thermal Mass storage system (accounting for at least 25% of total required capacity); Solar thermal technology / Solar Air conditioners (generating at least 10% of total required capacity); Heat recovery system (contributing to at least 10% of total required capacity); Central vacuum system (serving at least 50% of NLA);	6	6	5	8	8	7
IN2	Green Building Index Accredited Facilitator						
	To support and encourage the design integration required for Green Building Index rated buildings and to streamline the application and certification process: At least one principal participant of the project team shall be a Green Building Index Facilitator who is engaged at the onset of the design process until completion of construction and Green Building Index certification is obtained.	1	1	0	3	3	0
TOTAL		**7**		**5**	**11**		**7**

F7. Points Score:

ASSESSMENT CRITERIA OVER ALL POINTS SCORE		
ITEM	**Current GBI**	**GBI survey result**
Energy Efficiency	14/35	13/24
Indoor Environmental Quality	16/21	20/25
Sustainable Site Planning & Management	13/16	12/14
Material & Resources	5/11	6/12
Water Efficiency	8/10	12/14
Innovation	5/7	7/11
TOTAL SCORE	**61/100**	**70/100**

F8. Rating Award:

Green Building Index Classification		Current GBI	GBI Survey Result
POINTS	**GBI RATING**		
86+ points	Platinum		
76 to 85 points	Gold		
66 to 75 points	Silver		*70 points* *"SIME Project"* *-Silver-*
50 to 65 points	Certified	*61 points* *"SIME Project"* *–Certified-*	

APPENDIX G

SIME PROJECT BASED ON LEED SCORE

Appendix E is the assessment of SIME Plantation project by LEED. SIME Plantation is an office building that is under construction at Subang Jaya within the local authorities of Majlis Perbandaran Ampang Jaya territory. This project is constructed under the guideline of LEED Green Building Rating System. This project begins its construction in June 2009 and expected to finish its completion on 30th November 2011.

LEED Requirement to meet Certification Level (Core and Shell) Block F (26th November 2009)			3rd Sept 09	3rd Oct 09	30th Oct 09	26th Nov 09			
Required Information	Prerequisite	Credit Points Planned/ Potential	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
SUSTAINABLE SITES									
SSP1 Create and implement Erosion and Sedimentation Control Plan	Prerequisite						p	Pending/ Critical	
Action Item: Require the following document. 1. Require construction site drawing indicating all the measures taken to prevent Erosion Control during construction. 2. Provide photos on the progress during the construction of basement floors. 3. Provide a Plan in report form explaining the implementation of Erosion and Sedimentation Control. Remark: Pending Main contractor to provide drawings and report/In progress								Main con will submit next week	Main Contractor or Main Contractor or Main Contractor
SSC1 Site Selection		1	1	1	1	1	A	Pending	Owner
Action Item: Owner to provide a letter indicating that the development land does not fall into any of the following category: Prime farmland as defined by the United States Department of Agriculture in the United States Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5) ; Previously undeveloped land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by FEMA (Federal Emergency Management Agency); Land that is specifically identified as habitat for any species on Federal or State threatened or endangered lists; Within 100 feet of any wetlands as defined by United States Code of Federal Regulations 40 CFR, Parts 230-233 and Part 22, and isolated wetlands or areas of special concern identified by state or local rule, OR within setback distances from wetlands prescribed in state or local regulations, as defined by local or state rule or law, whichever is more stringent; Previously undeveloped land that is within 50 feet of a water body, defined as seas, lakes, rivers, streams and tributaries which support or could support fish, recreation or industrial use, consistent with the terminology of the Clean Water Act; Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt) Other type of land/Please specify								Require Owner to provide similar letter as Plantation	

LEED Requirement to meet Certification Level
(Core and Shell)
Block F (26th November 2009)

Required Information	Prerequisite	Credit Points Planned/ Potential	3rd Sept 09 Credit Points Actual	3rd Oct 09 Credit Points Actual	30th Oct 09 Credit Points Actual	26th Nov 09 Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
SSC2 Development Density & Community Connectivity		5	5	5	5	5	A	Received	
Action Item: Owner to provide a letter indicating that the development land was previously used land. Action Item: Show in a key plan at least 10 basic services are available within 1/2mile from building entrances. Services includes the following 1) Bank; 2) Place of Worship; 3) Convenience Grocery; 4) Day Care; 5) Cleaners; 6) Fire Station; 7) Beauty; 8) Hardware; 9) Laundry; 10) Library; 11) Medical/Dental; 12) Senior Care Facility; 13) Park; 14) Pharmacy; 15) Post Ooffice; 16) Restaurant; 17) School; 18) Supermarket; 19) Theatre; 20) Community Center; 21) Fitness Center; 22)museum. Action Item: Provide a key plan to show all the development within the neighbour hood of 1/2mile, showing the buildup, land area and the type of development.									Owner Architect Architect
SSC3 Brownfield Development		0							
Action Item: Owner to provide a letter indicating the status of the land (whether it is a contaminated site) Develop on a site documented as contaminated (by means of an ASTM E1903-97 Phase II Environmental Site Assessment or a local Voluntary Cleanup Program) OR on a site defined as a brownfield by a local, state or federal government agency							N		Owner
SSC4.1 Alternative Transportation :Public Transportation		6	6	6	6	6	A	Received	
Action Item: Provide a key plan showing the location of bus stops, taxi stops and rail stops within ¼ mile and ½ mile from the building main entrance.									Architect
SSC4.2 Alternative Transportation: Bicycle storage and Changing rooms		1		1	1	1	A	Received	
Action Item: Provide bicycle parks for 5% of the building occupant within 200yards from building main entrance. Action Item: Provide shower facilities for 0.5% of the building population within 200yards from building main entrance.									Architect Architect
SSC4.3 Alternative Transportation: Fuel Efficient Vehicles		3		3	3	3	A	Received	
Action Item: Provide a total of 5% preferred parking spaces marked as LEV parking from the total parking.									Architect
SSC4.4 Alternative Transportation: Parking Capacity		2		2	2	2	A	Received	
Action Item: Provide a total of 5% preferred parking spaces marked as Carpool or Vanpool parking from the total parking. Action Item: Don't exceed the parking requirement of local authority.									Architect Architect
SSC5.1 Site Development : Protect or Restore Habitat		**0**					**N**		
SSC5.2 Site Development: Maximize Open Space		1					C		
Action Item: Reduce the development footprint (defined as the total area of the building footprint, hardscape, access roads and parking) and/or provide vegetated open space within the project boundary to exceed the local zoning's open space requirement for the site by 25%.									

LEED Requirement to meet Certification Level
(Core and Shell)
Block F (26th November 2009)

Required Information	Prerequisite	Credit Points Planned/ Potential	3rd Sept 09 Credit Points Actual	3rd Oct 09 Credit Points Actual	30th Oct 09 Credit Points Actual	26th Nov 09 Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
SSC6.1 Stormwater Design: Quantity Control		**1**					**C**	In progress	
CASE 1 — EXISTING IMPERVIOUSNESS IS LESS THAN OR EQUAL TO 50% OPTION 1 Development peak discharge rate and quantity for the one- and two-year 24-hour design storms. OR OPTION 2 Implement a stormwater management plan that protects receiving stream channels from excessive erosion by implementing a stream channel protection strategy and quantity control strategies. CASE 2 — EXISTING IMPERVIOUSNESS IS GREATER THAN 50% Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the two-year 24-hour design storm.									
SSC6.2 Stormwater Design: Quality Control		**1**					**C**	**In progress**	
Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall1 using acceptable best management practices (BMPs).BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if (1) they are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards, or (2) there exists in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.							N		
SSC7.1 Heat Island Effect (Non-Roof)		0					C	In progress	
OPTION 1: Use any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots):• Provide shade from existing tree canopy or within five years of landscape installation; landscaping (trees) must be in place at the time of occupancy.• Provide shade from structures covered by solar panels that produce energy used to offset some non- renewable resource use.• Provide shade from architectural devices or structures that have a solar reflectance index (SRI2) of at least 29.•Have hardscape materials with an SRI2 of at least 29.• Have an open-grid pavement system (at least 50% pervious). OPTION 2: Place a minimum of 50% of parking spaces under cover (defined as underground, under deck, under roof, or under a building). Any roof used to shade or cover parking must have an SRI of at least 29, be a vegetated green roof, or be covered by solar panels that produce energy used to offset some non-renewable resource use.									

LEED Requirement to meet Certification Level (Core and Shell) Block F (26th November 2009) Required Information	Prerequisite	Credit Points Planned/ Potential	3rd Sept 09 Credit Points Actual	3rd Oct 09 Credit Points Actual	30th Oct 09 Credit Points Actual	26th Nov 09 Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
SSC7.2 Heat Island Effect (Roof)		1					C	In progress	
OPTION 1: Use roofing materials having a Solar Reflectance Index (SRI)3 equal to or greater than the values in the table below for a minimum of 75% of the roof surface. Roofing materials having a lower SRI value than those listed below may be used if the weighted rooftop SRI average meets the following criteria: (Area SRI roof/Total roof area) * (SRI of installed roof/Required SRI) ≥75% OR OPTION 2: Install a vegetated roof for at least 50% of the roof area. OR OPTION 3: Install high albedo and vegetated roof surfaces that, in combination, meet the following criteria: (Area of SRI Roof / 0.75) + (Area of vegetated roof / 0.5) ≥Total Roof Area									
SSC8 Light Pollution Reduction		0					C	In progress	
SSC9: Tenant Design and Construction Guidelines Action: Provide a tenancy Agreement incorporating a description of the sustainable design and construction feature		1			1	1	p	In progress	
WATER EFFICIENCY									
WEP 1 Water Use Reduction : 20% Reduction									
Action Item: Provide 20% water efficiency by using Water Sense recommended low flow sanitary fittings to meet EPA 2005 requirement	Prerequisite							Confirm	
WEC 1.1 Water Efficient Landscaping : Reduce by 50%		2				2	P	Confirmed	
Action Item: Reduce landscape water use from potable by 50%. Replace it with harvested rain water. Landscape Architect to show calculation on water use and method to reduce 50% savings.									Landscape Con.
WEC 1.2 Water Efficient Landscaping : No Irrigation		2					P	Pending	
Action Item: Reduce landscape water use from potable by 100%. Replace it with harvested rain water. Landscape Architect to show calculation on water use and method to reduce 100% savings. (No potable water use)									Landscape Con.
WEC 2 Innovative Waste Water Technologies		0					N		
WEC 3 Water Use Reduction		2					P	Pending	
Action Item: Provide 30% water efficiency by using WaterSense recommended low flow sanitary fittings to meet EPA 2005 requirement.									Architect/ Owner
EAP 1 Fundamental of Commissioning	Prerequisite						P	Pending	
Action Item: Appoint C x A as soon as possible									Owner
EAP 2 Minimum Energy Performance	Prerequisite						P	Pending	
Action Item: Show by design calculation compared to ASHRAE 90.1-2007 baselines a savings of 10% of energy use.									MEP Engineer
EAP 3 Fundamental of Refrigerant Management		1	1	1	1	1	A	Pending	
Action Item: Show that Zero use of CFC-based refrigerants in new base building HVAC&R systems.									MEP Engineer

LEED Requirement to meet Certification Level (Core and Shell) Block F (26th November 2009)			3rd Sept 09	3rd Oct 09	30th Oct 09	26th Nov 09			
Required Information	Prerequisite	Credit Points Planned/ Potential	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
EAC 1 Optimize Energy Performance		5	1	2	3	3	P	In progress	
Action Item: Show by design calculation compared to ASHRAE 90.1-2007 baselines a savings of 20% of energy use.									MEP Engineer
EAC 2 On Site Renewable Energy		4					C	Pending	
Action Item: Use on-site renewable energy systems to offset building energy cost. Calculate project performance by expressing the energy produced by the renewable systems as a percentage of the building annual energy cost and using the table below to determine the number of points achieved.Use the building annual energy cost calculated in EA Credit 1 or use the Department of Energy (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database to determine the estimated electricity use. (Table of use for different building types is provided in the Reference Guide.)									
EAC 3 Enhanced Commissioning		0					C		
EAC 4 Enhanced Refrigerant Management		2	2	2	2	2	A	Received	
Action Item: Provide calculation for the following. Provide calculation for LCODP = [ODPr x (Lr x Life +Mr) x Rc]/Life on all refrigerant used in this project; Provide calculation for LCGWP = [GWPr x (Lr x Life +Mr) x Rc]/Life on all refrigerant used in this project; Provide calculation for LCGWP + LCODP x 10^5 on all refrigerant used in this project									MEP Eng. MEP Eng. MEP Eng.
EAC 5.1 Measurement & Verification		3					C	Pending	
Action Item: BAS system design must be capable of measuring the energy use in the building by tenant and system. Develop and implement a Measurement & Verification (M&V) Plan consistent with Option A : Calibrated Simulation (Savings Estimation Method 2), Consisting of 1. Description of the infrastructure design, 2. Existing meter location 3. Single-line electrical schematics identifying end-use circuits 4. Existing meter specification 5. Guidelines for carrying out tenant sub-metering. OR Option B: Energy Conservation Measure Isolation, as specified in the International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003.Consisting of 1. Description of the infrastructre design, 2. Existing meter location 3. Single-line electrical schematics identifying end-use circuits 4. Existing meter specification 5. Guidelines for carrying out tenant sub-metering.									MEP Engineer
EAC 5.2: Measurement and Verification		3						Pending	
Action Item: Include a centrally monitored electronic metering network in the base building design that is capable of being expanded to accommodate the future tenant sub metering as required by LEED for C&I Rating System EA3:M&V. Develop a tenant measurement and verification plan that documents and advices future tenants of this opportunity and means of achievement.									

Required Information	Prerequisite	Credit Points Planned/ Potential	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
EAC 6 Green Power		0							
MATERIALS & RESOURCES									
MRP 1 Storage & Collection of Recyclables	Prerequisite						A	Pending	
Action Item: Provide an easily accessible dedicated area or areas that serve the entire building for the collection and storage of materials for recycling, including (at a minimum) paper, corrugated cardboard, glass, plastics and metals.									Architect
MRC 1.1 Building Reuse: Maintain Existing Walls, Floors & Roof		0					N		
MRC 1.2 Building Reuse: Maintain 50% of Interior Non-Structural Elements		0					N		
MRC 2.1 Construction Waste Management: Divert 50% From Disposal		0					N		
MRC 2.2 Construction Waste Management: Divert 75% From Disposal		0					N		
MRC 3.1 Materials Reuse: 5%		0					N		
MRC 3.2 Materials Reuse: 10%		0					N		
MRC 4.1 Recycled Content: 10% (post-consumer + 1/2 pre-consumer) (Excluding MEP system)		0					C		
MRC 4.2 Recycled Content: 20% (post-consumer + 1/2 pre-consumer) (Excluding MEP system)		0					C		
MRC 5.1 Regional Materials: 10% Extracted, Processed & Manufactured Regionally (Excluding MEP system)		**1**					**C**		
Action Item: Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for a minimum of 10% (based on cost) of the total materials value. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value. (Provide material cost tabulation)									Owner
MRC 5.2 Regional Materials: 20% Extracted, Processed & Manufactured Regionally (Excluding MEP system)		**1**					**C**	**1**	
MRC 6 Certified Wood		0							
Action Item: Provide an easily accessible dedicated area or areas that serve the entire building for the collection and storage of materials for recycling, including (at a minimum) paper, corrugated cardboard, glass, plastics and metals.									Architect
INDOOR ENVIRONMENTAL QUALITY	Prerequisite								
EQP 1 Minimum IAQ Performance							p		
Action Item: Ensure that the ASHRAE 62.1-2007 for ventilation system is met.									MEP Engineer
EQP 2 Environmental Tobacco Smoke (ETS) Control.	Prerequisite						A	Received Requires Review	
Action Item: No smoking allowed in the building.									Architect

LEED Requirement to meet Certification Level (Core and Shell) Block F (26th November 2009)			3rd Sept 09	3rd Oct 09	30th Oct 09	26th Nov 09			
Required Information	Prerequisite	Credit Points Planned/ Potential	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
EQC 1 Outdoor Air Delivery Monitoring		1		1	1	1	A		
Action Item: Install permanent monitoring systems that provide feedback on ventilation system performance to ensure that ventilation systems maintain design minimum ventilation requirements. Configure all monitoring equipment to generate an alarm when the conditions (either airflow value or CO2 level) vary by 10% or more from the value expected at design conditions, via either a building automation system alarm to the building operator or via a visual or audible alert to the building occupants. FOR MECHANICALLY VENTILATED SPACE 1. Monitor carbon dioxide concentrations within all densely occupied spaces (those with a design occupant density greater than or equal to 25 people per 1000 sqft.). CO2 monitoring locations shall be between 3 feet and 6 feet above the floor. 2. Provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow with an accuracy of plus or minus 15% of the design minimum outdoor air rate, as defined by ASHRAE 62.1-2007 (with errata but without addenda*) for mechanical ventilation systems where 20% or more of the design supply airflow serves non-densely occupied spaces, FOR NATURALLY VENTILATED SPACES 1. Monitor CO2 concentrations within all naturally ventilated spaces. CO2 monitoring shall be located within the room between 3 feet and 6 feet above the floor. One CO2 sensor may be used to represent multiple non-densely occupied spaces if the natural ventilation design uses passive stack(s) or other means to induce airflow through those spaces equally and simultaneously without intervention by building occupants. Note: CO2 monitoring is required in densely occupied spaces, in addition to outdoor air intake flow measurement.									MEP Engineer
EQC 2 Increased Ventilation		0							
EQC 3 Construction IAQ Management Plan: During Construction		1							
Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of the building as follows: •During construction meet or exceed the recommended Control Measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3). •Protect stored on-site or installed absorptive materials from moisture damage. If permanently installed air handlers are used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 shall be used at each return air grille, as determined by ASHRAE 52.2-1999 (with errata but without addenda*). Replace all filtration media immediately prior to occupancy.									

LEED Requirement to meet Certification Level (Core and Shell) Block F (26th November 2009)			3rd Sept 09	3rd Oct 09	30th Oct 09	26th Nov 09			
Required Information	Prerequisite	Credit Points Planned/ Potential	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
<u>EQC 4.1 Low-Emitting Materials: Adhesives & Sealants</u>		1					P	Pending	
Action Item: Specify that all adhesives and sealants used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the requirements of the following reference standards: Adhesives, Sealants and Sealant Primers: South Coast Air Quality Management District (SCAQMD) Rule #1168. VOC limits are listed in the table below and correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.									Main Contractor
<u>EQC 4.2 Low-Emitting Materials: Paints & Coatings</u>		1				1	P	Pending	
Action Item: Specify all paints and coatings used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the following criteria: 1. Architectural paints and coatings applied to interior walls and ceilings: Do not exceed the VOC content limits established in Green Seal Standard GS-11, Paints, First Edition, May 20, 1993. 2. Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates: Do not exceed the VOC content limit of 250 g/L Established in Green Seal Standard GC-03, Anti-Corrosive Paints, Second Edition, January 7, 1997. 3. Clear wood finishes, floor coatings, stains, primers, and shellacs applied to interior elements: Do not exceed the VOC content limits established in South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004. Note - The use of a VOC budget is permissible for compliance with this credit.								Jotun paint is meeting LEED. Jotun to submit details for sealer.	Main Contractor
<u>EQC 4.3 Low-Emitting Materials: Flooring Systems</u>							**P**	**Pending**	
Action Item: All flooring must comply with the following as applicable to the project scope. All carpet installed in the building interior shall meet the testing and product requirements of the Carpet and Rug Institute's Green Label Plus program. All carpet cushion installed in the building interior shall meet the requirements of the Carpet and Rug Institute Green Label program. All carpet adhesive shall meet the requirements of EQ Credit 4.1: OC limit of 50 g/L. AND All of the hard surface flooring must be certified as compliant with the FloorScore standard (current as of the date of this Rating System, or more stringent version) by an independent third-party. Flooring products covered by FloorScore include vinyl, linoleum, laminate flooring, wood flooring, ceramic flooring, rubber flooring, wall base, and associated sundries.									Main Contractor

An alternative compliance path using FloorScore is acceptable for credit achievement according to the following stipulations. 100% of the non-carpet finished flooring must be FloorScore-certified, and it must comprise, at minimum, at least 25% of the finished floor area. Potential examples of unfinished flooring include floors in mechanical rooms, electrical rooms, and elevator service rooms AND Concrete, wood, bamboo, and cork floor finishes such as sealer, stain and finish must meet the requirements of South Coast Air Quality Management District (SCAQMD) Rule 1113, Architectural Coatings, rules in effect on January 1, 2004. AND Tile setting adhesives and grout must meet South Coast Air Quality Management District (SCAQMD) Rule #1168. VOC limits correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.									Main Contractor
<u>EQC 4.4 Low-Emitting Materials: Composite Wood & Agrifiber Products</u>		1					P	Pending	
Action Item: Composite wood and agrifiber products used on the interior of the building (defined as inside of the weatherproofing system) shall contain no added urea-formaldehyde resins. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies shall contain no added urea-formaldehyde resins. Composite wood and agrifiber products are defined as: particleboard, medium density fiberboard (MDF), plywood, wheatboard,									Main Contractor
<u>EQC 5 Indoor Chemical & Pollutant Source Control</u>		1					P	Pending	
Action Item: Design to minimize and control pollutant entry into buildings and later cross-contamination of regularly occupied areas: 1. Employ permanent entryway systems at least ten feet long in the primary direction of travel to capture dirt and particulates from entering the building at regular entry points directly connected to the outdoors. Acceptable entryway systems include permanently installed grates, grilles, or slotted systems that allow for cleaning underneath. Roll-out mats are only acceptable when maintained on a weekly basis by a contracted service organization. Qualifying entryways are those that serve as regular entry points for building users. 2. Where hazardous gases or chemicals may be present or used (including garages, housekeeping/laundry areas and copying/printing rooms), exhaust each space sufficiently to create negative pressure with respect to adjacent spaces with the doors to the room closed. For each of these spaces, provide self-closing doors and deck to deck partitions or a hard lid ceiling. The exhaust rate shall be at least 0.50 cfm/sq.ft., with no air re-circulation. The pressure differential with the surrounding spaces shall be at least 5 Pa (0.02 inches of water gauge) on average and 1 Pa (0.004 inches of water) at a minimum when the doors to the rooms are closed. 3. In mechanically ventilated buildings, provide regularly occupied areas of the building with new air filtration media prior to occupancy that provides a Minimum Efficiency Reporting Value (MERV) of 13 or better. Filtration should be applied to process both return and outside air that is to be delivered as supply air. 4. Provide containment (a closed container for storage for off-site disposal in a regulatory compliant storage area, preferably outside the building) for appropriate disposal of hazardous liquid wastes in places where water and chemical concentrate mixing occurs.									MEP Engineer/ Architect

LEED Requirement to meet Certification Level (Core and Shell)
Block F (26th November 2009)

Required Information	Prerequisite	Credit Points Planned/ Potential	3rd Sept 09 Credit Points Actual	3rd Oct 09 Credit Points Actual	30th Oct 09 Credit Points Actual	26th Nov 09 Credit Points Actual	Credit Points Actual/Status A=Achieved P=In Progress N=No C=In Consideration	Remark (documentation)	Responsible
EQC 6 Controllability of Systems: Thermal Comfort		1							
Provide individual comfort controls for 50% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences. Operable windows can be used in lieu of comfort controls for occupants of areas that are 20 feet inside of and 10 feet to either side of the operable part of the window. The areas of operable window must meet the requirements of ASHRAE 62.1-2007 paragraph 5.1 Natural Ventilation (with errata but without addenda*). AND Provide comfort system controls for all shared multi-occupant spaces to enable adjustments to suit group needs and preferences. Conditions for thermal comfort are described in ASHRAE Standard 55-2004 (with errata but without addenda*) to include the primary factors of air temperature, radiant temperature, air speed and humidity. Comfort system control for the purposes of this credit is defined as the provision of control over at least one of these primary factors in the occupant's local environment.									
EQC 7: Thermal Comfort: Design		**1**		**1**	**1**	**1**	**A**		
Provide a comfortable thermal environment that supports the productivity and well-being of building occupants. Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy (with errata but without addenda*). Demonstrate design compliance in accordance with the Section 6.1.1 Documentation. Has this been provided in the current design?									MEP Engineer
EQC 8.1:Daylight & Views: Daylight 75% of Spaces		0							
EQC 8.2 Daylight & Views: Views for 90% of Spaces		0							
TOTAL POINTS		**57**	**16**	**25**	**27**	**30**			