Development of Green Building Rating System for Evaluating Existing Office Buildings in Dubai Based on Al Sa'fat Rating System

تطوير نظام لتقييم المباني المكتبية القائمة في دبي بناءًا على نظام السعفات لتقييم المباني الخضراء

by

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Abstract

Many Green building rating systems are applicable world-wide, yet, several green building rating systems are emerging as a reaction to contextual and cultural differences. Dubai has recently developed Al Sa'fat Green Building Rating system for new buildings assessment and the system is still under development and incorporation stage within the emirate's various governmental systems. However the new system, at this stage, is designed for the evaluation of new buildings only. At different scales, assessment of existing buildings stock in Dubai will help in detecting performance improvement opportunities, and also achieve the city strategic plan DSP 2021 by reducing carbon footprint, energy and water consumption and annual associated generated waste. Not to forget the marketing and financial value of certified green buildings among non-certified. This paper proposes a green building rating system designed for existing office buildings in Dubai, and derived from Al Sa'fat rating system for new buildings in terms of its structure and layout. International new buildings and existing building rating systems manuals for both BREEAM and LEED have been reviewed. In addition, existing green initiatives in Dubai and Al Sa'fat for new buildings has been reviewed, and a proposal has been generated based on the reviewed manuals. Multiple methods have been utilized to refine and test the system including surveys, interviews, Analytic Hierarchy Process (AHP), case study and walkthrough audit. The surveys' results are used to understand the importance of the rating system categories from public points of view. Survey results indicates that Building vitality is the most important category, followed by Energy, water, site, and materials respectively. Interviews results were used for the AHP process to create a weightage value for the categories. The result is 5 categories and total of 67 regulations among which nine regulations are prerequisites. Final proposal has 5 categories weighting as the following: 36.6% for Resource Effectiveness: Energy 500, 26.7% for Building Vitality 400, 18.6% for Resources Effectiveness: Water 600, 9.3% for Site & Ecology 300, and 8.8% for Materials and Waste 700. An Office Building case study (AWRostomani Head Office) in Port Saeed, Dubai, has been assessed using the proposed system and given a certification accordingly. The case study

received a score of 62.32%, hence qualified for silver certification. The same case study has been assessed in terms of concept in LEED system to check the compatibility of the proposed system with International system, and proved compatibility in terms of comprehensiveness of regulations. Set minimum standards differ according to climate, region culture and the history of existing buildings.

نبذة مختصرة

العديد من أنظمه تصنيف المباني الخضراء مصممة نظريا للتطبيق في جميع انحاء العالم ، ومع ذلك ، فان العديد من أنظمه تصنيف المباني الخضراء بدأت تظهر كرد فعل للاختلافات السياقية, المناخية والثقافية. وقد طورت دبي مؤخرا نظام تقييم المباني الخضراء للمباني الجديدة ، ولا يزال النظام قيد التطوير ومرحله التاسيس داخل مختلف الانظمه الحكومية في الإمارة. غير أن النظام الجديد ، في هذه المرحلة ، مصمم لتقييم المباني الجديدة فقط. لذا, وعلى مستويات مختلفة ، فان تقييم المباني القائمة في دبي سيساعد في الكشف عن فرص تحسين الأداء ، كما سيحقق الخطة الاستراتيجية للمدينة DSP 2021 من خلال الحد من البصمة الكربونية واستهلاك الموارد من طاقة و مياه, و تقليل كمية النفايات السنوية الناتجة من كثرة الإنتاج. بالإضافة إلى القيمة التسويقية و المالية العالية للمباني الخضراء مقارنة بغيرها من المباني غير المسجلة. تقترح هذه الورقة نظام تصنيف المباني الخضراء مخصص للمباني المكتبية القائمة في دبي ، والمستمدة من نظام تصنيف السعفات للمباني الجديدة من حيث بنية النظام المقترح وهيكله التنظيمي. للوصول إلى النظام المقترح تمت مراجعة و استعراض نظامين دوليين لتقييم المباني هما LEED و BREEAM , حيث تم الطرق على كل من دليلي تقييم المباني الجديدة و المباني القائمة للنظامين على وجه المقارنة و للاستفادة من القوانين و المفاهيم المشمولة في كليهما. كما تم استعراض و مراجعة المبادرات الخضراء الموجودة حاليا في دبي, و تقديم مقترح بناء على المراجعة الأدبية كمرحلة أولى, تلتها طرق متعددة لتنقيح و اختبار النظام المقترح تتضمن الدراسة الاستقصائية لموظفي مبنى مكتبي في دبي, ثم إجراء مقابلات مع مجموعة من المهنيين من قسم المباني في بلدية دبي بالإضافة إلى أصحاب الشركات العقارية البارزة و المهندسين و مديري المنشآت, و أخيرا استخدام عملية التسلسل الهرمي التحليلي AHP للوصول إلى نتائج مبنية على توافق الآراء و نسب مئوية لكل فئة في النظام المقترح. وتستخدم نتائج الدراسات الاستقصائية لفهم اهميه فئات نظام التصنيف من وجات النظر العامة, حيث تثير نتائجها إلى أن فئة حيوية المبنى هي أهم فئة ، تليها فئة ترشيد الطاقة ثم ترشيد المياه ثم الموقع و الإيكولوجيا , و أخيرا المواد و معالجة النفايات علي التوالي. بينما تشير نتائج المقابلات و عملية التسلسل الهرمي التحليلي إلى تقدم فئة ترشيد الطاقة في المرتبة الأولى من حيث الأهمية بنسبة مئوية 36.6 % , ثم حيوية البناء بنسبة 26.7 %, ترشيد المياه بنسبة 18.6 % , فئة الموقع و الإكولوجيا بنسبة 9.3 % , و أخيرا فئة المواد و معالجة النفايات بنسبة 8.8% . وقد تم تقييم دراسة إفراديه للمبنى المكتبي الرئيسي لمجموعة شركات عبد الواحد الرستماني الواقع في دبي بمنطقة بور سعيد باستخدام النظام المقترح ومنحت شهادة وفقا لذلك. وحصلت دراسة الحالة علي درجه 62.32 في المائة ، ومن ثم تاهلت للحصول علي

الفضية وفقا للنظام المقترح. وقد تم تقييم دراسة الحالة نفسها من حيث المفهوم في نظام LEED للتحقق من توافق النظام المقترح السعفة مع النظام الدولي ، وأثبتت التوافق من حيث شمولية الانظمه. وتختلف المعايير الدنيا وفقا للمناخ والثقافة الاقليميه وتاريخ المباني القائمة.

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Chapter 1: Introduction

1.1 Green Buildings Rating Systems around the World

The awareness about sustainable design in building sector is becoming one of the most popular topics nowadays. For new buildings, an average of 70% of construction companies is including some concepts of green technologies worldwide (CPWR, 2013). Additionally, buildings are responsible for nearly 50% of the world's energy use (Altin, 2017). Existing buildings can accommodate these technologies in different levels depending on the unique condition of the single building. In a way to measure, and eventually improve, how efficient and sustainable is any building, and catching up with the growing global awareness of the increasing impacts of buildings sector on the environment (Vierra, 2016), several certification and assessment system has been generated. The main aim of these bodies is to measure and rate building performance in terms of energy consumption, water consumption, occupants' behavior, waste management, gases emission, and their overall impact on the natural environment (Traboulsi, 2013).

There is an estimate of approximately 600 GBRS (green building ratings systems) around the world (Tien Doan et al., 2017). Many studies have been conducted to compare the most prevailing rating systems in terms of content, context, focus, economy, etc. Altin (2017). The formation of BREEAM, Building Research Establishment's Environmental Assessment Method, in early 1990s in UK encouraged the push towards sustainable design, and another system, LEED (Leadership in Energy and Environmental Design) has been developed by US Green Building Council in 2000 (USGBC.org, 2018). Although BREEAM in UK and LEED are being globally adopted as well, there are several other rating systems such as Energy Star (US), Green Globes (US & Canada), Living Building Challenge (US), NZEB (US), Passive House Institute (US), SITES (US), WELL Building Standards (US), BCA Green Mark Scheme (Singapore), Beam (HK), CASBEE (Japan), EDGE (universal standard by International Finance Corporation IFC), Green Star SA (South Africa), and Pearl Rating System for Estidama (UAE), and Green

Building Index (Malaysia) (Shan and Hwang, 2018; Illankoon et al., 2017). All of the above systems except the Energy Star System are considered "Multi-Attribute Systems". Multi-Attribute Rating System focuses in many aspects of building performance rather than one such as the Sustainability of the site, water efficiency, materials and resources, IAQ, innovation in design, regional priorities, emissions, project and environmental management, beauty, air tightness, wildlife habitat, human health, outdoor recreation opportunities, transportation, ecology, etc . Energy Star only focuses on the use of energy or water within buildings (Vierra, 2016).

1.2 Importance of rating and building Certification

Certification of buildings can offer a wide spectrum of benefits to the building operation, owners, and the users. It is important to highlight that the efficiency and sustainability of a building does not come from it being certified, yet, official certification through a selected rating system has various pros beyond the sustainability itself. In a study for 12 LEED Certified buildings conducted by USGBC, it has been found that buildings' consumption of energy and water was reduced, achieving savings on the municipal bills ranging between 30-97% of the overall (Vierra, 2016). Additionally, operational costs witnessed an average of 8-9% while the return of investment increased up to 6.6%. In a report by US Department of Energy (2015), an analysis of thousands of LEED and Energy Star certified buildings worldwide showed that certified buildings have higher rates in rents by up to 17%, higher occupancy by up to 18%, higher sales' prices by up to 31%, lower utility costs by more than 13%, and more stable rental rates compared to non-certified buildings in real estate market. Aside from economic value, pursuing a green building certification can be used as a marketing and educational tool. In addition, creating better indoor environment is found to elevate the levels of occupants' productivity and health, which is attributed to factors such as lighting, indoor air quality, and use of certified materials. Although a number of studies have found some efficacy in individual cases of certified building, other prospective benefits of certifying buildings include reduced life cycle cost, increased thermal comfort, better aesthetics, natural resources protection, reduced greenhouse emissions, and overall better environmental protection (Darko et al., 2018).

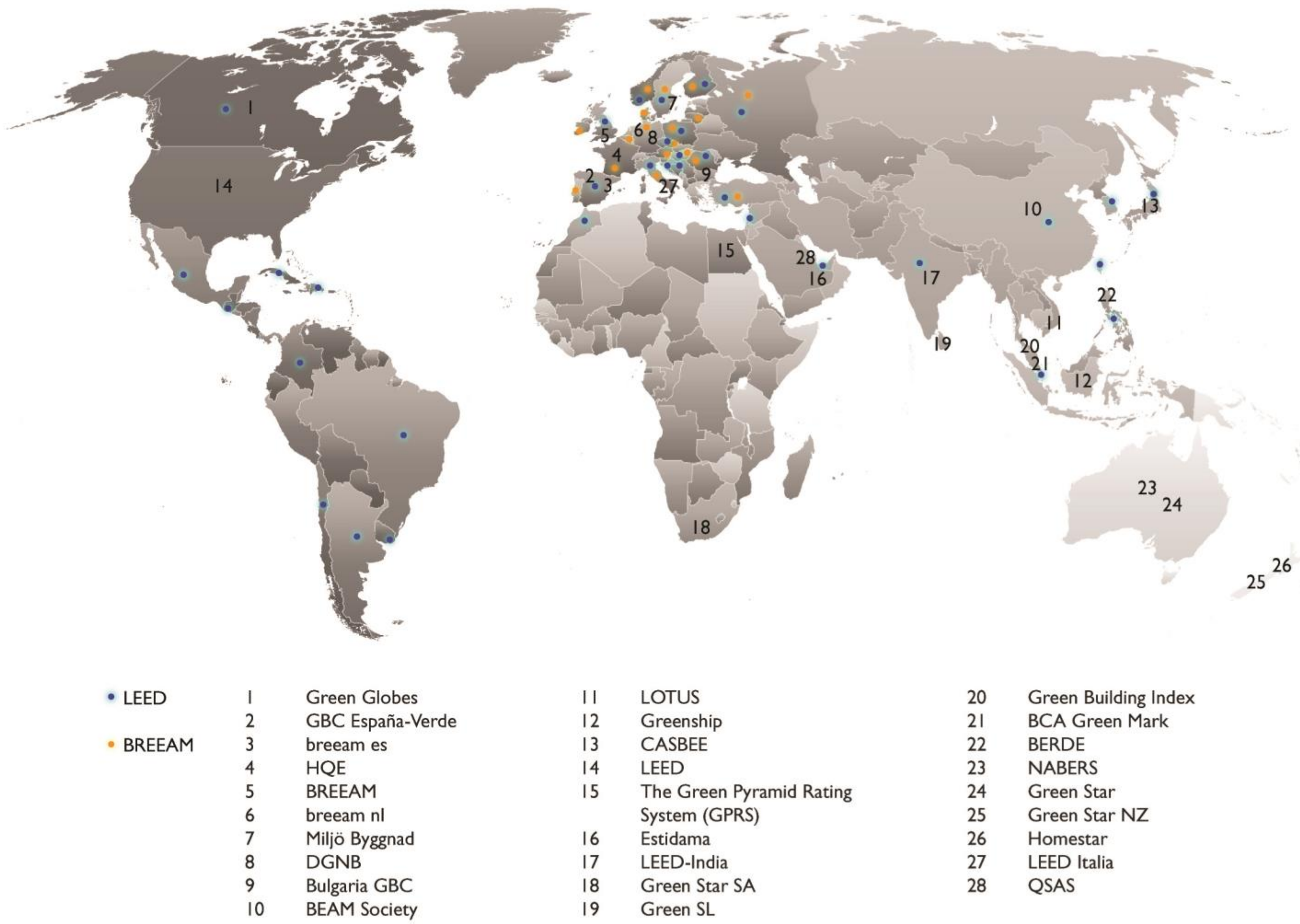


Figure 1.1 GBRS around the world (Zack Academy, 2017)

One of the main issues emerging along with the search for greener and more sustainable design is the lack of reliable resources and long term data to be used when selecting and applying new green technologies. A building might include the most recent concept and products of energy and water conservation, however, the actual impact of these products over their life cycle can very possibly be inaccurate as they have not been in the actual environment long enough to be tested. This concern is calling for implementing Life Cycle Assessments (LCAs) for materials and products as a vital element in assessing any buildings overall performance (Vierra, 2016).

1.3 Aims & Objectives

As part of the active movement being carried by Dubai authorities and government in terms of green initiatives, the study aim to develop a green building rating system suitable for use for existing office buildings in Dubai context. The proposed system will eventually help in assessing existing office buildings performance by giving them rating percentages, and hence identify and propose improvement opportunities as a later stage. In terms of its structure and categories, the proposed system is designed from Al Sa'fat rating system for new buildings currently developed in Dubai. However, a comprehensive review of International rating systems used in Dubai; LEED and BREEAM, has been conducted to develop additional regulations and rating criteria. Furthermore, both public and experts' feedback has been collected through different methods to revise and support the proposed system, and develop an applicable weighting system for the criteria. The main objectives for this study include the below:

1. Review the new buildings and existing/ in use manuals for two main international rating systems used in Dubai.
2. Construct Rating system for existing office buildings, in line with Al Sa'fat Green Building Rating System for new buildings in Dubai.
3. Collect initial feedback from public opinion, and detailed expert's feedback at a following stage. This is crucial as it allows for understanding market view points and gather data via face to face meetings.

4. Create a weighting system for the proposed regulations to provide a quantifiable rating, which is an integrated part of rating system and allow for more convenient description of performance.
5. Analyze an office building as case study to understand the operation and maintenance procedures from a practical point of view, and utilize the collected data to provide a fair rating for the case study as a testing step for the proposed system.

Chapter 2: Literature Review

2.1 Development of Rating Systems

2.1.1 Global Review

The world has witnessed a rapid emergence of a wide range of green building rating systems (Shan and Hwang, 2018; Doan et al.,2017; Mattoni et al.,2018). Several research efforts aimed to capture the features of the emergent rating systems and compare them in a way to enhance them and/ or develop new ones (Zuo and Zhao, 2014; Awadh, 2017; Waidyasekara). Many papers focus on the contextual applicability of green rating systems (Rana and Bhatt ,2016; Ahmed ,2016; Mochtar and Larasati ZR, 2014; Onuoha et al. ,2017; Shaawat and Jamil , 2014; Alyami ,2015). Others addressed improving systems criteria and weighting (Bansal et al.,2015; Kamil Sabie, Pitts and Nicholls, 2014; Shareef and Altan, 2016; and developing social dimensions in green rating systems (Atanda and Öztürk, 2017). Shao et al. (2018) discussed improving existing rating system in China rather than completely proposing new ones. The paper argues that the development of sustainable building industry in China is slow due to the lack of awareness about green buildings benefits and incentives. Thus, the paper proposed a cause-and-effect rating system in which the indicators and perimeters are interdependent to help governments and professionals in identifying key dynamics for green buildings. The proposed system initially included 7 categories and 30 criteria were derived from international green building rating systems. Then refined by surveying 10 expert to cancel 1 category and 8 criteria. To incorporate the "interdependency" target, the study proposed a multiple criteria decision making (MCDM) model that utilizes Analytical Network Process (ANP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) methods to construct the proposed system and generate weighting for the criteria. Shao et al. study showed that the most important categories in assessing buildings in China are management and innovation and counted for 41% of the total weightage. Tien Doan et al. (2017) discussed four GBRS continent-wise: LEED in the Amirecas, BREEAM in Europe, CABSEE in Asia, and Green Star in Australasia as a way to develop a comprehensive comparison between the systems. According to Tien Doan et al., BREEAM is applied in 77 countries, LEED in 160, CABSEE in 1, and Green Star in 1 only. Tien Doan et al. used a two-steps methodology which includes the review of research papers and the review of GBRS manuals. Rana and Bhatt (2016) studied developing green building rating tool specific for Gujarat state, India, only. According to their study of 3 rating systems: LEED India, GRIHA, and SB Tool, the existing rating systems currently used in India might have rating criteria that are not fully applicable on all projects. Rana and Bhatt give the example of “trees restoration and preservation” criteria which is not applicable in projects with no trees. They also argue that different regions need to have specific rating systems tailor made to meet the needs of different locations.

Bansal et al. (2015) criticizes that GRIHA system in India lacks certainty and does not accommodate a wide range of projects data because the evaluation is based on linguistic assessments such as efficient and not efficient, acceptable and not acceptable, high and low option, etc., which are dependent on the satisfaction of the assessor expert. This allows a level of inaccuracy due to the human nature of the assessor. Therefore a development of more flexible system will facilitate buildings assessment in India and will address this issue in currently used GHIRA. Bansal et al. proposed a formula implementing fuzzy logic that results in the assessment values to be between 0 and 1 value. The proposed formula links the variables of GHIRA’s criteria and their existing weightage to get the “weighted rating” (Bansal et al., 2015). Ahmed (2016) discussed developing a contextual green rating system for Bangladesh. In her study she compared Bangladesh context with the Indian context and analyzed the use of GHIRA in India, along with LEED. As per Ahmed, selection of LEED is a result of market demand especially in Garment industry, as buyers showed more interest in business that engage LEED in premises certification. In Ahmed’s paper the focus is given to Sustainable Sites and Energy and Atmosphere categories as they hold most of the LEED weights. Ahmed suggests using basic LEED criteria and modifying them accordingly to suit Bangladesh context. Mochtar and Larasati ZR (2014) discussed the need to develop new green criteria for Indonesia. The paper conducted a comparative analysis between four rating systems: Green-ship GBCI (Indonesia), Jakarta's Decree on Green Building, Green Mark (Singapore), and Green Building Index (GBI by Malaysia). The selection of the analyzed rating systems was justified by the fact that the issuing countries have similar climatic context. Systems were examined in terms of contextual background, development process, categories, and weights. The study highlights that due to the unique island nature of the Indonesian cities (more than 17,000 islands), it's difficult to control individual governments and standardize the construction. Additionally, the high concentration of population in some islands over the others result in uneven development of the infrastructure, hence there is a need to develop a rating system flexible enough to be applicable all over Indonesia, taking into consideration the existing weaknesses of the voluntary Green-ship GBCI and using Green Mark system as a benchmark. Onuoha et al. (2017) proposed developing green program in Nigeria taking into considerations lessons and experience from Malaysian context. Selection of Malaysia is based on the facts that both countries are located in the same latitude and both have hot humid climate, both have a private sector driven property market, and both have similar economic situation in which both are ranked among top twenty major emerging economies. The study implies the use of comparative analysis method, in which the patterns of similarities and differences are analyzed between a number of cases to draw lessons and reach a conclusion (Mills et al., 2006). Atanda and Öztürk (2017) argues that most of the major rating systems lack the incorporation of "social dimensions" in assessment criteria. From literature review, the paper defines main social components to be addressed in rating systems as: "equity, education, participation and control, social cohesion, cultural values, health and safety". Then seven rating systems (BREEAM, LEED, CASBEE, Green Star, SB Tool, GSAS, and SBAT for South Africa) are compared in terms of the proposed social criteria and to what extent is culture represented in each system.

2.1.2 Development of Rating Systems: Regional Review

In the Middle East Region, Shaawat and Jamil (2014) provided a proposal for guidelines to be applied in order to develop new rating systems for Saudi Arabia and GCC. In their paper Shaawat and Jamil compare between nine (9) mainstream rating systems used in GCC: 2 from Middle East while the remaining are worldwide, and discuss the differences and similarities among them. LEED, BREEAM, CABSEE, BCA Green Mark, BREEAM Gulf, GSAS, and PBRS. Discussion included the origin, the launching date, rating type, and Area of coverage. The comparison was made for weightage of each category in the rating systems separately. For example, the relative weightage for Indoor Air Quality category for the 9 GBRS has been compared to see which system gives more importance the IAQ category. Similarly, same has been conducted for sustainable site, water, energy use and GHG emissions, and material durability and reliability. According to Shaawat and Jamil, the rating systems currently used in GCC region is are based on American and European factors, and do not address issues such as resources availability and climate differences in accurate manners. Hence the paper proposes categories to be addressed in developing rating systems in GCC an average weightage for each category. Categories proposed are: Site Sustainability, Availability of Water, Renewable energy resources and GHG emissions, Materials Durability and recycling, Indoor Environment Quality, and “other” categories that might include management and regional trends. Most of the weight in their proposal is given to Availability of Water category (32 points out of 100) followed by Energy Resources (20 points), Materials (15 points), Others (13), and lastly IEQ and Site Sustainability with 10 points each.

Kamil Sabie, Pitts and Nicholls (2014) discussed the development of sustainable rating systems for the gulf context. The paper presents that although there is a growing consciousness about the sustainability in construction market, a questionnaire distributed to 120 professionals in the GCC region indicated a hazy understanding of the main green building's concept. The paper selected three systems used in the GCC at the time of study: LEED v3 2009, BREEAM-Gulf 2008, and Pearl 2010. The study analyzed 30 LEED certified non-residential projects and compared them to BREEAM and Pearl systems to understand the indicators with most value to the projects. Indicators selection for the proposed assessment system was made based on several factors: if an indicator is repeated in all three systems it is immediately selected as proposed, remaining criteria were selected according to regional environmental priorities, local stakeholder's objectives, and existing authorities regulations. This result in 5 categories and 24 indicators framework proposal, which was then refined in terms of importance and validity by the means of survey that included 91 professionals. Top categories was energy with 97.7% followed by water with 93.4%. Out of the 24 proposed indicators four has been excluded upon the survey: Electric cars, heat islands effects, cycle facilities, and construction site management.

Shareef and Altan (2016) selected different green building rating methods in their study. They reviewed and compared between 6 methods: two international rating systems, 1 Middle Eastern system, 2 Middle Eastern regulations, and 1 tool. LEED US, BREEAM UK, Estidama Abu Dhabi, JGBG (Jordan Green Building Guide), Dubai Green Building Guide and Regulations, and Saba (Jordanian developed computer program for rating building) have been discussed. Similar to Shaawat and Jamil, the comparison include the structure of each system, categories addressed, certification levels, and certification process. Results from Shareef and Altan paper indicates that Saba tool gives the majority of the weight to WE category, reflecting the fact the water scarcity in the Jordanian context. Additionally, Estidama and Dubai Green Building regulations are recommended for GCC as they address the region characteristics more than LEED, regardless of the fact that LEED is widely used internationally and in the Middle East.

Another paper presented by Shady Attia (2014) examined the applicability of green systems in hot arid areas. Attia discussed four rating systems in the Middle East: Green Pyramid Rating System in Egypt

(GPRS), Green Building Standard SI 5281 in Israel, Pearl Building Rating System in Abu Dhabi (PBRS), and Qatar Sustainability Assessment System (GSAS). The four systems are also briefly analyzed compared to LEED and BREEAM. Attia's study shows that although the systems are similar in principle, they give different weight for different categories. For example, GPRS and PBRS emphasize on water preservation more than energy preservation compared to GSAS and SI 5281. Overall examination, according to Attia, indicates that although there are increasing efforts in implementing green systems in the selected regions, the discussed systems are, to a certain extent, dependent on LEED and BREEAM systems and still need improvement to be more flexible and considerate to local contexts. Attia points to the lack of technical in-situ testing of the proposed rating systems. Attia also recommends the participation of professionals and stakeholders to improve and give real time feedback from the industries so as to be incorporated in the rating system development.

Alyami (2015) discussed that international rating systems composed in UK and US are not originally designed to be applied in developing countries including Saudi Arabia. Alyami provides the example of some of LEED's points such as wetlands, flood plains, certified wood and maximizing daylight which are of minor relevance to gulf region. Similarly, BREEAM Gulf criteria "watercourse contamination" is not as common as sand storm contamination, yet, it was not incorporated as a criterion in BREEAM Gulf. Hence, Alyami proposes a customization to the Saudi Environmental Assessment Method (SEAM) to improve the system in terms of its criteria and weighting points. The study comparatively analyzes four international systems: LEED, BREEAM, SBTool, and CASBEE, and then identifies the possible applicable criteria in the Saudi context. The four systems are compared in ten areas including health of indoor environment, Building management, sustainable site and ecology, energy efficiency, water efficiency and waste management, materials, economic aspects, pollution, quality of service, and innovation. Afterwards, Delphi technique questionnaires have been composed and conducted in four rounds of consultation with local and international professionals and experts are used as methodology to refine the proposed scheme. Last stage of the research applied Analytic Hierarchy Process (AHP) to analyze the received responses. Upon completion of the analysis Alyami developed the rating system and allocate weights for the proposed categories. As KSA have three different climatic zone: Hot arid, hot humid, and mild hot, the study also identifies the challenges that the proposed scheme might not be directly applicable and future research is required to propose coefficient or mathematical formulas in which climatic differences can be incorporated.

Similar to Alyami, Bannani et al. (2016) addressed the issue of developing green building rating system in KSA, but only to address the non-residential buildings. The study implements the use of literature review, GBRS comparisons, interviews, and AHP to propose and validate green building rating system in Saudi. In their study, Bannani et al. also compared five rating systems: LEED, BREEAM, Green Star, CASBEE, and Estidama to derive the most important criteria and to propose and highlight the criteria that were missed out in the compared GBRS but relevant to Saudi context. Then, all the relevant criteria were shared in interviews and questionnaire forms with academic professionals, architects, engineers, and sustainability experts to refine the proposed criteria. The result is nine main categories with total of 36 sub criteria. Then the paper used AHP method to identify the level of importance of the proposed criteria and create a weighting system. The outcome showed that out of the nine categories, the "water efficiency" is weighing the most compared to the other GBRS (except Estidama) in which water comes at a lower importance (water comes after energy, Land and waste, and IEQ in LEED, BREEAM, and Green Star). This reflects to the high importance of the water efficiency criteria in Saudi context built environment.

In Oman, Al-Jebouri et al. (2017) emphasized the need to develop rating system for construction industry based on the Omani context in terms of climate, politics, culture, and social features as there is no existing one so far. Similarly, Al-Jebouri et al. paper reviews existing international systems, and propose five main “themes” rather than categories for the indicators: environment, economy, culture, social, and governmental regulations. 11 categories then are classified under the themes, and total of 86 proposed indicators under the categories. Literature review, pairwise comparison, and professionals’ survey are used as methodologies in the proposal development. Unlike Kamil Sabie, Pitts, and Nicholls (2014) and Alyami (2015), top weighting indicator in Oman’s proposal is IEQ rather than Water and energy.

2.2 Review of International GBRS Used in Dubai: New construction Manuals Vs. Existing Building Manuals

According to Emirates Green Building Council (Emirates GBC), the rating systems that have been in use in UAE market include LEED, BREEAM, Estidama Pearl rating system- Abu Dhabi, and Al Sa’fat- Dubai (Emirates GBC, 2016). Number of green activities has rapidly boomed in 2015. As per GBIG, About 76% of the activities are associated with new building design and construction, 17% for Interior design and construction, and only 6% for Existing buildings retrofit. There are about 1036 recorded green activities in buildings in United Arab Emirates, among which only 4 are associated with BREEAM (all in Sharjah, Al Zahia Residences Project), and remaining are LEED certified or registered (GBIG, 2018). In Abu Dhabi, since 2010, Estidama PRS has been mandatory for all new buildings in Abu Dhabi, and minimum of 2 pearl is mandatory for governmental buildings (Estidama, 2015). Estidama PRS has been applied for rating more than 1577 design projects, 120 construction projects, more than 1950 villas construction projects, and about 2000 Pearl Qualified Professionals (PQP) (EGBC, 2017). In Dubai, Dubai Municipality released and made mandatory the Green Building regulations and Specifications manual in 2011, and on all new buildings from 2014 (EGBC, 2017). In 2016, Al Sa’fat rating system has been released and in use for new buildings (Al Sa’fat, 2016).

2.2.1 Leadership in Energy and Environmental Design

2.2.1.1 LEED for New Construction

LEED 2009 NC rating system is used to rate new construction projects and major renovation and retrofitting works that requires capital investment (USGBC, 2018). LEED NC focuses on office buildings, yet it can be applied on other commercial buildings, laboratories, factories and manufacturing plants, and high rise residential buildings, and the latest version was published on 1st July 2016 (USGBC, 2016). The system includes seven base rating categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Indoor Environmental Quality (IEQ), Materials and Resources (MR), Indoor Environmental Quality (IEQ), Innovation in Design (ID), and regional priority (RP). Credit allocation for categories are as follows: 26 points for SS, 10 for WE, 35 for EA, 14 for MR, and 15 for IEQ, with total of 100 points. Regional priority (RP) and Innovation in Design (ID) are additional categories that count above the 100 possible points from the first five base categories, with 6 possible points for ID and 4 for RP, the result is a total of 110 possible points. The development of LEED NC came through a committee of different professionals from the building industries with USGBC membership (USGBC, 2017).

2.2.1.2 LEED for Existing Building: LEED v4 EB O+M and LEED v4.1 EB O+M

In January 2018, LEED v4.1 has been released in beta stage for review and projects teams' comments. LEED v4.1 is an update for the existing LEED v4 manual developed in 2009 (USGBC, 2018). In the new update, only LEED for O+M and interiors manual has been released, the remaining manuals to be released upon complete review and successful launch of the LEED v4.1 O+M. LEED v4 is the core and base for the new version, and is still active for all projects until the official release of LEED v4.1. That being said, a review of LEED v4 shall be included in this study.

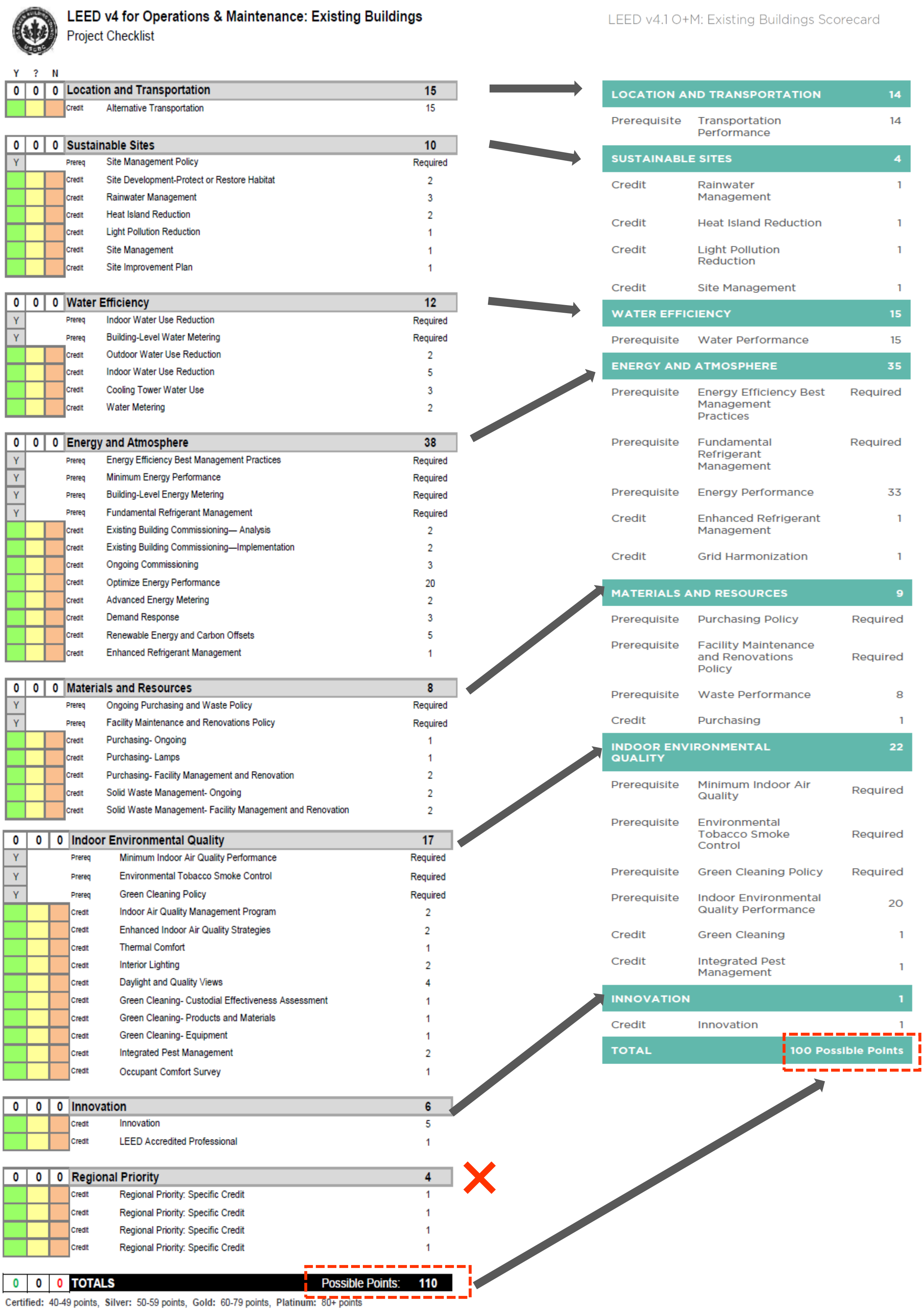
LEED v4 Operation and Maintenance manual includes 7 buildings categories: O+M Existing Buildings, O+M Schools, O+M Retail, O+M Data Centers, O+M Hospitality, O+M Warehouses and Distribution Centers, and O+M Multifamily (USGBC, 2018). Scoring criteria is distributed among 8 categories classification: LT (Location and transportation), SS (sustainable sites), WE (water efficiency), EA (energy and atmosphere), MR (materials and resources), EQ (indoor environmental quality), IN (innovation), and RP (regional priority). There is a total of 37 credits and 12 prerequisites which may have also internal prerequisites (Table 2.1). The weight of the credits is different from one to another depending on the importance of the goal, and all credits have sub sections explaining the intent, requirements, step-by-step guidance, required documents, explanations, and tips, etc.. There are 2 main "periods" defined under the intent and requirements section: establishment period and performance period. The time of assessment of any building structure is named as the "establishment period", in which policies are proposed and programs are placed to allow for the next step "performance period". In the performance period, the proposed strategies and policies are continuously implemented and the ongoing performance of the structure is measured. Since the number of credits is high and it can discourage professionals from obtaining certification, creating a credit selection criterion can help in choosing the credits according to their weight, and with reference to the minimum required documents for each credits. For example, a study by Mazzola et al. in 2017 proposed a mathematical method to best select minimum credits to achieve for LEED O+M certification of a selected historical building. Their approach has two phases: phase one handles the prerequisites classification (to propose a workflow of prerequisites achievement from the ones with highest score to lesser score, or workflow from one prerequisite to other related prerequisites), and phase 2 has 2 sub-phases that concern about the credits selection (sub-phase 2A) and classification (sub-phase 2B, and follows the same proposed prerequisites classification approach in phase 1). As per the study, the main aim is to select credits with highest score and least required documentation work (Mazzola et al., 2017).

2.2.1.3 LEED NC, LEED EBOM v4.1, and LEED EBOM v4

In the beta version of LEED v4.1, some credits are removed, some are moved to other categories, some categories have reduced points and some has more points. RP credit has been removed (0 points); LT, SS, EA and IN have reduced points (15 to 14, 10 to 4, 38 to 34, and 6 to 1 point respectively); and WE, MR, and EQ points increased (12 to 15, 8 to 9, 17 to 23 points respectively). EA is still with highest number of points in both versions. Some titles have been renamed, and some credits have been merged in one. Some prerequisites have been redefined for WE, EA, MR, and EQ under “performance” scores rather than “management”. IN category credit can only be achieved under LEED accredited professional. RP credits are removed from direct scoring, and can possibly be indirectly incorporated in the different performance score. In v4.1, 90 of the achievable score points are coming with prerequisites and only 10 are allocated to credits with total of 100 achievable points, while in v4 all prerequisites are “required” with no allocated point weight, and a total of 110 achievable points. All of the categories and credits details are provided in the manual, and the scorecard is simplified to main titles/ points only. Figures 1 & 2 show the scorecards for LEED v4 O+M and LEED v4.1 O+M respectively. Table 1 shows the allocated points for each category in LEED for NC and LEED v4.1 O+M.

System	Location & Transportation	Sustainable Sites	Water Efficiency	Energy and Atmosphere	Materials and Resources	Indoor Environmental Quality	Innovation in Design	Regional Priority	Total
LEED NC	NA	26	10	35	14	15	6	4	110
LEED v4.1 O+M	14	4	15	35	9	22	1	0	100
LEED v4 O+M	15	10	12	38	8	17	6	4	110

Table 2.1 LEED NC and LEED EBO+M comparisons (source author)



LEED v4 for Operations & Maintenance: Existing Buildings
Project Checklist

Y	?	N			
0	0	0	**Location and Transportation**		**15**
			Credit	Alternative Transportation	15
0	0	0	**Sustainable Sites**		**10**
Y			Prereq	Site Management Policy	Required
			Credit	Site Development-Protect or Restore Habitat	2
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1
			Credit	Site Management	1
			Credit	Site Improvement Plan	1
0	0	0	**Water Efficiency**		**12**
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	5
			Credit	Cooling Tower Water Use	3
			Credit	Water Metering	2
0	0	0	**Energy and Atmosphere**		**38**
Y			Prereq	Energy Efficiency Best Management Practices	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Existing Building Commissioning— Analysis	2
			Credit	Existing Building Commissioning—Implementation	2
			Credit	Ongoing Commissioning	3
			Credit	Optimize Energy Performance	20
			Credit	Advanced Energy Metering	2
			Credit	Demand Response	3
			Credit	Renewable Energy and Carbon Offsets	5
			Credit	Enhanced Refrigerant Management	1
0	0	0	**Materials and Resources**		**8**
Y			Prereq	Ongoing Purchasing and Waste Policy	Required
Y			Prereq	Facility Maintenance and Renovations Policy	Required
			Credit	Purchasing- Ongoing	1
			Credit	Purchasing- Lamps	1
			Credit	Purchasing- Facility Management and Renovation	2
			Credit	Solid Waste Management- Ongoing	2
			Credit	Solid Waste Management- Facility Management and Renovation	2
0	0	0	**Indoor Environmental Quality**		**17**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
Y			Prereq	Green Cleaning Policy	Required
			Credit	Indoor Air Quality Management Program	2
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight and Quality Views	4
			Credit	Green Cleaning- Custodial Effectiveness Assessment	1
			Credit	Green Cleaning- Products and Materials	1
			Credit	Green Cleaning- Equipment	1
			Credit	Integrated Pest Management	2
			Credit	Occupant Comfort Survey	1
0	0	0	**Innovation**		**6**
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	0	0	**Regional Priority**		**4**
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
0	0	0	**TOTALS**	Possible Points:	**110**

Certified: 40-49 points, Silver: 50-59 points, Gold: 60-79 points, Platinum: 80+ points

LEED v4.1 O+M: Existing Buildings Scorecard

LOCATION AND TRANSPORTATION		**14**
Prerequisite	Transportation Performance	14
SUSTAINABLE SITES		**4**
Credit	Rainwater Management	1
Credit	Heat Island Reduction	1
Credit	Light Pollution Reduction	1
Credit	Site Management	1
WATER EFFICIENCY		**15**
Prerequisite	Water Performance	15
ENERGY AND ATMOSPHERE		**35**
Prerequisite	Energy Efficiency Best Management Practices	Required
Prerequisite	Fundamental Refrigerant Management	Required
Prerequisite	Energy Performance	33
Credit	Enhanced Refrigerant Management	1
Credit	Grid Harmonization	1
MATERIALS AND RESOURCES		**9**
Prerequisite	Purchasing Policy	Required
Prerequisite	Facility Maintenance and Renovations Policy	Required
Prerequisite	Waste Performance	8
Credit	Purchasing	1
INDOOR ENVIRONMENTAL QUALITY		**22**
Prerequisite	Minimum Indoor Air Quality	Required
Prerequisite	Environmental Tobacco Smoke Control	Required
Prerequisite	Green Cleaning Policy	Required
Prerequisite	Indoor Environmental Quality Performance	20
Credit	Green Cleaning	1
Credit	Integrated Pest Management	1
INNOVATION		**1**
Credit	Innovation	1
TOTAL		**100 Possible Points**

Figure 2.1 LEED v4 O+M score card (left) and Figure 2.2 GBRS LEED v4.1 O+M score card (USGBC.org 2018)

2.2.2 Building Research Establishment Environmental Assessment Method

BREEAM was established in 1990 by British Research Establishment located in Watford, UK, and is administrated by the non-profit BRE Trust organization (BREEAM, 2016; Winrock International Institute for Agricultural Development, 2014). BREEAM has developed different versions for contextual application such as BREEAM-NOR (Norway), BREEAM (Latvia), and BREEAM-Gulf (GCC region), with the latest withdrawn from the program in 2011 (BREEAM, 2011). BREEAM has six schemes for: new construction (non-domestic), refurbishment (domestic (only UK) and non-domestic), communities master planning, in-use buildings (non-domestic), homes (new built homes, in UK only), and Infrastructure. IT also covers ten general (10) categories: Management, Health and Wellbeing, Energy, Transport, Water, Materials, Land Use and Ecology, Pollution, Waste, and Innovation.

2.2.2.1 BREEAM New construction International 2016

The latest version of BREEAM NC International was revised and issued for international use, such as GCC region, in 2016. The manual describe performance standards for new non-domestic buildings using the main ten general categories and total of 56 criteria, with the weights for each category as in table 2.1. A range of slightly different weightage has been given for each category based on the project type: Fully Fit-out, Shell only, or shell and core. Due to the fact that BREEAM NC international is proposed to be used in any country, the manual provides a section for weightings modification to fit local conditions under scoring and rating chapter. The section clarify that weights for categories in a specific country can be reviewed and refined according to the first project that apply for certification in that specific country or region. The revised weights are then documented as “Approved Standards and weightings lists” (ASWL) and used as standard weights for the projects to follow, only within the span of the current version of BREEAM under which the first project was registered or certified. For this reason, the manual also identifies five climatic zones to be used as reference: equatorial, arid dry, warm temperate, snow temperate, and polar. Buildings assessed by BREEAM NC International 2016 need a minimum of 30% to pass the assessment, and are certified in five levels based on the achieved points to: Pass (30-44), good (45-54), very good (55-69), excellent (70-84), and outstanding (85+) (BRE Global, 2014).

2.2.2.2 BREEAM In-Use International 2016

In BREEAM in-use International, the assessment is divided into 3 parts: (1) Asset performance, (2) Building Management, and (3) Occupants management. Each of the three parts is assessed in relevant BREEAM nine general categories, and only innovation category out of the ten categories is not included in the manual. Part 1 is assessed in 8 categories only excluding management category, with a total of 71 addressed issues and 257 possible credits; part 2 is assessed in 7 categories only excluding transport and waste category, with a total of 87 addressed issues and 223 possible credits; and part 3 is assessed in all 9 categories, with a total of 51 addressed issues and 566 possible credits (table 2.2). The manual has a “Building Details” section which to be including all the building and assets data and explanation, and requires to be filled before the assessment. For the three parts assessment in the in-use scheme, specific “eligibility criteria” should me met such as the completion of the structure, the existence of spaces that are occupied for a minimum of 30 minutes per day or designed to be occupied, and the assessment of only one building usually (except in certain cases where multiple buildings share common services, buildings have similar design and age, buildings use same building management policies, and share same envelope specifications). For the assessment of part 2 and 3 in particular, the building should be in use for minimum of one year and all relevant consumption data should be available for the same period. In BREEAM in-use, buildings need a minimum of 25% to pass the assessment, but still considered “acceptable” if achieved 10-24% of the score. Scoring range is: unclassified (<10), acceptable (10-24), pass (25-39), good (40-55); very good, excellent, and outstanding has the same percent range as BREEAM NC International 2016. Each part has minimum standards to be achieved. Even if the total score satisfy the minimum total, certification will not be achieved if any part has less than the minimum required.

Table 2.2 BREEAM in Use 3 parts assessment categories and weights (BREEAM IU International 2017)

BREEAM In-Use International 2016										
Part 1 (Asset Performance)				**Part 2 (Building Management)**				**Part 3 (Occupants Management)**		
Category	issues	credits		Category	issues	credits		Category	issues	credits
Management	0	0		Management	13	46		Management	7	46
Health & Wellbeing	11	33		Health & Wellbeing	13	37		Health & Wellbeing	5	75
Energy	30	108		Energy	36	60		Energy	5	64
Transport	4	18		Transport	0	0		Transport	8	89
Water	10	40		Water	7	26		Water	4	57
Materials	7	26		Materials	7	20		Materials	9	86
Waste	1	4		Waste	0	0		Waste	9	79
Land Use & Ecology	2	6		Land Use & Ecology	3	10		Land Use & Ecology	1	3
Pollution	6	22		Pollution	8	24		Pollution	3	67
Totals	**71**	**257**			**87**	**223**			**51**	**566**

Tables 2.3 and 2.4 show the overall weights for each category for BREEAM NC and in-use international 2016. For BREEAM NC, the range has been used directly in the table for comparison. For BREEAM in-use, each part is assessed separately and has a total percentage of 100. For the purpose of this study, the total weight of each category will be referred to where applicable, as it will allow consistent comparison between new construction and in-use manuals.

Table 2.3 BREEAM NC categories and weights (BREEAM NC International 2017)

Environmental section	Weighting Non-residential		
	Fully fitted out	Shell only	Shell and core
Management	12%	13.5%	13%
Health and wellbeing	14%	8%	8.5%
Hazards	1%	1.5%	1%
Energy	19%	19.5%	19%
Transport	8%	11%	8.5%
Water	6%	3%	6.5%
Materials	12.5%	16.5%	13.5%
Waste	7.5%	8.5%	8%
Land Use and Ecology	10%	13%	11%
Pollution	6.5%	1%	7%
Surface water run-off	3.5%	4.5%	4%
Total	100%	100%	100%
Innovation (additional)	10%	10%	10%

Table 2.4 BREEAM IU weights (BREEAM IU International 2017)

Environmental Section	Weighting		
	Part 1	Part 2	Part 3
Management	-	15%	12%
Health & Wellbeing	17%	15%	15%
Energy	26.5%	31.5%	19.5%
Transport	11.5%	-	18.5%
Water	8%	5.5%	3.5%
Materials	8.5%	7.5%	4.5%
Waste	5%	-	11.5%
Land Use & Ecology	9.5%	12.5%	5%
Pollution	14%	13%	10.5%
Total	100%	100%	100%

2.3 Existing Green initiatives in Dubai

2.3.1 Emirates Green Building Council

Emirates Green Building Council was established in 2006 with its main office in Dubai, and is the first green building council in MEAN region (EmiratesGBC, 2015). The council conducts regular workshops and organizes programs on sustainability, building retrofits, benchmarking, health and wellness, and environmental awareness. Emirates GBC released several publications including technical manuals for buildings retrofitting in UAE, benchmarking of hotels and schools' water and energy performances, green market briefs city wise (Abu Dhabi and Dubai), and studies on zero energy buildings. Emirates GBC partner with more than 15 bodies including Abu Dhabi Urban Planning Council, Ajman Municipality, Clean Energy Business Council, Dubai Supreme Council of Energy (DSCE), Dubai Sustainable Tourism, Emirates Nature WWF, Global Real Estate Sustainability Benchmark (GRESB), Masdar, and Royal Institute of Chartered Surveyors (RICS) (Emirates GBC, 2017). The council's website also provides green buildings tooltips for homes, office and school typologies, in which green building design tips for energy conservation, water, interior spaces and external building design are provided in a 3d interactive models. Additionally, the "Academy Database" provides a wide collection of policies, researches, reports, case studies, technologies and other related topics websites links from all around the world that can be filtered based on country/ region.

2.3.2 Technical Guidelines for Retrofitting Existing Buildings

In 2015, Emirates GBC issued "Technical Guidelines for Retrofitting Existing Buildings" based on UAE's climate and environmental conditions, in alignment with Abu Dhabi 2030 vision, and DIES (Dubai Integrated Energy Strategy). This manual is not a rating tool, but rather includes instructions for enhancing existing buildings behavior and operations, ultimately leading to less resources consumption and reduced operational costs. The manual consists of five chapters that offer a total of 31 sections and methods on energy (chapter 1), water management (chapter 2), air quality (chapter 3), materials and waste (chapter 4), and innovation and management (chapter 5). Fourteen sections address energy conversation including energy auditing, lighting control and retrofit, HVAC, thermal insulation, air tightness, sub-metering for chilled water, network optimization and solar water heating systems. Six sections come under water management include water auditing, efficient fixtures, grey water systems, condensate recovery from air conditioning systems, irrigation and landscape, and water quality. Chapter 3 for air quality discuss outdoor air quality and indoor air quality testing, interior materials and chemicals, fresh air supply, demand control ventilation, and energy recovery ventilation systems. Chapter four have two sections addressing waste management and green purchasing policies. Lastly chapter 5 for innovation and management has three sections which suggests techniques for increasing tenants' awareness and education, facility management training, and safety.

2.3.3 Green Building Regulations & Specifications in Dubai

One of the main pillars of Dubai Strategic Plan 2021 is "The Place". The Place focus on creating an integrated city in which resources are being used and managed sustainably, infrastructures are connected, environment is clean and healthy (Dubaiplan2021.ae, 2018). The Key Performance Indicators (KPIs) to measure "The Place" goals as per DSP 2021 are as below:

1. Level of Satisfaction with the infrastructure of Dubai to be analyzed by area
2. Tracking and reducing the rate of carbon dioxide emissions per gross domestic product (GDP)
3. Rate of annually generated solid waste per capita
4. Improving response time emergencies (police, civil defense, and ambulance)
5. Reducing road fatalities in every 100,000 of population

Prior to DSP 2021, there was DSP 2015, which was planned in 2007. In the DSP 2015 the corresponding pillar was the pillar of "Infrastructure, Land & Environment". This pillar deals with developments in the fields in urban planning, Energy and water, transportation infrastructure, and environment and waste management (Dubaiplan2021.ae, 2018). One of the outcomes of the planning DSP 2015 was the "Green Building Regulations and Specifications" manual, which was first generated in 2011, and lastly updated in 2015 as per the Dubai Electricity and water Authority. The "Green Building Regulations and Specification Manual" is designed for new buildings use only, however the instructions and standards given in the manual are of high importance for major retrofitting and renovation works. The manual is composed of six chapters explaining: Definitions, Ecology & Planning, building Vitality, Resource effectiveness (energy, water, materials & waste). The manual specifies minimum values of building and environmental elements such as roof solar reflective index (SRI), maximum limits of indoor air contaminations (Formaldehyde, Volatile Organic Compound, respirable dust, carbon dioxide, carbon monoxide, bacteria, Fungi, etc.), thermal comfort upper and lower limits, U values (roof, external walls, glazing systems), efficiency requirement for HVAC equipment, lighting power densities values per space usage, pipes and ducts insulation thicknesses, and recommended flow rates for fixtures types. As per the manual, the performance of building is measured in one of two ways: elemental method or performance method. In elemental method, the performance is based on specs of approved materials and equipment, while in performance method the performance is measured using specific tools as per the targeted equipment/ perimeter. In the manual there is reference to other standards such as ASHRAE 90.1-2007 for ventilation and lighting, ASHRAE 62.2-2007 for occupancy density values (in terms of demand controlled ventilation calculation) BSI British standard BS 5422:2009 for pipes and ducts insulation values, ARI and ISO standards and test procedures.

2.3.4 Manual of Green Building Materials, Products, & Their Testing Facilities

Additionally, the "Manual of Green Building Materials, Products, & Their Testing Facilities" has been compiled in 2012 by the same Authority under Dubai Central Laboratory Department. The manual included different types of green products and materials that are tested, and registered as certified green materials in Dubai. The mentioned list is used as a base for registered green suppliers contact data. The main 3 testing facilities registered in the report are Dubai Central Laboratory (established in 1997, its main goal is to issue standards, control measurements, perform materials and products testing, and centralize all the labs in Dubai Municipality in one department (Dubai Government, 2018)), Material Lab (independent facility for construction materials testing such as UV values, thermal conductivity, acoustic properties, Solar Reflectance Index (SRI), etc. (Mlab.ae, 2018)), and Geo-Chem Middle East (established in 1990, with the main activity of testing and inspection of chemical and waste water, Vegetable oil, Agriculture products, petroleum products, etc. (Geochem.ae, 2018).

One of the main setbacks of referring to these manual is that they are not frequently updated. As formerly mentioned, Dubai Green Building Regulations manual has been issued in 2015, while the materials manual was issued 3 years earlier than that. As noticed earlier, this might be due to the lack of credible data of new technologies and materials as they are just being introduced to market, and their long term performance measures are not ready yet to be used as municipality standard (Mosly, 2015). Another reason is that although the talk about green designs is being more into topic nowadays, yet the actual implementation in building industry is still on a narrow scale due to several factors such as culture, cost, lack of Knowledge, difficulty in educating stakeholders and contractors, low awareness level among end users, and market demands, leading to little benchmarking data (Dadzie et al., 2018). These factors raise the need to refer to international green building standards and regulations in addition to the local regulations while taking into consideration climatic differences, products availability and market demands to help developing reliable rating system and updating them.

2.3.5 AL Sa'fat Green Building Rating System

Al Sa'fat rating system was developed by Dubai Municipality in 2016 for all new buildings in Dubai (Al Sa'fat, 2016). The name of "Al Sa'fat" comes from the Arabic word meaning "frond", which refers to the traditional use of fronds as building materials in UAE (Saseendran, 2016). Hussain Nasser Lootah, the Director General of Dubai Municipality, said that Al Sa'fat is designed to improve environmental building performance and enhance human health, in conformance with Dubai strategic Plan 2021 for sustainable city. The rating manual, published in both Arabic and English, shall be applied on all areas of Dubai including Free zones, and new building including Villas, residential building, offices, resorts and hotels, laboratories, labour and student accommodations, public buildings, and any modifications or additions of buildings parts that require DM approval and new building permits (Al Sa'fat, 2016). Temporary buildings, heritage buildings, special construction such as large scale and extremely high buildings are exempted from applying the regulations. The effective date of implementation, as per circular No. 222 from DM, is first of January 2018. The certification of building is given on four levels: Bronze, silver, gold, and platinum. The manual is divided into seven sections numbered in the form of 3 digits (000): 100 Administration, 200 definitions, 300 Ecology and Planning, 400 building vitality, 500 resource effectiveness: Energy, 600 Resource effectiveness: Water, and 700 Resources effectiveness: Materials and Waste. Each section provides minimum requirements for each sa'fa level. Before the 4 sa'fat levels there is a "general requirement" level to be met for all buildings. For residential villas and industrial buildings, minimum bronze sa'fa should be achieved, while for all other applicable buildings types a minimum of silver sa'fa should be achieved. Achieving any sa'fa requires meeting its requirements along with all other lower sa'fat levels requirements. For example, achieving gold sa'fa level means that general requirements, bronze sa’fa requirements, silver sa’fa requirements, and gold sa’fa requirements are met. Similar to Dubai green building regulation manual discussed in previous section, two methods are used to measure the compliance of the building with the rating requirements: elemental method and performance method. The manual present each sa’fa requirements in a separate table, and the chapters order in each section does not reflect the sa’fa level. For example, in section 300 ecology and planning, chapters 1, 4, and 5 includes general requirements regulations; while chapters 1,2,3, and 4 includes silver sa’fa requirements also; and chapter 3 only have regulations for gold sa’fa rating; but neither bronze sa’fa nor platinum sa’fa has any regulations in section 300. For a better overview it will be useful to combine all the lists in one table to understand how the requirements increase/ change between levels. The table 2.4 shows the sections and chapters in numerical order as in comes in the manual, and highlights sections for different sa’fat levels in corresponding color: Bronze: Bronze, Silver: dark grey, Gold: light yellow, and Platinum: light grey. There are 101 regulations stated in the guidelines, among which 33 are for general requirements, 9 additional for bronze sa’fa, additional 39 for silver sa’fa, 16 additional for gold sa’fa, and 4 additional for platinum sa’fa. As previously mentioned, a minimum of Silver sa’fa should be achieved for all buildings except residential villas and industrial buildings, this means that by achieving silver sa’fa a minimum of 81 regulations out of 101 should be achieved.

Although the Sa’fat rating system is designed for new buildings rating only, there are few articles in the manual that refer to existing buildings. Chapter one (Ventilation and Air Quality 401) in section 4 (Building Vitality) has few regulations that apply for both new and existing buildings such as 401.01 (Minimum Ventilation Requirements for Adequate Indoor Air Quality), 401.04 (Isolation of Pollutant Sources), 401.07 (Indoor air quality compliance for existing building), and 401.09 (Inspection and Cleaning of HVAC Equipment). Chapter 2 in the same section (thermal comfort 402) also has regulations 402.01 (thermal comfort). Chapter 4 (Hazardous Materials 404) has regulations 404.01 for the reapplication of low emitting materials such as paints and coatings, 404.02 for adhesives and sealants, and 404.03 for carpets systems. Chapter 6 (water quality 406) has regulations 406.01 (Legionella Bacteria and Building Water Systems) and 406.02 (Water Quality of Water Features) that are applicable to new and existing buildings. In section 5 (Resource Effectiveness: Energy 500) chapter 2 (Conservation and Efficiency: Building Systems 502) regulations 502.02 (Demand Controlled Ventilation) and 502.14 (maintenance of mechanical systems) are applicable for new and existing buildings. In Chapter 3 (Commissioning and Management 503) regulations 503.02 refers to decommissioning of building services only for existing buildings. In Section 6 (Resource Effectiveness: Water 600) chapter 1 (Conservation and Efficiency 601) regulations 601.02 (condensate drainage) apply for new and existing buildings. In the last section (Resource Effectiveness: Materials and Waste 700) chapter 1 (materials and resources) regulations 701.03 (Asbestos Containing Materials) and 701.04 (Lead or Heavy Metals Containing Materials) apply for new buildings and maintenance or alteration of existing buildings.

To familiarize professionals and local market with the rating system, Dubai Municipality introduced a training program that explain the regulations of the Sa’fat rating system, required documents and certificates, and steps to get buildings certified, in which by the end of the programs the professionals will undergo a test to receive a “ Sa’fat certified engineer” (SCE) title. The first batch of Sa’fat certified engineers, which included 11 engineers and 9 students, graduated in May 2018 (AlKhaleej, 2018).

Table 2.5 Al Sa'fat sections and regulations (AlSa'fat.ae 2016)

Section	chapter	Regulation No.	regulation Title
Ecology and Planning 300	Access and Mobility -301	301.01	Preferred Parking
		301.02	Enabled Access
		301.03	Bicycle Storage
		301.04	Charging facilities for Electrical and Hybrid Vehicles
	Ecology and Landscaping - 302	302.01	Local Species
	Neighbourhood Pollution - 303	303.01	Exterior Light Pollution and Controls
	Microclimate and Outdoor Comfort - 304	304.01	Urban Heat Island Effect
		304.02	Heat Rejection Equipment Installation
		304.03	Green Roofs
		304.04	Colours on the Outside of Buildings
		304.05	Orientation of Glazed Façades
		304.06	Hardscape
		304.07	Shading of Public Access Areas
	Environmental Impact Assessment - 305	305.01	Environmental Impact Assessment
Building Vitality 400	Ventilation and Air Quality - 401	401.01	Minimum Ventilation Requirements for Adequate Indoor Air Quality
		401.02	Air Quality during Construction, Renovation or Decoration
		401.03	Air Inlets and Exhausts
		401.04	Isolation of Pollutant Sources
		401.05	Openable Windows
		401.06	Indoor Air Quality Compliance - New Buildings
		401.07	Indoor Air Quality Compliance - Existing Buildings
		401.08	Sealing Doors and Window Frames
		401.09	Inspection and Cleaning of HVAC Equipment
		401.10	Parking Ventilation
		401.11	Environmental Tobacco Smoke
	Thermal Comfort - 402	402.01	Thermal Comfort
	Acoustic Comfort - 403	403.01	Acoustical Control
		403.02	Sound Insulation
		403.03	Extended breaks and prevention of shaking
	Hazardous Materials - 404	404.01	Low Emitting Material: Paints and Coatings
		404.02	Low Emitting Material: Adhesives and Sealants
		404.03	Carpet Systems
	Day lighting and Visual Comfort - 405	405.01	Provision of Natural Daylight
		405.02	Views
	Water Quality - 406	406.01	Legionella Bacteria and Building Water Systems
		406.02	Water Quality of Water Features
	Responsible Construction - 407	407.01	Impact of Construction, Demolition and Operational Activities
		407.02	Ensuring Quality and Safety for construction Activities
Resource Effectiveness: Energy 500	Conservation and Efficiency: Building Envelope - 501	501.01	Minimum Envelope Performance Requirements
		501.02	Thermal Bridging

		501.03	Air Conditioning Design Parameters
		501.04	Air Loss from Entrance and Exit
		501.05	Air Leakage
		501.06	Air Leakage Test
		501.07	Thermal Storages
		501.08	Thermal Dissipation
		501.09	Innovative Techniques to Enhance Building Thermal Envelope Performance
		501.10	Surrounding Shadow Factors
	Conservation and Efficiency: Building Systems - 502	502.01	Energy Efficiency – HVAC Equipment and Systems
		502.02	Demand Controlled Ventilation
		502.03	Elevators and Escalators
		502.04	Lighting Power Density - Interior
		502.05	Lighting Power Density - Exterior
		502.06	Lighting Controls
		502.07	Electronic Ballasts
		502.08	Control Systems for Heating, Ventilation and Air Conditioning (HVAC) Systems
		502.09	Control Systems for Hotel Rooms
		502.10	Exhaust Air Energy Recovery Systems and Condensation of water
		502.11	Pipe and Duct Insulation
		502.12	Thermal Storage for District Cooling
		502.13	Ductwork Air Leakage
		502.14	Maintenance of Mechanical Systems
		502.15	Control of Air Flow
		502.16	Control of Chilled Water
		502.17	Control of Air Conditioning Zones
		502.18	Cooling of Corridors and Public Areas
		502.19	Air Conditioning and Ventilation of Parking Areas
		502.20	Air Conditioning of Industrial Buildings
		502.21	Cooling Water Purification to Enhance Cooling Efficiency
		502.22	Heat Exchangers
	Commissioning and Management - 503	503.01	Commissioning of Building Services – New Buildings
		503.02	Re-Commissioning of Building Services – Existing Buildings
		503.03	Electricity Metering
		503.04	Air Conditioning Metering
		503.05	Central Control and Monitoring System (CCMS)
		503.06	Pollutants Control and Pressure Maintenance
		503.07	Cost of the Expected Performance Assessment
		503.08	Performance and Commissioning Reports
		503.09	Sustainable Awareness

	Onsite Systems: Generation & Renewable Energy - 504	504.01	On-Site Renewable Energy – Small to Medium Scale Embedded Generators
		504.02	Outdoor Lighting
		504.03	On-Site Renewable Energy – Solar Water Heating System
		504.04	On site Renewable Energy – Electrical power generation
Resource Effectiveness: Water 600	Conservation and Efficiency - 601	601.01	Water Efficient Fittings
		601.02	Condensate Drainage
		601.03	Condensate Recovery
		601.04	Water Efficient Irrigation
	Commissioning and Management - 602	602.01	Water Metering
	Onsite Systems: Recovery and Treatment - 603	603.01	Wastewater Reuse
		603.02	Water Consumption for Heat Rejection Including Cooling Towers
Resource Effectiveness: Materials and Waste 700	Materials and Resources - 701	701.01	Thermal and Acoustical Insulation Materials
		701.02	Certified / Accredited Timber
		701.03	Asbestos Containing Materials
		701.04	Lead or Heavy Metals Containing Materials
		701.05	Ozone Depletion Potential (ODP) Material Management:
		701.06	Recycled Content
		701.07	Regional Materials
		701.08	Composite Wood Products
	Waste Management - 702	702.01	Construction and Demolition Waste
		702.02	Bulk Waste Collection
		702.03	Waste Storage
		702.04	Waste Collection
		702.05	Recyclable Waste Management Facilities

Chapter 3: Methodology

3.1 Applicable Research Methodologies

Several methods are used to address the study question, based on the perspective. From the carried literature review, suggested methods for this paper include literature review, case study, energy auditing, interviews, and computed simulation.

3.1.1 Literature Review

Literature review is an essential part of nearly any research work (cooper, 1998). As the history of official rating systems started in 1990 by the formation of BREEAM, It is essential to review the development of the rating tools in the last four decades and how they interact with building industries. All the papers reviewed in this study implemented literature review to a certain extent. Tien Doan et al. , 2017; Rana and Bhatt, 2016; Ahmed, 2016; Mochtar and Larasati, 2014; and Atanda and Öztürk, 2017 reviewed several GBRSs in their papers such as LEED, BREEAM, GHIRA, GREEN Mark, CASBEE, GREEN Star, SBAT Estidama, and SB Tool in a comparative analysis process to understand the categories and criteria. Other studies reviewed also other journals to compare their findings and support results. Akreim and Suzer (2018) reviewed 32 relevant papers published between 2008 and 2017 to identify main factors that promote the adoption of green buildings among decision makers. Li et al. (2017) reviewed 57 journal articles published between 2004 and 2016 from selected academic databases and international journals in the field of green buildings and construction management. The aim of their paper was to build a holistic review of the efforts done on the GBRS country wise and author wise (Li et al., 2017). Zuo and Zhao (2014) reviewed 129 papers on green building concept and examined the common topics and methodologies used. The study also identified green buildings definition and benefits form technical, environmental, economical, and social perspectives. Their paper found that most papers focused on environmental aspects of green buildings, and that social aspects and the interaction between green buildings and users are largely overlooked by the rating systems and also researchers who discussed them (Zuo and Zhao, 2014).

3.1.2 Case Study

Case study methodology can help in getting a holistic investigation about a certain topic (Feagin et al., 1991). This method focus on understanding a topic from by studying a case in its real-life context (Yin, 2011), describing it, and possibly predicting future events (Djurić, Nikolić and Vuković, 2010). Case studies provide detailed and rounded description of the case(s), which is referred to as "thick description" (Greetz, 1973). Once a clear result is generated from the studied case, it can be used to study other cases within similar conditions. There are several types of case studies including: 1) representative case, 2) prototypical case, 3) deviant case, 4) crucial case, and 5) archetypal case (Djurić, Nikolić and Vuković, 2010). One criticism against case study is the fact that cases might be very specific, hence is not an appropriate method for building theories. This conception, however, has been defended by the process of selecting more numbers of cases, and then building theories based on the collective result (Widdowson, 2011). A balance between the time available of the study and the quality of the result needs to be considered, as more number of case studies can eventually lead to lesser details. According to Kothari (2004), there are five major phases involved in case study method: 1) recognition and selection of the case(s); 2) data collection by carefully examining the selected case(s); 3) identification of the main issues in the case to propose a solution or theory; 4) application of the proposed solutions or measures; and 5) follow-up program to evaluate the success of the solutions/ measures (Kothari, 2004). Jesus, Almeida, and Almeida (2005) used case study methodology to compare between a certified green building and other reference buildings in terms of cost, environmental impact, and social impact. The aim of the paper was to achieve balance between investing in green building and encourage stakeholders to invest in sustainable design. Hu (2015) used

Sydney city as a case study for development of sustainable strategies in global cities. The paper discussed sustainable re-development, green economy, connectivity, urban design and attractive public spaces as part of the strategic planning of the city (Hu, 2015). Siva, Hoppe, and Jain (2017) used the case study of Singapore to analyze the limitations and benefits of Singapore "sectorial innovation system" in achieving the country's goal of having a minimum of 80% certified buildings by 2030.

3.1.3 Surveys Data Collection

Surveys are one of the most traditional ways of collecting data, and are probably commonly used in different research fields such as health services, social sciences, marketing, psychology, and sociology, to collect information about services feedback, users' habits, expert's opinions, etc. (Mathers, Fox and Hunn, 2009). Statistical surveys are carried out among a sample of selected population to answer questions about specific group (Andres, 2013). Survey data collection can be conducted in three main general ways: self-administered, interviewer-administered, or a combination of both (Skinner, 2007). Self-administered approach can be conducted by mail, in groups, or through internet or email, while the interviewer-administered can be conducted by telephone or in person, i.e., interviews (Alam et al., 2014). Interview as a method can be classified according to the nature of the structure used into three types: 1) structured interview, 2) unstructured interview, 3) semi-structured interview, and 4) focus group interview (Alshenqeeti, 2014). In structured interviews the questions are very much defined which expect defined answers such as yes and no with little space for elaborating (Rose, 1994), on the other hand, although the unstructured interview has a specific topic, there are no focused questions and may flow similar to everyday conversations (Dana, Dawes and Peterson, 2013). Semi-structured interview has a mixture of defined questions and also allow for open questions and share characteristics of both. It gives more freedom for the interviewees to express their opinions, however, preparation for semi structured interviews requires skill so as not to make the questions too leading, and also might be time consuming due to the questions nature (Keller and Conradin, 2018). Lastly, focused group interviews are multiple interviews conducted for a group of people to get information about a specific topic. This technique has been used for data collection since 1926 (Powell, Single and Lloyd, 1996).The group interviews can include 4 or more people up to 9 or 10 people (Doody, Slevin and Taggart, 2013; and Rabiee, 2004). Focused group interviews are advised to have an open-ended questions and reduce or avoid directive questions to obtain the participant’s standpoint (Dilshad and Latif, 2013). Focus groups are considered less expensive than individual interviews (Schwab, 2016), it is a way for sharing and exchanging opinions and disagreements among the participants and adds a human dimension to the study, it helps explain why certain people think in a particular way, and assist is explaining human behavior in health, culture and sociology fields (Murray and Andrasik, 2015). On the contrary, focus groups can be hard to control, analyze, and can often lead to irrelevant discussions. Additionally, the group setup might be discouraging for some people to express their opinion, particularly in the presence of dominant opposing opinion (Tausch and Menold, 2016).

3.1.4 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a method developed in 1970s by Thomas L. Saaty to help in decision making process (Saaty & Peniwati, 2008). The AHP involves breaking down the main problem into smaller problems referred to as “indicators” that are easier or simpler to handle in a hierarchal structure referred to as the AHP “model” (Saaty, 1994). The AHP provides a consensus-based approach in which all the parties involved in the decision making can support or at least accept, involving paired comparisons for the indicators. AHP can be used in several fields and situations such as choice making, benchmarking, ranking, conflict resolution, and quality management (Forman and Gass, 2001). The number of comparisons to be carried out is calculated as per the below formula, where n is the number of items to be compared:

$$\frac{n(n-1)}{2}$$

Saaty developed a 9-points scale for paired comparison, which has the odd numbers (1, 3, 5, 7, 9) to indicate the importance where 1 is neutral and 9 is the most important. After all the comparisons are done, a “reciprocal matrix” is prepared to include all the results from the paired comparisons. The reciprocal matrix shows the comparison of the rows to the columns, where the value is greater than 1 this means the row item is more important than the column. On the other hand, where the value is less than 1 this indicates that the row is less important than the column, and the reciprocal value has been used. The following step is to “normalize” the matrix by adding all the values in one column and then dividing each number in the column by the total value. The resultant value is referred to as the “priority vector” or “Eigen Vector”, other names for the same are proper vector, characteristic vector, or latent vector (Teknomo, 2011). Next is to measure the consistency of the result and conduct a consistency analysis to insure that the used ratings are relatively consistent, which includes:

1. Consistency Measure,
2. Consistency Index (CI), and
3. Consistency Ratio (CR)

There are several online based and downloadable software that are used to calculate these values such as Expert Choice (expertchoice.com, 2018), PriEsT (Siraj, Mikhailov, and Keane, 2015), MakeItRational (makeitrational.com, 2013), Super Decisions (superdecidions.com, 2018), BPMSG (Klaus, 2018), Transparent Choice (transparentchoice.com, 2018), Easy AHP (easyahp.com, 2016), and Microsoft Excel (Bunruamkaew, 2012). Although AHP is used in several fields and by many institutions and researchers (Emrouznejad and Marra, 2017), there are few criticisms against the methods. Pöyhönen, Hämäläinen and Salo (1997) discussed that the 1-9 numerical scale of the verbal statement in the AHP method is perceived differently from one subject to the other, which may lead to higher inconsistency rate and weak results. Another main criticism is the problem of “rank reversal”, which refers to the change in alternatives rankings caused when some of the alternatives are deleted or added (Saaty, 1987; Csato', 2017; Maleki and Zahir, 2012; Wang and Luo, 2009; Stam and Silva, 1997).

3.1.5 Energy Auditing

Energy auditing refers to the process of evaluating building's resources consumptions and the possible available conservation measures (Androutsopoulos and Alexandri, 2017). As per ASHRAE's 2011 publication "Procedures for Commercial Building Energy Audits, 2nd edition", energy audit has 3 main levels, 1, 2, and 3 (previously I, II, III). Energy Auditing level 1, or Walk-through audit consist of a quick site visit to detect immediate low budget or zero budget energy saving opportunities. In level 1, recorded consumption data for a period of time is analyzed to understand the consumption patterns. Audit level 2 includes a broader analysis and more of major retrofitting measures proposals. Level 3 audit is the most comprehensive and detailed audit which includes full energy and cost analysis, and usually requires much longer time, tools use, and cost. Precise energy auditing has several advantages: can provide accurate details when proposing conservation opportunities, therefore reducing consumption costs, operational costs, decreasing carbon footprint of buildings, and increasing life span of the mechanical equipment (Deb, Yang and Kwok Wei, 2016). Common energy auditing shortcomings include poor review, insufficient consumption data analysis and benchmarking, overestimating or underestimating costs, poor improvements scope with missing major opportunities, proposing measures with unreasonably long payback periods, long estimated life estimate, and missing life cycle analysis (Widdowson, 2011). Upon conducting energy audit, energy conservation measures (ECMs) are usually proposed. Compared to the 2004 version of the book, ASHRAE 2011 publication provides details about energy auditing methods and tools, revise the guidelines for the 3 audits levels, proposed 25 forms for easy auditing that can be customized as per the cases, which helps in comprehensive understating of buildings' conditions (Kelsey, 2013).

3.2 Methodology in This Research: Selection and Justification

It's often that achieving proper understanding of the topic requires the combination of multiple methods (Denzin, 1978). For the sake of this research a combination of multiple methods, a triangulation of methods, is applied and include several stages:

3.2.1 Stage one: Literature Review

The paper utilizes detailed literature review of international rating systems used in the Dubai, and of papers which discussed the same topic in different or similar contexts as references, as a first stage to gain thorough information about the research question. Literature review has been used in all of the reviewed papers in this study. In this research, four manuals for two international rating systems have been reviewed: LEED and BREEAM, for new buildings versions and existing building in both systems.

3.2.2 Stage two: Online Survey

Second stage involves an online survey using Surveymonkey.com, a very handy free tool to share the first survey online. The survey was shared with 154 people from different backgrounds such as architects, FM professionals, real estate professionals, students, and also office building occupants from other backgrounds. It has 3 sections and one main questions: participant details, rate the main categories using 5 points Likert scale, and add any additional categories. The aim of this short survey to gather public opinion regarding the importance of office building's aspects, hence it is kept short. For Data analysis in this stage, the Median and the Interquartile range (IQR) have been calculated in Excel to understand the spread of the data and if consensus is present among the responses. Using an online survey had many benefits for the author and for the participants. It provided faster and non-costly method of data collection compared to hard copy surveys. It also provided more accurate results as participant had confined options to select from. Although few responses were not complete, it was easier and more convenient to share the survey back to them for revisions request at their suitable time. Additionally, online survey results are easy to analyze as the results are available online all the time, and new responses are being updated in real time continuously.

3.2.3 Stage three: Face to Face Interviews

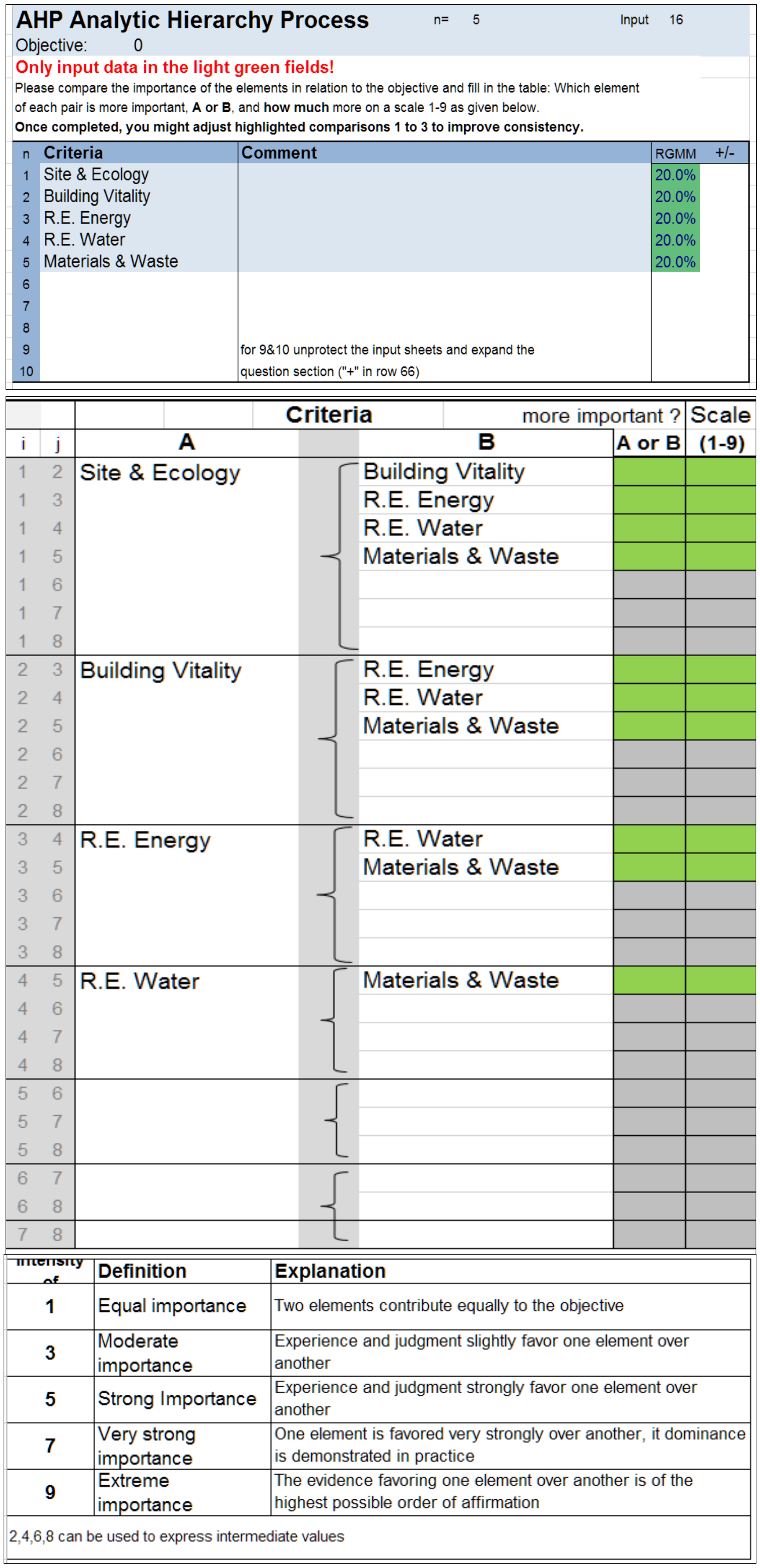
Third stage involved interviewing with experts in sustainability, consultants, procurement specialists, facility management engineers and stakeholder face to face with more specific questions. The author prepared interview main points and questions and shared one day before the confirmed interviews date with the interviewees, to allow for their preparation and familiarize them with the topic. After the interviews the participants were requested to give feedback on the proposed system's criteria and conduct pair wise comparisons between the main categories directly on given laptop. Feedback for the individual regulations has been given in terms of whether the proposed regulation is relevant or not; relevant regulations as per the interviewees judgment has been confirmed and given one point, and irrelevant regulations has been removed. The panel of participants included a total of 15 interviewees from as per the table 3.1.

3.2.4 Stage four: Analytic Hierarchy Process AHP

Fourth stage applied analytical Hierarchy Process (AHP) for the gathered experts' opinions to analyze their feedback and produce a weighting system for the proposed green building rating system. Due to the interviewees' time limitations, the pair wise comparison were conducted only for the main categories to get relevant weighting. AHP is conducted using BPMSG (Business Performance Management Singapore) a Microsoft Excel 2013 AHP template (figure 3.1) created and developed by Dr. Klaus D. Goepel to support business performance and management, provide consultancy services, and conduct training for analytic hierarchy process (bpmsg.com, 2018). The interviewees were requested to do AHP directly on the software template for convenience and accuracy. If there is any discrepancy in the pairwise comparison selection and in case of higher than acceptable consistency ratio, the software will highlight that specific field to be revised directly on the spot, which will be difficult and inconvenient in case of manual filling to resend the file and wait for the revisions. Upon collection of the 15 interviewees' responses, the software automatically calculate and update the summery sheet with the cumulative weightings values as per all the responses, and also calculate the consistency ratio of each response to make sure it is less than 0.1 for the judgment to be acceptable (Saaty, 2008).

Table 3.1 List of Interviewees

Type of Organization	Name	Name of Interviewee	Designation
Government	Dubai Municipality, Building Dept.	Salim Mohammad Zid	Sr. Building Services Engineer
Properties Market	AWRostamani Group	Al Rostamani Real Estate	
		Prakash Aruldhas	Sr. Facilities Manager
		William Harvey	Building Supervisor
		Varghese Varkey	Sr. Project Manager
		Yaseen Akby	Security Manager
		Sladana Nestorovik	House Keeping Manager
		Maryam Shaiba	Project Coordinator
		Mohammad Abbas	MEP Engineer
		Group Procurement Dept.	
		Shweta Sagar	Procurement Lead
		Amani Badr	Procurement
	Juma Al Majed Group	Tarig H. Shalabi	CFO
		Mohammad Sunalla	Chief Property Officer
		Shaukat Ali Mir	Chief Projects Development Officer
FM	Emrill Facility Management	Ilyas Ahmed	Operations Manager
Consultancy	Dimx Atelier	Mujeeb Urahman	Architect



AHP Analytic Hierarchy Process n= 5 Input 16

Objective: 0

Only input data in the light green fields!

Please compare the importance of the elements in relation to the objective and fill in the table: Which element of each pair is more important, **A or B**, and **how much** more on a scale 1-9 as given below.

Once completed, you might adjust highlighted comparisons 1 to 3 to improve consistency.

n	Criteria	Comment	RGMM	+/-
1	Site & Ecology		20.0%	
2	Building Vitality		20.0%	
3	R.E. Energy		20.0%	
4	R.E. Water		20.0%	
5	Materials & Waste		20.0%	
6				
7				
8				
9		for 9&10 unprotect the input sheets and expand the		
10		question section ("+" in row 66)		

i	j	Criteria A	Criteria B	more important ? A or B	Scale (1-9)
1	2	Site & Ecology	Building Vitality		
1	3		R.E. Energy		
1	4		R.E. Water		
1	5		Materials & Waste		
1	6				
1	7				
1	8				
2	3	Building Vitality	R.E. Energy		
2	4		R.E. Water		
2	5		Materials & Waste		
2	6				
2	7				
2	8				
3	4	R.E. Energy	R.E. Water		
3	5		Materials & Waste		
3	6				
3	7				
3	8				
4	5	R.E. Water	Materials & Waste		
4	6				
4	7				
4	8				
5	6				
5	7				
5	8				
6	7				
6	8				
7	8				

Intensity of	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong Importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, it dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation

2,4,6,8 can be used to express intermediate values

Figure 3.1 Pairwise Comparison format in BPSMG Excel Template

3.2.5 Stage five: Case study Analysis

Last stage will be a checking stage after the categories and the regulations have been revised and confirmed. This stage will involve an office building case study selection and checking against the proposed system to test it and accordingly provide rating. A walk-through energy audit is conducted in this stage to collect basic building data .This stage is essential to check the applicability of the proposed regulations and if they reflect all building's aspect in comprehensive and convenient aspect.

3.3 Walkthrough Energy Auditing

3.3.1 Building Information:

Facility name: AWRostamani Head Office

Address: AlIttihad Road, Port Saeed, Dubai, UAE

Facility Manager: AlRostamani Real Estate CO. LLC

Year of Construction: 2000

No. Of floor: Ground + Mezzanine + 9 + 2 Basements

Conditioned Area: 36,772 sqm

Site visit date: 7th .August.2018

Figure 3.2 Case Study Location Map (Google 2018)

3.3.2 Findings & Observations

3.3.2.1 Building Description

AWRostamani Head office has fully glazed façade. Building massing consists of large cube podium (showroom and main reception) and a linear block above (offices), with the main two facades facing east and west. Podium (showroom) has multiple skylights. Main structure is reinforced pre-stressed column and beam/slab system. Showroom has a truss roof system to support the span. There are 3 entrances: 2 pedestrian entrances (Main entrance facing Al Etihad Rd, and back entrance for service), and one vehicles entrance (back leading to the basements). Functional spaces types (other than WC and common corridors) are: showroom, offices, auditorium (2nd floor), and public pantries (in 2nd and 9th floor). Building demographic pattern shows that floors G, M, 1st, 2nd, 6th, 7th, and 9th are only used by AWRostamani departments, while 3rd, 4th, 5th, and 8th are partially leased to external tenants.

3.3.2.2 BMS system

BMS system is provided and maintained by Honeywell Ltd. The BMS system controls AC, lighting, and water consumption. The main EBI server machine computer (Dell PowerEdge T320) is located in the 5th floor BMS room. Field's equipment such as duct air sensors, room sensors, transformers, ducts sampling tubes, CO sensors, humidity sensors, mixing valves, etc. are linked to BMS through DDC (direct digital control) networking approach using LON networking protocols (local operating network). Interface equipment consists of no. 6 master controllers (Excel 10 Zone Manager), no. 1 OpenLink controller for Light management (LITECOM application), no. 1 OpenLink for Chillers, and no. 2 convertors for LITECOM & York Chillers.

3.3.2.3 Air Conditioning

Chilled water AC system is used in the building, York Brand. There are 4 chillers (2master & 2slave) installed at the construction time, they age about 18 years and their expected life span is 15-20 years. Water circulate from 4 pumps located in the roof to the chillers, get cooled, and circulate to the FCUs in each floor. Inside the FCU, the water passes through the coil to cool the air as per the sensors reading and set temperature, and controlled remotely by an outstation linked to the BMS system. Temperature is set at 22-24 degrees. FCU are located throughout the building except showrooms in the ground floor. In Showroom AHUs are used, and in common areas there are FAHU. 2 split units are used in the server rooms in each floor, so as in case of FCU failure server room cooling will remain functioning. CO2 sensors are located in the parking floors (B1 and B2) and. Maintenance of chillers, AHUs, and FCUs are carried by Johnson Controls Inc. are in good condition due to regular maintenance, but major renovation night take place for chillers replacement as they reach there end of expected life span. All actuators, thermostats, fan coil board, and chillers' sensors are linked to BMS system. On Feb-March 2018, Madico SG 20 Solar shield window films have been applied over 776 sqm area of the building's facades (except 9th floor facades due to tenant's rejection) to reduce heat gain, especially from the west facade.

3.3.2.4 Lighting

All lights in common areas and offices used by the company's staff are LED, except in the basement 1 & 2 the exit sign boards are 8 watt electric tubes. There are exterior floor lights for the showroom. All corridors have motion sensors. Lights are off each alternate Friday, and kept on Saturdays. On weekdays external tenants' office lights are operating until 8 pm, then switched off manually by security if not in use. Signboards are controlled by timers. All lights, addressable switches, relay controllers, relays, and master switch panel are connected to BMS through LITECOM application as formerly mentioned. A central battery system is provided in emergency cases.

3.3.2.5 Water

Water consumption is monitored by BMS system. Main water use in in WC and common pantries in each floor. Wash basins' tabs are of Grohe brand (manual type), toilets' water flushing system is by Geberit brand, and urinals are with sensor system Toto brand. Flushing system is more than 15 years old, thus some of the flushing buttons (usually the small button) are not working. Similarly, Toto urinals sensor digital control is getting damaged in several toilets, and replacements are not available as the fixture is very old. No private wet pantries are allowed in offices. Faucets aerators are installed in all taps. Heaters operate manually only in winter.

3.3.2.6 Security

Building is covered by 87 cameras, viewed form the BMS room in the 5th floor. SIRA regulations are the followed standards for the security system. Main system's components are cameras, monitors, and real time DVR (digital video recording), with recording capacity of 31 days. The system is connected to UPS (unity power supply), and also to 3-hours battery backup system in emergency cases. Employees' access for individual departments is granted via fingerprint devices, all linked to IT department database where all fingerprints are saved. There is no access control system in the main entrance and back entrance in the ground floor, only security guards on both entrances.

3.3.2.7 Waste Management

Waste recycling policy was introduced mid of 2017 to the H.O. Two external companies assist in the collection: Emrill (cleaning services) and Averda (waste collection). Aside from the general waste bins located in the main garbage room in the ground floor, there is a total of 12 dual bins (recyclable, non-recyclable) distributed in the building, and 1 triple bin located in the main entrance reception. According to Ms. Ana, House Keeping manager, Emrill cleaners collect the waste from the dual bins to the segregation stations in the basement, from there Averda technician collect and transport to specified segregation locations. Collection by Averda occurs 3 times per month, and a refund amount of approx. 3 AED per ton is paid back to the building management.

Waste paper collection is also introduced in 2016 by the Procurement department for the wasted printing paper. Infofort Green Box initiative is managing the process. There is one “Green box” in each department next to the printing machine. Wasted papers are collected on monthly bases and a report is submitted to the procurement department on the weight of recycled paper, the number of trees saved, water gallons saved, oil gallons saved, and offset CO2 tons. From the starting of the initiative in the H.O to the date, as per Infofort records, a total of 1511 Kg of paper, 25.18 trees, 10577 gallons of water, 579.22 gallons of oil, and 25 t of CO2 are saved.

3.3.2.8 Others

There is total of 6 elevators, Mitsubishi brand: 3 for public use (go up to 8^{th} floor level only), 1 for service (up to 8^{th} level only), and 2 private elevators (1 for group management that goes up to 9^{th} floor and 1 goes up to 1^{st} floor only). Routine maintenance is carried every 1 to 1.5 months by AG MELCO Elevator CO. There are also 2 generators: 1 for the IT dept. and 1 for the rest of the building.

All office PC monitors are put on sleep mode after 15 min of inactivity and after the working hours. Printers and photocopy machines are Energy Star certified. They are put into sleep mode at the end of working day. There are 4 no. of vending machines in the building, operating all the time.

3.3.3 DEWA readings:

Table 3.2 shows the energy and water consumption over the last 12 months as per DEWA green bill. Only payments details were available for August and September 2017, hence the consumption can be calculated backwards based on: the amount paid, the electricity rate, the fuel rate, and the fixed meter service charge of 40 AED, aed 1660 as in the below formula:

Total Electricity price = Electricity Charges + Fuel Charges + Meter Charges + 1660 + Vat**

= [(consumption-6000) X electricity rate) + ((consumption X fuel rate) + 40+ 1660] x 1.05**

= [(consumption-6000) X 0.38) + ((consumption X 0.065) + 40+ 1660] x 1.05**

Electricity rate is 38 fils, and fuel charges are 0.006 aed. The value 1660 is the sum of charges at the 3 first slabs of consumption as per DEWA 4 slab categorization (green, yellow, orange and red in order). As it is always the case to exceed the first 3 (by far), then that amount will always be in all the bills, hence for simplification purposes it is considered a constant.

In the same way, water missing consumption can be calculated based on the total amount paid, water rate, and fuel rate as in below formula:

Total Water price = Water Charges + Fuel Charges + Meter Charges + 750 + Vat**

= [(consumption-20000) X Water rate) + ((consumption X fuel rate) + 4 + 750] x 1.05**

= [(consumption-20000) X 0.046) + ((consumption X 0.006) + 4 + 750] x 1.05**

**VAT applicable only from Jan 2018

Water rate is 0.046 aed, fuel rate is 0.006, and 4 is standard meter charge. Again, water consumption is categorized into 3 slabs as per DEWA (green, yellow, and orange), hence the 750 aed is the sum of the charges of the first two categories as it will be always in the bill.

Missing carbon footprint is calculated using 0.44 as electricity conversion factor as per DEWA. Formula is as below:

Carbon Footprint = Electricity (KWH) X Electricity Conversion Factor

Data highlighted in red are calculated using the above generated formulas. All data for November 2017 is missing, remaining months data is available as per table 3.2. To have a fair comparison of the change in electric consumption and whether there are any improvement, consumption will be used instead of the total paid amount, as 2018 payments include 5% VAT. An example is August in 2017 to August 2018. Amount paid is 291,518 aed and 292,310.03 respectively, however the actual consumption is 656,400 kWh and 626,900 kWh respectively. This indicates a reduction by 29,500 kWh, which is 4.5%, from the last year. However, the consumption in the month of July 2018 increased by 5% from last year (27600 kWh).

The general trend of the consumption is high levels at the months of August and September, then declines gradually to its minimum in February and March 2018 (Figure 3.3).

Table 3.2 DEWA Bill consumption details

Month	Electricity			Water		Sewage (AED)	Carbon Footprint (kgCO2e)
	Consumption (KWh)	Fuel Surcharges (Cons*0.065 fils)	Total Price (AED)	Consumption (IG)	Price (AED)		
July 017	576,800.00	37,492.00	268,900.80	122,572	6,518.13	1,225.72	253,792.00
August 017	656,400.00	42,666.00	291,518.00	142,666	7,252.64	1,426.66	288,820.00
September 017	721,600.00	46,904.00	320,532.00	139,362	7,080.82	1,393.62	317,500.00
October 017	606,400.00	39,416.00	269,268.00	149,637	7,615.12	1,496.37	266,816.00
***November 017**		0.00					
December 017	401,200.00	26,078.00	117,954.00	159,560	8,131.12	1,595.60	176,528.00
January 018	330,300.00	21,469.50	148,056.80	150,318	7,714.30	1,503.18	145,332.00

February 018	318,800.00	20,722.00	148,350.30	155,744	8,329.31	1,557.44	140,272.00
March 018	296,700.00	19,285.50	138,024.08	150,525	8,044.37	1,505.25	130,548.00
April 018	356,800.00	23,192.00	166,105.80	162,430	8,694.38	1,624.30	156,992.00
May 018	418,600.00	27,209.00	194,981.85	152,584	8,156.78	1,525.84	184,184.00
June 018	529,200.00	34,398.00	246,659.70	122,604	6,519.87	1,226.04	232,848.00
July 018	549,200.00	35,698.00	243,814.00	144,813	7364.28	1,448.13	241,648.00
August 018	626,900.00	40,748.50	292,310.03	143,050	7,636.23	1,430.50	275,836.00

* Missing/ not available data.

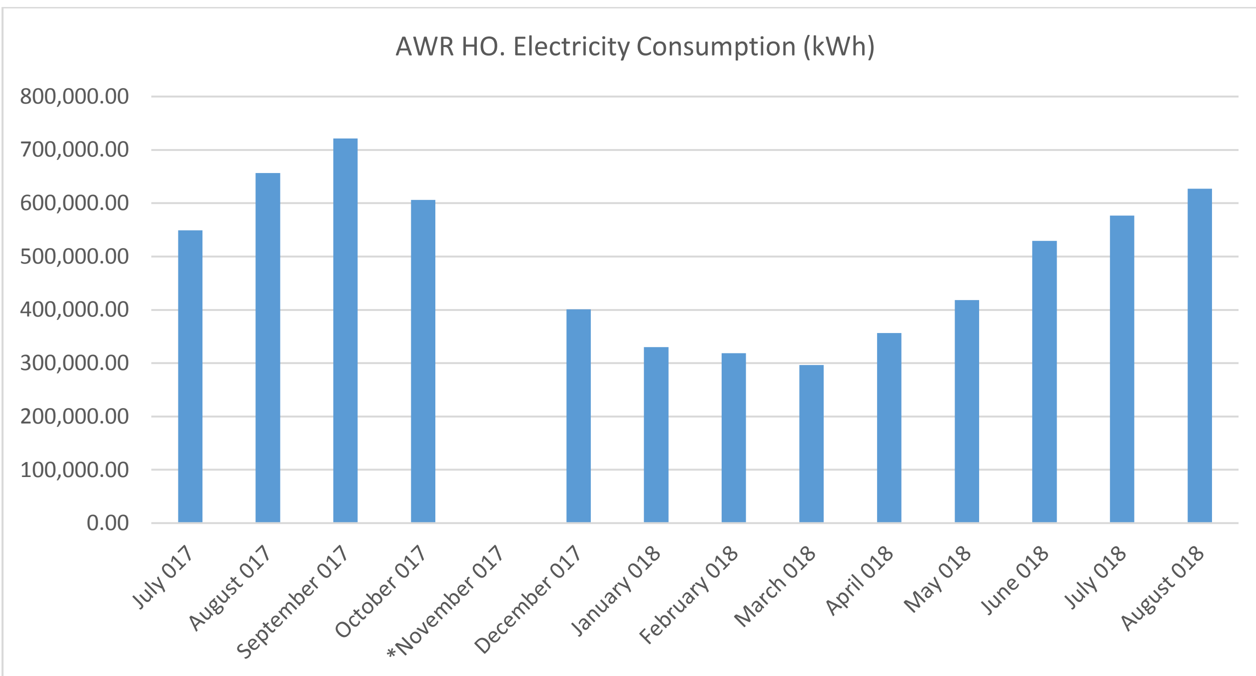


Figure 3.3 Monthly Electricity Consumption in KWH from July 2017 to August 2018

Chapter 4: Discussion & Results

4.1 Results Overview

Upon completion of surveys and interviews stages, the initially proposed main categories and regulations has been revised. The main agreement between the interviewed professionals is that management is the key in all aspects of existing buildings management. Therefore, Occupants' management category was removed, and one occupant management and satisfaction regulation has been added in all categories. The intention is to emphasize the importance of occupant management in each category by the relevant means instead of having one separate category for it. In terms of regulations initially there were 68 regulations, the one regulation under occupant management category was removed, and 5 relevant regulations added in the other categories. Additionally, 1 regulation from Site and Ecology, 2 regulations from Building Vitality (400), one from Resource Effectiveness: Energy (500), and one from Resource Effectiveness: Materials and Waste (700) were considered too specific, not applicable, or incorporated already within other regulations, therefore were removed. The result is 5 categories and total of 67 regulations. Figure 4.1 represents the proposed system's structure, and table 4.1 at the end of this section shows the proposed regulations and its comparison with BREEAM and LEED as per the literature review.

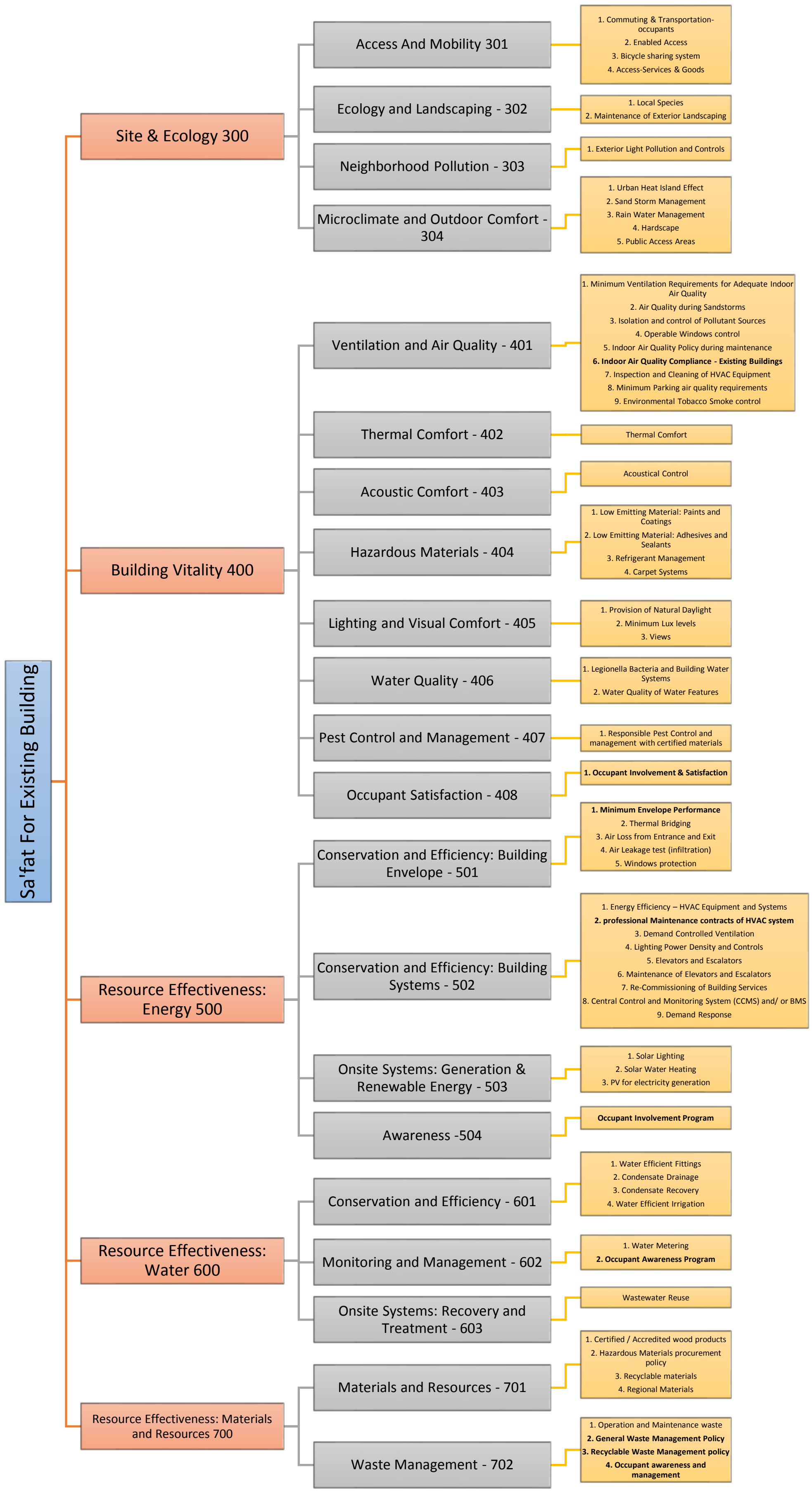


Figure 4.1 Proposed Sa'fat for Existing Buildings (source author)

4.1.1 Discussion of Public Survey Results

Surveys have been conducted both online and in person to increase the rate of participation. A total of 63 usable responses, 46 from online survey and 17 from physical survey of the selected case study occupants, have been recorded and utilized in this stage to understand the categories level of importance from occupants' point of view. Survey's results indicate a higher importance for Building Vitality first and Energy second, followed by Water in the third place, Site & Ecology fourthly and finally Materials and Waste (figure 4.2). The interquartile range for Site & Ecology and Building Vitality was 1, highlighting a low spread of the date between the values of 2 and 3 for Site & Ecology, and values 4 and 5 for Building Vitality. The highest spread of Data was for Water category with an IQR value of 3 indicating a polarization of opinion regarding the water category value. A possible reason for this polarization is that some of the participants looks at the importance of water category from environmental perspective, while others consider it from costs viewpoint, and also with limited period of interaction in a typical office work space. The results suggests that the most important category from occupants perspective is Building Vitality, as it addresses critical issues of indoor working environment such as light, thermal comfort, that have direct effect on productivity and employees' comfort. Although Energy category also has a high rating value, however its importance comes mainly from a financial point of view rather than from environmental. This is due to the limited access and interaction tenants have with actual main buildings assets, and also to the fact that in the scenario of the selected case study the electricity expenses are carried by the building owner.

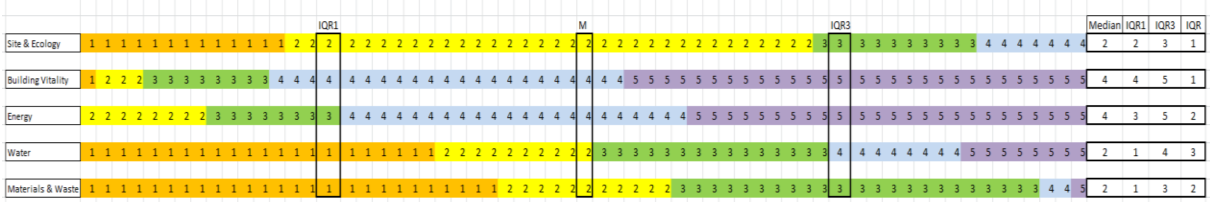


Figure 4.2 survey responses, with Building Vitality and Energy taking most of the higher rating (purple for 5 and blue for 4.

That being said, more interest in energy saving is expected to come from the building management rather than individual tenants. The average score of each category in order is as follows: Building Vitality 4.19/5, Energy 4.016/5, Water 2.523/5, Site & Ecology 2.175/5, and Materials and Waste 2.064/5.

4.1.2 Weightage of Categories

The Analytic Hierarchy Process was conducted upon interviews with 15 participants from different fields. AHP produced a weighting system for the five categories (sections) as per the experts consolidated opinions. Figure 4.3 shows weighting values from the AHP process. Resource Effectiveness: Energy: 500 section come first with the highest percentage of 36.6% among all categories, followed by Building Vitality: 400 with 26.7 % in the second place, then Resources Effectiveness: Water 600 with 18.6%, Site & Ecology 300 with 9.3%, and last comes Materials and Waste 700 with 8.8%. The highest consistency ratio (CR) for individual participants was 0.1 and the lowest was 0.03, whereas the combined CR value was 0.037, demonstrating acceptable consensus among the responses (Saaty, 2008).

	Criterion	Comment	Weights	+/-
1	Site & Ecology		9.3%	0.6%
2	Building Vitality		26.7%	2.2%
3	R.E. Energy		36.6%	2.0%
4	R.E. Water		18.6%	1.5%
5	Materials & Waste		8.8%	0.6%
6			0.0%	0.0%
7			0.0%	0.0%
8			0.0%	0.0%
9		for 9&10 unprotect the input sheets and expand the	0.0%	0.0%
10		question section ("+" in row 66)	0.0%	0.0%

Eigenvalue		Lambda: 5.010	MRE:	7.2%
Consistency Ratio	0.37	GCI: 0.01	Psi: 6.7%	CR: 0.2%

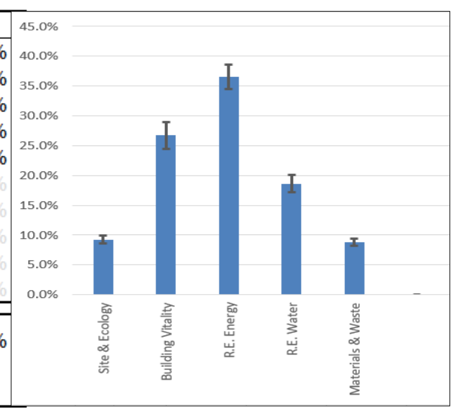


Figure 4.3 and 4.4 AHP weightage for each category

Confirmed Individual regulations other than the prerequisites, as per the interviews, have been weighted one point each. Thus, total number of achievable points per section will be as follows: 12 points for Site & Ecology 300, two prerequisites and 20 possible points for Building Vitality 400, three prerequisites and 15 points for Resource Effectiveness: Energy 500, one prerequisites and 6 points for Resource Effectiveness: Water 600, and three prerequisites and 5 points for Materials and Waste 700, with a total sum of 58 possible points in a straight additive process.

4.1.3 Score Calculation and Classification Proposal

As in the case of BREEAM and LEED, it is more convenient to use a score scheme out of 100%, thus an additional percentage formula need to be applied after the additive points' process as in formula below for each category individually, making use of the AHP weightage results:

Final Category score = (Achieved points/ Total Possible Category Points) x Category AHP Weight

Where "achieved points" are given by the Assessor, "total possible category points" are constant for each category, and "category AHP weight" is the constant weight from the AHP. For Flexibility, convenience and to encourage the use of the system by buildings' owners, the requirements of each Sa'fa has not been specified by the achievement of specific regulations, as it is the case in of Sa'fat for New Buildings, however, a total of nine regulations have been set as prerequisites to insure main concepts are met. In Sa'fat for existing office buildings, a minimum of 50% of the possible regulations in each category is required to pass general requirement level including the prerequisites. IF the total value is below 50% in the total score then the building is considered unqualified and hence will not receive certification. Achieving a total score from 50-60 qualifies for Bronze Sa'fa certification, a score between 61-74 qualifies for Silver Sa'fa certification, between 75-84 qualifies for Gold Sa'fa rating, and score above 85 qualifies for Platinum Sa'fa certification.

4.2 Discussion of AHP and Interviews Results

4.2.1 Site & Ecology 300

Site & Ecology gained a total weight of 9.3% in the AHP results, making it the second last before Materials & Waste category. The proposed Site & Ecology section has five chapters and 12 regulations, among them 1 chapter and 7 regulations are new (not in the Sa'fat for new buildings). Ten of the AHP participants rated Site & Ecology with less than 10% of the total weight, four participants rated between 10% - 20%, and one rated between 20% - 30%.

Site and Ecology category addresses transportation, users' movement in the outdoor environment to the facility/ building. The Location of Dubai in Hyper-arid climatic zone presents high temperature ranges, low rainfall higher evaporation rates, higher humidity levels (Paul, Tenaiji, and Braimah, 2015), which are discouraging factors to pedestrian movements and increase reliability on vehicle transportation). Bicycle sharing system can be used between September to March potentially as the weather is cooler, and is being supported by Roads and Transport Authority in Dubai (RTA, 2018). In hotter summer seasons alternative to biking should be provided as biking can cause sun strokes, dehydration, and fainting.

15 out of 23 surveyed employees working in the selected case study office (located in Deira) live in Ajman, Sharjah, Dubai Nahda, and Qusais area. A one way 10 Km distance, which can typically take less than 7 minutes, takes up to 55 to 1 hour daily due to traffic patterns. Provision of staff transportation, working from home option in specific day(s), etc. will help in reducing carbon footprint, increase time efficiency, and promote environmental awareness. Additionally, improvement of landscape and walkways by proper landscape, way finding, lighting, water features, and walkway safety are ways that promote walking and ultimately reduce transport related environmental impacts (Sabbagh, Yannas, and Cadima, 2016). Both LEED and BREEAM discuss alternative transportation options when possible

such as provision of staff transportation, working from home option in specific day(s), etc. that will help in reducing carbon footprint, increase time efficiency, promote environmental awareness. However, Climatic conditions that will have large effect on people readiness to adapt options like walking and bicycles use are not clearly considered, possibly because the LEED and BREEAM are intended for international use.

4.2.2 Building Vitality 400

Building Vitality received 26.7 % rating among all the categories, more than ¼ of the weighting, making it at the second place after the category "Resource Effectiveness: Energy". The proposed Building Vitality section is composed of 8 chapters and 22 regulations among which 2 chapters and 8 regulations are new. Eight participants rated Building vitality above 30%, five between 20-30%, and two below 10%, showing an agreement on the high importance of the category among the others.

Building Vitality category mainly addresses issues of indoor environmental quality based on minimum related systems requirements and occupants' feedback. These issues include air quality, thermal comfort, humidity, acoustical control, lighting comfort, water quality, and occupant satisfaction feedback (Ibrahim, 2015). Building Vitality is very important to address, as an estimate of 90% of an American's life is spent indoor (EPA, 2001). This percentage is likely to be higher in the case of Dubai due to severe climatic conditions. However, pollutants in indoor is also estimated to up to 10 times more than outdoor (Ching-boon, 2016). Additionally, sandstorms in Dubai occur each year during late winter and summer months. According to Cherian (2018) sand storms in UAE can cause allergic rhinitis, inflammation of nasal canals, and more exposure to lung diseases. Sandstorms bring fine dust through doors and windows frame that stays in the air before it settles. Filters in HVAC systems need to be installed and maintained to prevent clogging. Therefore, sandstorm needs to be addressed with other pollutants in assessing IAQ as it adds to the pollutants in the indoor space. Air quality during sand storms point need to be look at together with operable windows control (under chapter 401), and maximum air flow rate of 10 m3/m2 at 50 Pa (under Resource effectiveness: energy, chapter 501). ASHRAE 62.1 specifies minimum ventilation rates for indoor environment to minimize associated health risks on one side, and maintain energy efficiency of the HVAC systems (Muller, 2014). Additionally, minimum parking air quality requirements regulation is included for the same reasons.

Thermal comfort target in spaces occupied with many users is a challenging goal, as it is subject to the changing nature of human perception (Kontes et al., 2017). Achieving thermal comfort has direct and indirect effects on operations, costs, productivity and consequently end users satisfaction (Morales-Valdés, Flores-Tlacuahuac and Zavala, 2014; Fisk and Rosenfeld, 1997). The use of BMS and its related components monitors and manages changes in temperature to maintain standard comfort levels, yet due to the differences between indoor and outdoor temperatures, different cultures and nationalities, difference in gender and age, differences in occupations and work nature in a multitenant working building complaints will still arise. LEED v4.1 addressed this issue by assigning 50% of the indoor environmental quality points to occupants' satisfaction in general; however it does not have separate points for thermal comfort specifically as it was the case in LEED v4. In addition to the occupants' satisfaction score, LEED V4.1 "indoor environmental quality" is measured based on CO2 score, and VOC score.

Lighting and Visual comfort also play a big role in occupants' productivity and overall satisfaction (Giarma, Tsikaloudaki and Aravantinos, 2017). The section existed in Sa'fat for new buildings, and there is a reference to few values under section 500 Resource effectiveness: Energy only. An elaboration on these data can be recommended to include a full section for common spaces, offices, special spaces, schools, etc. as guidance for performance efficiency and design. Provision of daylight is desirable in certain seasons in Dubai but also should be controlled to prevent/ minimize glare and heat gain via direct daylight.

Responsible and integrated pest control and management (IPM) is an environmentally friendly approach to control pests in both agricultural and non-agricultural contexts (Alam et al., 2016). IPM in buildings focuses reducing the factors that encourage pests' growth such as food, waste, and water, by the means of several elements that includes building maintenance, regular sanitation, use of chemicals, and education of buildings occupants (Mitchell, n.d.). As per market study conducted by Rentokil Initial PLC, a commercial pest control company (2018), the demand for regular pest control is growing in MENA region due to the population growth, supply chain business growth such as food related businesses, and increasing governmental regulations on environment, health, and food safety (Rentokil Initial PLC, 2018). According to Mahmood Rasheed, Imdaad chief executive, majority of pests' infestation complaints are from cockroaches and bedbugs, followed by ants, spiders, and lizards and snakes (Samoglou, 2015). Pests requires professional engagements to insure maximum control without effecting humans' health or existing natural habitat, as the use of poor, unlicensed chemicals by non-professional can lead to serious health issues and in some cases to death (Khaleej Times, 2017). This regulation is addressed in LEED for indoor environment and in BREEAM with emphasis in maintaining any existing surrounding habitat.

4.2.3 Resource Effectiveness: Energy 500

Resource Effectiveness: Energy 500 received more than 1/3 of the weight in the AHP process, which making it the most important category with 36.6% of the total weight. Three participants rated Energy with more than 40% of the total, five gave a rating between 30-40%, six between 20-30% and only one rated below 20%. The proposed Energy section has four chapters and 18 regulations, among which one chapter and 6 regulations are new.

Resource Effectiveness: Energy 500 section targets 4 main areas of building evaluation: 1) building assets and components such as BMS, HVAC, Lighting, vertical circulation, security, etc.; 2) building envelope performance, 3) the presence of any renewable energy systems and 4) any occupant awareness and management programs and policies.

Proper maintenance and retrofitting of building envelope is a key point to maintain as much as possible from the cooled air inside the building. Both BREEAM and LEED refer to ASHRAE 90.1 for minimum envelope's requirement. As per ASHRAE 90.1, climate zones 1 and 2 u-values requirements are assumed for use Indian subcontinent, Middle East, and Africa. U-values for wall, roof, and floor for non-residential are 0.7, 0.27-0.36, and 0.61-1.83 respectively w/m^2.K. Dubai Green building regulations (new buildings) minimum U-values are 0.3, 0.57, and 0.57 w/m^2.K for roof, wall, and floor respectively. Comparatively, Abu Dhabi International Energy Code set higher U-values standards for roof and wall of 0.221, 0.329 and lower standard for floor of 1.828 w/m^2.K respectively for commercial buildings. U-values regulations for commercial buildings across other GCC countries vary for roof from 0.22 w/m^2.K in Riyadh to 0.437 w/m^2.K in Doha, and for wall from 0.57 w/m^2.K to 0.857 w/m^2.K in Riyadh and Muscat, while floor has the same U-value standard of 1.825 w/m^2.K in Doha, Muscat, and Riyadh (SASO, 2017; DUPM, 2018; and DGBR, 2015). In AL Sa'fat for new buildings, minimum roof u-value is set to 0.3 w/m^2.K for all four sa'fat levels, while external wall minimum u-value is 0.57 w/m^2.K for bronze and silver Sa'fa and 0.42 w/m^2.K for Golden and Platinum Sa'fa. For glazing components, critical perimeters include thermal transmittance values (U-value), light transmission (LT), and solar heat gain coefficient (SHGC), and the percentage of glass to opaque elements in the building's facade. Windows and curtain walls treatment with automatic or manual blinds and/ or solar films to reduce heat gain through windows. Minimum glazing u-value in Sa'fat ranges from 2.1 w/m^2.K (when glazing area is less than 40% of the total area) to 1.9 w/m^2.K (when glazing is more than 60%). Application of low emissivity solar films can improve the glazing u-value by up to 38%, and is considered a cost-effective retrofitting strategy to reduce cooling loads (IWFA, 2014). Improving glazing specs and U-value by applying glazing treatment reduces heat gain (Shields, 2017). LEED v4 only discuss blinds to control glare, while BREEAM emphasizes on glare and maximizing daylight. Similarly, daylight control is of crucial importance as it affects users performance by boosting productivity and health, however, uncontrolled daylight brings excessive heat gain and also may also results in glare (Jha, 2016). For these factors, minimum solar heat gain coefficient and U-values are set in accordance with National Fenestration Rating Council (NFRC) and ASHRAE 90.1. lower u-values and SHGC are recommended for warm climate, however, while more reduction in SHGC tend to have positive effect on cooling loads, reductions in u-value tend to have a threshold after which more reduction become ineffective and make less economic sense (Tarabieh, Mashaly and Rashed, 2017).

Proper insulation of weak points and joints of different materials, and regular testing helps in detecting leakage points and treating them accordingly. Furthermore, minimization of treated air loss from automatic sliding doors entrance through use of vestibule entrance if possible, and installation of air curtains. It is worth mentioning that BREEAM specifies minimum infiltration rates of 2.5 m3/ m2 at 50 Pa. On the other hand, minimum infiltration rate value given by Sa'fat for new buildings is 4 times more, reflecting higher tolerance in regulations and a level of consideration of the still growing local market and labors skills (Francoz and Wang, 2017).

Professional maintenance contracts for major building’s systems such as HVAC system, elevators components, lighting, and security should be carried out routinely by specialists. Recording of components’ age, specs, power, and monitoring their energy consumption through building management system BMS assist in tracking and detecting problems when emerging, planning preventive maintenance programs, and has a direct effect on the building life span (Pereira, Rodrigues and Rocha, 2016; and Mydin, 2016).

4.2.4 Resource Effectiveness: Water 600

Resource Effectiveness: Water weighted 18.6% in the AHP results, coming in the third place after Resource Effectiveness: Energy and Building Vitality. Four participants marked water category with less than 10%, six gave it between 10%-20%, two between 20%-30%, and three between 30%-40%. The proposed system added one new chapter and one regulation, with a total of 3 chapters and 7 regulations.

Water category weights 15 out of 100 possible points in LEED v4.1, it comes third in importance after Energy and Atmosphere and Indoor Environmental Quality, respectively. In BREEAM 3-parts assessment though, water comes second last in part 1 with only 8%, and last in both part 2 and 3 with 5.5% and 3.5% respectively. these weights do not reflect many challenges facing water management in UAE such as groundwater scarcity (less than 100 mm/year rainfall (Masdar, 2018), high salinity and reliability on desalination for potable water production, limitation in treating and re-using waste water, and inefficient existing water consumption patterns in Dubai and UAE in general (Masdar, 2018; Dajani, 2018; Paul, Tenaiji, and Braimah, 2015). Water category in the proposed system takes almost 1/5 of the total weights showing higher sensitivity towards water than LEED and BREEAM compared to the other categories. The survey results analysis indicates and IQR of 3 for Water Efficiency. This indicates that the respondents' opinions were polarized rather than centralized; half of the responses gave a value of 1 (lowest importance) for water efficiency, while most of the other half rated water efficiency as 4 or 5 (high importance). As per Mr. Salim, higher weightage of energy category compared to water can be justified by the fact that desalination process requires high energy, which adds to the weight of energy category more than water. However, as mentioned formerly one cannot neglect the inefficient water consumption patterns in Dubai. There are governmental efforts to manage water demand and reduce pressure by implementing initiatives and policies. These include education programs for the young generation, using aquifers for fresh water storage, applying policies for extracting ground water, and looking for more energy saving technologies for water desalinization (WETEX, 2017). Aside from water saving fixtures and technologies, the need for occupants awareness program becomes vital as part of facility management programs to educate both FM employees and building occupants.

4.2.5 Resource Effectiveness: Materials and Waste 700

Resource Effectiveness: Materials and Waste 700 received the lowest weight from the AHP, with less than 10% of the total percentage. This section has two chapters and a total of eight regulations, among which 3 are new. 10 participant rated Materials and resources below 10%, three between 10-20%, and two above 20%.

Materials & Waste section addresses regional and sustainable materials procurement, recyclability of purchased materials, procurement of environmentally hazardous materials, general waste management, and occupants awareness programs and policies to reduce, reuse and recycle.

The use of regional materials reduces shipment cost, promotes local market, enhances materials adaptability to local climate, and allows greater purchase control and more flexibility (Smith, 2018).

Additionally, one of the challenging points is the handling, management, and disposal of hazardous materials. Both systems discussed material purchasing concepts that might reduce harm on environment which result from purchase and use. LEED require a facility management policy to maintain good condition of materials, safely install them and dispose of them with minimum environmental impact. BREEAM discussed details such as needs, quantities, acceptable suppliers, efficient use by end users, robustness of materials, minimizing packaging, etc. Management policies should specify safe and regular disposal of operational waste resulting from refurbishment, reactive maintenance or planned maintenance such as lights, carpets, mechanical systems elements, etc.

without affecting IEQ and occupants' experience. On the other hand, building management should also have a clear disposal and reuse policy of day to day waste in accordance with Dubai municipality in terms of waste disposal points such as main garbage room, and floor by floor garbage rooms minimum standards, and shared with occupants as part of the awareness program. Special bins for recyclable materials and providing a regular report for amount of recycled waste and estimated saved resources such as trees and oil, and CO_2 off set can play a role in both awareness program and also as a marketing tool.

Table 4.1 Al Sa'fat for existing buildings regulations comparison with LEED and BREEAM

Section	chapter	regulation Title	Notes 1
Site & Ecology 300	Access and Mobility -301	Commuting & Transportation-occupants	in Both
		Enabled Access	Not in any, existing
		Bicycle sharing system	in BREEAM only, was in LEED previous v
		Access-Services & Goods	Not in any, partially addressed in BREEAM
	Ecology and Landscaping - 302	Local Species	in Both, existing
		Maintenance of Exterior Landscaping	in BREEAM only
	Neighborhood Pollution - 303	Exterior Light Pollution and Controls	in Both, existing
	Microclimate and Outdoor Comfort - 304	Urban Heat Island Effect	in LEED only, existing
		Sand Storm Management	Not in any
		Rain Water Management	in Both
		Hardscape	Not in any, Existing
		Public Access Areas	Not in any, Existing modified
Building Vitality 400	Ventilation and Air Quality - 401	Minimum Ventilation Requirements for	in Both, existing

		Adequate Indoor Air Quality	
		Air Quality during Sandstorms	Not in any
		Isolation and control of Pollutant Sources	in Both, existing
		Operable Windows control	in BREEAM only, modified
		Indoor Air Quality Policy during maintenance	in Both
		Indoor Air Quality Compliance - Existing Buildings	in Both, existing
		Inspection and Cleaning of HVAC Equipment	in Both, existing
		Minimum Parking air quality requirements	Not in any, existing modified
		Environmental Tobacco Smoke control	in LEED only, existing
	Thermal Comfort - 402	Thermal Comfort	In BREEAM only, existing
	Acoustic Comfort - 403	Acoustical Control	In BREEAM only, existing
	Hazardous Materials - 404	Low Emitting Material: Paints and Coatings	in Both, existing
		Low Emitting Material: Adhesives and Sealants	in Both, existing
		Refrigerant Management	in Both
		Carpet Systems	existing
	Lighting and Visual Comfort - 405	Provision of Natural Daylight	in BREEAM, existing
		Minimum Lux levels	in BREEAM only
		Views	existing, not in any

	Water Quality - 406	Legionella Bacteria and Building Water Systems	in BREEAM only, existing
		Water Quality of Water Features	in BREEAM only, existing
	Pest Control and Management	Responsible Pest Control and management with certified materials	in Both
	Occupant Satisfaction	**Occupant Involvement & Satisfaction**	in Both
Resource Effectiveness: Energy 500	Conservation and Efficiency: Building Envelope - 501	**Minimum Envelope Performance**	Not in any, existing.
		Thermal Bridging	not in any, existing
		Air Loss from Entrance and Exit	not in any, existing
		Air Leakage test (infiltration)	in Both but different expressions, existing
		Windows protection	not in any
	Conservation and Efficiency: Building Systems - 502	Energy Efficiency – HVAC Equipment and Systems	
		professional Maintenance contracts of HVAC system	
		Demand Controlled Ventilation	existing
		Lighting Power Density and Controls	
		Elevators and Escalators	not in any, existing
		Maintenance of Elevators and Escalators	not in any
		Re-Commissioning of Building Services – Existing Buildings	existing
		Central Control and Monitoring System (CCMS) and/ or BMS	in BREEAM, existing
		Demand Response	in LEED only

	Onsite Systems: Generation & Renewable Energy - 503	Solar Lighting	in BREEAM, existing is solar water heating and electricity generation
		Solar Water Heating	
		PV for electricity generation	
	Awareness -504	**Occupant Involvement Program**	
Resource Effectiveness: Water 600	Conservation and Efficiency - 601	Water Efficient Fittings	in BREEAM, existing
		Condensate Drainage	existing, not in any
		Condensate Recovery	existing, not in any
		Water Efficient Irrigation	in LEED, existing
	Monitoring and Management - 602	Water Metering	in Both, existing
		Occupant Awareness Program	in BREEAM
	Onsite Systems: Recovery and Treatment - 603	Wastewater Reuse	existing
Resource Effectiveness: Materials and Waste 700	Materials and Resources - 701	Certified / Accredited wood products	in BREEAM, existing
		Hazardous Materials procurement policy	in Both with different scope
		Recyclable materials	in Both
		Regional Materials	in Both
	Waste Management - 702	Operation and Maintenance waste	
		General Waste Management Policy	in Both, existing in different terms
		Recyclable Waste Management policy	
		Occupant awareness and management	

4.3 Case Study Assessment

AWRostamani HQ Building in Deira, Dubai, has been selected to be assessed by the proposed system. This step is conducted to ensure that the proposal covers all the aspects of building assessment. The main site walk-through audit has been conducted on 7th of August 2018, and two more visits have been carried out for more clarifications at a later date. Based on the data collected, the building has been awarded a score for each category (Table 4.2), and detailed awarded points check list is in Appendix E.

As per the proposed scheme, AWRostamani achieved 62.32 % score, which qualifies it for Silver Sa'fa certification. The site visits results shows regular maintenance plans and also periodic retrofitting plans. In terms of site & Ecology, the building achieved the minimum requirement of 50% of possible points. There are limited plantation and landscaping area due to the congested commercial nature of Deira Port Saeed area. Clear accesses are provided for pedestrian, vehicles, and services. The Building management provides shared transportation services for specific categories of technicians and staff, reducing both the load on the employees and on environment. All Exterior lights are controlled by timers. There is no strategy for collecting rainwater for reuse.

The building Vitality of AWRostamani achieved 14 out of 20 possible points. There is an overall satisfaction about the indoor environment quality by the tenant, and well control over the building systems via the BMS system. Manual testing is also conducted from time to time for air temperature, CO2 levels, IAQ, and lighting levels through the use of thermal cameras, laser guns, CO2 meter, and other in house tools and kept for FM regular use. There is no specific strategy designed to deal with sandstorm pollution, and there are no designated spaces for smoking. A specialized external team for indoor plantation, pest control and cleaning services as part of annual House Keeping contracts (Averda, Emrill, and Plantscape). Each office has a minimum of one natural plant to enhance the aesthetics. Plenty of daylight filters to the office spaces from the full glazed facades, which raised the issue of overheating and increased cooling load during summer months. Hence, the thermal performance is improved through the application of solar film and manual blinds. As a result, electricity consumption reduced as per the records by up to 4% (In August 2018 compared to August 2017). Improved in the Glazing U-value is estimated to be 1.83 w/m^2.K after the application of the solar films according to the elemental performance data (Madico, 2016), a verification energy model can be conducted as a second step to calculate the actual load reductions due to the film installation. Occupant satisfaction sheet is shared regularly to the offices as part of the auditing process conducted by the Internal Audit Department of the group.

Table 4.2 Case study assessment score

Section	Possible Points	Achieved Points	AHP Factor%	Final Weight%
Site & Ecology	12	6	9.30	4.65
Building Vitality	20	14	26.70	18.69
RE: Energy	15	10	36.60	24.4
RE: Water	6	3	18.60	9.30
RE: Materials & Waste	5	3	8.80	5.28
Total	**58**	**36**	**100.00%**	**62.32**

Annual maintenance contracts with companies such as Honeywell, Emrill, and Johnson Controls are awarded for major building components especially HVAC, vertical circulation, and BMS. Thermal sensors, variable frequency drives, lighting motion sensors, etc., are activated and in good conditions. There is no presence for renewable energy resources, however plans and offers for the installation of PV solar panels on the podium roof are being discussed and relative documents have been shared with the researcher, and are in progress in other AWRostamani AACO related buildings.

All water taps have been fitted with faucet aerators, and a plan for replacement with sensors is being studied. There are no waste water recycling plans or condensate recovery so far. Water consumption is also monitored through BMS along with lighting and HVAC. There are several awareness posters at a small scale in development stage.

Procurement of items and materials is focused on local materials as a first option. Green certified procurement is desired but not mandatory. There are also several waste recycling programs by procurement team and also the soft services specialist Ms. Ana such as office paper recycling, and segregation bins. Overall, the building has several sustainability policies implemented at different levels.

4.4 Assessment of Concept Comparison with LEED

LEED Location and Transportation category has one prerequisite of surveying tenants annually in terms of their transportation modes. AWRostamani HO is occupied by more than 50% of AWR employees, therefore most of the transportation data is recorded by Human Resources Department. Approximately 95 workers are using company provided shared transportation, and 55 occupants use company provided individual vehicles. Less than 10 either walk or use bicycles. Analyzing the collected data to get CO2 footprint per occupants will be the following step to achieve this category's points. In Sustainable sites category, only light pollution reduction measures are in place by the use of timers, mainly for energy saving purposes. There are no rainwater management plan or heat island reduction. The building is covering the full plot limit and hence exterior spaces are under Municipality ownership. For water Performance category, all water consumption data are recorded in BMS system, thus similar to Transportation Performance score, an analysis of the collected data and calculation of regulation score is to be pursued. Annual Energy Consumption has been provided in chapter 3 (Methodology) section 3.2.5 (Case Study Analysis). The required data to achieve Energy and Atmosphere prerequisites and score depends on annual energy consumption, Gross floor area, weighted occupancy, weighted operating hours, outside air temperature and location details. All of the required data are documented except weighted occupancy, which requires an occupancy survey to get actual number. No grid harmonization or enhanced refrigerant management concept are present, consequently these categories 2 points are lost. In Materials and Resources category, both Purchasing Policy and Facility Maintenance and Renovation Policy prerequisites are active and achieved, and waste performance is already in operation. However, Purchasing regulation need to be developed as per LEED guideline to include bio-based tested products, paper and wood certified products, and cradle to cradle certified products. Indoor Environmental Air Quality is monitored by BMS and manual testing as mentioned earlier, and green cleaning policy is taken place but still controlled by budget. As smoking indoor is prohibited by DM, the prerequisite of Indoor Environment Quality performance is achieved by default, yet there are no smoking designated areas within the building. There are no innovative techniques specially used in the building, and also no LEED accredited professionals involved in the building's improvement plans at the moments. Nevertheless, the building FM team is aiming to improve the buildings performance within a limited approved OPEX budget and the next step is to involve Green building specialists to evaluate the improvements results in detail.

Chapter 5: Conclusion

5.1 Conclusion

This paper aims to propose a rating system for existing office buildings in Dubai, derived from the recently developed Al Sa'fat green building rating system for new buildings. The goal of the study has been achieved through the triangulation of several methods including literature review, online and physical surveys, interviews, Analytic hierarchy process, and finally case study assessment. The paper also compared the manuals of new buildings and in-use international rating systems currently used in Dubai as a tool to understand how each system differs in terms of its new building and existing /in-use versions. The main drive of the study is to compose a rating system that reflects specific local concerns such as water issues and climate characteristics, through collecting both public and experts opinions to support the proposal. An assessment stage of an existing building followed to test the proposal comprehensiveness and receive feedback from the building's management team on the same.

5.2 Limitations and Challenges

As it is the case in almost every study, several limitations faced the author during the writing of this paper. This is due to the limited time period of the paper and the nature of the methods used. The main challenge was in the survey stage to collect time efficient reliable and usable responses. Out of 150 sent online surveys, a number of 61 responses received in a period of 10 weeks from which only 46 were usable, a rate less than 50% of shared surveys. To increase the reliability of response, more physical surveys have been conducted in 2 days period (Thursday and Saturday) in the assessed case study. The physical survey was shared with 24 tenants, from which 17 participated.

Another challenge was in accepting and scheduling the interviews conveniently with the experts and professionals. In one case, two professionals from the same company accepted the interview invitation but requested to be conducted at the same time.

Additionally, there were few inaccessible data in the case study walkthrough due to security reasons such as the location and specs of cameras, monitoring system details, and IT server details.

5.2 Future Research

The proposed system can be considered as the first seed for existing buildings rating systems in Dubai. Future development of this system should consider weighting each regulation accordingly, with a detailed pairwise comparison and AHP process. This will help system users identify the most important regulations with the higher weightage to gain more points. Also, an integration between the proposed system and local codes can assist in smooth acceptance of the system, and encourage its application. Educational and also rewarding programs can be organized for promoting the need for existing buildings assessment from financial, environmental, and health perspective.

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Appendices

Appendix A: Survey Questions


Developing Existing Buildings Rating System in Dubai, Part 1

Participant Details

1. Name

2. Organization

3. Designation

0 of 5 answered

Developing Existing Buildings Rating System in Dubai, Part 1

Building Assessment Categories

4. Please rank the below 5 building assessment categories in Dubai according to importance (1 is least important):

- Site and Ecology (including landscape, exterior lighting, outdoor walkways, and any exterior features)
- Building Indoor Environment (including indoor plantations, lighting, thermal comfort, acoustics, common Areas, and any interior features)
- Energy Efficiency
- Water Efficiency
- Material Use and Waste Management

5. Please add any additional categories you think are important for existing buildings assessment in Dubai:

PREV DONE

0 of 5 answered

Appendix B: Interview 1 (DM)

Main interview discussion points. Al Sa'fat Rating System

A) Al Sa'fat: New Buildings Rating System

1. How was Al Sa'fat RS developed
2. How long the development process take before releasing the manual
3. The system was announced in 2016, to be applied by Jan 2018; has it been effectively put in use
4. If yes, are there any statistics on the number of building applied for it
5. If yes, how do you rate the success of the system
6. How is the reaction of professionals, stakeholders, and also public to it
7. When are the system's all media channels are expected to operate fully, including website, and mobile app
8. Are there any intentions to modify the released manual
9. What are the future plans for further developing Al Sa'fat, Will it be applicable in all UAE?
10. What are the main challenges/ limitations faced with developing /implementing Al Sa'fat

B) Al Sa'fat: Developing Existing Buildings Rating System- office buildings

1. Is there any ongoing or near future plan for developing existing building version
2. What are the main challenges for greening existing buildings in Dubai
3. What are the main categories/ sections and chapters to be considered as rating criteria, from your point of view, for existing buildings in Dubai according to the current context
4. How do you see the proposed system from practicality and efficiency point of view
5. Are there any major issues not covered
6. Are there any unnecessary/ not applicable issues mentioned
7. What do you think of the initial survey feedback results (survey shared with architects, real estate companies, designer, engineers, and also unrelated occupants for general feedback)
8. Do you expect that this system will be implemented (fully/ partially) in the near future
9. Recommendations to improve / strengthen the proposal

Appendix C: Interview 2 (Professionals)

Main interview discussion points. Real Estate point of View

A) Al Sa'fat: Developing Existing Buildings Rating System- office buildings

1. What are the main Challenges in Operating your properties, especially office buildings in terms of:
   - A. Energy use
   - B. Water use
   - C. Indoor air quality
   - D. Lighting
   - E. Waste management
   - F. Materials procurement
   - G. Occupant management
   - H. Pest management
   - I. Systems maintenance
   - J. Culture
   - K. others
2. Are there any plan for recording building data such as data of energy use and water use, indoor air quality measure, and occupants' satisfaction/ feedback of the spaces
3. How do you rate the performance of your office building(s) overall (1-10)
4. Are there any existing plans to apply green measures for your existing and new buildings
5. What are the main challenges for greening existing buildings in Dubai
6. What are the main aspects to be considered as green rating criteria, from your point of view, for existing buildings in Dubai according to the current context
7. Are you aware of Al Sa'fat rating system
8. Do you think the market will be ready in case of the system is to be imposed on Existing Buildings

Appendix D: Pairwise Comparison

AHP Analytic Hierarchy Process n= 5 Input 16

Objective: 0

Only input data in the light green fields!

Please compare the importance of the elements in relation to the objective and fill in the table: Which element of each pair is more important, **A or B**, and **how much** more on a scale 1-9 as given below.

Once completed, you might adjust highlighted comparisons 1 to 3 to improve consistency.

n	Criteria	Comment	RGMM	+/-
1	Site & Ecology		20.0%	
2	Building Vitality		20.0%	
3	R.E. Energy		20.0%	
4	R.E. Water		20.0%	
5	Materials & Waste		20.0%	
6				
7				
8				
9		for 9&10 unprotect the input sheets and expand the		
10		question section ("+" in row 66)		

Intensity of	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong Importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, it dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6,8 can be used to express intermediate values		

		Criteria		more important ?	Scale
i	j	A	B	A or B	(1-9)
1	2	Site & Ecology	Building Vitality		
1	3		R.E. Energy		
1	4		R.E. Water		
1	5		Materials & Waste		
1	6				
1	7				
1	8				
2	3	Building Vitality	R.E. Energy		
2	4		R.E. Water		
2	5		Materials & Waste		
2	6				
2	7				
2	8				
3	4	R.E. Energy	R.E. Water		
3	5		Materials & Waste		
3	6				
3	7				
3	8				
4	5	R.E. Water	Materials & Waste		
4	6				
4	7				
4	8				
5	6				
5	7				
5	8				
6	7				
6	8				
7	8				

Appendix E: Case Study Assessment score

Section	chapter	regulation Title	Achieved
Site & Ecology 300	Access and Mobility - 301	Commuting & Transportation-occupants	1
		Enabled Access	1
		Bicycle sharing system	
		Access-Services & Goods	1
	Ecology and Landscaping - 302	Local Species	1
		Maintenance of Exterior Landscaping	
	Neighbourhood Pollution - 303	Exterior Light Pollution and Controls	1
	Microclimate and Outdoor Comfort - 304	Urban Heat Island Effect	
		Sand Storm Management	
		Rain Water Management	
		Hardscape	
		Public Access Areas	1
Total possible Points: 12, AHP Weight: 9.3%			6

Building Vitality 400	Ventilation and Air Quality - 401	Minimum Ventilation Requirements for Adequate Indoor Air Quality	1
		Air Quality during Sandstorms	
		Isolation and control of Pollutant Sources	1
		Openable Windows control	1
		Indoor Air Quality Policy during maintenance	1
		Indoor Air Quality Compliance - Existing Buildings	1
		Inspection and Cleaning of HVAC Equipment	1
		Minimum Parking air quality requirements	1
		Environmental Tobacco Smoke control	
	Thermal Comfort - 402	Thermal Comfort	1
	Acoustic Comfort - 403	Acoustical Control	
	Hazardous Materials - 404	Low Emitting Material: Paints and Coatings	
		Low Emitting Material: Adhesives and Sealants	
		Refrigerant Management	1
		Carpet Systems	1
	Lighting and Visual Comfort - 405	Provision of Natural Daylight	1
		Minimum Lux levels	1
		Views	1
	Water Quality - 406	Legionella Bacteria and Building Water Systems	1
		Water Quality of Water Features	
	Pest Control and Management	Responsible Pest Control and management with certified materials	1
	Occupant Satisfaction	Occupant Satisfaction	1
Total possible Points: 22, AHP Weight: 26.7%			**16**

Resource Effectiveness: Energy 500	Conservation and Efficiency: Building Envelope - 501	Minimum Envelope Performance	1
		Thermal Bridging	
		Air Loss from Entrance and Exit	
		Air Leakage test (infiltration)	1
		Windows protection	1
	Conservation and Efficiency: Building Systems - 502	Energy Efficiency – HVAC Equipment and Systems	1
		professional Maintenance contracts of HVAC system	1
		Demand Controlled Ventilation	1
		Lighting Power Density and Controls	1
		Elevators and Escalators	1
		Maintenance of Elevators and Escalators	1
		Re-Commissioning of Building Services – Existing Buildings	1
		Central Control and Monitoring System (CCMS) and/ or BMS	1
		Demand Response	
	Onsite Systems: Generation & Renewable Energy -	Solar Lighting	
		Solar Water Heating	
		PV for electricity generation	
	Awareness	Occupant Awareness Program	1
Total possible Points: 18, AHP Weight: 36.6%			12

Resource Effectiveness: Water 600	Conservation and Efficiency - 601	Water Efficient Fittings	1
		Condensate Drainage	
		Condensate Recovery	
		Water Efficient Irrigation	1
	Monitoring and Management - 602	Water Metering	1
		Occupant Awareness Program	1
	Onsite Systems: Recovery and Treatment - 603	Wastewater Reuse	
Total possible Points: 7, AHP Weight: 18.6%			4

Resource Effectiveness: Materials and Waste 700	Materials and Resources - 701	Certified / Accredited wood products?	
		Hazardous Materials procurement policy	
		Recyclable materials	1
		Regional Materials	1
	Waste Management - 702	Operation and Maintenance waste	1
		General Waste Management Policy	1
		Recyclable Waste Management policy	1
		Occupant awareness and management	1
Total possible Points: 8, AHP Weight: 8.8%			6