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Evaluation of green building rating systems for Egypt

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EVALUATION OF GREEN BUILDING RATING SYSTEMS FOR EGYPT

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STATEMENT

"To the children of the world, and those not as yet born:

We have tried our best to speak up for you"

Herbert Girardet and Miguel Mendonca

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ABSTRACT

The average life of most structural types of buildings is fifty years. This projected lifespan will accordingly have an impact not only on the current inhabitants but also on the future generations. Therefore, nowadays, the subject of environmental conditions, and how our actions affect it, is of considerable consideration. The Egyptian economy was previously dependent on the agricultural, industrial, and transportation sector. Today, the construction industry plays an important role in the economic growth of the country, which is the key to developing our quality of life. Despite the difficult conditions and political instability facing Egypt in the last four years, the construction sector attained a growth of over 5% in 2013 against 3.3% in 2012 (Central Bank of Egypt-Egypt Economic Report). According to Egypt's Vision 2030: Sustainable Development Strategy; it is forecasted that the population in Egypt will reach to 140 million by 2050; which will consequently necessitate an increase in the percentage of the planning and built-up areas leading to the use of more construction sites, land areas to cover this alarmingly rapid demographical increase. In parallel, there will be more demand for materials, energy, and water resources to accommodate this fast growth in population and urban growth.

Additionally, buildings contribute significantly to the amount of disposed municipal, and construction and demolition waste. Consequently, there is an urgent need to provide guidelines and strategies for the development of the construction sector as a catalyst to green building. Thus, the various developed green building rating systems worldwide such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Methodology (BREEAM) in order to assess the potential impacts of the building on the environment, economy and society, play a vital role in defining the level of sustainability in the construction industry.

This research evaluates various green building rating systems through a quantitative and qualitative comparative analysis. The basis of this analysis was on an explicit criteria framework. The assessed rating systems are: Building Research Establishment Environmental Assessment Methodology New Construction (BREEAM NC 2014); Comprehensive Assessment System for Built Environment Efficiency (CASBEE 2014) for Building New Construction; Excellence in Design for Greater Efficiencies by the International Finance Corporation (EDGE IFC) Homes v1.1, Pearl Rating System (PRS)

Design and Construction by ESTIDAMA v1.0; Green Pyramid Rating System NC (GPRS); Global Sustainability Assessment System Building Typologies (GSAS v2.0); Leadership in Energy and Environmental Design NC (BD and C) (LEED v4.0); and TARSHEED Residential v1.0. The selection of rating systems relied on an explicit criterion. The next phase included the selection of a case study (new construction) in order to measure its performance using three rating systems, namely, LEED, TARSHEED, and GPRS. The outcome of this research is a set of recommendations to Egypt Green Building Council committee for the development of future versions TARSHEED rating system.

Keywords: Certification systems, Green building rating system, Sustainable building, Residential building case study in Cairo, Sustainable construction, Evaluation of building environmental assessment tools, Egypt Sustainable Development Strategy 2030

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LIST OF ACRONYMS

ASHRAE	American Society for Heating, Refrigerating and Air-Conditioning Engineers
BBL	Unit of Volume for Oil Barrel
BEA	Building Environmental Assessment
BEE	Built Environment Efficiency
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Methodology
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
DGNB	German Sustainable Building Council (Deutsche)
ECP	Egyptian Code of Practice
EDGE	Excellence in Design for Greater Efficiencies
EGGBC	Egypt Green Building Council
ENLCI-	Egypt National Life Cycle Inventory
EOL	End of Life
EPD	Environmental Product Declaration
GFA	Gross Floor Area
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GPRS	Green Pyramid Rating System
GSA	General Service Administration
GSAS	Global Sustainability Assessment System
IBEC	Institute for Building Environment and Energy Conservation
IISBE	International Initiative for a Sustainable Built Environment
ISO	International Organization for Standardization
LCA	Lifecycle Assessment
LCCA	Lifecycle Cost Analysis
$LCCO_2$	Lifecycle of Carbon Dioxide

LCEA	Lifecycle Energy Analysis
LEED	Leadership in Energy and Environmental Design
LEnSE	Label for Environmental, Social and Economic Buildings
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
SBTool	Sustainable Building Tool
TARSHEED	Rationalization, New non-governmental rating system in Egypt
USGBC	United States Green Building Council
VRV	Variable Refrigerant Volume
World GBC	World Green Building Council
WCED	World Commission on Environment and Development

CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION

Today there are huge considerations about the environment and the outlook of the planet that have become a crucial issue in our daily thoughts, media coverage and political discussions.

In 1987, a report was developed on Sustainable Development in the World Commission on Environment and Development (WCED), identified later as the 'Brundtland Report', named according to the chair of the commission, G.H. Brundtland (Glavinich 2008). According to WECD, Sustainable development is defined as,

'Humanity has the ability to make development sustainable- to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs' (1987).

Furthermore, its definition highlights that; 'The concept of sustainable development does imply limits- not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activity' (WECD 1987).

Several industries affect the sustainable development of a country. Among those is the construction sector, which is of extreme importance to sustainable development since it demands energy, water, sites, and materials in order to erect and operate projects and buildings. Thus, the buildings and the construction industry have direct and indirect effects on the environment. There are various aspects to consider when designing a sustainable building. Those sustainable indicators of a building are (a) water efficiency; (b) energy efficiency; (c) materials and resources; (d) waste management; and (e) indoor environmental quality (UNEP SBCI 2009). Each indicator plays an important role in signifying the level and degree of sustainability of the building. Through considering the energy usage in buildings in Egypt, the energy consumption of residential and commercial buildings recorded a rise of more than 40% of the total energy consumption, due to the rapid increase in population (EIA 2015). Furthermore, it is anticipated that the entire quantity of energy needed for buildings will increase in the coming decades; therefore, energy security is one of the crucial and main concerns for the future. Additionally, fossil fuel resources are decreasing in quantity while their prices are increasing more rapidly than predicted. According to EIA, the generating capacity of Egypt was 27 GW in 2013 of which the most is fueled by natural gas and of less than 6% are generated from renewables (including hydropower) (EIA 2015).

1.2. EGYPT: COUNTRY FACTS

1.2.1. Geography and Demographics

The history of Egypt dates back to 4000 B.C. The total area of Egypt is 1,001,450 square kilometers; distributed into 995,450 square kilometers of land areas and 6,000 sq. kilometers of water as shown in Figure 1.1 (MCIT 2015).

Egypt is the second most populated African country. Furthermore, it connects three continents Africa, Asia, and Europe through the Mediterranean Sea. The highly populated and densely governorates in Egypt makes it a very challenging and dynamic country. Greater Cairo Governorate, which is the largest metropolitan city in Egypt, has a population of around 18 million citizens with a population density of 20,000 inhabitants per square kilometer.

1.2.2. Energy Supply and Demand

Among the many challenges that Egypt is facing, is to fulfill the rising oil demand with its declining production. An annual average increase of 3% was recorded for the total oil consumption over the past 10 years, averaging about 775,000 bbl. /d in 2014 (EIA 2015). Figure 1.2 shows that Egypt's oil consumption has surpassed its production since 2010. Additionally, Egypt’s 2013 total energy production was about 691,000 barrels per day (EIA 2015). Furthermore, Egypt suffers regular electricity power cut because of rising demand, natural gas supply shortages, old infrastructure, and insufficient generation and transmission capacity. In addition to that, the constant political and social conflict in Egypt has decelerated the government's strategies to expand power generation capacity by 30 GW by 2020 as planned (EIA 2015).

Figure 1.1 Map of Egypt (MCIT 2015)

Almost 152 billion kilowatt-hours (KWh) of electricity was produced in 2012, of which about 70% was powered by natural gas, 20% by oil, and less than 10% by renewables, mostly hydropower generation (EIA 2015).

Furthermore, the electricity consumption in Egypt has been increasing where the peak load demand has amplified at an average annual rate of 8% over the last decade, reaching about 30 GW in 2013/2014. The rapid growth of energy use has created anxieties over problems of energy supply, energy sustainability and exhaustion of energy resources; this increasing consumption of energy sources has led to serious environmental problems such as global warming and air pollution (Nabih, et al. 2011). This deficit and insufficiency in the production of resources is due to the uncontrolled system caused by the scattered and unorganized approaches followed by the building users.

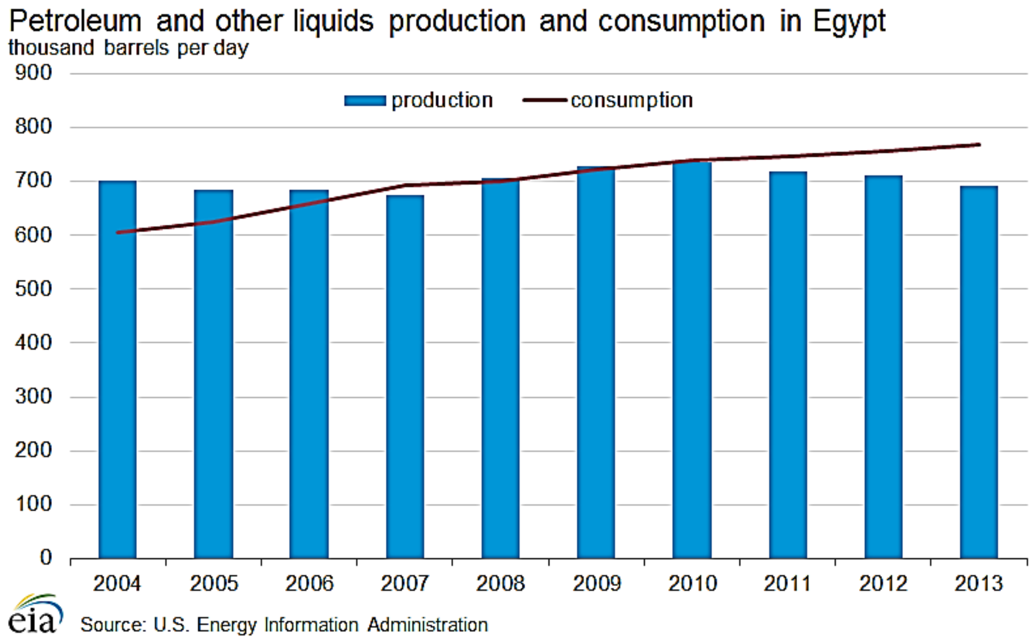

Figure 1.2 Oil Production and consumption in Egypt (U.S. Energy Information Administration 2014)

The establishment of concrete codes, rules, and regulations and ensuring that all stakeholders, building operators and occupants adhere to them, is the key for a successful promotion of green buildings in Egypt.

Due to the depleting fossil fuel resources worldwide, one of the solutions to overcome this problem is to adapt to renewable energies in Egypt particularly that 60 percent of its area has a solar energy intensity that exceeds 6.4 kWh/m^2/day, see Figure 1.3. Renewable energy use in the Egyptian market is very limited when compared with other regions around the world. Thus, the call for renewable energy is of ultimate importance in the meantime. Furthermore, the advances in on-site renewable energy technology have brought the concept of net zero energy buildings; see Appendix A.

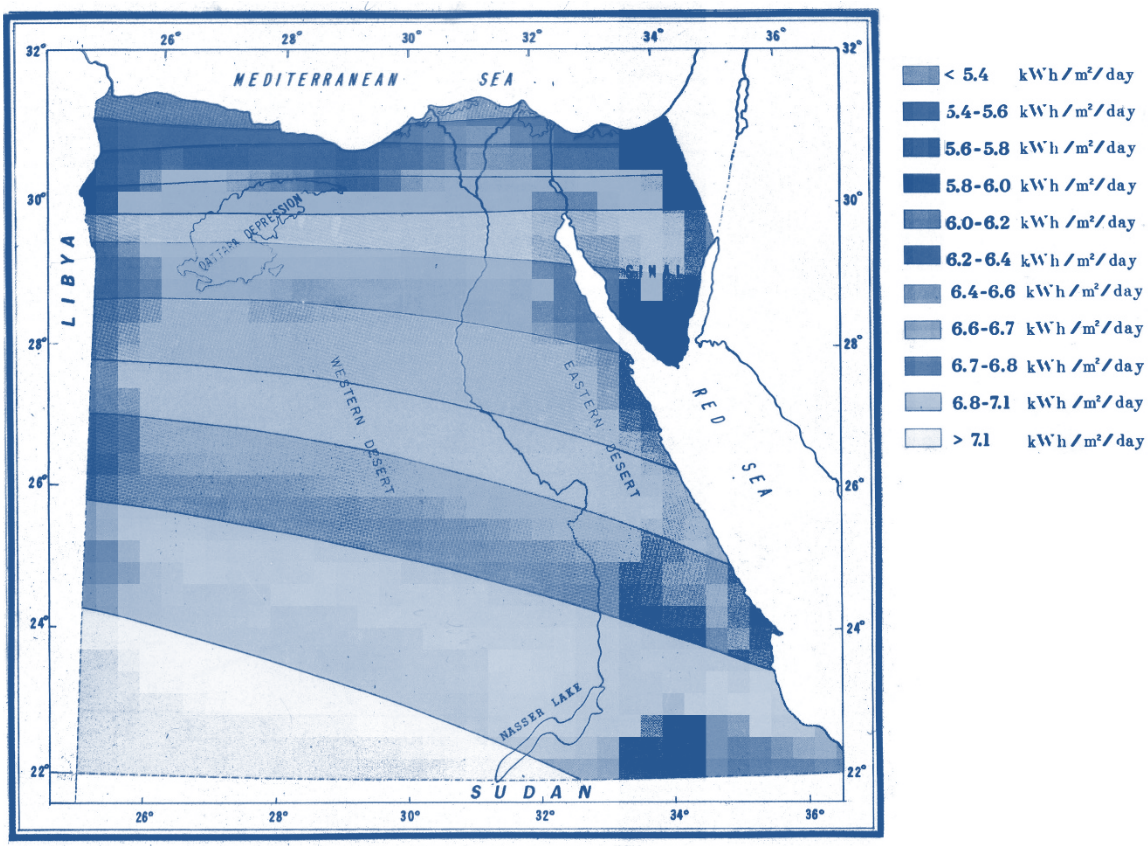

Figure 1.3 Egypt annual average of direct solar radiation (EEAA 2008)

1.2.3. Water Supply and Demand

The Egyptian Ministry of Water Resources and Irrigations (MWRI) systems reported the restraint of the current national economic situation due to water scarcity. Worldwide, the threshold of water scarcity is defined at 1000 m^3/capita/year and Egypt has already surpassed this limit since more than 20 years. Assumptions say that by the year 2025, Egypt will be in absolute water scarcity with consumption of 500 m^3/capita/year due to the increasing population (MWRI 2014). Furthermore, factors that lead to water stress and scarcity are literacy and awareness, consumers' behavior, and cropping methods; see Figure 1.4 for illustration on how social factors lead to water scarcity.

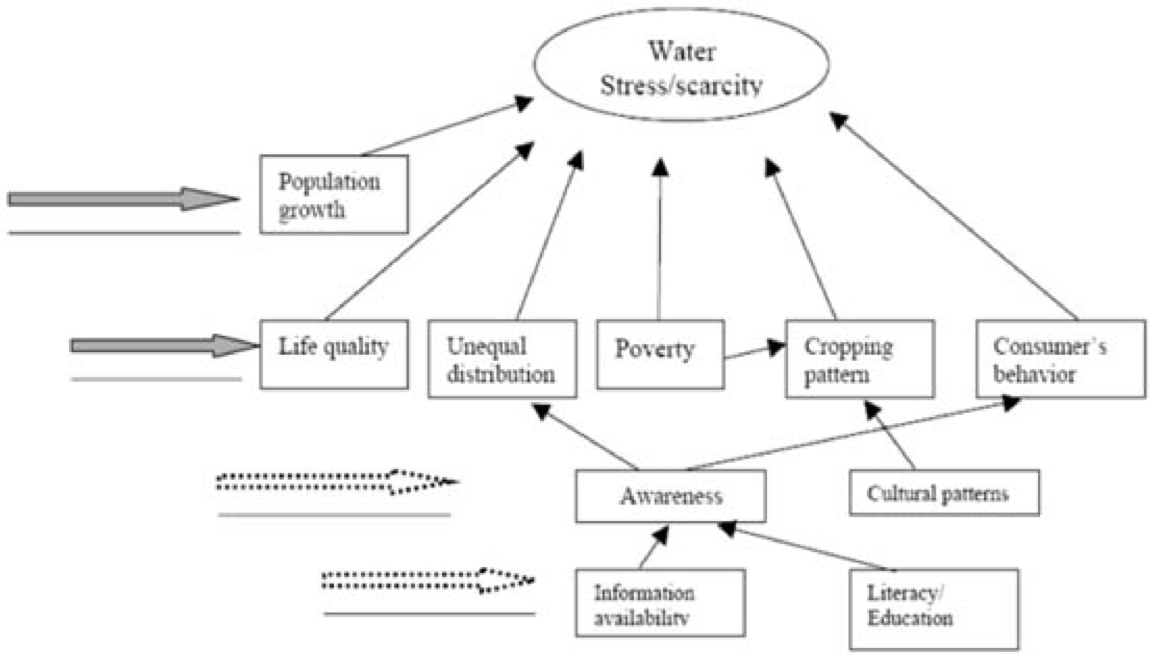

Figure 1.4 The development of water scarcity due to various social factors
(Abdin and Gaafar 2009)

1.2.4. Waste Generation and Disposal

One of the main challenges facing Egypt is waste disposal. According to ElHaggar, the Municipal Solid Waste (MSW) in Egypt is among the largest, contributing to about 21% of the total waste generated with an average annual amount of 15 million tons (ElHaggar 2007). Not only does the increasing number of MSW will lead to the reduction of natural resources, but it will also affect the environment and the human well-being (ElHaggar 2007). Furthermore, the average annual amount of construction and demolition waste in Egypt is 3-4 million tons (ElHaggar 2007). Thus, there is a strong need to control this increasing amount of waste, and to minimize waste amounts through closed loop approaches.

In 2015, the per capita waste generation was around 200 Kg/year. An illustration of forecasted total solid waste and the per capita generations in Egypt is in Figure 1.5; where it is expected that by the year 2020 that the total MSW will exceed 30 Million Tons (MT) (SWEEPNET 2014). Furthermore, the construction waste generated by low and high-rise buildings, hotels, and governmental projects represent over 75% of the total country's various projects as shown in Figure 1.6 (ElHaggar 2007)

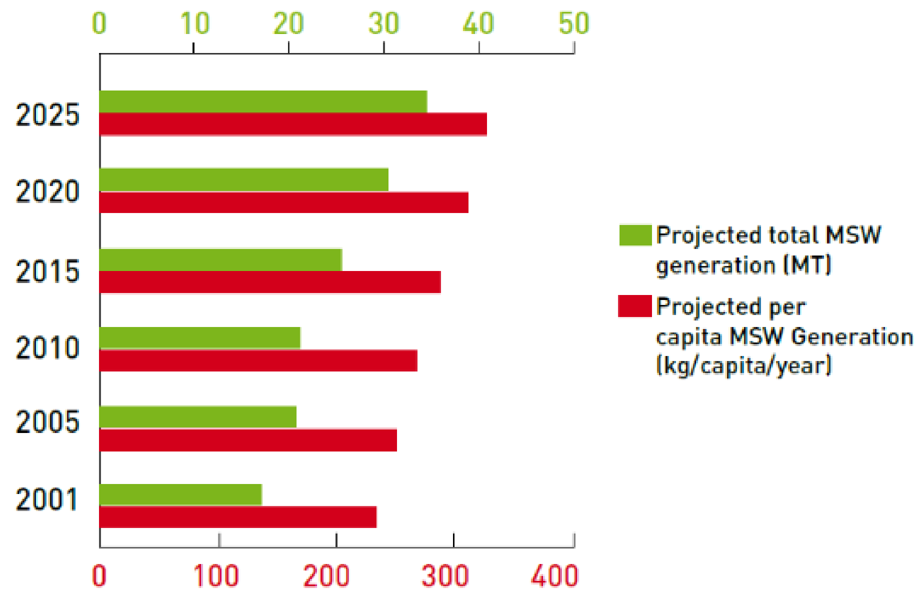

Figure 1.5 Projected Total and per capita MSW generation in Egypt (SWEEPNET 2014)

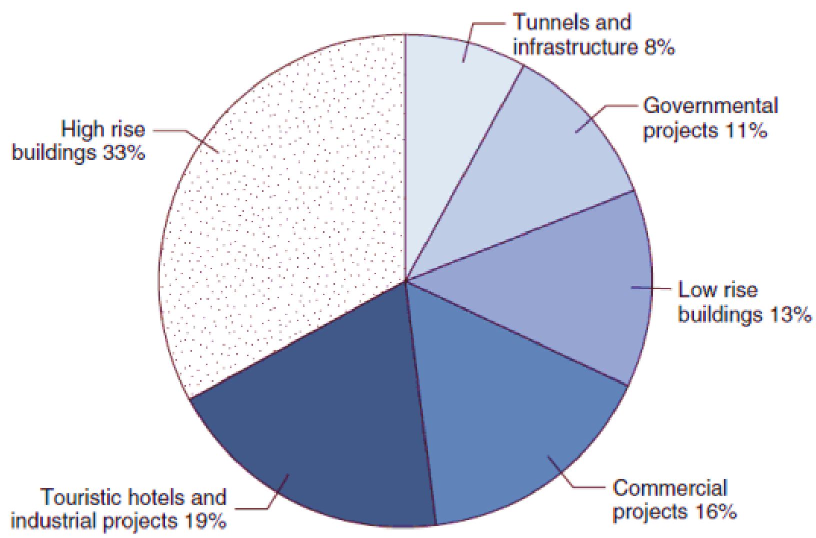

Figure 1.6 Percentage of Construction waste generated by projects in Egypt (ElHaggar 2007)

1.2.5. Ecological Footprint and Climate Change

The environmental footprint of the per capita is continuously increasing in Egypt. The increasing GHG emissions have led to the formation of black cloud. The World Bank has reported that the carbon dioxide emissions in Egypt have been increasing from 0.6 metric tons/capita in 1960 to over 2.6 metric tons in 2010 (2012).

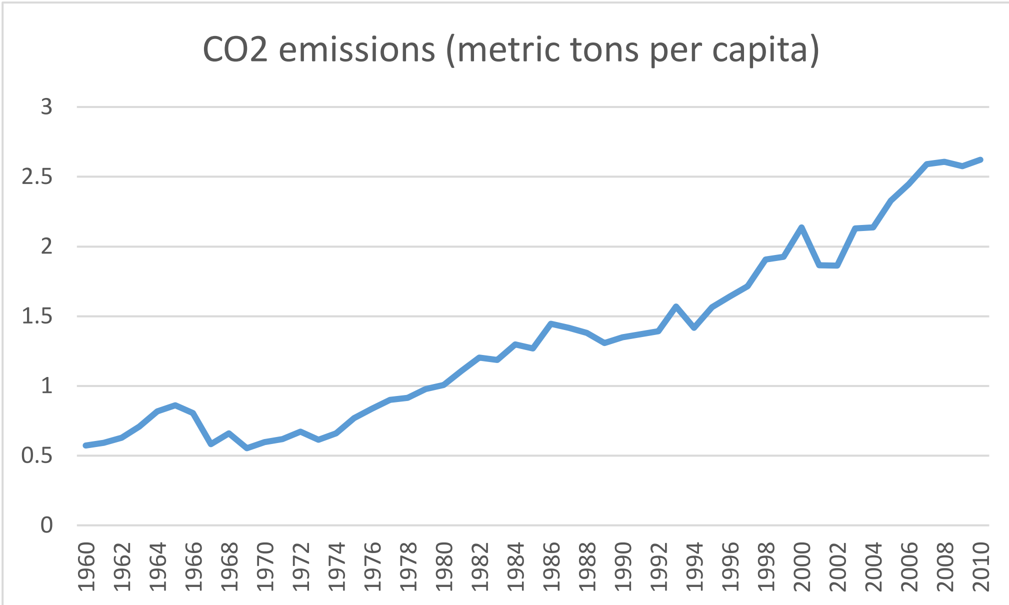

Figure 1.7 The growth of CO_2 emissions in metric tons per capita in Egypt (World Bank 2012)

Based on the Egyptian Energy Efficiency code in buildings, there are possible 20% energy savings in Buildings through following the code as shown in Table 1-1 (Afifi 2010).

Table 1-1 Associated CO_2 and Energy savings in (% and Billion KWh) (Afifi 2010)

% Energy Saving	Energy Saved (Billion kWh)	CO_2 Reduction (Million Ton CO_2)
5%	2.7104	1.49
10%	5.42	2.98
20%	10.84	5.96

Among all industries that have a significant impact on climate change, the construction sector is the largest of all (Sev 2011). According to Sev, fresh water consumption within building limits represents 17%, whereas salvaged wood represents 25%, and material and energy use represent 40% (2011).

Therefore, the facts depicted in this section call for an alarming need to the integration of sustainable and construction approaches and systems into the Egyptian market.

1.3. THE GREEN BUILDING REVOLUTION

The concept of sustainable development that many countries are moving toward has introduced the hypothesis of green building to promote sustainability in the construction and building sectors. As many countries now around the world are shifting to sustainable development in almost all sectors, the green building revolution was an outcome of it leading to sustainable construction, which became an international concern Haselbach 2008).

1.4. EGYPT: SUSTAINBLE BUILDINGS CORE ISSUES

Through the entire lifecycle of a building, a considerable amount of energy, water and materials are used; which raises the share of the building in the greenhouse gas emissions and in the huge amount of waste disposed to landfills. Those matters have essentially provoked the establishment of green building, which consequently encouraged the creation of their ideologies, certifications, and assessment systems and promoted sustainable design and the preservation of the natural environment (Vierra 2014). There are several environmental issues related to buildings in Egypt such as; (a) the use of air-conditioning intensively in summer; (b) the use of inefficient lighting systems; (c) the excessive use of water resources and; (d) the lack of sustainable waste management strategies. Among those issues, the energy use in buildings is the most stressful indicator with 45-50% of the total energy used in all industries (Egypt NEEAP 2012). The principle philosophy and scheme of green buildings is, to establish an effective and adequate indoor and outdoor environmental quality with the accurate amount and cost of resources and power.

Moreover, the recently launched 'Sustainable Development Strategy of Egypt's vision 2030' by the Egyptian government as part of the Economic conference held in Sharm El Sheikh, aims at the economic development, human capital and the competitiveness of the Egyptian market (SIS 2015). Among the objectives of the strategy is to (1) improve the productive capacity of the energy sector; (2) reduce the waste disposal and the associated costs with it; (3) improve the wellbeing of the Egyptian citizens; and (4) reduce the environmental footprints and greenhouse gases from the various sectors (MOP

2015). Thus, sustainability in the construction and buildings sectors through a green building rating system will have a vital role in the successful achievement of this strategy.

1.5. THE IMPACT OF THE CONSTRUCTION INDUSTRY ON THE ENVIRONMENT

The construction sector is a very dynamic sector in Egypt. It contributes to about 7% of the national GDP. It is expected that the investment in this sector will exceed US $8 billion by 2016. The strategic location of Egypt has made it a remarkable country for investments in the real estate, leisure developments, and infrastructure projects. Figure 1.8 illustrates the percentage of building attributions to global pollution (Hawken et al. 2000). With these global pollutions, and the growth in real estate investments on one hand, and on the other hand, Egypt's vision 2030, the construction sector thus needs a major development and transition in its performance for its sustainability and development. Furthermore, the Central Bank of Egypt indicated that the construction sector is a key contributor to the growth of the national GDP in the Fiscal year 2012/2013 (2013).

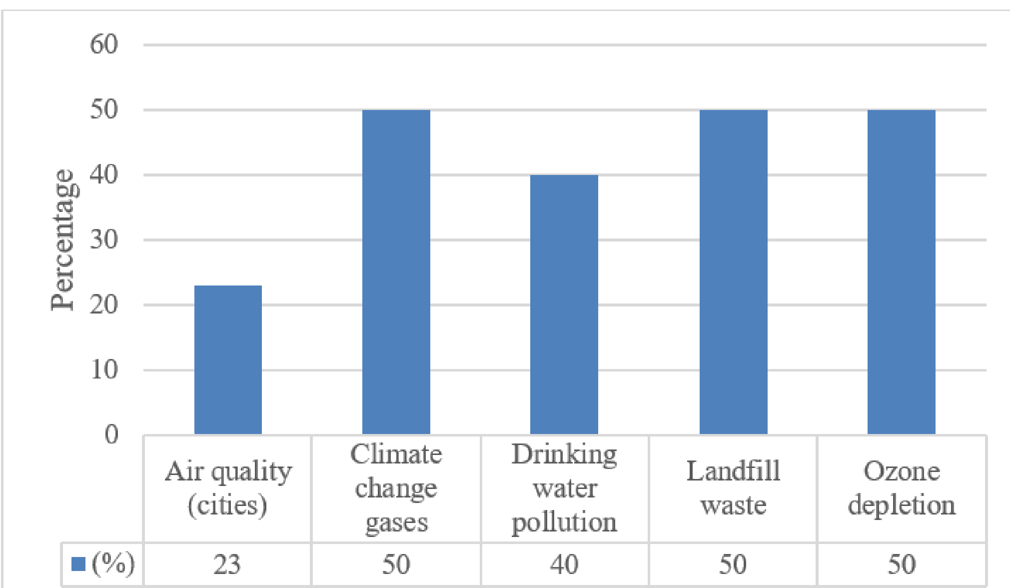

Figure 1.8 Percentage of building attribution to the global pollution (Hawken et al. 2000)

1.6. RESEARCH MOTIVATION

The demand of high-performance buildings is of great concern globally effecting a massive number of property owners including the entire governmental sectors to pursue third party certification to authenticate their responsibility to the environment (Glavinich 2008). There is a significant need for a sustainability assessment tool that considers the three aspects (social, environmental, economic). Despite that, some of the current building assessment tools aim at promoting green or sustainable buildings, they only consider the environmental aspect and neglect the other sustainability pillars. Therefore, a building assessment tool that cuts through the sustainability aspects comprehensively is in alarming need. Among the attributes that have acted upon this research field:

1. The challenge of energy and water resources in Egypt and the greenhouse gas (GHG) emissions problems.
2. The lack of the implementation of construction, energy and environmental regulations and codes in Egypt; see Appendix C.
3. The demand for the societal awareness about resources depletion and environmental, social and economic challenges.

The central motivation for this work is to include the following principle aspects, which are; (1) current environmental challenges in Egypt, (2) the lack of sustainability awareness in the Egyptian community, and (3) the economic challenges that Egypt is facing.

1.7. RESEARCH QUESTION

The following question will help in classifying the data needed for this research.

What is the most suitable rating system for Egypt?

1.8. RESEARCH OBJECTIVE

The major aspects of any sustainable building are energy efficiency, water efficiency, materials and resources, indoor environmental quality and waste management (UNEP SBCI 2009). These aspects have a considerable impact on the environment that would necessitate an assessment system to appraise them. Globally, various rating systems were developed to fit the setting of their originating regions. Therefore, in order to assess the performance of buildings in Egypt, there should be a rating scheme that accommodates the Egyptian setting. The aim of this research is to recommend guiding principles established on a relative analysis of selected green building rating systems. The research will consider those attributes through a developed framework.

The research hypothesizes that the adoption of several green building assessment systems will; (1) lead to the sustainable evolution of Egypt, and (2) promote the effective utilization of energy, water, materials, and waste disposal for a better society and living standards. The confirmation of this hypothesis relies on the findings of the case study in chapter four.

1.9. RESEARCH METHODOLOGY

The following represents the process followed in the research in order to satisfy its objectives:

1. Summarize and synergize existing literature on sustainable development, the history of green buildings, climate change, life cycle assessment, approaches to sustainable buildings and green building rating systems.
2. Identify available green building assessment systems worldwide.
3. Perform a comparative study between selected rating systems.
4. Select a case study to examine how particular rating systems measure its sustainability level.
5. Discuss case study assessment results.
6. Present a list of recommendations to Egypt Green Building Council Committee.

The methodology employed in this research is comprised of several phases. The first phase was having a strong background about green building in general, its history and definitions, assessment tools types, and impacts of green buildings on the development of countries. The second phase was associated with understanding the methodology and structure of selected green building assessment systems for performing a comparative analysis between selected rating tools. The basis of the comparative analysis is to cover all aspects in selected rating systems. The backbone reference of the comparison is a comprehensive data from all of the selected rating systems. The results of this analysis include issues that Egyptian green building rating systems should take into consideration based on local context and conditions. The third phase was the selection of a case study in order to evaluate how each green building rating system measures the sustainability level of a common building. The final stage, which is the outcome of this research, is a list of recommendations and suggestions to Egypt Green Building Council for future versions of TARSHEED rating system. An outline of the methodology is in Figure 1.9.

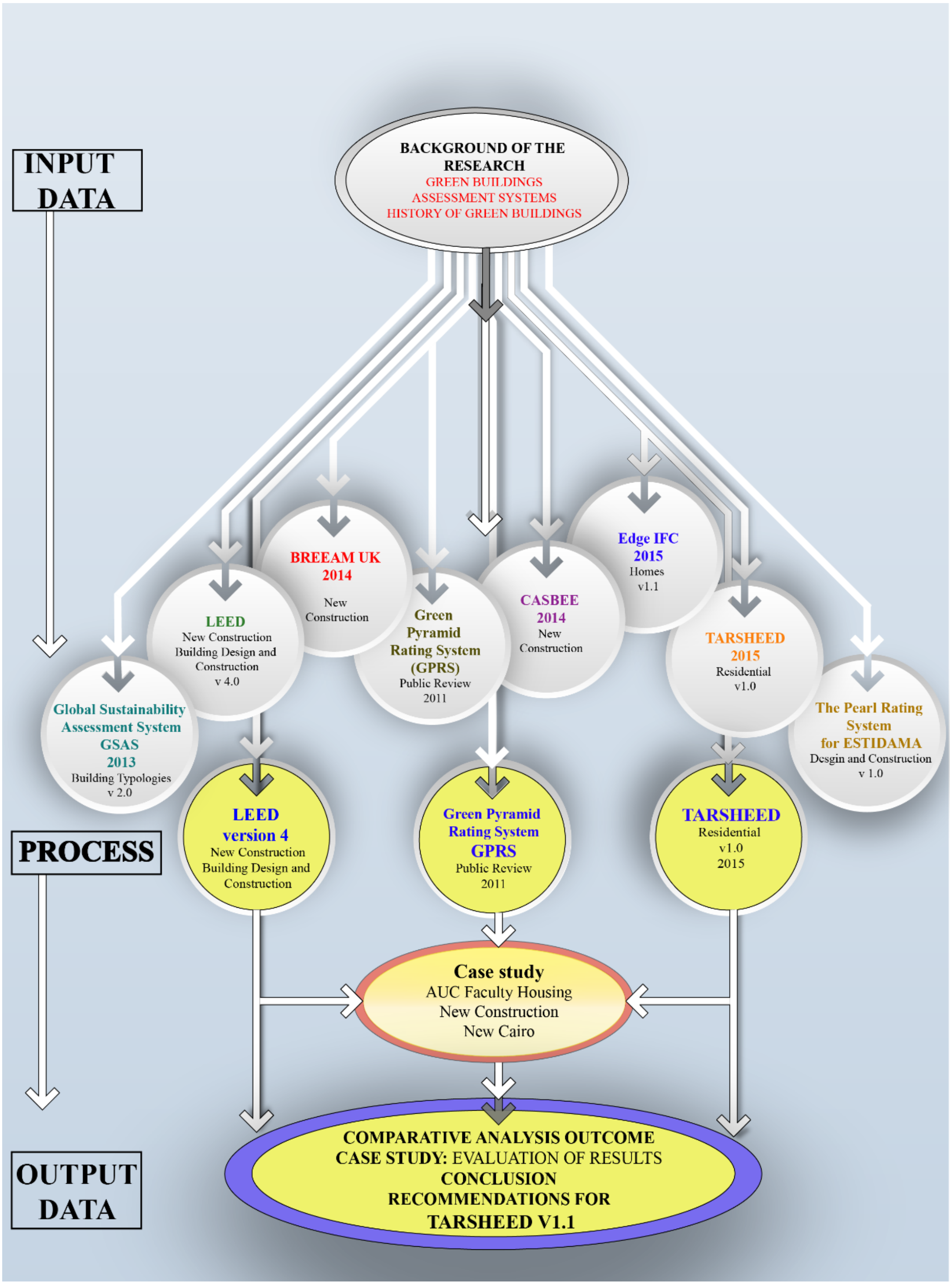

Figure 1.9 Research Structure

1.10. CASE STUDY: FACULTY HOUSING OF THE AMERICAN UNIVERSITY IN CAIRO

This research will look into the applicability and implementation of the various green building rating systems on a selected project. The selection of the case study was according to the following criteria: (1) a new construction residential building, (2) a building that can meet the green building rating systems minimum program requirements (MPRs), and (3) a mid-rise building that can represent the typical building sizes in Egypt. The assessment of the building was evaluated based on three rating systems. The basis for the selection of these rating systems was reliant on the results and outcome of the comparative analysis performed in this research. The building is comprised of a basement, ground, three typical floors and roof level. This analysis will enable a better understanding of how rating systems measure the level of sustainability of a common project.

CHAPTER 2
LITERATURE REVIEW

2.1. INTRODUCTION

This chapter will present a summary of the various existing literature on green building rating systems. This review aims at understanding the logic behind each system, the reason for their criteria selection, and the values given to their aspects. In the process, it will refer to the history of green buildings and building environmental assessment systems, their methodology, structure, and criteria weighting. This will help in developing the framework of the comparative analysis in the next chapter.

One of the most important needs in modern life is housing. The increasing population in Egypt, which is the largest in the Middle East, has resulted in the continuing expansion of the construction and the building industry. The construction industry, which is among the major actors in the economic evolution in Egypt, is expected to be a top leader and influencer in the Egyptian economy in the succeeding age. Consequently, this will (a) necessitate more building materials, (b) generate more waste (c) have a negative impact on the environment (through climate change, ozone depletion, human toxicity, acidification, and so forth); and (d) require more energy and water resources. Therefore, the construction industry of any country has a strong correlation with its sustainable development (Howlett et al. 2010).

Developing countries are facing several environmental problems such as global warming, climate change and the increasing levels of CO_2 emissions. This is clearly depicted in the report conducted by the World Bank (2013) which shows that the CO_2 emissions in Egypt have been continuously increasing from 1.82 tons/capita in 2002 to 2.7 tons/capita in 2010 (World Bank). Furthermore, due to the lack of green building codes and regulations in Egypt, this has negatively affected the country's environmental conditions and therefore, its social and economic conditions.

The purpose of local legislative rules and regulations is to encourage the adequate design and construction of buildings. The design of green buildings is concerned with its whole life-cycle performance (Gowri 2004). Green design is defined by the ASHRAE GreenGuide as a design that 'is aware of and respects nature and the natural order of things; it is a design that minimizes the negative human impacts on the natural surroundings, materials, resources, and processes that prevail in nature'. This definition identifies green building designs comprehensively. In order to implement this definition, it was necessary to develop a system that could convert these design aims into concrete targets that can measure the performance of building operations. Despite the fact that Egypt has already established its national green building rating system, known as 'Green Pyramid Rating system', the number of certified and registered buildings did not reach the global averages. Thus, there is a strong need in Egypt for a comprehensive assessment system that has a holistic evaluation of the environmental performance of the building not only through its construction or operation but also through its lifecycle. Globally and even within the same country, there are several rating systems that assess and appraise the environmental performance of the building. Moreover, the development of green building rating systems such as BREEAM, LEED, CASBEE, Pearl Rating System (PRS) of ESTIDAMA, and GSAS aimed at measuring building's performance and promoting its sustainability. Additionally, local conditions and characteristics of regions or countries influenced the development of most of the existing environmental systems (Alyami and Rezgui 2012). Among those conditions are; (a) climatic and geographic conditions, (b) possible renewable energy sources; (c) regulations and legislations; and (d) population growth rate (Alyami and Rezgui 2012).

2.2. WHAT IS GREEN BUILDING?

Throughout a building lifecycle (Design, Construction, Operation, and Demolition), the regulated control and use of structural systems and processes that affect the environment from the early design stages such as siting and design through the construction, operation, maintenance, renovation, and demolition, are known as Green or Sustainable building practices. This framework develops and supplements the traditional building design affairs of the economy, utility, durability, and comfort (Papadopoulou 2012).

The focal intention of Green building is to diminish and reduce the buildings' impact on the environment and human health (Papadopoulou 2012). According to Papadopoulou, green or sustainable building concentrates on making use of renewable resources such as using sunlight through passive and active solar techniques, and preserving local vegetation, integrating green roofs, and reducing grass in order to regulate the use of water (2012). Additionally, the author adds that there are also other techniques for sustainable buildings such as the use of recycled materials instead of the conventional materials (2012). Furthermore, green buildings, which incorporate efficient insulations, proper glazing, effective water heaters, and ecological air conditioning; entitle savings in cost and greenhouse gas emissions (Yudelson 2007). The author also concludes that reaching an agreement between two opposing priorities; the environmentalists' commitments and the economists' concerns will lead to green building; a win-win situation.

The American Society of Testing and Materials (ASTM) standard, defines Green Building as 'a building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional and global ecosystems both during and after its construction and specified service life'.

Sustainable design becomes mandatory because of environmental requirements. Accordingly, many countries such as United Kingdom, United States, Germany and Australia have established their own green building standards to promote sustainability.

2.2.1. Green Building Features

There are several aspects that form the term 'Green Building'; aspects such as Building's Site and Surrounding Land, Energy Efficiency, Water Efficiency, Indoor Air Quality, Materials and Resources, and Building Envelope design and elements. Conventional buildings must implement all previous features within their boundaries while taking into account their surroundings to be defined as 'Green buildings'. Following each aspect, the design team should tackle a list of sub-aspects. For instance, the design team must precisely examine and select the most appropriate wall insulations, window to wall ratios, external shading devices, and glazing specifications when it comes to building envelope issue (Sayigh 2014).

2.3. HISTORY OF GREEN BUILDINGS

The Office of the Federal Environmental Executive defines ‘Green Building’ as “the practice of 1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and 2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and demolition — the complete building life cycle.” (Cassidy 2003). Green building is not new at all; it has only gained reputation and demand over the last few decades (Gissen 2002). The origins of green buildings date back to more than a century ago, where building designs were a combination of passive techniques and mechanical systems in order to provide internal daylighting and ventilation. According to Gissen, since mid-1800’s, passive systems such as roof ventilators and underground air-cooling chambers were used in buildings such as London’s Crystal Palace and Milan’s Galleria Vittorio Emanuele II, with the aim of controlling the quality of indoor air (2002). Hence, buildings influenced by those integrated systems have had a reduced impact on the environment than others since the processes and consequences of construction changed considerably.

Starting the 1900’s, passive solar techniques; such as deep-set windows to protect from the sun, were implemented in high-rise buildings such as New York’s Flatiron Building and the New York Times Building (Gissen 2002). By the second quarter of the 20th century, the construction industry hosted novel technologies such as air-cooling systems, new lighting systems, new glass materials and technologies, and steel structures leading to the vast usage of HVAC systems. ‘Environmental movement’ practices started emerging intensively due to the OPEC oil embargo of 1973 (Yudelson 2008). With the oil crisis that the U.S. faced and the increase in prices of fossil fuels, the question of ‘why there is a huge dependence on oil for their transportation and buildings’ arose. In 1973, an energy task force was initiated by the American Institute of Architects as a response to this energy emergency, which was then upgraded to AIA Committee on Energy in 1975 (Cassidy 2003). According to Cassidy, early 1990s witnessed further attempts with readymade energy efficient wall systems, water recovery systems, and prefabricated construction units that reduce construction and demolition waste which were experimented globally by various architects (2003).

2.4. LIFECYCLE OF GREEN BUILDINGS

The considerable and precise use of natural resources in the various aspects of the building supports the concept of 'Green Buildings' and the public awareness about sustainability. Environmentally friendly materials reduced building loads, the use of renewable energy, and the proper design of buildings; will result in moderating the impact of the building on the environment significantly. As recently observed, there are alarming environmental challenges associated with building construction and operation such as global warming, waste accumulation and ozone layer depletion. König et al. considered that the life cycle of a building could be determined through the configuration in (a) its four different stages (new build, use, restoration and maintenance, and deconstruction; and (b) defining the process stages of each lifecycle phase (2010).

Throughout the lifespan of buildings including its construction, operation, refurbishment, and demolition phases, there are extensive uses of energy, water, and materials directly and indirectly. The direct use of resources could be through the lifecycle of a building, whereas; the indirect use of resources is through the production of materials during the building construction and operation. Thus, it is very important to include the lifecycle assessment (LCA) in the evaluation of the environmental performance of buildings. LCA tool analyzes the environmental impact of practices or products in all their stages starting from extraction, manufacturing, use, and disposal or recycling "end-of-life" (EOL) (Cabeza et al. 2014). The following are some of the literature about the environmental evaluation of products and processes (LCA). Lifecycle analysis of a building includes several aspects and issues; for instance, a single building could contain more than 60 standard materials and over 2000 products where each has its own lifespan and processes (Moffatt and Kohler 2008).

Ximenes and Grant in their study determined the benefits of wood products as a building material in two houses in Sydney, Australia (2013). The authors proved that wood when used in floors and sub-floors coverings, have significant savings in greenhouse gas emissions (GHG) (Ximenes and Grant 2013).

Babaizadeh and Hassan conducted a study on the use of nano-sized titanium dioxide (TiO_2) coating on windows of residential buildings (2013). The authors conducted a Life Cycle Assessment (LCA) and a Life Cycle Inventory (LCI) in order to assess the: (1) material's environmental impact; and (2) quantity of energy and emissions during the production process (Babaizadeh and Hasssan 2013). Based on (Babaizadeh and Hasssan 2013), LCA and LCI supported in identifying the advantages and disadvantages of the TiO_2 coating on the environment. It was concluded that the material has benefits in air purification and the overall environmental performance of the building (Babaizadeh and Hassan 2013).

Asdrubali et al. employed LCA on three traditional Italian buildings: (1) a detached residential house, (2) a multi-family and (3) a multi-story office building (2015). The LCA was employed through the life cycle phases of the buildings from the construction and operation stages to the end of life (EOL) stage (Asdrubali et al. 2015). It was resolved that the operation stage has the highest impact on buildings over all other stages (Asdrubali et al. 2015). Asdrubali et al. suggested that LCA is able to determine the sustainability of buildings (2015). A positive aspect of the research conducted by Asdrubali et al. is that it covers the operative instruments such as graphs and tables that can support practitioners in employing LCA in their projects (2015). On the other hand, the perception that the authors consider about LCA that it can measure the total sustainability of the building is a debate, as LCA does not cover the social aspect nor the cost attributes of processes or products.

Ottele et al. conducted a comparative lifecycle analysis (LCA) for different façade systems in the Netherlands: (a) European brick façade; (b) a directly greened façade; (c) an indirectly greened façade; (d) a façade with a living wall system based on planter boxes; and (e) a façade with a living wall system based on felt layers (2011). The authors intended to compare the benefits of each type of system in order to assess the potential of energy reduction and savings in cooling and heating (Ottele et al. 2011).

Furthermore, Life Cycle Inventory (LCI), which is among the different phases of LCA, incorporates collecting and measuring the inputs and outputs of a product or a process through its lifespan (Cabeza et al. 2014). Ali et al. suggested that Egypt must develop its personalized National Life Cycle Inventory database (ENLCI) (2014). The authors' definition of Life cycle inventory categories was clear (2014). Furthermore, the development of an ENLCI in the Egyptian context can encourage a cleaner environment (Ali et al. 2014). The suggestion in this study will necessarily lead to the formation of a participatory framework among all stakeholders including investors, agencies, and ministries.

The correlation of different issues such as building physics, technology and energy, water requirement, façade, climatic conditions, internal and external loads, and maintenance and emergencies requires an integrative approach. It is fundamental to employ a state-of-the-art planning and building simulation tools during the design and planning phases of a sustainable building. Accordingly, based on the simulations; alternative concepts and designs will arise as a better solution to the building. Building simulations, which provide detailed calculations, allow for optimum designs for (1) achieving a target comfort level to meet the building inhabitant expectations, and (2) creating savings in energy and cost (Bauer et al. 2009). The authors also stated that this integrated approach of green buildings, which requires a shift from the chronological method of planning to the integrative one, requires broadness in the path of a 'Life Cycle engineering approach'. The evaluation of a given concept or planning decision requires an integrated communication between engineers, architects, and designers, which will consequently have an effect through the lifecycle of the building. Furthermore, the highest sustainability levels during construction occur through the integration of the 'Life Cycle Engineering' approach into the design of the building at its early stages (Bauer et al. 2009).

2.5. ENERGY THRESHOLDS AS A DESIGN TARGET VALUE

A prerequisite for Green Buildings is the efficient and thorough management of lands, water, energy, and materials. The minimization of water and energy usage and requirements, and the use of non-hazardous materials on one hand, and the creation of comfortable indoor environments on the other hand; might initially seem contradicting. However; it is achievable through the proper understanding of the concept of green building. In order to achieve a target, there should be a suitable plan for it. During the design phase, target values are essential as a threshold to the minimization of energy usage in the building. The location, type, and function of a building allows for a precise specification of its energy threshold.

Bauer et al. consider there are three main criteria in energy indicators: 1) minimizing building energy requirements through constructional measures; 2) increasing energy efficiency for technical systems; and 3) using regenerative energy sources for the generation of cooling, heating, and electricity for buildings (2009). Green building is considered a valuable property investment if assessed through its entire life cycle. The building shape, form, and envelope have a critical effect on minimizing its energy requirements. Furthermore, the quality of the building materials and insulations, shading systems, and the amount and type of wall fenestrations determine the building energy requirements. The energy indicator in green buildings, same for all other indicators, needs to have a holistic consideration of all systems for their optimization (Bauer et al. 2009).

Moreover, the previous and recent fluctuations and shortages of the primary energy sources such as oil, and gas, have today raised concerns about the independence from those traditional energy sources for new development projects and buildings (Bauer et al. 2009). There are two categories of regenerative or renewable energy sources. The first category is natural energy such as wind, solar, and water in the form of wave and tides and hydro. This type of energy is available anywhere; however, their performance and degree of availability differs according to the region and climatic conditions. The other category is 'Regenerative raw materials', which in other words called biomass that have no any further greenhouse gas emissions. Renewable energy resources do not cause any environmental stress. Despite renewables have a low energy cost, they have higher initial investment costs since their output levels are small or fluctuating, which would require large areas for energy generation and storage. The following conditions and requirements need to be followed in order to be able to utilize renewable or regenerative energy sources in a cost-effective and efficient way; (1) Minimizing of energy requirements; and (2) Heating and cooling temperatures should be properly adjusted in accordance with the average indoor temperature (Bauer et al. 2009).

2.6. GREEN BUILDING DEVELOPMENT

As a method of moderating the effect of buildings on its surroundings, several countries have established their local rating system while others are either emerging or prospecting, see Appendix B. Despite that, the development of most of the assessment systems was reliant on a single or a set of other previously developed rating systems, their local context priorities would make them differ from each other. Furthermore, the majority of the assessment systems were set to be voluntary for projects; however, their nature has changed to be obligatory for buildings' permits. For instance, ESTIDAMA requires that all government funded residential buildings should receive a minimum certification of '1 Pearl' in order to receive project construction initiation approval. Also, BREEAM requires all buildings on the government estate to receive BREEAM certification (BREEAM 2015). Furthermore, laws and regulations in Japan require that buildings achieve CASBEE assessment with a minimum Built Environment Efficiency (BEE) score of one (Lee 2013). See Appendix B for a list of green building terminologies.

2.7. GREEN BUILDING CHALLENGES AND COSTS

The adoption of green buildings could create 30 percent savings in energy consumptions when compared to traditional buildings (Zuo and Zhao 2014). According to WGBC, the construction of a green building will involve an average increase of 3-5% in cost over conventional buildings (2013). The basis of these results was reliant on a study of a building of a built up area of 15,000 m^2 (WGBC 2013). According to WGBC, the public should not only consider the costs of going green but, the costs of not going green as well (2013). Moreover, the introduction of a carbon trading system will allow the expansion of renewable and cleaner energy sources.

According to Ross et al., despite that, green buildings are higher in costs than traditional buildings; it is argued that this variation in costs, also called 'green premium', are recoverable from the savings in operations through green performances (2007). The authors added that the efficient building insulation which results in lower electricity bills and in the improvement of the occupants' productivity; turns into a revenue from the asset funded in high-performance buildings (Ross et al. 2007). They also included that studies revealed that the payback period of investments in green buildings is less than 10 years. Additionally, most of the cost analyses do not consider the social benefits; such as (1) the 'monetized value' of the reduction in greenhouse gases (GHG); (2) the minimized heat island effect; and (3) the less pressure by the users on the utility grid (Ross et al. 2007). Even for financial analyses related to green building capital costs, the subject of Net Present Value (NPV) is not properly addressed (Ross et al. 2007).

Furthermore, it is fundamental to implement design strategies such as building orientation and window to wall ratio in the initial project phases in order to avoid high costs related to green building. These strategies would a have a significant impact on the level of building sustainability (Gonchar 2011). Similarly, research has proved that green building costs are not always higher than traditional buildings, especially with the incorporation of program management, cost strategies, and environmental strategies during the preliminary design phase of the building through its lifecycle (USGBC 2013).

2.8. BACKGROUND ON GREEN BUILDING ASSESSMENT SYSTEMS

Building environmental assessment system (BEA) is a method used to evaluate the impact of buildings on the environment. It not only cover the general environmental aspects of buildings such as energy, water, waste, and materials, but also it includes assessment for issues such as indoor air quality, lighting, ventilation, etc.. Development of building environmental assessment methods has found its way since early 1990's. The majority of green building rating systems incorporates an extensive array of building types and state; for instance, different schemes cover commercial, residential and, retail buildings (Lee 2013). Furthermore, the assessment of those buildings can range from new construction, core and shell to existing building condition. The pioneer rating system was Building Research Establishment Assessment Method (BREEAM). The British Research Establishment (BRE) introduced this rating system with the purpose of assessing, evaluating, and certifying the level of sustainability in buildings. The scope of this rating system was initially focusing on new buildings at their construction phase, which was later developed to include the whole life cycle of the building (BREEAM 2015). Moreover, the BREEAM initiative has led to the development of other rating systems such as LEED, CASBEE, SBTool and the Pearl Rating System (PRS) for Estidama. The growth in the number of green building rating systems was due to the rapidly increasing impact of buildings on the environment and its resources; therefore, it was necessary to evaluate the building's performance in order to identify and award buildings based on their level of sustainability. The following represent the criteria that are assessed by most green building rating systems; (1) energy, (2) water, (3) materials, (4) sites, (5) pollution, and (6) indoor air quality.

2.9. STRUCTURE AND METHODOLOGY OF GREEN BUILDING RATING SYSTEMS

The concern of green buildings has expanded the establishment of rating systems. There is a consistency between most of the rating systems in their structure and organization. Wallhagen et al. affirmed that assessment tools set specific criteria for the environmental performance of buildings through forming a set of issues (2013). The authors also add that green building assessment tools use a set of issues, parameters, and LCA methodologies in structuring their systems. Most of the rating systems have different categories with a number of credits that through their summation define the degree of sustainability of each project or building. However, every building assessment system embraces different methodologies and criteria methods (Jones Lang LaSalle 2008). Zuo and Zhao emphasized that the formation of the different rating systems depends on countries' conditions and regional contexts (2014). The authors also add that the local context defines the amount of credits or percentages given to a certain category. It is important that the rating system chosen for a certain project covers issues related to the country in which it is constructed. Furthermore, even for countries in the same region, the magnitude and importance of certain categories can differ according to their availability and value.

Yu et al. performed a brief review of the various already existing rating systems, such as China Green Building Evaluation Standard' (GB50378-2006), LEED, BREEAM, CASBEE, in order to create a comparative analysis for the development of a rational rating system for malls and warehouses in China (2015). According to Yu et al., the national standard of China GB50378-2006, which attempts to rate public and residential buildings, is incoherent since each building type has its own function, size, layout, surroundings, and indoor air quality and energy requirements. This approach endeavors to prevent the consequences of unreasonable functioning. Each of the current rating systems has its own category and indicator weightage; however, store buildings which have their own characteristics and features would have the same categories but with different weighting,

Furthermore, according to Yu et al., there are two main categories to establish a weighting system. One is the objective category and the other is the subjective category. The former category relies on the numerical value of each indicator through calculations and accordingly the weight is determined, whereas, for the latter, the importance of the indicator is according to the experts' perception and experiences (2014).

The Development of a new rating system or the amendment of existing ones to fit the local context, such as LEED-India and BREEAM-Gulf, has witnessed a widespread among research studies and analysis. In a developing country such as Jordan, (Ali and Al Nsairat 2009) examined the opportunity of developing an assessment system for residential units, according to the local context of this country and the methods of applying the aspects of sustainable development to it. The authors imply that there are several factors that have raised the necessity of a rating system in Jordan, among them are; (a) the significant concerns about the environment, society, and economy; and (b) the inefficient use of resources and their depletion. Additionally, a suggested green building assessment system called (SABA) was shared with stakeholders and sustainability experts (Ali and Al Nsairat 2009).

Despite that sustainable building is supposed to have multidimensional extents, the emphasis is usually on the environmental aspect with no attention to the social and economic aspects (Mateus and Bragança 2011). Furthermore, the authors performed a chart that represents the weighting factor to the elements that indicate sustainability in a certain building/project, for five different rating systems.

2.9.1. Human Comfort

(Fekry, El Zafarany, and Shamseldin 2014) suggested that the current environmental assessment systems lack the proper evaluation of issues related to indoor and outdoor sensation and comfort. The authors propose the employment of questionnaires based on a relation scheme of product advancement and customer fulfillment known as 'Kano model' established in the 1980's. This theory allows for categorizing customer's satisfactions that would make information linked and associated allowing for a more accurate data and results (Fekry, El Zafarany, and Shamseldin 2014).

2.9.2. Incentives and Barriers to the Adoption of Green Buildings

Generally, there are two types of barriers to environmental and energy-efficiency developments in buildings; the first is related to financing the building, and the second is related to legislative concerns. Furthermore, there are several concerns regarding (1) the hidden costs and benefits, (2) resources availability, and (3) market maturity from green buildings (Rode, Burdett and Soares Goncalves 2011). Governmental constraints and limitations have a crucial effect in the development and establishment of energy efficient buildings. In developing countries, those two barriers affect the sustainability of the construction sector intensely. Despite that, Egypt has a comprehensive set of codes and regulations for building design and construction, their implementation are not enforced in the construction sector. This could be due to the following reasons: (1) the misplaced incentives, (2) the subsidies, low energy and electricity prices, and (3) the lack of awareness about the necessity of efficient use of resources. In 2006, a study of the barriers to the adoption of green building among over 870 property developers and owners revealed that the top reasons were due to the high initial costs associated with green buildings, followed by difficulties associated with the market, and the complicated certification process, as shown in Table 2-1 (Yudelson 2008):

Table 2-1 Barriers to Green building adoption survey results (Yudelson 2008)

Percentage	**Survey results**
57 %	It was hard to justify the greater initial costs of green buildings.
56 %	Green buildings added significantly to the initial cost
52 %	The market was not willing to pay a premium for green buildings.
36 %	The certification process was too complicated, with too much paperwork.
30 %	The market was not comfortable with new ideas or new technologies.
14 %	Sustainable design is not considered as a market barrier.

Furthermore, the duration spent by architects, engineers and developers in understanding the requirements of the rating system in order to employ it in their building assessment makes a potential barrier to green building rating systems to be widely used (Reeder 2010). Despite it is widely agreed that it is preferable to have a scheme for measuring the building performance, there is a lack of resources and data about green materials (Reeder 2010).

2.10. COST EFFECTIVENESS THROUGH INTEGRATED DESIGN APPROACH

Ebert et al. hypothesized that financial returns are key incentives to property management professionals when it comes to green building and their certifications (2011). The authors also added that sustainable building practices affect the value of the property positively through reducing its operational costs. Despite the fact that green buildings sometimes have higher initial costs, their environmental, health and social benefits can be witnessed in the short run (save 2009).

There is a common agreement among architects, engineers, and designers that the key to cost reduction of green buildings is through an integrated design approach. The integrated design process takes into consideration time management and the union of relevant parties for the study of various alternatives before the issuance of the final design. This approach takes a full perspective, and considers and ensures the coverage of all design disciplines together rather than looking at it from one angle.

2.11. CURRENT GREEN BUILDING LAWS AND REGULATIONS

Worldwide, there are Green building standards, regulations, and rules that act as a guide for professionals in the field of construction and design. The Following table (Table 2-2) presents some of the available standards, codes and regulations worldwide. The establishment of standards such as the International Organization for Standardization (ISO) and rules and regulations developed by specific governmental or non-governmental organizations aims at meeting certain goals related to sustainable building and construction, and countries' specific strategies. In Egypt, there are over fifty codes related to building design and construction, see Appendix C for a full list of available Egyptian Code of Practice (ECP) (HBRC 2016).

Table 2-2 Green Building Codes, Standards, Systems, and Regulations

Code type and name		Description
International Codes	ISO 15392: 2008: Sustainability in Building Construction[1]	Responsible for tackling issues related to buildings and the construction industry
International Codes	2015 International Green Construction code[2]	AIA, ASHRAE, IES, ASTM and USGBC developed this code. This code aims at promoting sustainable construction through setting out minimum rules for an integrative building construction process.
International Codes	2012 International Energy Conservation Code (IECC) and ANSI/ASHRAE/ IES Standard 90.1-2010[3]	This code is flexible in terms of climatic zones, which allows for its applicability and implementation in various countries and regions.
International Codes	CEEQUAL- Civil Engineering Environmental Quality and Award Scheme[4]	The intent of this scheme is to help owners, engineers, and contractors to provide better project conditions, design, and construction.
International Codes	EPEA Cradle to cradle building design[5]	This assessment considers the lifecycle of the building as a whole; it takes the precise detail of each aspect in the building's execution.
U.S. & Europe	EN15804 (CEN TC350) - Sustainability of Construction works[6]	This standard was set by the technical committee of the European commission in order to evaluate the sustainability of buildings through a lifecycle method. It measures new and existing buildings.
U.S. & Europe	U.S. DOE Building Energy Codes program[7]	Codes developed by the EPA through authorizing the Department of Energy (DOE) to take part in the advancement of national codes and the enforcement of their application.
Egyptian Codes	The Egyptian Electricity code 2015[8]	This code was consented by the Egyptian cabinet of Ministers and approved by the President in 2015.The code aims at (1) improving the energy efficiency, and (2) managing the demand use in order to preserve natural resources and provide services at affordable costs.
Egyptian Codes	ECP 306-2005 The Egyptian code for energy efficiency improvement in buildings Part 1[9]	This code is applicable to residential buildings. It covers requirements related to energy efficiency in buildings through passive and active strategies.
Egyptian Codes	ECP 602 Egyptian code for housing design and planning[9]	This code includes a set of criteria for building and site design. It is considered an essential part of Building Law no. 119 for 2008. The code includes data that shall be included in building and open space designs.
Middle East	Green Building Rules and Regulation in Dubai[10] *Applicable to Residential, Commercial, Public & Industrial Buildings.*	This is a mandatory green building rules and regulations set by Dubai Municipality. Construction, contracting and architectural consultancy firms in Dubai must implement this rule in their projects. It aims at creating a more sustainable urban environment along with Dubai's strategic plan.

[1] International Organization for Standardization. Sustainability in Building Construction General Principles.
[2] IGCC. 2015. http://www.iccsafe.org/codes-tech-support/
[3] IECC. http://www.iccsafe.org/iecc-toolkit/
[4] CEEQUAL. Improving Sustainability through best practice www.ceequal.com
[5] Environmental Protection Encouragement Agency. http://epea-hamburg.org/en/content/cradle-cradle-inspired-buildings
[6] CEN AFNOR Normalization CEN/TC 350 Sustainability of Construction works
[7] Building Energy Codes Program. https://www.energycodes.gov/
[8] Egypt Energy Code 2015. http://www.marefa.org
[9] Housing and Building National Research Center. NUCA. 2016. See Appendix C.
[10] Green Building Regulations and Specifications. Dubai Municipality

EL Fiky performed an analytical study of building laws, standards and regulations in Egypt, with the aim of examining their contribution to green architecture (2011). The author suggested that establishing an advisory council could support the public in applying green building principles in projects in Egypt. He also proposed that enforcing the green building laws by first applying them on governmental buildings and buildings funded by the government would promote green building implementation in Egypt. Furthermore, it is advisable to provide incentives to parties that are employing the green building strategies into their design and construction (El Fiky 2011).

2.12. REVIEW ON GREEN BUILDING ASSESSMENT SYSTEMS COMPARATIVE STUDIES

Through the literature, multiple studies with the goal of developing green building rating systems are available with the aim of accommodating specific countries' needs. Nguyen and Altan presented a comparative examination of five leading green building rating systems with the aim of identifying the best aspect in each of them (2011). LEED, BREEAM, CASBEE, Green Star, and HK-BEAM were the five rating systems assessed (Nguyen and Altan 2011). The authors' review process was through implementing a set of criteria that covers some aspects of the five rating systems. Aspects such as popularity and influence, availability, methodology, applicability, data collection process, accuracy and verification, user friendliness, development, and results performance were compared (Nguyen and Altan 2011). However, the authors did not analyze issues, performance, and parameters of green building rating systems in their comparative study.

Bahaudin et al. conducted a comparison between non-residential new construction green building rating systems from five countries; Malaysia, Singapore, USA, Indonesia, and South Korea with the aim of expanding the green building criteria to cover the whole lifecycle of buildings (2014). The authors remarked that most of the green building rating systems give more emphasis to the building operation and neglect the planning, design and construction phases in their criteria, see Figure 2.1.

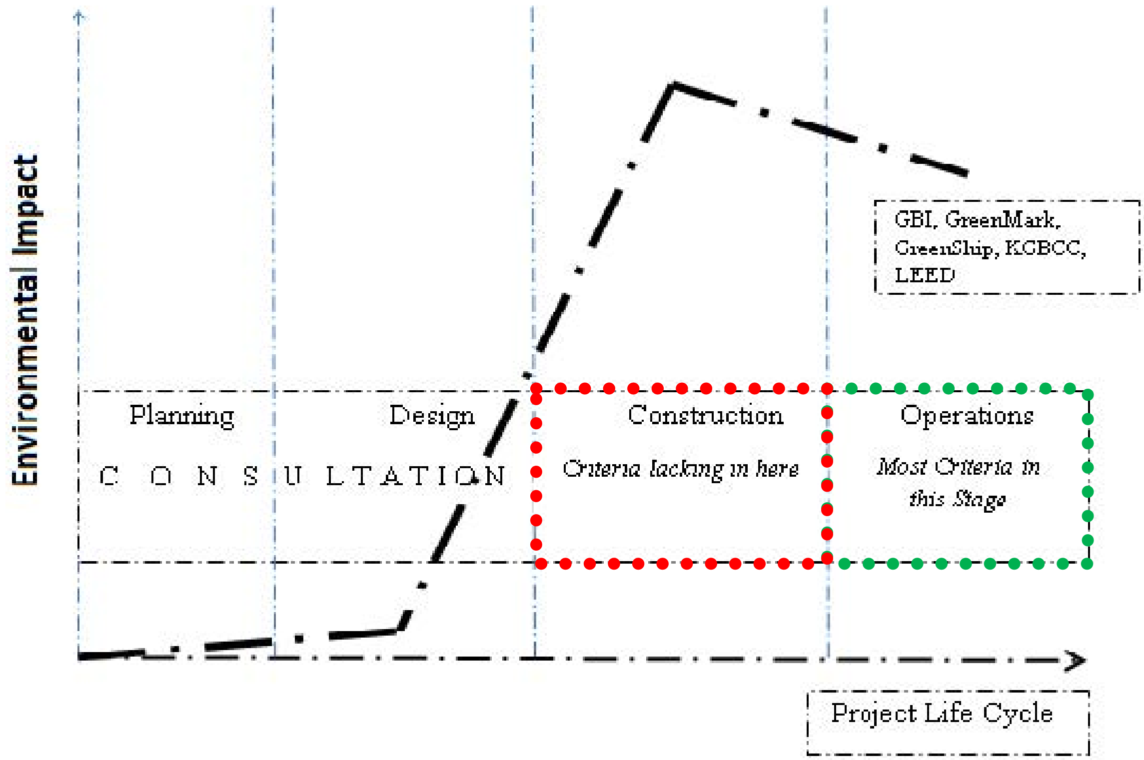

Figure 2.1 Building's environmental impact through its lifecycle (Bahaudin et al. 2014)

Furthermore, Wallhagen et al. deliberated that the method employed by green building rating systems in measuring the environmental performance of buildings is of great significance to buildings' owners and designers (2013). The authors proposed a framework for comparing three different green building tools: LEED v3 new construction (building design and construction), Code for Sustainable Homes, and EcoEffect. Furthermore, the design of the green building tool must have a balance between its theoretical characteristics (accuracy and consistency) and Practical characteristics (assessment time and cost) (Wallhagen et al. 2013). Wallhagen et al. have set a framework outline for applying comparison and contrast of the three green building rating systems (2013). The four phases in the framework were included in order to compare the following: (1) structure; (2) content; (3) aggregation; and (4) scope (Wallhagen et al. 2013). The authors classified issues in the three rating tools as procedures, features, and performance where (a) procedures were assigned during the detailed design, construction, and management phases; whereas (b) performance were assigned on the occupancy use phase. The result of their study indicated the issues that each rating system focuses on. The authors also recommended that issues related to future renovation, demolition and waste disposal/recycling, and embedded hazardous substances need to be addressed clearly in future building environmental assessment tools (2013).

Fowler and Rauch performed a comparative analysis between five green building rating systems: Green Globes U.S., BREEAM, CASBEE, LEED, and GB Tool (2006). The basis for the selection of a rating system that meets the U.S. General Services Administration (GSA) key requirements relied on a screening analysis (Fowler and Rauch 2006). The criteria that were set for the comparison of the assessment systems were: (1) applicability; (2) development; (3) usability; (4) system maturity; (5) technical content; (6) measurability and verification; and (7) communicability (Fowler and Rauch 2006). According to Fowler and Rauch, applicability was on the type of projects and buildings, development was on system management and transparency, usability was on cost easiness, and system maturity was on the number of certified buildings (2006). In addition to that, technical content was on relevance to sustainability, measurability was on documentation process, and communicability was in versatility. Furthermore, the authors concluded that BREEAM was inapplicable to all GSA project types. On the other hand, findings indicated that CASBEE is possibly applicable to the U.S. market buildings; however, its employment in GSA building classification is not possible (Fowler and Rauch 2006). The authors noted that LEED was the only rating system that is applicable to all GSA project types.

Sev considered that international building assessment tools have difficulties in their implementation in developing countries lacking regional adaptations (2011). He also added that despite that, the usage of most of these assessment tools is applicable in other countries; they solely consider their regional priorities. Moreover, the author performed a comparative analysis between BREEAM, LEED, SBTool, CASBEE and Green Star, which revealed that most of them cover the environmental issues only and neglect the social and economic aspects. Furthermore, most of the well-known building environmental assessment tools are not flexible for cultural and regional variations (Sev 2011). In the comparative study, the author analyzed the building lifecycle stages covered by the assessment tools (Sev 2011). He also emphasized that a sustainable building should have a closed loop lifecycle model.

Similarly, Gu et al. conducted an analysis of the most widely used building assessment tools; he also performed a comparison between three assessment systems: EcoHomes, LEED NC v2.2, and GBTool (2006). The assessment tools were compared based on two factors; the first is systems' various indicators while the second is 'indicators' weightings' (Gu et al. 2006). The authors then grouped the rating systems' various aspects into three key indicators: (1) direct ecological indicators, (2) indirect ecological indicators, and (3) non-ecological indicators. Direct ecological indicators are concerned with environmental aspects such as greenhouse gas emissions, preservation of local attributes, whereas the indirect indicators are those, which affect the environment indirectly, such as energy efficiency, water reuse and recycling, and waste management (Gu et al. 2006). The non-ecological indicators are those that will not have an impact on the environment, but will affect the quality of the development; which are the other aspects of sustainability (social and economic) such as preservation of historic buildings, and economic issues (Gu et al. 2006).

Wallhagen and Glaumann performed a comparative analysis between three environmental assessment systems; LEED-NC v3, Code for Sustainable Homes (CSH) and EcoEffect by testing them on a case study of an eight-floor residential building in Sweden (2011). The authors examined categories and issues of each rating tool, in some categories of the three different rating tools, there were similarities in their results; however, there were also categories with great differences. Yet among the same category in the three mentioned rating systems; each has its own priorities; for instance, in the Materials category, LEED emphasizes on the reuse and recycling; whereas CSH concentrates on the environmental impact from the early stages of the material extraction and manufacturing and EcoEffect require lifecycle data on the materials used (Wallhagen and Glaumann 2011).

Moreover, Lee performed a comparison of issues and metrics of five environmental assessment systems (2013). For the assessment of buildings, the author revealed that a set of quantitative and qualitative criteria have the ability to identify the performance of buildings. Furthermore, since green building rating systems have different origins and terminologies, it was necessary to select a scheme with common issues covered (Lee 2013).

A comparison between the rating level and scoring level of the five assessment schemes showed that in order for a building to achieve the lowest certification level, BEAM Plus was the most strict whereas CASBEE was the easiest (Lee 2013).

2.13. WORLDWIDE GREEN BUILDING ASSESSMENT SYSTEMS

Based on research performed by Hastings and Wall, systems for environmental evaluation for buildings, processes and products range from a single aspect to the multi-aspects evaluation (2007). The authors have defined three main approaches for sustainability evaluation of building performance:

1. Cumulative energy demand (CED) systems: It evaluates the energy consumption.
2. Life cycle analysis (LCA) systems: It considers the environmental aspects only.
3. Total quality assessment (TQA) systems, which evaluate ecological, economic and social aspects; it is also known as Sustainability rating systems such as LEED and BREEAM.

CED and LCA have the quantitative approach of measurement, whereas TQA could have both the qualitative and quantitative evaluation approach (Hastings and Wall 2007). See Appendix D for a complete list of single and multi-aspect assessment systems.

Globally, there have been many studies in the field of green building in both developing and developed countries. (Zuo and Zhao 2014) suggest that among most of the green building rating systems studied, there are mutual attentions and emphases through allocating consideration to two main aspects (a) process (method for process fulfillment) (b) outcome (method for process assessment).

There are over forty 'total quality assessment systems' which are commonly called green building rating systems; such as LEED in United States, BREEAM in UK, CASBEE in Japan, Minergie in Switzerland, HK Beam in Hong Kong, the Pearl Rating System for ESTIDAMA in Abu Dhabi, United Arab Emirates, and Green Pyramid Rating System (GPRS) in Egypt. A summary of available green building rating systems around the globe is illustrated in Figure 2.2.

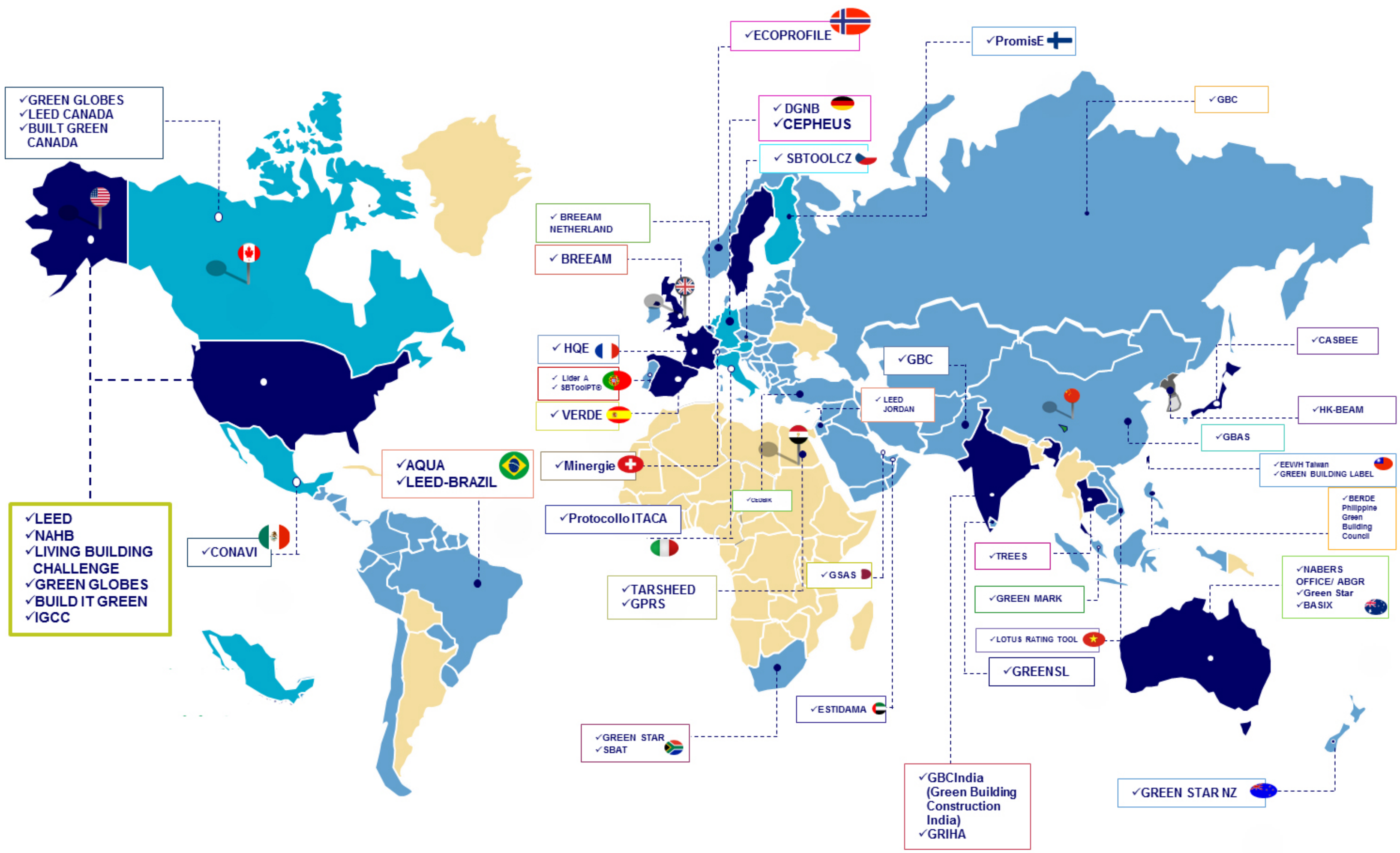

Figure 2.2 Green building rating systems around the world

2.13.1. Building Research Establishment Environmental Assessment Methodology (BREEAM)

Building Research Establishment Environmental Assessment Methodology (BREEAM) is the pioneer assessment system, established in 1990. Its introduction and control were through the Building Research Establishment (BRE) in the United Kingdom (BREEAM 2015). The launch of the first version of BREEAM for offices was in 1993. In 1998, the second version was released covering a wide range of building types. Furthermore, the year 2014 witnessed the release of the latest version of BREEAM UK New Construction (Non-Domestic); see Appendix E for its criteria weightings. Based on statistics performed in 2014, over 534,056 buildings are BREEAM certified whereas the number of registered projects for assessment are around two million (BREEAM 2015). Furthermore, BREEAM is applicable in 72 countries (BREEAM 2015). There are five certification levels in BREEAM; the highest is 'Outstanding' and the lowest is 'Pass' as shown in Table 2-3. BREEAM New Construction Technical Manual covers a variety of building types; see Appendix F (BRE 2014).

Table 2-3 BREEAM Certification Levels (BRE 2014)

Certification level	Points
Outstanding	85
Excellent	70
Very Good	55
Good	45
Pass	30

2.13.2. Leadership in Energy and Environmental Design (LEED)

LEED stands for Leadership in Energy and Environmental Design, a green building rating system originally developed in 1998 by the U.S. Green Building Council (USGBC) to offer a well-known standard for the construction industry to evaluate the environmental sustainability levels of building designs (USGBC 2014). The announcement of the latest version of LEED was on November 20th, 2013; however, projects can still register and work with the older version of LEED until October 2016. For a project to receive LEED certification, it has to satisfy prerequisites and earn points to achieve different levels of certification. Prerequisites and credits differ for each rating system, and teams choose from among them according to their project type and stage. There are five different schemes of LEED rating system, which are as follows:

1. Building Design and Construction
2. Interior Design and Construction
3. Building Operation and Maintenance
4. Neighborhood Development
5. Homes (USGBC 2014).

The LEED Assessment relies on evaluating eight main categories which are; (1) Location and Transportation, (2) Sustainable Sites, (3) Water Efficiency, (4) Energy and Atmosphere, (5) Materials and Resources, (6) Indoor Environmental Quality, (7) Innovation, and (8) Regional priority; see Appendix G. Projects applying for LEED certification should consider these categories and their specific prerequisites. The project must then pursue a set of credits in order to earn points. Additionally, some of the requirements under selected categories are obligatory and required in order to receive LEED certification. The number of points the project earns determines its level of LEED certification. A project that earns 40-49 points from the different categories would be 'Certified', whereas a project that earns 50-59 points is 'Silver', a project with 60-79 points is 'Gold' and a project with more than 80-110 points would be 'Platinum' (USGBC 2014). Refer to Appendix H for assessment fees for LEED rating system.

2.13.3. Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)

With the establishment of the international agreement 'Kyoto protocol', that commits its members to adhere to GHG emission reduction targets, CASBEE 'Comprehensive Assessment System for Building Environmental Efficiency' was established. The establishment of this rating system was through a joint collaboration between industrial, academic, and governmental entities with the support of the Housing bureau, a branch of the Ministry of Land, Infrastructure, Transport, and Tourism (MLITT)

(IBEC 2014). CASBEE’s mission is to evaluate and assess the environmental performance of buildings. The quality of the building, interior comfort, materials usage, energy efficiency, and internal power loads are all included in CASBEE assessment. There are five possible grades in the CASBEE rating: Superior (S); very good (A); Good (B+); slightly poor (B-) and Poor (C). Furthermore, CASBEE has several tools, which are known as CASBEE family. These tools can work according to the different project scales: construction such as residential and non-residential, and urban and district in the range of town and city development (IBEC 2014). The first assessment tool of CASBEE family was CASBEE for Office, completed in 2002. In July 2003, CASBEE for New Construction was established and one year later, CASBEE for Existing Buildings was created. The last tool in the CASBEE family was CASBEE for Renovation, launched in July 2005. The following three principles represent the basis for the CASBEE assessment tools: 1) Comprehensive assessment throughout the life cycle of the building, 2) Assessment of the “Building Environmental Quality (Q)” and “Building Environmental Load (L)” and 3) Assessment based on the newly developed Building Environmental Efficiency (BEE) indicator (IBEC 2014). Furthermore, CASBEE employs the value of Building Environment Efficiency (BEE) in the evaluation of the sustainability of a building (Wong et al. 2014).

The approach employed in CASBEE evaluation is through the concept of Building Environment Efficiency (BEE) with weighting coefficients; see Appendix I for a list of CASBEE New Construction 2014 scoring criteria. BEE is the core of CASBEE by plotting results on a graph to determine the building final score. The uniqueness of CASBEE relies on assessing multi aspects and deriving the final score from the relation between those aspects (Alyami and Rezgui 2012). Similarly, Gu et al. consider CASBEE as the most advanced assessment system covering almost all issues during building construction stage. See Appendix J for CASBEE certification fees.

2.13.4. The Pearl Rating System - ESTIDAMA

Sustainability is ‘Estidama’ in Arabic. Abu Dhabi, the capital of United Arab Emirates, has initiated the ‘Estidama’ with the aim of transforming this emirate into an icon of sustainability (UPC 2010). The Pearl Rating System (PRS) is the green building assessment system developed by Abu Dhabi Urban Planning Council in 2007 (UPC 2010). The aim of this system is to employ the basic concepts of green architecture through highlighting the need for balanced use of land, materials, energy, and water (UPC 2010). The mission and vision of PRS are to create a sense of equilibrium between Estidama's four aspects: (1) environmental, (2) economic, (3) cultural, and (4) social by creating more sustainable communities, cities and global enterprises (UPC 2010).

The Pearl rating system is divided into seven categories which are: (1) Integrated Development Process, (2) Natural Systems, (3) Livable Buildings, (4) Precious Water, (5) Resourceful Energy, (6) Materials, (7) Innovating Practice, see Appendix K. This rating system divides sections in mandatory and optional credits. The achievement of the mandatory credits is a prerequisite in order to receive the minimum pearl level '1 pearl'. A higher pearl rating is achievable by meeting all mandatory levels along with further credits as shown in Table 2-4 (UPC 2010). It is obligatory that buildings in Abu Dhabi achieve a minimum of '1 pearl' rating, whereas buildings financed by the government have to achieve a minimum of '2 pearls' rating.

Table 2-4 Pearl Building rating levels

Requirement	Pearl Rating Achieved
All mandatory credits	1 Pearl
All mandatory credits + 60 credit	2 Pearl
All mandatory credits + 85 credit	3 Pearl
All mandatory credits + 115 credit	4 Pearl
All mandatory credits + 140 credit	5 Pearl

There are various schemes of the Pearl Rating System for Estidama, which are as follows:

- Pearl Building Rating System: Design & Construction
- Pearl Villa Rating System: Design & Construction
- Pearl Community Rating System: Design & Construction (UPC 2015).

Table 2-5 Pearl rating system levels

Pearl Rating	Optional credit points required		
	Pearl Community Rating System	Pearl Building Rating System	Pearl Villa Rating System
1	All mandatory credits	All mandatory credits	All mandatory credits
2	55+	60+	30+
3	75+	85+	44+
4	100+	115+	57+
5	125+	140+	70+

2.13.5. Global Sustainability Assessment System (GSAS)

Global Sustainability Assessment System (GSAS), which was formerly known as QSAS, was developed by Qatari Diar Real Estate Investment Company with the purpose of promoting environmentally responsible building practices in Qatar and the whole Middle East region (GSAS 2013 a). The main objective of GSAS is the creation of a sustainable built environment that reduces the impact of buildings on the environment through maintaining and considering the regional requirements and needs (GSAS 2013 a).

The approach that was followed in the creation of this system was through initially considering and reviewing more than 140 green building rating systems, tools and guidelines around the world and then reassessing the most relevant and comprehensive schemes (GSAS 2013 b). There are three types of GSAS certification; (1) design and build certification, (2) construction management certification, and (3) operations certification.

Furthermore, there are various schemes and publications of GSAS assessment, which are: (1) District and Infrastructure, (2) Commercial, (3) Mosques, (4) Neighborhood, (4) Parks, (5) Residential/Group residential, (6) Education, (7) Hotels, (8) Light Industry, (9) Sports, (9) Railways, (10) Healthcare, (11) Workers' accommodation, (12) Existing buildings, and (13) bespoke.

There are eight categories in GSAS system, with direct emphasis on mitigation approaches, outlined as follows (GSAS 2013 a):

1. [UC] Urban Connectivity: Urban considerations during building planning phase.
2. [S] Site: Existing site conditions control during the building's development.
3. [E] Energy: Over the building's service life, control its depletion of fossil energy.

4. [W] Water: Control the overall water resource and the impact of buildings on it.
5. [M] Materials: Control the impact of the buildings use of materials on the environment.
6. [IE] Indoor Environment: Control the building's indoor environment.
7. [CE] Cultural and Economic value: Maintain and enhance the building's cultural and economic value.
8. [MO] Management and Operation: Define the building’s management and operations plan. See Appendix L for a list of GSAS Building Typologies categories and weights.

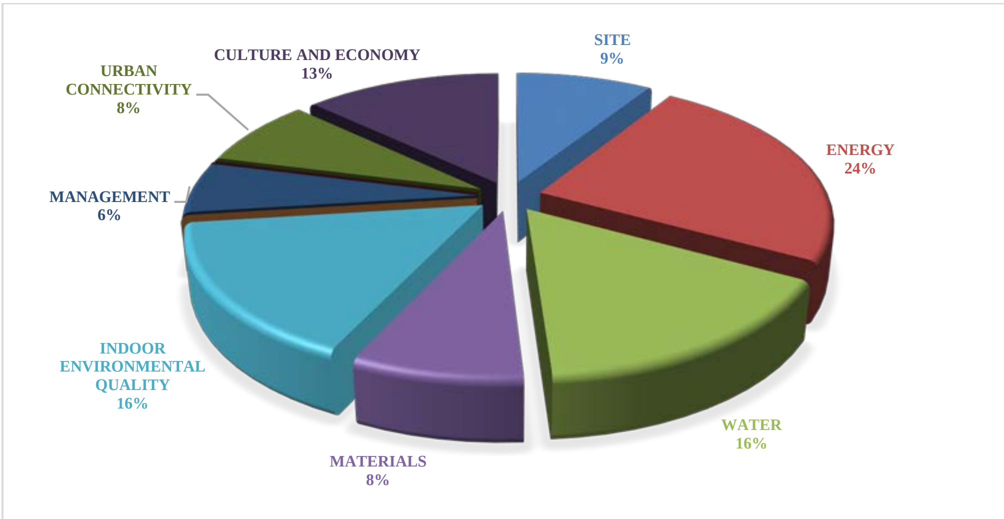

Figure 2.3 GSAS categories and weights (GSAS 2013 b)

Moreover, there are various aspects under each of the categories in Figure 2.3. The scoring mechanism in GSAS is measured on the scale of -1 → 3 [-1, 0, 1, 2, 3]. Only for the scoring in the ‘Urban Connectivity and Management’ category, it must be either 0 or 3 (GSAS 2013 a). A negative scoring makes an emphasis on the criteria that has a harmful impact on the environment; thus, promote trading-off of that impact and thoroughly considering the building performance in remaining criteria.

2.13.6. Excellence in Design for Greater Efficiencies (EDGE)

Excellence in Design for Greater Efficiency (EDGE) was a voluntary program developed by the International Finance Corporation (IFC), a member in the World Bank Group, demands reduction of 20% as an improvement. In July 2013, the launch of EDGE rating system was during an event called 'Transforming the Built Environment in Emerging Markets'. During the event, a partnership between The World Bank and IFC was established aiming at promoting and pushing the construction of green buildings in emerging markets (IFC 2015 a). The main mission of the EDGE tool is to 'encourage resource-efficient building growth by proving the business case for building green' (IFC 2015 a). Cost savings and greenhouse gas reductions, which are demonstrated in the EDGE tool, are achievable through the different choices that are offered by the software such as using buildings materials with lower environmental impact, efficient HVAC systems, natural ventilation, and water-saving plumbing (IFC 2015 a). Through the several case studies that are available on the EDGE-IFC website, it is clear that monthly heating, electricity, and water bills; the amount of the materials used in the construction were minimized which would essentially have an effect in reducing the building impact on the environment (IFC 2015 a). The newest version of EDGE (version 1.1) was available on May 15th, 2015. Accordingly, the employment of Edge software in the building design phase can determine the potential attainable cost savings by designing an EDGE building. The target of the EDGE green building program is to transform the traditional thinking about the building construction into a sustainable way of thinking; making building designers and users believe and understand that efficient buildings are 'practical and necessary' and not a luxury (IFC 2015 b).

The EDGE online software provides default settings for projects based on each building type, function and use (IFC 2015 b). Through the reduction of at least 20% in energy, water, and materials and according to the different scenarios provided by Edge, lower costs are achievable than conventional buildings. Among the factors that support in minimizing the resource consumption are: (a) reduced window to wall ratio, (b) energy-efficient lighting, and (c) superior HVAC systems (IFC 2015 b).

2.13.7. Green Pyramid Rating System (GPRS)

The Green Pyramid rating system was introduced according to the initiative that was taken by the Housing and Building National Research Center to establish the Green Building Council in 2009 (GPRS 2011). The objective of GPRS is to provide green credentials for the assessment of buildings in Egypt through raising awareness of the necessity of green buildings according to the Egyptian context and conditions (GPRS

2011). Its target is to allow innovative solutions and designs in the building sector in Egypt (GPRS 2011).

The focal intention of this rating system is the assessment of new buildings at their design stage and post construction stage. The methodology employed in the GPRS scoring system of GPRS is, a point weighting system divided under seven categories. There are three levels of green building certification in GPRS: (1) Silver Pyramid, (2) Golden Pyramid, and (3) Green Pyramid.

A minimum of 40-49 points is required for any new construction building to receive 'GPRS certified'. Accordingly, the award of certifications to projects relies on their total points; for example, for a project with 50-59 points, it will receive a silver certification whereas a project with 60-79 points will receive the Gold pyramid. The highest level of certification is 80 points and more awarding the project 'Green Pyramid' certification (GPRS 2011). Table 2-6 illustrates the weighting score of the different categories in GPRS (GPRS 2011).

Table 2-6 Weighting score of GPRS categories (GPRS 2011)

Green Pyramid Category	**Weighting**
Sustainable Site, Accessibility, Ecology	15%
Energy Efficiency	25%
Water Efficiency	30%
Materials and Resources	10%
Indoor Environmental Quality	10%
Management	10%
Innovation and Added Value	Bonus

2.13.8. SBTool

The International Initiative for a Sustainable Built Environment is the entity that developed SBTool rating system. This assessment system allows evaluation in four distinct stages, which are; (1) Pre-design; (2) Design; (3) Construction; (4) Operations. The scope of the SBTool is adjustable allowing it to have criteria's ranging from 120 down to 6 according to the size and requirement of buildings (IISBE 2015). This assessment system covers issues related to sustainable building rather than aspects related to green building only (IISBE 2015). Furthermore, SBTool considers regional and site-specific conditions allowing the systems users to adapt according to regional priorities and requirements (Sev 2011).

2.13.9. DGNB

DGNB, which is a German Green Building Council, is a non-profit and non-governmental organization. It was established by a group of individuals and companies from the construction and real estate industry in Stuttgart, Germany in 2007 (DGNB 2015). The main emphasis of the DGNB certification on buildings or districts' is in considering the holistic performance rather than individual calculations (DGNB 2015). There are various schemes for buildings in Germany, including new and existing offices, residential buildings, hotels, education facilities, dwellings, industrial, assembly buildings, and retail (DGNB 2015). This rating system has six different areas for evaluation that include 49 criteria, which make it a comprehensive assessment tool for the overall performance of buildings. The six topics covered in this tool are: (1) ecological quality, (2) economical quality, (3) social quality, (4) technical quality, (5) quality of the process, and (6) quality of the location (DGNB 2015).

2.13.10. Green Globes

Green Globes is an online assessment tool that measures the environmental performance of new and existing building, and interior fit-ups (GBI 2014). Green Globes, that was introduced in North Africa, is the first collaborative design guidance and ecological evaluation tool (White 2014). The main categories covered under the Green Globes assessment system are shown in Table 2-7.

Table 2-7 Green Globes environmental assessment areas, points and description (GBI 2014)

Environmental Assessment Area	Points	Description
Project Management	50	Integrated Design Process, Meetings, Performance Goals, Environmental Management, Commissioning
Site	115	Development Area, Ecological Impacts, Stormwater Management, Landscaping, Exterior Light Pollution

Energy	390	Performance, Demand, Metering, Measurement and Verification, Building Opaque Envelope, Lighting, HVAC Systems and Controls, Efficient Equipment, Renewable Energy, Energy Efficient Transportation
Water	110	Consumption, Cooling Towers, Boilers & Water Heaters, Water Intensive Applications, Treatment, Alternate Sources, Metering, Irrigation
Materials & Resources	125	Building Assembly, Interior Fit-outs, Reuse, Waste, Building Service Life Plan, Resource Conservation, Building Envelope
Emissions	50	Heating, Ozone-depleting Potential, Global Warming Potential
Indoor Environment	160	Ventilation, Source Control and Measurement, Lighting Design and Systems, Thermal Comfort, Acoustic Comfort
Total Points	**1000**	

2.13.11. TARSHEED

TARSHEED is the Arabic word of 'Rationalization'. TARSHEED is a newly developed rating system by Egypt Green Building Council (EGGBC), which is a prospective member of the World Green building council (WGBC 2015). EGGBC was established in November 2012 as a non-governmental organization. It aims at promoting green building practices in Egypt and in raising public awareness about sustainability and Green buildings. TARSHEED is a simple and easy to use 'rating system' that was developed after studying a number of green building assessment systems such as LEED, BREEAM, ESTIDAMA and EDGE IFC (EGGBC 2015). For a project to become TARSHEED certified it has to achieve a minimum of 20% reduction in energy, water, and habitat, see Appendix M for a detailed list of TARSHEED categories and weights (EGGBC 2015). There are two stages in the assessment of this rating system: (1) preliminary assessment at the design stage and (2) final assessment during construction and handover (EGGBC 2015). The core concept of TARSHEED is to achieve savings in the design case beyond the base case in a set of credits under each category.

The next chapter is dedicated to comprise comparison to identify gaps between green building rating systems. Among the subjects included assessment systems' selection criteria, green building rating systems' categories, weights, certificate validity, and maturity. Finally, a discussion and an analysis of the comparative analysis outcome is outlined.

CHAPTER 3
COMPARATIVE ANALYSIS

This chapter will present an overall comparison between selected green building rating systems. The analysis covers qualitative and quantitative comparative study. Later on, through this chapter, there will be a discussion of the comparative analysis results.

3.1. CRITERIA AND SCREENING ANALYSIS

The following represent the tracked stages in the selection of the assessment system. An investigation of the selection of rating systems is justified in the next sections of this chapter. Following these stages was crucial in order to perform the comparative analysis effectively and efficiently.

Stage 1: Classify the available green building rating systems

Stage 2: Perform a screening study by investigating the most applicable green building rating systems

Stage 3: Categorize the relation between the preliminarily selected rating systems and their relevance, applicability, measurability and availability based on the Egyptian context

Stage 4: Conduct an extensive data collection on each of the selected rating systems through studying their detailed reference guides and official documents.

3.1.1. Selection Criteria

The criteria that were set for the selection of the assessment systems for the comparative analysis are as follows:

1. **Scope and Magnitude:** Do rating systems offer a holistic evaluation of the building performance rather than only considering a single aspect?
2. **Quantifiable:** Can the rating system offer quantitative methods (weighting system) to assess the sustainability level of buildings?

3. **Validity and Relevance:** Is the rating system applicable to New Residential Building Construction types?

4. **Applicability:** Do other countries employ this rating system in their construction industry?

5. **Country ranking and green building rating system:** What is the basis of the rating system?

6. **Maturity, and Initiating time:** Selection to be based on the maturity level of the green building rating system

7. **Rating systems with remarkable outcomes:** Selection to be based on rating systems with remarkable achievement to the construction

3.1.2. Selected Green building Rating Systems

Following the previous screening criteria, the selection is as follows:

- **BREEAM UK New Construction 2014**: Pioneer and first established, see Appendix E for BREEAM New Construction 2014 Categories.

- **LEED New Construction (Building Design and Construction) version 4**: The most widely used rating system globally. LEED Homes was not selected since it is only employed in U.S. and Canada.

- **The Pearl Rating System (PRS) ESTIDAMA:** Rating system developed in one of the MENA region's countries – United Arab Emirates.

- **GSAS Building Typologies version 2**: The development of this rating system relied on studying forty different rating systems (regional and international). It is applicable in Qatar with the potential of expanding to Gulf countries. The selected scheme is GSAS Building Typologies-Design Guidelines and Assessment system.

- **CASBEE**: A rating system with a different calculation approach based on the Built Environment Efficiency (BEE) indicator where the final score is based on a relation between the built environment quality (Q) and the built environment load reduction (L) (CASBEE 2010).

- **EDGE IFC World Bank v1.1**: A new online building design tool and certification system. It aims at promoting and encouraging the construction of green buildings in developing and emerging countries (World GBC).
- **Green Pyramid Rating System (GPRS) Public Review**: This is national green building rating system in Egypt; developed by the Housing and Building National Research Center.
- **TARSHEED v1.0:** Egypt Green Building council, a non-governmental organization, developed this rating system.

Table 3-1 provides the main features of some green building rating systems. Once buildings achieve certain levels in different categories, they become 'sustainable' or 'green'. Rating systems, which act as a guidebook and checklist, allow professionals in the field for a comprehensive and measurable assessment of the building's impact on the environment. The achievement potential of the different aspects of sustainable development is possible through the lifecycle of the building. The process of accreditation proves the commitment of the building owners to sustainable development. Furthermore, the assessment method should have a clear path to the achievement of three main aspects of sustainable development. Additionally, the hierarchy, relationships, and sources should be clear in the rating system, and the scores must be comprehensible and easy to communicate. For a unified basis in performing the comparative analysis, it employed the latest versions of the selected eight rating systems. Thus, the basis on the assessment is on the following versions of the selected rating systems: BREAAM UK New Construction 2014, LEED for New Construction Building Design and Construction version 4, GSAS version 2.0, CASBEE 2014, ESTIDAMA PRS v1.0, TARSHEED v1.0 2014, GPRS v1.0, and EDGE IFC v1.1 Homes.

3.2. ROAD MAP OF THE COMPARATIVE ANALYSIS

The determination of the context of the comparative analysis was through the literature review and available worldwide green building rating systems. The next stage was assessing the applicability of selected rating systems based on the local context of Egypt. This stage included the selection of a case study to investigate green building tools' metrics in evaluating and defining green buildings. The last two stages included suggestions and recommendations for future versions of TARSHEED; see Figure 3.1.

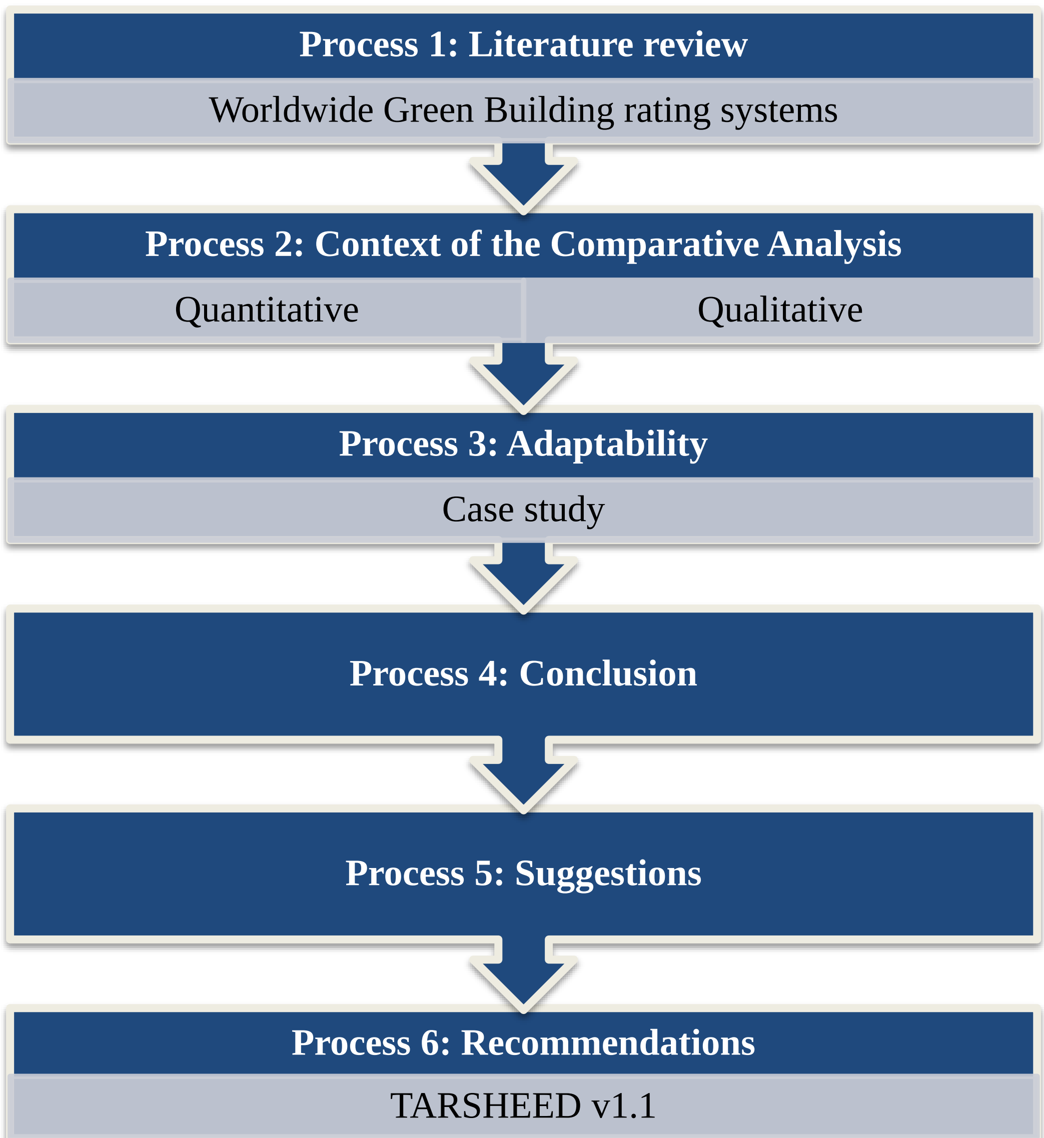

Figure 3.1 Roadmap of the comparative analysis

Table 3-1 Main Features of BREEAM, LEED, ESTIDAMA, CASBEE, GSAS, Edge IFC, TARSHEED and GPRS (BRE 2014; USGBC 2013; UPC 2010; IBEC 2014; GSAS 2013 a; IFC 2015 b; EGGBC 2015; and GPRS 2011).

Comp. item	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Location, year Developed by	The United Kingdom, 1990 BRE Non-profit organization	The United States of America, 1998 USGBC (Non-profit organization)	Abu Dhabi, United Arab Emirates, 2007, Urban Planning Council (governmental)	Qatari Diar Real Estate Investment Company	Japan, 2001 (joint of government, industry, academy)	World Bank, IFC	Egypt, 2015.Egypt Green Building Council. NGO Voluntary	Egypt, 2009. Egyptian Green Building Council. Governmental National
Categories	Managem-ent, health and wellbeing, energy, transport, materials, water, waste, land use & ecology, pollution and innovation	Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation, and Regional Priority	Integrated Development Process, Natural Systems, Livable Buildings, Precious Water, Resourceful Energy, Materials, Innovating Practice	Urban connectivity, Site, Energy, Water, Materials, Indoor Environment, Cultural and Economic value, Management and Operations	Building environmental quality: indoor environment, quality of service, outdoor environment on site; environmental load: energy, resources and materials, offsite environment	Building's operational Building embodied energy Water use.	Energy Water Habitat	Sustainable Site, Accessibility, Ecology Energy Efficiency Water Efficiency Materials and Resources Indoor Environmental Quality Management Innovation and Added Value

Comp. item	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Assessed Building	Residence, retail, industry units, offices, courts, school, healthcare, prison, multi-function building, unusual building	Residence, school, retail, commercial building, multifunction building, healthcare	All building typologies, Multi-Residential, retail, office, school, mixed-use, hospitals, warehouses, industrial buildings, laboratories, hotels	All building typologies; Commercial, residential, schools, core & shell, Districts, Parks, mixed use, mosques, hotels, light industries, sports, rail, healthcare, bespoke	Residence (multi-unit), retail, industrial temporary construction, multi-function building	Homes, hotels, Retail, Offices, Hospitals	New Construction -Residential -Commercial	New Construction Commercial Existing Banks Neighborhood
Where can be implemented	UK, and relatively overseas	USA, and relatively overseas	Mandatory in Abu Dhabi to achieve at least '1 pearl' in general buildings and '2 pearls' in buildings funded by the government	GCC: Qatar, UAE, Oman, Kuwait, Saudi Arabia, Bahrain	Japan, and relative application possibility overseas	Emerging developing countries	Egypt	Egypt

Comp. item	International rating systems						Egypt rating systems	
	BREEAM UK 2014	**LEED BD+C v4**	**PRS for ESTIDAMA v1.0**	**GSAS Typologies v2.0**	**CASEBEE BD (NC) 2014**	**EDGE Homes v1.1**	**TARSHEED Residential v1.0**	**GPRS Public review 2011**
Approach to scoring criteria	Addition of points: pre-weighted credits approach	Simple approach (1 for 1) Point based with mandatory requirements	Simple approach (1 for 1) Point based with mandatory requirements	Cumulative Score (CS)of all the assessed criteria	Special	EDGE provides users with a set of best-practice options to explore in order to identify an optimum design solution.	Achieve a minimum of 20% savings in the three categories	Simple approach: Summing up points from categories
Rating Levels	Unclassified <30 Pass ≥30 Good ≥45 Very good ≥55 Excellent ≥70 Outstanding ≥85	Certified 40–49 points Silver 50–59 points Gold 60–79 points Platinum 80+ Points	-All mandatory credits: 1 Pearl -All mandatory credits + 60 credit points: 2 Pearl -All mandatory credits + 85 credit points: 3 Pearl -All mandatory credits + 115 credit points: 4 Pearl -All mandatory credits + 140 credit points: 5 Pearl	BEE = 3.0 (excellent) BEE = 1.5–3.0 (v. good) BEE = 1.0–1.5 (good) BEE = 0.5–1.0 (fairy poor) BEE = less than 0.5 (poor)	Level 1 ☆→ 0≤CS≤ 0.5 Level 2 ☆☆→ 0.5<CS≤ 1 Level 3☆☆☆ → 1<CS≤ 1.5 Level 4 ☆☆☆☆ → 1.5<CS≤ 2 Level 5 ☆☆☆☆☆→ 2<CS≤ 2.5 Level 6 ☆☆☆☆☆☆→ 2.5<CS≤ 3.0	Edge certified once achieved 20% in the three main areas to reach Edge standards [Pass/no pass basis]	TARSHEED 20 → 20% savings than the base case	40-49 points Certified 50-59 points Silver Pyramid 60-79 points Gold Pyramid 80 or more points: Green Pyramid

3.3. CONTEXT OF THE COMPARATIVE ANALYSIS

The following table (Table 3-2) includes issues to be covered in the comparative analysis. It comprises aspects related to the structure, contents, assessment costs, weighting methods, and maturity.

Table 3-2 Outline of the Comparative Study

Structure	Technical contents & Sustainability aspects Metrics[1] (Comprehensive)	Access to rating system	Cost of Assessment	Local context (Regional priority)	Weighting method	Registration & Assessment process	Maturity	Lifecycle stage coverage
Hierarchy Categories and issues Issues (nature, kind & function)	Environmental: Climate change, stratospheric ozone depletion, fossil fuel depletion, Resource use &waste, emissions to air, land, embodied energy etc.	Available info: online and FAQ, review, email requests	Fees	Climate	Scoring & Rating level Final result	Submission Review	Number of countries Registered and certified projects	Building lifecycle stages: -Pre-design -Design -Core and Shell -Post construction -Tenant fit-out -Existing and operation
	Social: enhance productivity, wellbeing/comfort, safety, IAQ (Acoustics, Thermal) Quality of water	Case studies	Expert involvement	Geographic location	Prerequisite or a minimum percentage from each category	-Certification stages -Validity		
-Procedures -Features -Performance	Economic: reduce operating costs, risk mitigation	-Workshops & training	Verification	Cultural differences			Versatility (Adaptability)	
	Impacts natural and built environment (Spatial and temporal boundary)	-Available languages						

[1] LEnSE Methodology Framework

3.3.1. Rating Systems' Categories Contents Comparison

The following comparison identifies the similarities and differences of contents coverage in each rating system, see Table 3-3.

Table 3-3 Green building rating systems 'Contents' comparative analysis

Category	Issues	International rating systems						Egypt rating systems	
		BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
SITE	site selection, reuse of land	●	●	●	●				●
	site assessment, natural system assessment		●	●					
	construction activity and pollution prevention	●	●		●				
	natural system protection, the ecological value of site and protection of ecological features		●	●	●				●
	mitigating ecological impact, ecological balance								●
	Heat island effect		●		●	●			
	Light pollution reduction, outdoor lighting full cutoff		●			●		●	
	parking footprint and shaded parking				●			●	
	protect or restore habitat, habitat creation and restoration		●	●	●				●
	rainwater management, runoff		●		●			●	
	Accessibility, bicycle racks, alternative method of transportation, pathways	●			●			●	●

Category	Issues	International rating systems						Egypt rating systems	
		BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
WATER	water consumption	●	●	●	●	●	●	●	●
	indoor water use reduction		●	●			●	●	●
	outdoor water use reduction		●	●		●		●	●
	water monitoring	●		●				●	●
	water leak detection and prevention	●		●	●				●
	Water Efficient Equipment	●						●	
	Building level water metering		●						●
	landscape water use reduction, irrigation			●				●	●
MATERIALS	lifecycle impact, LCA	●			●			●	
	storage and collection of recyclables, waste management		●	●				●	
	Insulation	●					●		
	materials and building reuse		●	●	●	●		●	●
	Timber for sustainable Forestry		●	●		●		●	
	Regional materials		●	●				●	
	Modular flooring system, flooring			●			●		
	Designing for robust, elimination of exposure to hazardous and toxic materials	●						●	
	Design for disassembly			●	●			●	

Category	Issues	International rating systems						Egypt rating systems	
		BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
INDOOR ENVIROMENTAL QUALITY	visual comfort, daylighting, glare control, anti-glare measures	●	●	●	●	●	●		●
	Thermal comfort	●	●		●	●			●
	Acoustic performance	●	●		●	●			●
	Safety and security	●						●	
	Indoor air quality (enhanced)	●	●					●	
	construction indoor air quality management, indoor chemical and pollutant source control		●	●	●			●	
	Smoke control		●	●					●
	Legionella			●					●
	Natural ventilation			●	●			●	●
	mechanical ventilation								
	emissions from materials		●	●	●			●	●
	Glare control							●	
ENERGY	reduction of CO2 emissions, green power and carbon offset, CO_2 emissions	●	●		●			●	
	Energy monitoring, fundamental commissioning and verification, energy monitoring and reporting, energy delivery performance,	●	●	●	●	●		●	●
	External & outdoor lighting controls	●					●	●	

Category	Issues	International rating systems						Egypt rating systems	
		BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
	low and zero carbon technologies, global warming, NO_x, SO_x and particulate matter, environmental impact	●		●	●				●
	energy efficient cold storage, fundamental refrigerant management, ozone impacts of refrigerants and fire suppression systems, VRV cooling system	●	●	●			●		
	energy efficient transportation systems and elevators, vertical transportation, efficiency in building services systems	●		●		●			●
	energy efficient appliances	●		●			●	●	●
	minimum energy performance, operations and management system		●	●	●	●			●
	building level energy metering, advanced smart energy metering		●		●		●	●	
	renewable energy production		●	●	●	●	●	●	●
	Demand response, Energy demand performance		●		●			●	
	Cool building strategies, Passive external gain/loss reduction			●		●	●		●
	Operations and maintenance				●	●		●	●

Category	Issues	International rating systems						Egypt rating systems	
		BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
OTHERS	Sustainability awareness plan, sustainability communication			●	●			●	
	Heritage and Cultural identity			●	●	●			●
	Support of National Economy, National development plan			●	●			●	●
	shading of adjacent properties				●				
	Public transport			●	●				●
	Reduce use of private transport			●	●				●
	earthquake resistance					●			
	Townscape and landscape, Open space		●		●	●		●	
	Green vehicles		●						
	Environmental Product Declaration		●						
	Building product disclosure and optimization, material ingredients		●						
	Regional priorities	●	●				●		●

The previous table has summarized the sustainable building indicators (site, water, materials, indoor environmental quality, energy, and others). The comparison indicated that (1) LEED and GSAS are the most comprehensive in terms of the ‘site’ category; (2) GPRS covers the majority of ‘water’ and ‘indoor environmental quality’ categories issues; and (3) TARSHEED includes most of the ‘materials’ issues. Furthermore, most of the ‘energy’ category issues were covered by TARSHEED, GPRS, and PRS for Estidama. The variation in issues’ inclusion relies on the local needs and requirements of each country. In addition, PRS, GSAS, CASBEE, and GPRS cover heritage and cultural identity issues; and PRS, GSAS, GPRS, and TARSHEED cover issues related to national development plan. This indicates the local priorities and necessities of each country.

3.3.2. Coverage of Sustainability Aspects

The following table compares the three sustainability aspects, environmental, social and economic in the selected rating systems.

Table 3-4 Building Assessment systems' Comparison of covered Sustainability aspects (Aspects: LEnSE)

Aspect	Category	Parameter	International rating systems						Egypt rating systems	
			BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Environment	Climate Change	Reduce GHG emissions	✓	✓	✓	✓	✓	✓	✓	✓
		Reduce stratospheric ozone depletion	✓	✓	✓	✓	✓	✓	✓	✓
		Mitigate impact on site ecology	✓	✓	✓	✓	✓		✓	✓
	Preserve natural resources and waste management	Minimize waste production	✓	✓	✓	✓	✓	✓	✓	✓
		Minimize primary energy consumption	✓	✓	✓	✓	✓	✓	✓	✓
		Limit raw materials use	✓	✓	✓	✓	✓	✓	✓	✓
		Minimize water consumption	✓	✓	✓	✓	✓	✓	✓	✓
		Minimize land consumption	✓		✓		✓		✓	✓
		Embodied energy	✓	✓	✓	✓	✓	✓		✓
	Environmental Management	Improve environmental management	✓	✓	✓	✓	✓		✓	✓
		Limit climatological risk	✓	✓	✓		✓			
		Limit Geological risk	✓		✓		✓			✓

Aspect	Category	Parameter	International rating systems						Egypt rating systems	
			BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Social	Improve Occupant's wellbeing	Visual comfort	✓	✓	✓	✓	✓	✓	✓	✓
		Thermal comfort	✓	✓	✓	✓	✓	✓	✓	✓
		Acoustic comfort	✓	✓	✓	✓	✓	✓	✓	✓
		IAQ	✓		✓	✓	✓	✓	✓	✓
		Water Quality	✓		✓	✓	✓		✓	
		Outdoor comfort		✓	✓	✓	✓		✓	
		Provision privacy								
		Reduce exposure to hazardous substances	✓	✓	✓	✓	✓	✓	✓	✓
		Provide Health targets		✓		✓	✓		✓	✓
	Improve Amenity Accessibility	Public services	✓	✓	✓	✓	✓			
		Public transport	✓	✓	✓	✓				✓
		Pedestrian network	✓	✓	✓	✓	✓			✓
		Bicycling network	✓	✓	✓	✓			✓	
		Carpooling		✓	✓	✓				
	Security	Building security	✓		✓	✓	✓		✓	
	Social and cultural value	Participatory framework	✓	✓	✓	✓	✓			✓
		Social and Ethical responsibility	✓	✓	✓	✓	✓		✓	✓
		Sensitivity to the local community	✓	✓	✓	✓			✓	✓
		Affordable housing					✓			
		Building Aesthetics	✓				✓			
		Heritage & Cultural			✓	✓				

Aspect	Category	Parameter	International rating systems						Egypt rating systems	
			BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Economic	Whole Lifecycle	Reduce LCC	✓	✓	✓	✓				
		Preserve/improve the quality and value of site	✓	✓	✓	✓			✓	✓
		Building adaptability	✓	✓	✓	✓	✓			
		Ease of maintenance	✓	✓	✓	✓	✓			✓
	Financing and Management	Improve economic feasibility	✓		✓		✓			
		Reduce construction& financing costs	✓	✓	✓	✓				
		Improve construction & management standards	✓	✓	✓	✓	✓	✓	✓	
	Externalities	Locally sourced materials	✓	✓	✓	✓		✓	✓	✓
		Improve building user productivity	✓	✓	✓	✓	✓	✓	✓	✓
		Optimize long-term local employment opportunities		✓		✓	✓		✓	
		Innovation	✓	✓	✓	✓				✓
		Support of National Economy			✓	✓				✓

The previous table has summarized the covered pillars of sustainable development. The comparison has indicated that BREEAM, LEED, and CASBEE were the rating systems with the most comprehensive view to environmental concerns whereas GSAS has covered most of the social aspects. In observing the economic aspect, the PRS for Estidama and GSAS were the most inclusive rating systems.

3.3.3. Criteria: Weighting

The following represents a comparison between the weighting of each category in the studied rating systems; BREEAM, LEED NC BD+C v4, ESTIDAMA, GSAS Building Typologies v2, GPRS Public Review version, TARSHEED v1, and CASBEE, see Figure 3.2.

Table 3-5 Comparison of categories' weights

GREEN BUILDING RATING SYSTEM	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
SITE	10%	26%	9.00%	9%	15%		14.700%	15%
ENERGY	19%	10%	26.00%	24%	20%	20% efficiency	40%	25%
WATER	6%	35%	23.00%	16%	2.250%	20% efficiency	25%	30%
MATERIALS	12.5%	14%	11.00%	8%	12.750%	20% efficiency	11.900%	10%
INDOOR ENVIRONMENTAL QUALITY	15%	15%	23.00%	16%	35.000%		8%	10%
WASTE	7.5%	NA		NA	0		0	NA
MANAGEMENT	12%	NA	6.00%	6%	15%		0	10%
INNOVATION	10%	4%	2.00%	NA	0		0	0%
URBAN CONNECTIVITY/ TRANSPORT	8%	0	0.00%	8%	0		0	0%
POLLUTION	10.0%	0	0		0		0	0%
CULTURE AND ECONOMY	0%	0	0	13%	0			0%
TOTAL (excluding INNOVATION)	100%	100.00%	100.00%	100%	100%	20% efficiency	100.000%	100%

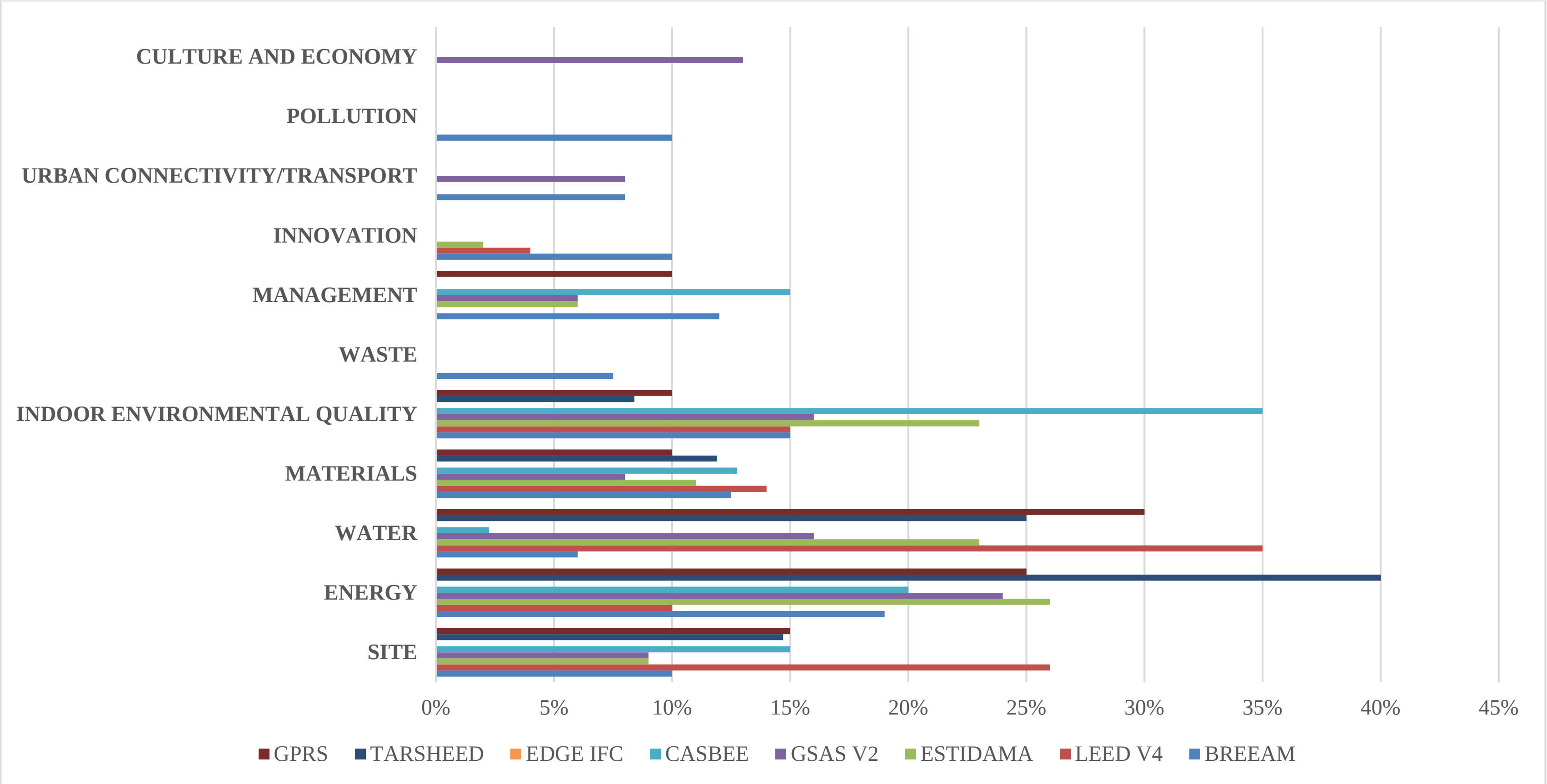

Figure 3.2 Graphical illustration of categories' weightings of the assessed green building rating systems

The previous table indicates the importance and urgency of certain categories to their countries. For instance, LEED allocates a high percentage to the 'water' category, which means that water is a high priority resource in the United States. Moreover, the categories weights in both of the Egyptian rating systems are largely similar except for the energy category. The justification to this could be due to the recent energy shortages that Egypt faced which TARSHEED has taken into account.

3.3.4. Category, Issues, and Aspects

The following table represents a quantitative analysis of the maximum possible points, categories and aspects, weighting, and scoring levels covered by each of the studied rating systems.

Table 3-6 Distribution of Categories, Issues, and Aspects

Item	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Possible points	132	110	180	Score of 3	100%	Pass/no	Saving in %	180
Category count	10	8	7	8	2	3	3	7
Aspects	107	67	86	58	20	36	7	17
Sub aspects					46		27	70
Weighting	Percentage	points	Points	Points	BEE score	Pass/no pass	Percentage	points
Scoring result levels	5 levels	4 levels	5 levels	6 levels	5 levels	1 level	1 levels	4 levels

According to Table 3-6, BREEAM has the most count of aspects, which include issues in the form of features and actions by the building on the surrounding and vice versa. The PRS for Estidama comes in the second level with 86 aspects covered under seven different categories.

3.3.5. Validity

The following comparison represents the validity of certificates issued by each rating system; see Table 3-7.

Table 3-7 Validity

Item	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Validity	Till next stage*	5 years	Till next stage*	Till next stage*	3 years	-	Till next stage*	5 years

*Next stage of the building lifecycle-if require certification for a new stage, then it has to follow the appropriate rating

According to Table 3-7, the certificate of most of the rating systems is valid till the building's next phase such as that of the operation and maintenance.

3.3.6. Cost of Assessment

The following table includes the cost of assessment in the three stages of certification (registration, precertification, and certification) for a residential building of 2000 sq.m.

Table 3-8 Comparison of 'Cost of Assessment' Certification fees (e.g. Residential Building area (example 2000 m^2)

Stage	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Registration/ Interim certificate	2970 $	900 $	0	5000 QR	0	~ $ 310	0	Not stated
Precertification		3250	--				4800 LE	N/A
Certification	1480 $	970	0	4000	600,000 fee +48000 tax (JP)	$ 1700	7200 LE	N/A
Total	4450 $	$ 5120	0 DHS	9000 QR	648,000 JP	$ 2010	12000 LE	--
Converted to $	$ 4450	$ 5120	0	$ 2471	$ 5500	$ 2010	$ 1533	--
Calculated according to GFA	NO	YES	N/A	YES	YES	YES	YES	

According to Table 3-8, CASBEE is the most expensive rating system whereas ESTIDAMA requires no costs for certification.

3.3.7. Access to rating system

Table 3-9 Access to rating system Comparison

Comparison point	International rating systems						Egypt rating systems	
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Website Information availability	✓	✓	✓	✓	✓	✓	Under development	✓
Technical guide	Free access	Require charge	Free access	Require charge	Free access	Free access	Free access	Free access
Case studies	✓	✓	✓		✓	✓		
Workshop/ trainings	✓	✓	✓	✓	✓	✓		

3.3.8. Adaptability

The following table compares subjects such as rating system adaptability locally and internationally. It also includes data such as rating system application flexibility, and local context and regional concerns.

Table 3-10 Adaptability Comparison

Comparison point		International rating systems						Egypt rating systems	
		BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASBEE BD (NC) 2014	EDGE Homes v1.1	TARSHEED Residential v1.0	GPRS Public review 2011
Adaptability	Local application	✓	✓	✓	✓	✓		✓	✓
	International application	✓	✓		✓		✓		
Flexibility		International bespoke	LEED country specific			BEE measure each project	Possible savings in a set of options		
Regional Concerns	Climatic and atmospheric issues	Consideration to climatic and precipitation zones	Regional priority in v4 became a separate category			Regional priority credit available	Country specific technical solutions (Location and climatic data)		
	Cultural values and Heritage			✓	✓	✓			✓

According to Table 3-10, BREEAM, LEED, CASBEE, and EDGE take a full consideration of climatic conditions. On the other hand, the PRS for Estidama, GSAS, CASBEE, and GPRS reward projects that preserve cultural values and heritage.

3.3.9. Maturity

The following comparison in Table 3-11 presents (1) the number of registered and certified buildings in the studied eight green building rating systems from their inception and (2) their nature of assessment.

Table 3-11 Number of certified and registered buildings (Data accessed BREEAM 2015; USGBC [as of August 2015]; PRS for ESTIDAMA [June 2014]; IBEC CASBEE [as of June 2014]; GSAS [as of June 2015]; EDGE IFC 2015; GPRS [as of December 2015])

Comparison items		**International rating systems**						**Egypt rating systems**	
		BREEAM	**LEED all rating systems**	**PRS for ESTIDAMA**	**GSAS**	**CASEBEE**	**EDGE Homes**	**TARSHEED**	**GPRS**
Registered		2,214,155	265,726 project (total) 49,000 for NC				1801	--	3
Certified		534,056	109811 projects (total) 18,300 for NC	726,884 sq. m.	373 projects	128 projects	2035 homes in 40 projects	--	2
Number of registered and certified buildings		2,345,647 Project	53343 project				3836 units	--	
Assessment	**Voluntary**	●	●		●	●	●	●	NA
	Obligatory		● only for U.S. Federal buildings(Gold)	●					NA

According to Table 3-11, BREEAM has the highest number of registered and certified buildings mainly in UK and Europe. However, worldwide, LEED is the most employed rating system.

3.3.10. Lifecycle Stages Coverage

The following comparison includes the covered building lifecycle stage by each of the studied assessment systems (BREEAM, LEED, PRS, CASBEE, GSAS, EDGE, TARSHEED, and GPRS); see Table 3-12.

Table 3-12 Building lifecycle stages covered by the eight New Construction Rating systems (point of comparison adapted from Jones Lang LaSalle 2008)

Rating System	Pre-Design/ Planning/Site Selection	Design / Procurement / Construction	Core & Shell	Post Construction review	Tenant Fit-Out / Refurbishment	Existing Building- Management / Operations / Maintenance
BREEAM UK 2014	●	●		●		
LEED NC BD+C v4		●	●	●		
PRS for ESTIDAMA Design & Construction 2011		●		●		
GSAS Typologies v2.0		●		●	●	●
CASBEE New Construction 2014	●	●		●	●	●
Edge IFC Homes v1.1 2015		●		●		
TARSHEED Residential v1.0		●		●		
GPRS Public review 2011		●				

3.4. OUTCOME OF THE COMPARATIVE ANALYSIS

In this study, the categories, aspects, and issues, weighting methods and sustainability pillars of the eight green building assessment systems (BREEAM, LEED BD+C v4, CASBEE, ESTIDAMA v1, GSAS v2 Building Typologies, EDGE IFC Homes v1.1, TARSHEED Residential v1.0, and GPRS Public Review New Construction) were examined and compared. From the comparison, it was clear that the eight assessed rating systems had similarities and differences. There are shared categories such as Site, Land and Transportation, Energy Efficiency, Water Efficiency, Materials, and Indoor Environmental Quality. However, some rating systems have separate categories that are not addressed; for example, the 'Management' category that is available in BREEAM and GSAS is not addressed in other rating systems, but could be tackled under different categories (Energy, Water, Materials etc..) such as in LEED, CASBEE, and GPRS. Moreover, the evaluation of the rating systemS performed in this study also addressed the assessment systems' maturity levels, their certification validity, and the cost of assessment, adaptability, availability of information, and case studies and support. Furthermore, since green building rating systems allow for assessing the sustainability level of buildings, they also allow for an enhancement to the operation and efficiency of buildings. Yet some assessment systems measure the sustainability level of buildings in points such as LEED, BREEAM, LEED, GPRS and ESTIDAMA, others in percentages and savings such as EDGE and TARSHEED or even in a more integrated method such as that of GSAS and CASBEE. There are differences between green building assessment systems to a fluctuating extent. Even though there might be common categories as discussed, but their scope and perception of issues and content, differ according to local needs and priorities. For example, some rating systems give the highest percentage to the 'Water Efficiency' category while others give 'Energy Efficiency' the highest weight; this gives a clear insight of the issue of more stress in a specific region or country.

The comparative analysis provided a clear understanding of the metric of each rating system. When considering the prerequisite aspects in the studied assessment tools, some provide higher percentages than others do, while others focus on achieving maximum percentage or points. Additionally, and despite that most of the green building rating systems studied have been established through the involvement of multi-stakeholder; most of them did not include the idea and methodology of their aspects evaluation and prioritization. However, among the positive points of LEED assessment system reference guide that it allows its users to understand the behind the intent of each credit; giving the chance to further understand and apply savings to a certain issue. However, it is essential to apply each rating system on one project in order to recognize their comprehensiveness.

CHAPTER 4

CASE STUDY

AUC FACULTY HOUSING-NEW CAIRO

4.1. INTRODUCTION

It was necessary for this study to investigate how rating systems measure the sustainability levels of a common building. The building selected is the Faculty Housing of the American University in Cairo that is to be located in the fifth settlement in New Cairo, Egypt at average coordinates of 31°46'52"E and 30° 29'38" N as shown in Figure 4.1. The University has constructed a faculty housing near to this area where the new building will be of the same plot area and similar design specifications. For the purpose of calculations required by each rating system and due to limitations of data available, the assessment of this case study includes the use of data from the already existing Building. The New Construction building is comprised of basement, ground, three typical floors and roof floor with areas as shown in Table 4-1:

Table 4-1 Case Study: Building Area

Built up Area	**The area in square meters**
Basement Floor	3808
Ground Floor	3220
First Floor	2415
Second Floor	2415
Third Floor	2415
Roof Floor	2457
Total Area (m^2)	**16730**

Figure 4.3 and Figure 4.4 include the buildings' floor plans. Each floor comprises ten apartments classified into studios, one, two, and three bedroom apartments.

Figure 4.1 AUC Faculty Housing location

This building will be assessed using LEED, TARSHEED, and GPRS (see Figure 4.2) for two reasons; (1) validate the results derived from the comparative study, and (2) examine how each rating system evaluate the sustainability level of the building. The selection of the three rating systems was according to the following: (1) for LEED; it is the most employed in Egypt; (2) GPRS is the national green building rating system developed by the government; and (3) TARSHEED is the newly developed green building rating system in Egypt by a non-governmental organization.

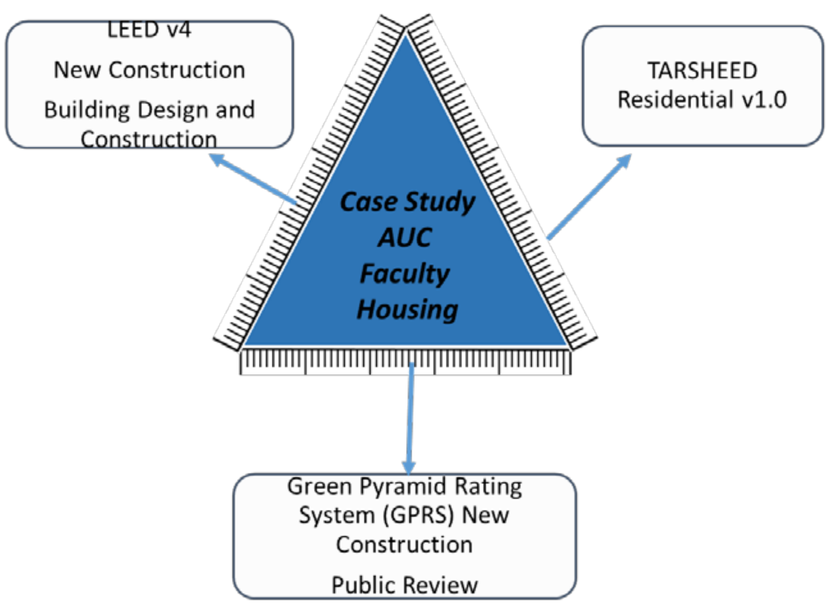

Figure 4.2 Case Study Assessment

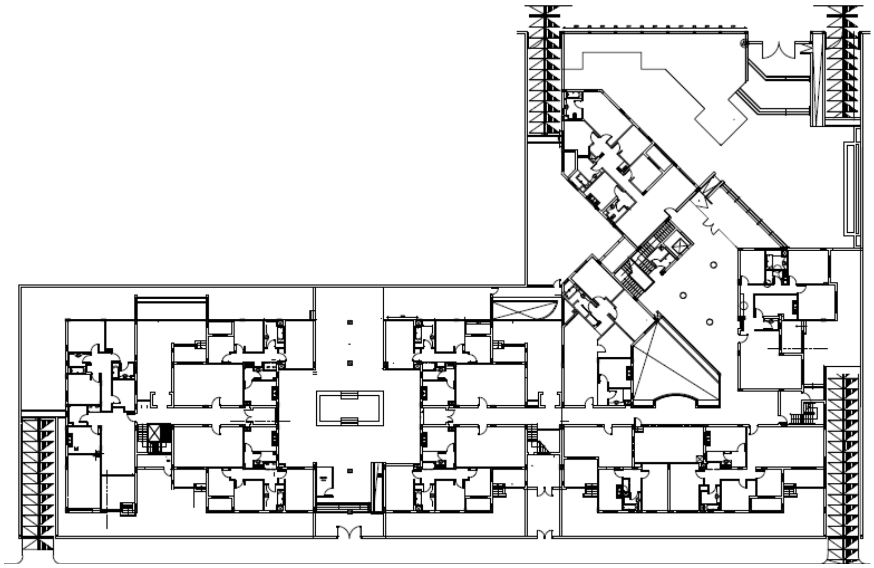

Figure 4.3 Building's Ground Floor plan (AUC Construction Office)

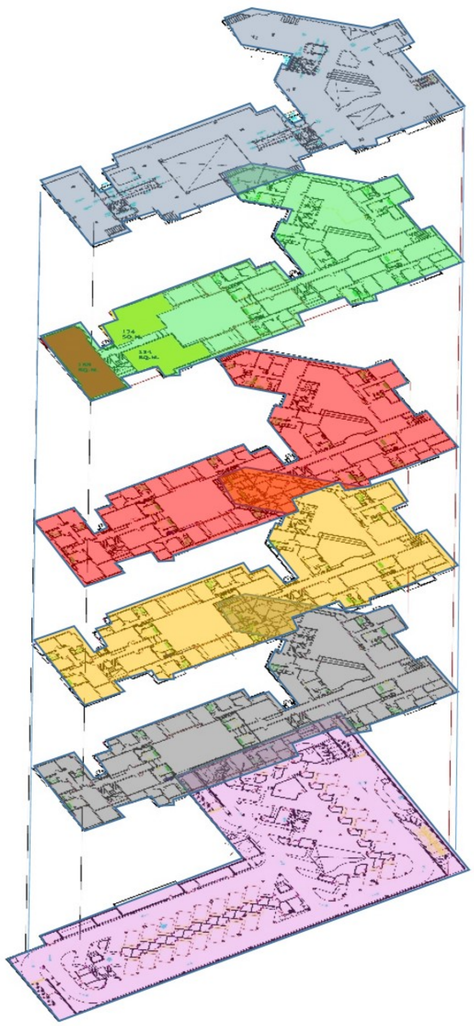

Figure 4.4 Building Architectural floor plans

4.2. GREEN BUILDING RATING SYSTEMS (LEED NC BD+C V4, TARSHEED V1.0, AND GPRS) ASSESSMENTS

4.2.1. LEED New Construction (Building Design and Construction v4) Assessment

First, the building satisfies all LEED minimum requirements. This was determined after studying the design documents of the project and referring to the construction office at the American University in Cairo. The following scorecard (Table 4-2) represents the possible achievable points that the project would attain in pursuing LEED certification. The next subchapters include further details of each calculated credit.

Remark: The calculations were made based on indicators from previous projects.

Table 4-2 LEED v4 New Construction Building Design and Construction score card (USGBC 2015)

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name AUC Faculty Housing
Date: 21-Nov-2015

Y	?	N			
1			Credit	Integrative Process	**1**
9	**0**	**7**	**Location and Transportation**		**16**
			Credit	LEED for Neighborhood Development Location	16
1			Credit	Sensitive Land Protection	1
1		1	Credit	High Priority Site	2
2		3	Credit	Surrounding Density and Diverse Uses	5
3		2	Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
		1	Credit	Green Vehicles	1
5	**0**	**5**	**Sustainable Sites**		**10**
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
1		1	Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
		3	Credit	Rainwater Management	3
1		1	Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name AUC Faculty Housing
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Y	?	N			
6	**0**	**5**	**Water Efficiency**		**11**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
1		1	Credit	Outdoor Water Use Reduction	2
4		2	Credit	Indoor Water Use Reduction	6
		2	Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1

19	**0**	**14**	**Energy and Atmosphere**		**33**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
3		3	Credit	Enhanced Commissioning	6
13		5	Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
		2	Credit	Demand Response	2
1		2	Credit	Renewable Energy Production	3
1			Credit	Enhanced Refrigerant Management	1
		2	Credit	Green Power and Carbon Offsets	2

7	**0**	**6**	**Materials and Resources**		**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
3		2	Credit	Building Life-Cycle Impact Reduction	5
1		1	Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
1		1	Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
1		1	Credit	Building Product Disclosure and Optimization - Material Ingredients	2
1		1	Credit	Construction and Demolition Waste Management	2

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist
Project Name AUC Faculty Housing
Date: 21-Nov-2015

9	**0**	**7**	**Indoor Environmental Quality**		**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
1		1	Credit	Enhanced Indoor Air Quality Strategies	2
1		2	Credit	Low-Emitting Materials	3
1			Credit	Construction Indoor Air Quality Management Plan	1
1		1	Credit	Indoor Air Quality Assessment	2
1			Credit	Thermal Comfort	1
1		1	Credit	Interior Lighting	2
1		2	Credit	Daylight	3
1			Credit	Quality Views	1
1			Credit	Acoustic Performance	1
1	**0**	**5**	**Innovation**		**6**
		5	Credit	Innovation	5
1			Credit	LEED Accredited Professional	1
1	**0**	**3**	**Regional Priority**		**4**
1			Credit	Regional Priority: Specific Credit	1
		1	Credit	Regional Priority: Specific Credit	1
		1	Credit	Regional Priority: Specific Credit	1
		1	Credit	Regional Priority: Specific Credit	1
58	0	52	**TOTALS**	Possible Points:	**110**

Certified: 40 to 49 points**, Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

The availability of data played an important role in the precise evaluation of some credits. The following represent some credits that required detailed calculations.

4.2.1.1. Location and Transportation Category

Credit 4: Surrounding Density and Diverse Uses

The Walking distance from Building entrance to services is within 800 meters

If four to seven services are within 600 meters radial distance, then the project can receive one point. Two points are attainable if eight or more services are within the same radial distance of 800 meters. Furthermore, LEED requires that the distance measured should be from the main entrance of the building up to the targeted location. Therefore, the building has the capability of achieving two points; see Figure 4.5.

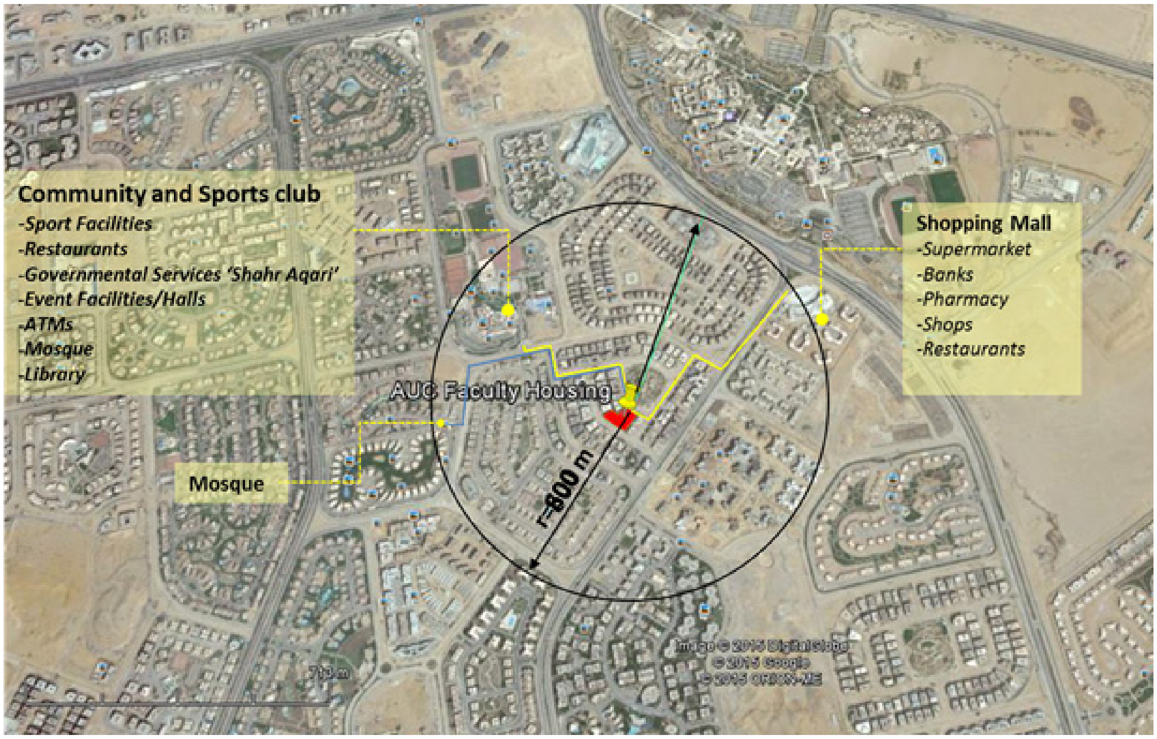


Figure 4.5 Locations of Services in relation to the building

Credit 6: Bicycle Facilities

The following table represents the data needed for acquiring this credit.

Table 4-3 Bicycle facilities prerequisite data

Number of units	40 unit apartment
Average number of occupants per unit	Average 3 occupants per unit
Total occupants	40x3=120 residents
No. of visitors per day	80

Long-term bicycle storage= 120*0.3 = 36, however, the minimum is that each apartment has one storage at least so its 40 bicycle storages in addition to two short-term bicycle storages. Therefore, forty-two bicycle storages are required. The building only provides five storages to the total occupants, so the project does not meet this credit.

Credit 7: Reduced Parking Footprint

The number of parking lots provided to the total occupants is one space per an apartment. Since the project achieved one credit if Surrounding Densities and Diverse Uses, it has to provide a parking reduction of 40% from the standard ratios (USGBC 2014). According to the base ratios 1.5 parking space is required for apartments of more than 140 square meters and 0.25 parking spaces per visitor per apartment, so 1.75 parking spaces are the base case for one apartment. The following equation shows the parking reduction percentage according to the given information.

Parking reduction= (70-40)/70 *100 = 43.33%

This result is more than 40% thus, the project qualifies for one credit.

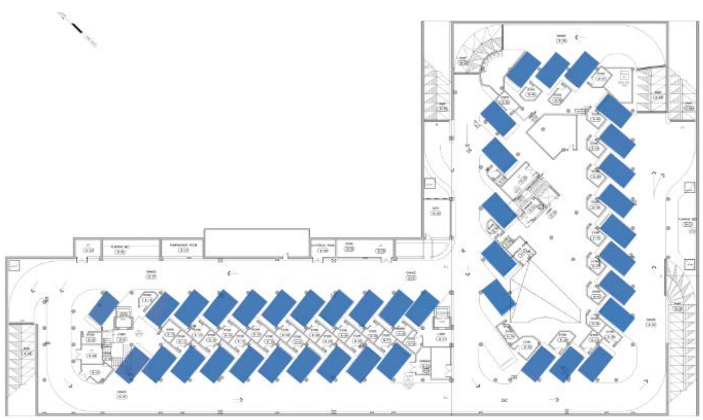


Figure 4.6 Basement floor indicating the parking spaces provided

4.2.1.2. Sustainable Sites Category

Credit 2: Site Development-Protect and Restore Habitat

According to this credit requirement, the Minimum financial contribution is equal to the total site area multiplied by 4$ per square meter; therefore, it would be 3700 square meters x $4/square meter = $14800 is required to receive one credit for supporting a local organization for land trust or conservation. The project will not consider this credit at this stage of initial assessment.

Credit 3: Open Spaces

This credit emphasizes on creating an interface between the building occupants and the environment, passive recreation and social interactions.

The following represent the minimum areas required in order to qualify for this credit.

Required open space=30% * 3700 = 1100 m^2 (minimum)
Vegetated space = 25% * 1396 = 275 m^2 (minimum)
The project qualifies for the one point of this credit.

Credit 5: Heat Island Reduction

This credit requires that a minimum of 75% of parking spaces is under cover. All parking spaces provided by this building are ‘covered parking lots’; located in the basement level of the building as shown in Figure 4.6. The project qualifies for 1 point for this credit.

Credit 6: Light Pollution Reduction

This credit awards projects that allow for better night-time luminosity (USGBC 2014). It counts on the usage of the backlight up light-glare method (BUG) for the entire exterior lightings located within the project’s limits; see Appendix N (1) (USGBC 2014).

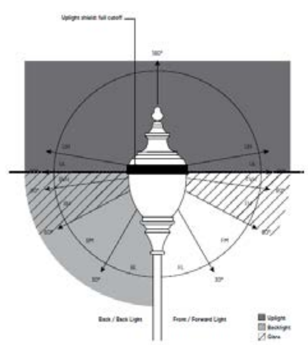


Figure 4.7 BUG method employed in this credit (USGBC 2014)

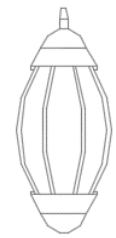
W5	FIXTURE IS DESIGNED FOR WALL MOUNTED PURPOSES. BODY : MADE OF DIECAST ALUMINUME TREATED AND PAINTED WITH ELECTROSTATIC POWDER COAT FOR ATMOSPHERIC FACTORS RESISTANCE LENSES: LENSES OF CLEAR GLASS OR SAND – PLASTED GLASS APPLICATIONS: GARDENS, TRASSES, PUBLIC ENVIROMENT, ETC... ART CODE: 3530–IL– "WITH IP 44" MANUFACTURER: THORN OR APPROVED EQUAL	

Figure 4.8 Description of the roof floor exterior luminaire

4.2.1.3. Water Efficiency Category

Credit 1: Outdoor Water Use Reduction

This credit requires the reduction of the project’s landscape water necessity by a minimum of 50% from the base case. The irrigation system employed in this project is drip irrigation, allowing for a reduction of 50% of water use than the required per month base case, see Appendix N (2); therefore, the project qualifies for 1 point, refer to Appendix N (2).

Credit 2: Indoor Water Use Reduction

There are no water recovery options available in the design of this project. Thus, the reduction is reliant on fittings and fixtures. According to calculations, 40% reduction than the base case of the prerequisite (Indoor Water Use Reduction) is attainable. Therefore, the project qualifies for 4 points; refer to Appendix N (3).

Credit 4: Water Metering

This credit supports a project that tracks water consumption within the project limits. It offers one credit by installing permanent water meters in areas such as irrigation, domestic hot water, indoor plumbing fixtures and fittings (USGBC 2014). The project qualifies for one credit.

4.2.1.4. Energy and Atmosphere Category

Credit 2: Optimize Energy Performance

This credit requires the establishment of energy performance target [KW/m2 (year)] by the schematic design stage. The achievement of this credit requires employing a 'Whole Building Energy Simulation'. The maximum attainable points of this credit are 18 points. From the calculations of the building's energy requirement and possible improvement methods; the building has the potential of achieving about 33 percent improvement in energy performance; refer to Appendix O. Accordingly, the building achieves 13 out of 18 points in this credit.

Credit 3: Advanced Energy Metering

This credit requires that the project offers a tracking system for building level energy-use.

The project is employing an advanced metering system. Therefore, it qualifies for the one point offered by this credit.

4.2.1.5. Materials and Resources

Credit 1: Building Life-Cycle Impact Reduction

The project qualifies for three credits through the preparation of a 'Whole Life Cycle Assessment' indicating a 10% reduction in at least three of the impact categories such as greenhouse gasses, eutrophication, depletion of nonrenewable energy resources, refer to Appendix M to 'impact categories for reduction'.

Credit 2: Building Product Disclosure and Optimization: Environmental Product Declaration

This credit requires the use of 20 different products installed that would last with the building life from a minimum of five diverse producers (USGBC 2014). The project qualifies for one point in this credit.

4.2.2. TARSHEED Assessment

The following tables will present the assessment of the case study using the TARSHEED rating system. The tables include assessment of the three categories of TARSHEED.

First, the ‘Energy Category’ is the highest weight (40%) since it is the major contributor to carbon dioxide emissions and global warming. The ‘Energy Category’ covers aspects related to building envelope, cooling, heating, appliances, hot water, lighting, and renewable energy (EGGBC 2015).

4.2.2.1. Energy Category Assessment

There are four main aspects the ‘Energy Category’ of TARSHEED, those are:

(1) Building envelope
   a. Window to wall ratio
   b. External window shading
   c. Roof insulation
   d. External walls insulation
   e. Basement or floor slab insulation
   f. Low e-coated glass
   g. Higher performance glass
   h. Air tightness
(2) Building basic energy requirements
   a. Cooling
   b. Heating
   c. Hot water
   d. Lighting
(3) Appliances
(4) Common areas lighting, machines, and equipment

Calculations were based on an online calculator developed by EGGBC (EGGBC 2015). This online system requires very basic data about the building with few technical requirements. These data are related to building area, envelope, design elements, costs, and number of occupants.

Remark: The calculations were made based on indicators from previous projects.

The following Table 4-4 represents TARSHEED's energy scorecard:

Table 4-4 TARSHEED Energy scorecard (EGGBC 2015)

	Energy	**Base case**	**Improved percentage**	**Saving**
	Envelope	15.00%		
E01	Window to wall ratio	2.00%	2.00%	**27.62%**
E02	External window shading	2.00%	2.00%	
E03	Roof insulation	2.00%	1.00%	
E04	External walls insulation	2.00%	0.50%	
E05	Basement or floor slab insulation	1.00%	0.50%	
E06	Low-e coated glass	1.50%	1.50%	
E07	Higher performance glass	1.50%	1.50%	
E08	Air tightness	3.00%	3.00%	
Building basic energy requirements		60.00%		
E09	Cooling	25.00%	17.50%	
E10	Heating	5.00%	0.00%	
E11	Hot water	10.00%	10.00%	
E12	Lighting	20.00%	19.68%	
E13	Appliances	15.00%	3.00%	
		3.00%		
E14	Smart meters	2.00%	2.00%	
E15	The killer switch	1.00%	0.00%	
	Common areas	7.00%		
E16	Efficient pumps and fans	2.00%	2.00%	
E17	Efficient elevators	2.00%	1.50%	
E18	Outdoor lighting and controls	3.00%	1.50%	
E19	Renewable energy		0.00%	
	Total energy saving	**100.00%**	**69.18%**	

4.2.2.2. Water Category Assessment

Table 4-5 TARSHEED Water scorecard (EGGBC 2015)

	Water	**Percentage**	**Base case**	**Improved percentage**	**Saving**
	Indoor	**68.99%**	100%	53.41%	
W01	Showerheads*	24.15%	35%	16.90%	20 %
W02	Kitchen sink faucets*	13.80%	20%	11.21%	
W03	Lavatory faucets*	13.80%	20%	10.92%	
W04	Water closets*	17.25%	25%	14.37%	

	Irrigation	**31.01%**	100%	23.88%	
W05	Reduce grass	15.51%	50%	10.34%	
W06	Irrigation efficiency	15.51%	50%	13.55%	
	Add on				
W07	Graywater /AC condensate /rainwater			0.00%	
	Total water saving	**100.00%**		**77.29%**	
*UPC and IPC code					

4.2.2.3. Habitat Category Assessment

Table 4-6 TARSHEED Habitat scorecard (EGGBC 2015)

	Habitat	**Percentage**	**Improved percentage**	**Saving**
	Outdoor	**43%**	**31.48%**	
H01	Ready-mix concrete	5%	0.53%	25 %
H02	Reflective tiles for roof and outdoor paving	10%	4.44%	
H03	Reflective paint for external walls	5%	6.25%	
H04	Shaded parking	10%	9.75%	
H05	Bicycle racks	3%	2.63%	
H06	Organic food producing garden	8%	6.60%	
H07	Outdoor lighting full cutoff	2%	1.28%	
	Material	**34%**	**17.06%**	
H08	Proper disposal of construction waste	5%	2.00%	
H09	Recycling construction waste	2%	1.11%	
H10	Waste segregation at source	10%	5.00%	
H11	Produce your own compost	2%	0.67%	
H12	Local flooring	8%	2.67%	
H13	Local ceramic	5%	3.89%	
H14	Recycled content	1%	0.85%	
H15	Material reuse	1%	0.88%	
	Indoor	**23%**	**23.00%**	
H16	Entryway system	3%	3.00%	
H17	Low VOC paints	10%	10.00%	
H18	Windows for living spaces	10%	10.00%	
Total habitat saving		**100%**	**71.54%**	

The following represent TARSHEED's Assessment Results for the building:

27.62 % Energy savings
20 % Water savings
25 % Habitat savings

The project qualifies for TARSHEED 20%.

4.2.3. Green Pyramid Rating System Assessment

The following table (Table 4-7) represents the assessment of the case study using Green Pyramid Rating System (GPRS) for Public Review. This rating system is comprised of seven categories: (1) Sustainable Site, Accessibility, and Ecology, (2) Energy Efficiency, (3) Water Efficiency, (4) Materials and Resources, (5) Indoor Air Quality, (6) Management, and (7) Innovation and Added Value.

Remark: The calculations were made based on indicators from previous projects.

Table 4-7 GPRS for New Construction score card (GPRS 2011)

Category / sub-category		**Credits expected**	**Evidence available**
1	**SUSTAINABLE SITE, ACCESSIBILITY, AND ECOLOGY**		
	1.M.1 Project Design and Implementation Plan	✓	✓
	1.1.1 Desert area development	1	✓
	1.1.2 Informal area redevelopment	-	
	1.1.3 Brownfield site redevelopment	-	
	1.1.4 Compatibility with National Development Plan	1	✓
	1.2.1 Transport infrastructure connection	1	✓
	1.2.2 Catering for remote sites	1	✓
	1.2.3 Alternative methods of transport	1	✓
	1.3.1 Protection of habitat	-	
	1.3.2 Respect for sites of historic or cultural interest	1	✓
	1.3.3 Minimizing Pollution during construction	1	✓
		7/10 points	
2	**ENERGY EFFICIENCY**		
	2.M.1 Minimum Energy Performance Level	✓	✓
	2.M.2 Energy Monitoring & Reporting	✓	✓
	2.M.3 Ozone Depletion avoidance	✓	✓
	2.1 Energy Efficiency Improvement	6	✓
	2.2 Thermal Comfort Strategies	2	✓
	2.3 Energy Efficient Appliances	3	✓
	2.4 Vertical Transportation Systems	2	✓
	2.5 Peak Load Reduction	3	✓
	2.6 Renewable Energy Sources	4	✓
	2.7 Environmental Impact	4	✓
	2.8 Operation and Maintenance	1	✓
	2.9 Optimized balance of Energy and Performance	4	✓
	2.10 Energy and Carbon Inventories	-	
		29/50 points	

3	**WATER EFFICIENCY**		
	3.M.1 Minimum Water Efficiency	✓	✓
	3.M.2 Water Use Monitoring	✓	✓
	3.1 Indoor Water Efficiency Improvement	5	✓
	3.2 Outdoor Water Efficiency Improvement	4	✓
	3.3 Efficiency of Water-based Cooling	3	✓
	3.4 Water Feature Efficiency	-	
	3.5 Water Leakage Detection	6	✓
	3.6 Efficient water use during construction	3	✓
	3.7 Waste Water Management	-	
	3.8 Sanitary Used Pipes	4	✓
		25/50 points	
4	**MATERIALS AND RESOURCES**		
	4.M.1 Schedule of Principal Project Materials	✓	✓
	4. M.2 Elimination of exposure to hazardous and toxic materials.	✓	✓
	4.1.1 Regionally procured materials	2	✓
	4.1.2 Materials fabricated on site	1	✓
	4.1.3 Use of readily renewable materials	2	✓
	4.1.4 Use of salvaged materials	1	✓
	4.1.5 Use of recycled materials	-	
	4.1.6 Use of lightweight materials	1	✓
	4.1.7 Use of higher durability materials	1	✓
	4.1.8 Use of prefabricated elements	2	✓
	4.1.9 Life Cycle Cost (LCC) analysis of materials in the project	1	✓
		11/20 points	

5	**INDOOR ENVIRONMENTAL QUALITY**		
	5.M.1 Minimum Ventilation and Indoor Air Quality	✓	✓
	5.M.2 Control of Smoking in and around the Building	✓	✓
	5.M.3 Control of Legionella and other health risks	✓	✓
	5.1 Optimized Ventilation	1	✓
	5.2 Controlling emissions from building materials	5	✓
	5.3 Thermal Comfort	2	✓
	5.4 Visual Comfort	2	✓
	5.5 Acoustic Comfort	1	✓
		11/20 points	

6	**MANAGEMENT**		
	6.M.1 Integrated Plan and Method Statement for site operations	✓	✓
	6.M.2 Compliance with Health & Safety and Welfare regulations	✓	✓
	6.M.3 Demolition Method Statement18	✓	✓
	6.1.1 Containers for site materials waste	2	✓
	6.1.2 Employing waste recycling workers on site		
	6.1.3 Access for lorries, plant and equipment	1	✓
	6.1.3 Identified and separated storage areas	2	✓
	6.2.1 Project Waste Management Plan	1	✓
	6.2.2 Engaging a company specialized in recycling and disposal	2	✓
	6.2.3 Protecting water sources from pollution	2	✓
	6.2.4 Waste from mixing equipment	-	
	6.2.5 Control of emissions and pollutants		
	6.3.6 Providing a Building User Guide	3	✓
	6.3.7 Providing a Periodic Maintenance Schedule	2	✓
		15/20 points	
7	**INNOVATION AND ADDED VALUE**		
	7.1 Cultural Heritage	1	✓
	7.2 Exceeding Benchmarks		
	7.3 Innovation		
		1/3 points	

The following table (Table 4-8) represents the resulted calculation through a relationship between credit achieved and credit available. The results of the evaluation using GPRS indicated that the building qualifies for a green pyramid rating level of 'Silver'.

Table 4-8 GPRS Final Result Calculation

Green Pyramid Category	**A** Credits Available	**B** Credits Achieved	**C = B/A x 100%** % Credits Achieved	**D** Category Weight	**E = C x D** Category Score
1: Sustainable Site, Accessibility, Ecology	10	7	70%	15%	10.5
2: Energy Efficiency	50	29	58%	25%	14.5
3: Water Efficiency	50	25	50%	30%	15
4: Materials and Resources	20	11	55%	10%	5.5
5: Indoor Environmental Quality	20	11	55%	10%	5.5
6: Management	20	15	75%	10%	7.5
7: Innovation and Added Value	3	1	33%	Bonus	
TOTAL					**58.5**
GREEN PYRAMID RATING					**SILVER**

4.3. LEED-NC BD+C V4 VERSUS TARSHEED RESIDENTIAL V1.0 VERSUS GPRS-NC PUBLIC REVIEW RESULTS COMPARISON

The following table (Table 4-9) is a summary of the assessment result of the three rating systems; LEED New Construction Building Design and Construction version 4, TARSHEED version 1 for Residential Buildings, and GPRS New Construction for Public Review. The results shown in the table indicate how strict and how simple the rating systems are. A further correlated and illustrative comparison between categories is in Figure 4.9.

For example, in the evaluation of the 'Energy use' category; the building receives 20 out of 33 points (equivalent to 60.6%) in LEED-NC BD+C; similarly, GPRS allocates the building 58% savings in energy. On the other hand, in TARSHEED's assessment, the building achieves 69 percent savings out of the 40 percent devoted to the energy category.

Table 4-9 Summary of the Case Study Assessment Results through LEED, TARSHEED, and GPRS

Category	**LEED NC BD+C v4**	**TARSHEED Residential v1.0**	**GPRS NC**
Energy	60.6%	69%	58%
Water	54.54%	77%	50%
Sites and Transportation	53%	31.48%	70 %
Indoor environmental quality	50%	23%	55%
Materials	46.15%	17.06%	55%
Innovation	16.7%	-	33%
Regional priority	25%	-	0

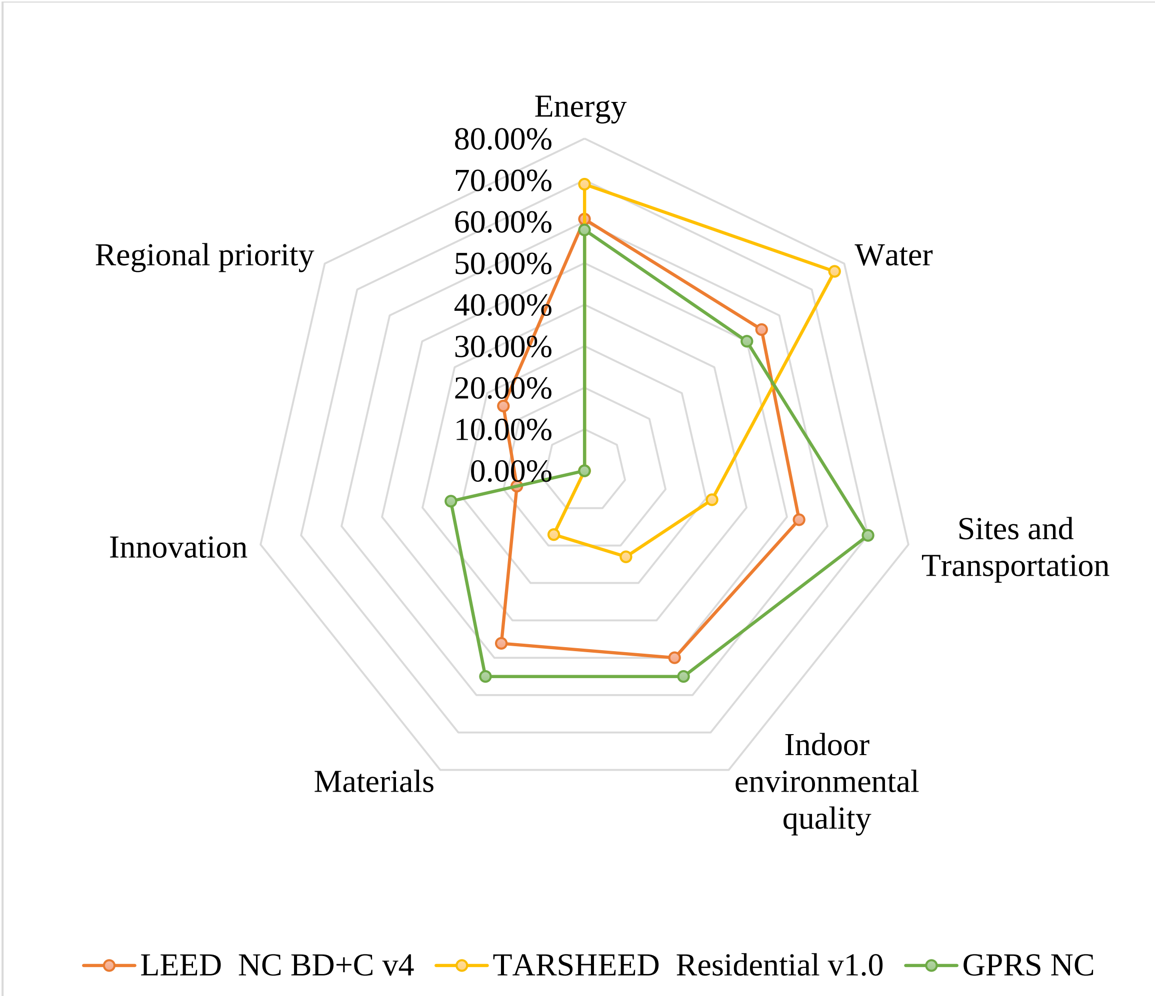


Figure 4.9 Comparison of the case study assessment results using LEED, TARSHEED, and GPRS

In analyzing the results from the 'Water' category, the building has the potential of achieving 54.54% savings in LEED, 77% in TARSHEED, and 50% in GPRS.

When observing the Sites and Transportation categories, the building has the potential of achieving 53% savings in LEED, 31.48% in TARSHEED, and 70% in GPRS.

When examining the category of 'Indoor environmental quality', the building receives 50% savings in LEED, 23% in TARSHEED, and 55% in GPRS. When considering the 'Materials' category, the building achieves an equivalent of 46.15% savings in LEED, 17.06% in TARSHEED and 55% in GPRS. On the other hand, the building achieves savings through innovative practices with 16.7% in LEED and 33% in GPRS consecutively, and it is not applicable in TARSHEED. For Regional priority, the building receives 1 out of 4 credits (equivalent to 25%) in LEED, and zero savings and credits in TARSHEED and GPRS.

From Table 4-9, it is clear that each assessment system has its own metrics in evaluating the sustainability level of the building. From the percentages in most of the categories, TARSHEED is more simple and easy to use in control and calculation. In contrast, LEED requires more documentations and calculations. Nevertheless, this does not imply that all categories through TARSHEED's assessment should receive higher percentages than those in LEED and GPRS. There could be another reason for this argument that the criteria of each category under each rating system could be more precise and detailed. This previous observation is applicable in LEED; for instance, the reference guide of LEED gives several options for the site and transportation categories with guiding steps and diagrams in order to achieve certain credits.

CHAPTER 5
CONCLUSION & RECOMMENDATIONS

5.1. CONCLUSION

With Egypt preceding to sustainable development through its latest 'Strategic Vision 2030' announced in March 2015, methods and tools are becoming crucial to achieving the vision's goals. There are hundreds of green building tools including one dimensional, two dimensional and total sustainability assessment tools. For example, multi-dimensional assessment tools take a holistic view of the environmental, social and economic aspects. Furthermore, a rating system that customized to suit its country or region might not be applicable in another country or region. Therefore, a rating system that is developed based on the local needs and the environment would be the most precise metric. From studying the eight rating systems, namely LEED, BREEAM, CASBEE, PRS, GSAS, EDGE, TARSHEED, and GPRS, it is clear that: (1) there are common characteristics between category terms and aspects; (2) the distribution of the weighting of the categories is according to the countries local needs and surroundings. For instance, BREEAM gives Energy the highest priority with 19%, followed by Health and Wellbeing (15%) and Materials (12.5%). Similarly, GSAS gives the highest priority to Energy with 24%, followed by Water (16%) and Culture and Economy (13%).

The research method involved a literature review about worldwide green building certification systems. Furthermore, it was necessary to examine and understand the selected rating systems' methodologies, prioritization, and weighting approaches. This allowed for a precise and an accurate analysis. After performing an overall comparative analysis between the assessment systems, a case study was selected for assessing its sustainability performance using LEED NC (BD and C) version 4, TARSHEED Residential version 1, and GPRS for Public review 2011.

There is a direct relationship between green building assessment systems and sustainable development of a country. Certification systems promote the development of sustainable design and construction, which lead to the mitigation of climate change and ensure environmental, economic and social sustainability. The benefits of sustainable design and construction through a green building assessment system would have paybacks on three stages; (1) human level benefits, (2) Country level benefits, and (3) global level benefits. The Green Building Market in Egypt requires the establishment of various green building rating systems with various features and benefits.

One of the primary advantages of TARSHEED is that it allows any professional in the construction and architectural field to become a member of Egypt Green Building Council (EGGBC). Unlike GPRS (national rating system) which accepts governmental employees as members. Furthermore, the development of TARSHEED relied on meeting the local needs and the environment of Egypt. It follows a simple approach that makes it applicable to developing countries by creating basic changes. Additionally, since green building might be new to some professionals in the construction industry in Egypt, this rating system was putting this fact into consideration. Hence, the system relies on inspection more than submissions with simple techniques to achieve green building certification.

5.2. RECOMMENDATIONS

Throughout this study, the comparative analysis, and the case study evaluation, gaps were identified in TARSHEED rating system. This gap analysis along with Egypt's local context have identified new measures that TARSHEED should consider in its future version. The following represent a set of recommendations to Egypt Green Building Council (EGGBC) committee for the development of TARSHEED.

The advancement of assessment system must be according to technical knowledge and countries' local strategies and needs. Besides meeting national laws and codes, there are other requirements that must be also achieved, such as design for robustness, indoor air quality, fire safety, and acoustic comfort. First, EGGBC committee has to take into consideration that the responsibility of TARSHEED rating system is much more than other rating systems. This is due to several reasons; first, that resource efficiency codes and regulations have not been put into action yet, second there is a need of raising awareness about sustainable architecture and construction, and third, the necessity of having a database of efficient and environmentally friendly materials and resources. The participation of several key stakeholders is the key to the development of further versions of the assessment system.

First, when considering the categories of TARSHEED: (1) Energy, (2) Water, and (3) Habitat, there is a necessity of including a 'Management' category to comprise the following:

- Integrated Design [Design team, Design process, Building information modeling]
- Options and credits for innovative practices.
- Credits targeting cost savings through the building lifecycle, such as including a life cycle cost assessment of the project.
- Credits addressing cultural and heritage values
- Credits awarding building aesthetics

Second, it is advisable to award Professionals with TARSHEED affiliation (membership) by allocating the project a specific percentage for their involvement in the project. The involvement of well-trained professionals in the project will allow for its development.

Third, some credits within categories require further expansion. For instance, categories such as Habitat (Indoor air quality, site and transportation, and materials) and Water (indoor and outdoor) had some gaps that require their re-consideration. These recommendations are as follow:

5.2.1. Habitat Category Recommendations

The following issues are among the recommendations to be included in the 'Habitat' category's future version addressing aspects related to site, land and transport:

1. The selection and use of previously used sites
2. Site considerations and evaluation
3. Control of Construction commotions
4. Heat Island effects
5. Public Transport
6. Private Transport and Green Vehicles

5.2.2. Water Category Recommendations

The following are the water efficiency recommended aspects that require reevaluation:

1. Water Leakage Detection
2. Analysis and Monitoring of water use

5.2.3. Indoor Air Quality Recommendations

The following represents the 'indoor air quality' recommended aspects that require reevaluation:

1. Human Comfort
2. Thermal Comfort
3. Acoustic Performance
4. Smoke Control
5. Surrounding amenities and their risk to human health

5.2.4. 'Others' Categories Recommendations

1. Heritage and Cultural Identity
2. Shading of Adjacent Properties
3. Building aesthetics
4. Environmental Product Declaration
5. Regional Priorities to include a set of options based on the location and its needs. The requirements of one area could be different from another, even within the same country.
6. Dust control and methods to mitigate its spread.
7. Catchment areas through a number of services available to building users within a walking distance of 500-700 meters (equivalent to 10 minutes). Basic amenities and services to include; (1) grocery, (2) clinic or hospital, (3) pharmacy, (4) Open areas, (5) school and nursery, (6) mosque, and (7) governmental services.

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APPENDICES

Appendix A Green Building Terminologies

Zero Energy Building (ZEB)

This term is used for energy efficient building. According to the US department of energy, the energy consumption in the net zero energy building is equivalent to its energy production (2015). In other words, this type of building sustains the reduction of energy consumption so it is almost equal to the renewable energy produced within the building boundary or through the trade of renewable energy certificates (US DOE 2015).

Environmental Product Declaration (EPD)

Environmental Product Declaration (EPD) is a method used to measure the environmental impact of a system or product in their life cycle assessment. This declaration requires the statement of the following data; environmental impact of raw mining and extraction of materials and their composition, energy use efficiency, the quantity of waste generated and quantity of chemical substances released to air, soil and water (Braune, Kittelberger and Kreißig 2011). Architects and engineers usually use EPD to compare the environmental effect of products that are under the same classification (Wagner 2013). In LEED's latest version (v4), it is required to submit EPD for twenty different installed products in the building sourced from five discrete manufacturers (USGBC 2013). Health Product Declaration (HPD), which is an added tool in LEED v4, requires detailed material ingredients and hazardous substances in order to achieve credits under the material ingredient reporting on the 'Building Product Disclosure and Optimization' credit (USGBC 2013).

Ecological Footprint

According to the Global Footprint Network; Ecological footprint, which is measured in global hectares, is metric for the area of productive land or water required per person in order to generate all resources it utilizes and absorbs, and all the waste it produces by using certain technology and resource management methods. The Ecological footprint changes rely on the production efficiencies and consumption quantities. The ecological footprint is in a continuous escalation in Egypt reaching to approximately 1.6 hectares per capita, which indicate that the efficiency of the production in relation to the resource consumption is declining (Global Footprint Network).

Appendix B List of Global Green Building Councils

Table 1 List of Global Green Building Councils and their maturity level (WGBC 2015)

Green Building Council	**Membership Level**	**Country**
Argentina Green Building Council	Established	Argentina
Austrian Sustainable Building Council	Emerging	Austria
Bahrain Green Building Council	Prospective	Bahrain
Bulgarian Green Building Council	Emerging	Bulgaria
Canada Green Building Council	Established	Canada
Chile Green Building Council	Established	Chile
Colombia Green Building Council	Established	Colombia
Costa Rica Green Building Council	Prospective	Costa Rica
Croatia Green Building Council	Established	Croatia
Czech Green Building Council	Prospective	Czech Republic
Dominican Republic Green Building Council	Prospective	Dominican Republic
Dutch Green Building Council	Established	Netherlands
Ecuador Green Building Council	Prospective	Ecuador
Egypt Green Building Council	Prospective	Egypt
El Salvador Green Building Council	Prospective	El Salvador
Emirates Green Building Council	Established	United Arab Emirates
France Green Building Council	Established	France
German Sustainable Building Council	Established	Germany
Ghana Green Building Council	Prospective	Ghana
Green Building Council Australia	Established	Australia
Green Building Council Bolivia	Prospective	Bolivia
Green Building Council Brazil	Established	Brazil
Green Building Council Espana	Established	Spain
Green Building Council Finland	Emerging	Finland
Green Building Council Indonesia	Emerging	Indonesia

Green Building Council Italia	Emerging	Italy
Green Building Council Namibia	Prospective	Namibia
Green Building Council Nigeria	Prospective	Nigeria
Green Building Council Of Georgia	Prospective	Georgia
Green Building Council Of Sri Lanka	Prospective	Sri Lanka
Green Building Council Slovenia	Prospective	Slovenia
Green Building Council South Africa	Established	South Africa
Guatemala Green Building Council	Emerging	Guatemala
Hellenic-Green Building Council	Prospective	Greece
Hong Kong Green Building Council	Established	Hong Kong China
Hungary Green Building Council	Emerging	Hungary
Indian Green Building Council	Established	India
Irish Green Building Council	Prospective	Ireland
Japan Sustainable Building Consortium	Established	Japan
Jordan Green Building Council	Established	Jordan
Kenya Green Building Society	Prospective	Kenya
Korea Green Building Council	Prospective	South Korea
Kuwait Green Building Council	Prospective	Kuwait
Latvian Sustainable Building Council	Prospective	Latvia
Lebanon Green Building Council	Emerging	Lebanon
Macedonia Green Building Council	Prospective	Macedonia
Malaysia Green Building Confederation	Established	Malaysia
Mauritius Green Building Council	Prospective	Mauritius
Montenegro Green Building Council	Prospective	Montenegro
Morocco Green Building Council	Prospective	Morocco
New Zealand Green Building Council	Established	New Zealand
Nicaragua Green Building Council	Prospective	Nicaragua
Oman Green Building Centre	Prospective	Oman
Pakistan Green Building Council	Prospective	Pakistan
Palestine Green Building Council	Prospective	Palestine

Panama Green Building Council	Emerging	Panama
Paraguay Green Building Council	Prospective	Paraguay
Peru Green Building Council	Established	Peru
Philippine Green Building Council	Emerging	Philippines
Polish Green Building Council	Established	Poland
Qatar Green Building Council	Emerging	Qatar
Saudi Arabia Green Building Council	Prospective	Saudi Arabia
Singapore Green Building Council	Established	Singapore
Slovak Green Building Council	Prospective	Slovakia
Sustentabilidad Para Mexico Ac	Emerging	Mexico
Sweden Green Building Council	Established	Sweden
Swiss Sustainable Building Council	Emerging	Switzerland
Taiwan Green Building Council	Established	Chinese Taipei
Tanzania Green Building Council	Prospective	Tanzania
Trinidad & Tobago Green Building Council	Prospective	Trinidad
Turkish Green Building Council	Established	Turkey
UK Green Building Council	Established	United Kingdom
Uruguay Green Building Council	Prospective	Uruguay
Us Green Building Council	Established	USA

Appendix C Egyptian Building Codes (HBRC 2016)

وزارة الإسكان والمرافق والتنميه العمرانيه
المركز القومى لبحوث الإسكان والبناء
إدارة المخازن
١

٢٠١٦/١٠/١

م	كود رقم	الكـــود المصـــــــــرى	الرقم الكودي	قرار وزارى	المجموعة	سعر البيع	إجمالي القيمة	بيان الكود
١	٠١١٠٠٨٩٠٠٠	تصميم وتنفيذ المنشآت الخرسانيه المسلحه	٢٠٣	٤٤لسنة٢٠٠٧	الخرسانة	٦٠,٠٠		
	٠١١٠٠٨٩٠٠١	مساعدات التصميم مع أمثله طبقا للكود المصرى ج١	٢٠٠٧/٢٠٣	———		٤٥,٠٠		
	٠١١٠٠٨٩٠٧١	مساعدات التصميم طبقا للكود المصرى ج٢	٢٠٠٧/٢٠٣	———		٢٥,٠٠		
	٠١١٠٠٨٩٠٠٢	دليل التفاصيل الإنشائيه وإعداد الرسومات	٢/٢٠٣	٩٨لسنة٢٠٠١		٣٠,٠٠		
	٠١١٠٠٨٩٠٠٣	دليل الإختبارات المعمليه لمواد الخرسانه	٣/٢٠٣	٩٨لسنة٢٠٠١		٦٠,٠٠	٢٢٠,٠٠	إجمالي كودات الخرسانة
٢	٠١١٠٠٨٩٠٠٤	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ١ (دراسة المواقع)	٢٠٢	١٣٩لسنة٢٠٠١	الأساسات	٣٠,٠٠		
	٠١١٠٠٨٩٠٠٥	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٢ (الإختبارات المعملية)	١/٢٠٢	١٣٩لسنة٢٠٠١		٥٠,٠٠		
	٠١١٠٠٨٩٠٠٦	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٣ (الأساسات الضحلة)	٢/٢٠٢	١٣٩لسنة٢٠٠١		٣٠,٠٠		
	٠١١٠٠٨٩٠٠٧	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٤ (الأساسات العميقة)	٣/٢٠٢	١٣٩لسنة٢٠٠١		٣٠,٠٠		
	٠١١٠٠٨٩٠٠٨	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج٥ (الأساسات علي التربة ذات المشاكل)	٤/٢٠٢	١٣٩لسنة٢٠٠١		٢٥,٠٠		
	٠١١٠٠٨٩٠٠٩	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج٦ (الأساسات المعرضة للإهتزازات الأحمال الديناميكية)	٥/٢٠٢	١٣٩لسنة٢٠٠١		٢٥,٠٠		
	٠١١٠٠٨٩٠١٠	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٧ (المنشآت السائدة)	٦/٢٠٢	١٣٩لسنة٢٠٠١		٣٠,٠٠		
	٠١١٠٠٨٩٠١١	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٨ (ثبات الميول)	٧/٢٠٢	١٣٩لسنة٢٠٠١		٢٥,٠٠		
	٠١١٠٠٨٩٠١٢	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٩ (لأعمال الترابية ونزح المياه)	٨/٢٠٢	١٣٩لسنة٢٠٠١		٣٠,٠٠		
	٠١١٠٠٨٩٠١٣	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ١٠ (التأسيس علي الصخر)	٩/٢٠٢	٣٥٣لسنة٢٠٠٤		٣٠,٠٠		
	٠١١٠٠٨٩٠١٤	ميكانيكا التربة وتصميم وتنفيذ الأساسات ج ٢٠ (المصطلحات الفنية)	١٠/٢٠٢	٣٥٣لسنة٢٠٠٤		٢٠,٠٠	٣٢٥,٠٠	إجمالي كودات الأساسات
٣	٠١١٠٠٨٩٠١٥	الدليل الإسترشادى للكود المصرى للأساسات	١١/٢٠٢	———	دلائل الأساسات	٣٥,٠٠		
	٠١١٠٠٨٩٠١٦	معجم ميكانيكا التربةوتصميم وتنفيذ الأساسات (إنجليزي - فرنسي - عربي)	١٢/٢٠٢	———		٢٥,٠٠	٦٠,٠٠	إجمالي دلائل الأساسات
٤	٠١١٠٠٨٩٠١٧	أعمال الطرق الحضريه والخلوية ج١ (الدراسات الأولية للطرق)	١/١٠٤	٣٦٩لسنة٢٠٠٨	الطرق	٣٥,٠٠		
	٠١١٠٠٨٩٠١٨	أعمال الطرق الحضريه والخلوية ج٢ (هندسة المرور)	٢/١٠٤	٣٦٩لسنة٢٠٠٨		٦٠,٠٠		
	٠١١٠٠٨٩٠١٩	أعمال الطرق الحضريه والخلوية ج٣ (التصميم الهندسي)	٣/١٠٤	٣٦٩لسنة٢٠٠٨		٤٠,٠٠		
	٠١١٠٠٨٩٠٢٠	أعمال الطرق الحضريه والخلوية ج٤ (مواد الطرق وإختباراتها)	٤/١٠٤	٣٦٩لسنة٢٠٠٨		٥٠,٠٠		
	٠١١٠٠٨٩٠٢١	أعمال الطرق الحضريه والخلوية ج٥ (تصميم وإنشاء الجسور)	٥/١٠٤	٣٦٩لسنة٢٠٠٨		٣٥,٠٠		
	٠١١٠٠٨٩٠٢٢	أعمال الطرق الحضريه والخلوية ج٦ (التصميم الإنشائى للطرق)	٦/١٠٤	٣٦٩لسنة٢٠٠٨		٣٥,٠٠		
	٠١١٠٠٨٩٠٢٣	أعمال الطرق الحضريه والخلوية ج٧ (حماية الطرق من أخطار السيول والرمال المتحركة)	٧/١٠٤	٣٦٩لسنة٢٠٠٨		٣٥,٠٠		
	٠١١٠٠٨٩٠٢٤	أعمال الطرق الحضريه والخلوية ج٨ (معدات تنفيذ الطرق)	٨/١٠٤	٣٦٩لسنة٢٠٠٨		٦٠,٠٠		
	٠١١٠٠٨٩٠٢٥	أعمال الطرق الحضريه والخلوية ج٩ (إشتراطات تنفيذ أعمال الطرق داخل وخارج المدن)	٩/١٠٤	٣٦٩لسنة٢٠٠٨		٤٠,٠٠		
	٠١١٠٠٨٩٠٢٦	أعمال الطرق الحضريه والخلوية ج١٠ (أعمال صيانة الطرق)	١٠/١٠٤	٣٦٩لسنة٢٠٠٨		٦٠,٠٠	٤٥٠,٠٠	إجمالي كودات الطرق
٥	٠١١٠٠٨٩٠٧٢	الدليل الإسترشادى لكود الطرق الحضرية والخلوية	———	٣٦٩لسنة٢٠٠٨	دليل الطرق	٣٥,٠٠	٣٥,٠٠	الدليل الإسترشادي للطرق
٦		كود الكباري الجزء الأول			الكباري	١٥,٠٠		
		كود الكباري الجزء الثاني				٣٠,٠٠		
		كود الكباري الجزء الثالث				٢٠,٠٠		
		كود الكباري الجزء الرابع				٣٠,٠٠		
		كود الكباري الجزء الخامس				٢٥,٠٠		
							١٠٩٠,٠٠	جملة

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وزارة الإسكان والمرافق والتنميه العمرانيه
المركز القومى لبحوث الإسكان والبناء
إدارة المخازن

م	كود رقم	الكـــود المصـــــــــرى	الرقم الكودي	قرار وزارى	المجموعة	سعر البيع	إجمالي القيمة	بيان الكود
							١٠٩٠,٠٠	ماقبله
٦		كود الكباري الجزء السادس			الكباري	٤٥,٠٠		
		كود الكباري الجزء السابع				٢٥,٠٠		
		كود الكباري الجزء الثامن				٣٥,٠٠		
		كود الكباري الجزء التاسع				٣٥,٠٠		
		كود الكباري الجزء العاشر				٢٥,٠٠		
		كود الكباري الجزء الحادي عشر				٢٠,٠٠	٣٠٥,٠٠	إجمالي كودات الكباري
٧	٠١١٠٠٨٩٠٢٧	التوصيلات الكهربائيه فى المبانى المجلد الأول (أسس التصميم)	٣٠٢	١٥٩لسنة٢٠١٣	الكهرباء	٦٥,٠٠		
	٠١١٠٠٨٩٠٢٨	التوصيلات الكهربائيه فى المبانى المجلد الثاني (شروط التنفيذ)	١/٣٠٢	٥٢٠لسنة٢٠١٢		٤٠,٠٠		
	٠١١٠٠٨٩٠٢٩	التوصيلات الكهربائيه فى المبانى المجلد الثالث (الإختبارات وإستلام الأعمال)	٢/٣٠٢	٥٣١لسنة٢٠١٣		٤٥,٠٠		
	٠١١٠٠٨٩٠٣٠	التوصيلات الكهربائيه فى المبانى المجلد الرابع (التأريض)	٣/٣٠٢	١٦السنة ٢٠٠٤		٢٥,٠٠		
	٠١١٠٠٨٩٠٣١	التوصيلات الكهربائيه فى المبانى المجلد الخامس (الوقاية من الصواعق)	٤/٣٠٢	١٦السنة ٢٠٠٤		٤٥,٠٠		
	٠١١٠٠٨٩٠٣٢	التوصيلات الكهربائيه فى المبانى المجلد السادس (تحسين معامل القدرة)	٥/٣٠٢	١٦السنة ٢٠٠٤		٣٠,٠٠		
	٠١١٠٠٨٩٠٣٣	التوصيلات الكهربائيه فى المبانى المجلد السابع (التوافقيات)	٦/٣٠٢	١٦السنة ٢٠٠٤		٣٠,٠٠		
	٠١١٠٠٨٩٠٣٤	التوصيلات الكهربائيه فى المبانى المجلد الثامن (الملامسات والبادئات المستعملة في التحكم للمحركات التأثيرية ثلاثية الطور)	٧/٣٠٢	١٦السنة ٢٠٠٤		٣٥,٠٠		
	٠١١٠٠٨٩٠٣٥	تصميم وشروط تنفيذ التوصيلات الكهربائيه فى المبانى المجلد التاسع (التحكم في الإضائة)	٨/٣٠٢	١٦السنة ٢٠٠٤		٢٥,٠٠		
	٠١١٠٠٨٩٠٣٦	تصميم وشروط تنفيذ التوصيلات الكهربائيه فى المبانى المجلد العاشر (مولدات الطوارئ)	٩/٣٠٢	١٦السنة ٢٠٠٤		٣٠,٠٠	٣٧٠,٠٠	إجمالي كود الكهرباء
٨	٠١١٠٠٨٩٠٣٧	الدليل الإسترشادى لكود الكهرياء الجزء الأول (أعمال التصميم)	١٠/٣٠٢	———	دلائل	٥٠,٠٠		
	٠١١٠٠٨٩٠٣٨	الدليل الإسترشادى لكود الكهرياء الجزء الثاني (تنفيذ الأعمال)	١١/٣٠٢	———		٣٥,٠٠		
	٠١١٠٠٨٩٠٣٩	الدليل الإسترشادى لكود الكهرياء الجزء الثالث (إستلام الأعمال)	١٢/٣٠٢	———	الكهرباء	٢٥,٠٠	١١٠,٠٠	إجمالي دلائل الكهرباء
٩	٠١١٠٠٨٩٠٦٦	الكود المصري لأسس تصميم وشروط تنفيذ أعمال الإنارة (الإنـــارة ج ١)	٣٠٨	٣٦٨لسنة٢٠٠٨	الإنارة	٥٥,٠٠		
	٠١١٠٨٩٠٧٣	الكود المصري لأسس تصميم وشروط تنفيذ أعمال إنارة الطرق والأنفاق (الإنـــارة ج ٢)	٢/٣٠٨	٣٣٤لسنة٢٠١٠		٥٥,٠٠	١١٠,٠٠	إجمالي الإنارة
١٠	٠١١٠٠٨٩٠٤٠	الكود المصرى لتكييف الهواء والتبريد الجزء الأول (تكييف الهواء)	٣٠٤	١٣٩لسنة٢٠٠٤	التكييف	٤٠,٠٠		
	٠١١٠٠٨٩٠٤١	الكود المصرى لتكييف الهواء والتبريد لجزء الثاني (التبريد)	١/٣٠٤	١٣٩لسنة٢٠٠٤		٤٥,٠٠		
	٠١١٠٠٨٩٠٤٢	الكود المصرى لتكييف الهواء والتبريد الجزء الثالث (أعمال التحكم والكهرباء)	٢/٣٠٤	١٣٩لسنة٢٠٠٤		٣٠,٠٠	١١٥,٠٠	إجمالي التكييف والتبريد
١١	٠١١٠٠٨٩٠٤٣	المنشآت والكبارى المعدنيه (A.S.D (Steel Construction	٢٠٥	٢٧٩لسنة٢٠٠١	STEEL	٣٥,٠٠		
	٠١١٠٠٨٩٠٤٤	الكود المصرى لتنفيذ المنشآت المعدنية علي أساس الأحمال والمقاومة المعيارية L.R.F.D	١/٢٠٥	٣٥٩لسنة٢٠٠٧		٤٠,٠٠	٧٥,٠٠	إجمالي كود الإستيل
١٢	٠١١٠٠٨٩٠٤٥	أسس تصميم وإشتراطات تنفيذ أعمال المبانى ١٩٩٤	٢٠٤	٣٥١لسنة٢٠٠٤	المباني	٣٥,٠٠	٣٥,٠٠	كود المباني
١٣	٠١١٠٠٨٩٠٤٦	أسس تصميم وإشتراطات تنفيذ إستخدام البوليمرات المسلحة بالألياف في مجال التشييد		٤٩٢لسنة٢٠٠٥	بوليمرات	٣٥,٠٠	٣٥,٠٠	كود البوليمرات
١٤	٠١١٠٠٨٩٠٤٧	تحسين كفاءة إستخدام الطاقة في المباني الجزء الأول (المباني السكنية)	١/٣٠٦	٤٨٢لسنة ٢٠٠٥	تحسين	٢٥,٠٠		
	٠١١٠٠٨٩٠٦٨	تحسين كفاءة إستخدام الطاقة في المباني الجزء الثاني (المباني التجارية)	٢/٣٠٦	١٩٠لسنة ٢٠٠٩		٣٠,٠٠		
			———	———	إستخدام الطاقة	٠,٠٠	٥٥,٠٠	إجمالي إستخدام الطاقة
١٥	٠١١٠٠٨٩٠٤٨	حساب الأحمال والقوى الإنشائيه وأعمال المبانى	٢٠١	٤٣١لسنة ٢٠١١	الأحمال	٤٠,٠٠	٤٠,٠٠	كود الأحمال

٢٣٤٠,٠٠	الإجمالى

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أحمد يوسف
مخازن المركز القومي لبحوث الإسكان والبناء

م	كود رقم	الكـــود المصـــــــــرى	الرقم الكودي	قرار وزارى	المجموعة	سعر البيع	إجمالي القيمة	بيان الكود
							٢٣٤٠,٠٠	ماقبله
١٦	٠١١٠٠٨٩٠٤٩	تصميم الفراغات الخارجيه والمبانى لإستخدام المعاقين	٦٠١	٣٠٣لسنة٢٠٠٣	المعاقين	٢٥,٠٠	٢٥,٠٠	كود المعاقين
١٧	٠١١٠٠٨٩٠٥٠	تصميم وإختيار أسس البياض الخارجي - الداخلى - الخاص	٤٠١	٤٥٤لسنة١٩٩١	البياض	٢٠,٠٠	٢٠,٠٠	كود البياض
١٨	٠١١٠٠٨٩٠٥١	الكود المصرى للحريق الجزء الأول (أسس التصميم وإشتراطات التنفيذ لحماية المنشآت من الحريق)	٣٠٥	١٥٢لسنة١٩٩٨	الحريق	٤٠,٠٠		
	٠١١٠٠٨٩٠٥٢	الكود المصرى للحريق الجزء الثانى (متطلبات أنظمة خدمات المبنى للحد من أخطار الحريق)	١/٣٠٥	١٥٤لسنة٢٠٠٠		٣٠,٠٠		
	٠١١٠٠٨٩٠٥٣	الكود المصرى للحريق الجزء الثالث (أنظمة الكشف والإنذار عن الحريق)	٢/٣٠٥	٢٦٠لسنة١٩٩٩		٢٥,٠٠		
	٠١١٠٠٨٩٠٥٤	الكود المصرى للحريق الجزء الرابع (أنظمة الإطفاء بالمياه)	٣/٣٠٥	٣٤٤لسنة٢٠٠٧		٤٠,٠٠	١٣٥,٠٠	إجمالي كود الحريق
١٩	٠١١٠٠٨٩٠٥٥	إشتراطات الأمان للمنشآت متعددة الأغراض الجزء الأول (الجراجات)	———	٣٧٩لسنة٢٠٠٧	الجراجات	٣٠,٠٠	٣٠,٠٠	كود الجراجات
٢٠	٠١١٠٠٨٩٠٥٦	كود التركيبات الصحية في المباني الجزء الأول (أسس تصميم وشروط التنفيذ)	٣٠١	٥٣٢لسنة٢٠١٣	التركيبات الصحية	٤٥,٠٠		
	٠١١٠٠٨٩٠٧٨	كود التركيبات الصحية في المباني الجزء الثانى (أعمال التغذيه بالمياه ومعالجة المياه فى التجمعات السكنيه الصغيره)	١/٣٠١	١٠لسنة٢٠١٢		٢٥,٠٠		
	٠١١٠٠٨٩٠٧٩	كود التركيبات الصحية في المباني الجزء الثالث (أعمال التغذيه بالمياه الساخنه وحمامات السباحه)	٢/٣٠١	١٤٩لسنة١٩٩٩		٣٠,٠٠		
	٠١١٠٠٨٩٠٨٠	كود التركيبات الصحية في المباني الجزء الرابع (تجهيز المطابخ - المستشفيات - التخلص من القمامه)	٣/٣٠١	١٤٠لسنة٢٠٠١		٣٠,٠٠	١٣٠,٠٠	إجمالي كود التركيبات
٢١	٠١١٠٠٨٩٠٥٧	كود المحطات المجلد الأول أسس تصميم وشروط تنفيذ محطات الرفع (صرف صحى)	١٠١	١٦٨لسنة١٩٩٧	المحطات	٦٠,٠٠		
	٠١١٠٠٨٩٠٥٨	كود المحطات المجلد الثانى أسس تصميم وشروط تنفيذ أعمال المعالجه (صرف صحى)	١/١٠١	١٦٩لسنة١٩٩٧		٥٥,٠٠		
	٠١١٠٠٨٩٠٥٩	كود المحطات المجلد الثالث أسس تصميم وشروط تنفيذ محطات التنقيه (مياه الشرب)	٢/١٠١	٥٢لسنة ١٩٩٨		٥٥,٠٠		
	٠١١٠٠٨٩٠٦٠	كود المحطات المجلد الرابع أسس تصميم وشروط تنفيذ الروافع (مياه الشرب)	٣/١٠١	٥٣لسنة ١٩٩٨		٣٠,٠٠	٢٠٠,٠٠	إجمالي كود المحطات
٢٢	٠١١٠٠٨٩٠٦١	تصميم وتنفيذ خطوط المواسير لشبكات مياه الشرب والصرف الصحى	١٠٢	١٩٧لسنة٢٠١٠	المواسير	٣٥,٠٠	٣٥,٠٠	كود المواسير
٢٣	٠١١٠٠٨٩٠٦٢	كود الريوز (إستخدام مياه الصرف الصحى المعالجه فى مجال الزراعه)	٥٠١	١٧١لسنة٢٠٠٥	الريوز	٢٥,٠٠		
	٠١١٠٠٨٩٠٨١	الملحق الأول لكود الريوز (الدليل الإرشادى لإستغلال مياه الصرف الصحى المعالجه فى مجال الزراعه)	١/٥٠١	١٧١لسنة٢٠٠٥		٣٠,٠٠		
	٠١١٠٠٨٩٠٨٢					٠,٠٠	٥٥,٠٠	إجمالي كود الريوز
٢٤	٠١١٠٠٨٩٠٨٣	أسس تصميم وشروط تنفيذ المصاعد في المباني الجزء الأول (المصاعد الكهربائية)	١/٣٠٣	١٣٦لسنة٢٠٠٧	المصاعد	٣٥,٠٠		
	٠١١٠٠٨٩٠٨٤	أسس تصميم وشروط تنفيذ المصاعد في المباني الجزء الثانى (المصاعد الهيدروليكية)	٢/٣٠٣	١٣٦لسنة٢٠٠٧		٣٥,٠٠		
	٠١١٠٠٨٩٠٨٥	أسس تصميم وشروط تنفيذ المصاعد في المباني الجـزء الثالث (السلالم والمشايات الكهربائية)	٣/٣٠٣	١٣٦لسنة٢٠٠٧		٣٥,٠٠		
	٠١١٠٠٨٩٠٦٣	أسس تصميم وشروط تنفيذ المصاعد في المباني الجـزء الرابع (مصاعد البضائع فقط)	٤/٣٠٣	٤٤٠لسنة٢٠١٥		٣٥,٠٠	١٤٠,٠٠	إجمالي كود المصاعد
٢٥	٠١١٠٠٨٩٠٦٤	تشغيل وصيانة محطات تنقية مياه الشرب وروافعها وشبكاتها الجزء الأول (محطات تنقية مياه الشرب)	١/١٠٣	٣٣١لسنة٢٠٠٧	تشغيل وصيانة	٤٥,٠٠		
	٠١١٠٠٨٩٠٦٥	تشغيل وصيانة محطات تنقية مياه الشرب وروافعها وشبكاتها الجزء الثاني (صيانة شبكات المياه)	٢/١٠٣	٣٣١لسنة٢٠٠٧	مياه الشرب	٢٠,٠٠	٦٥,٠٠	كود تشغيل وصيانة
٢٦	٠١١٠٠٨٩٠٦٧	الكود المصري لإدارة مشروعات التشييد	٣١١	٣٦٤لسنة٢٠٠٩	التشييد	٣٥,٠٠	٣٥,٠٠	كود التشييد
٢٧	٠١١٠٠٨٩٠٦٩	الكود المصري لمعايير تصميم المسكن والمجموعة السكنية	٦٠٢	٨٠لسنة٢٠٠٩	المسكن والسكنية	٢٠,٠٠	٢٠,٠٠	كود المسكن والمجموعة
٢٨	٠١١٠٠٨٩٠٧٠	المعايير التصميمية والمنشآت الصحية كود المستشفيات ج١ (مكونات عامة - مركزية - خاصة ومتطلباتها)	١/٦٠٣	٢٢٢لسنة٢٠١٠	المستشفيات	٤٠,٠٠		
	٠١١٠٠٨٩٠٧٧	المعايير التصميمية والمنشآت الصحية كود المستشفيات ج٢ (متطلباتهاوالشبكات الخدميةومعايير الحفاظ علي بيئة نظيف	٢/٦٠٣	٣٧٥لسنة٢٠١١		٤٠,٠٠		
	٠١١٠٠٨٩٠٨٦	المعايير التصميمية والمنشآت الصحية كود المستشفيات ج٣ (تطوير المباني القائمة)	———	٨٢٨لسنة٢٠١٤		٢٠,٠٠	١٠٠,٠٠	إجمالي كود المستشفيات
٢٩	٠١١٠٠٨٩٠٧٦	الكود المصري للتهوية في المباني	———	١٦٠لسنة٢٠١٣	التهوية	٢٥,٠٠	٢٥,٠٠	كود التهوية
٣٠	٠١١٠٠٨٩٠٨٩	أسس تصميم وإشتراطات تنفيذ عزل الرطوبة والمياه في المباني	———	٥٠٩لسنة٢٠١٢	عزل رطوبة	٢٥,٠٠	٢٥,٠٠	كود العزل
٣١	٠١١٠٠٨٩٠٨٧	الكود المصري لأخلاقيات وقواعد سلوكيات ممارسة مهنة الهندسة (المسودة النهائية)	———	١٢٣لسنة٢٠١٣	أخلاقيات الهندسة	٢٠,٠٠	٢٠,٠٠	كود أخلاقيات المهنة
							٣٤٠٠,٠٠	إجمالي الكودات

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أحمد يوسف

وزارة الإسكان والمرافق والتنميه العمرانيه
المركز القومى لبحوث الإسكان والبناء
إدارة المخازن

م	كود رقم	الكـــود المصـــــــــرى	الرقم الكودي	قرار وزارى	المجموعة	سعر البيع	إجمالي القيمة	بيان الكود
							٣٤٠٠,٠٠	ماقبله
٣٢	٠١١٠٠٨٩٠٨٨	الكود المصري لتنفيذ أعمال الصوتيات والتحكم في الضوضاء للمباني	———	٥٧٨لسنة٢٠١٣	الصوتيات والضوضاء	٤٥,٠٠	٤٥,٠٠	الصوتيات والضوضاء
١	٠١١٠٠٨٩٢٠٠	دليل معايير تنسيق عناصر الطرق	———	———		٢٥,٠٠		
٢	٠١١٠٠٨٩٢٠١	الأسس والمعايير التخطيطية للمجتمعات العمرانية في جنوب الوادي	———	———	معايير وكتب	٢٥,٠٠		
٣	٠١١٠٠٨٩٢٠٣	الكتاب المصرى لندوة المسكن الملائم	———	———		١٠,٠٠	٦٠,٠٠	إجمالي المعاجم والملاحق
		قائمة مواصفات بنود الأعمال الصادرة من المركز						
م	كود رقم	مواصفات بنود الأعمال	الرقم الكودي	قرار وزارى	المجموعة	سعر البيع	إجمالي القيمة	بيان الكود
١	٠١١٠٠٨٩٤٠٠	مواصفات بنود أعمال النجاره	٣/٩٠٢	٢٠٧لسنة٩٤		٤٥,٠٠		
٢	٠١١٠٠٨٩٤٠١	مواصفات بنود أعمال الألومنيوم	٤/٩٠٢	٢٢٠لسنة٩٤		٣٠,٠٠		
٣	٠١١٠٠٨٩٤٠٢	مواصفات بنود أعمال الصحيه	١/٩٠٢	٢٠٥لسنة٩٤		٣٥,٠٠		
٤	٠١١٠٠٨٩٤٠٣	مواصفات بنود أعمال الأرضيات والتكسيات وأعمال الرخام	٢/٩٠٢	٢٠٦لسنة٩٤		٢٥,٠٠		
٥	٠١١٠٠٨٩٤٠٤	مواصفات بنود أعمال عزل الرطوبه والمياه	٦/٩٠٢	٢٠٥لسنة٩٥	مواصفات	٣٠,٠٠		
٦	٠١١٠٠٨٩٤٠٥	مواصفات بنود أعمال الدهانات	٨/٩٠٢	٢٠٧لسنة٩٥		٢٥,٠٠		
٧	٠١١٠٠٨٩٤٠٦	مواصفات بنود أعمال الخرسانه والخرسانه المسلحه	٧/٩٠٢	٢٠٦لسنة٩٥		٢٥,٠٠		
٨	٠١١٠٠٨٩٤٠٧	مواصفات بنود الأعمال الترابيه (الحفر والردم)	٥/٩٠٢	٢٠٤لسنة٩٥		١٥,٠٠		
٩	٠١١٠٠٨٩٤٠٨	مواصفات بنود أعمال المصروفات العموميه والإلتزامات الماليه	٩/٩٠٢	٢٥٦لسنة٩٥		١٥,٠٠		
١٠	٠١١٠٠٨٩٤٠٩	مواصفات بنود أعمال الحداده المعماريه	١١/٩٠٢	١٦٦لسنة٩٧		٣٥,٠٠		
١١	٠١١٠٠٨٩٤١٠	مواصفات بنود أعمال البياض	١٠/٩٠٢	١٦٤لسنة٩٧	بنود	٣٥,٠٠		
١٢	٠١١٠٠٨٩٤١١	مواصفات بنود أعمال العزل الحرارى	١٣/٩٠٢	١٧٦لسنة٩٨		٣٠,٠٠		
١٣	٠١١٠٠٨٩٤١٢	مواصفات بنود أعمال الكهرباء (جزء أول)	١٢/٩٠٢	١٧٣لسنة٩٨		٣٥,٠٠		
١٤	٠١١٠٠٨٩٤١٣	مواصفات بنود أعمال الكهرباء (جزء ثانى)	١٢/٩٠٣	١٧٣لسنة٩٩		٣٥,٠٠		
١٥	٠١١٠٠٨٩٤٢٢	عقد خدمات إستشاريه هندسيه للدراسات والتصميمات (نموذج إسترشادى)	١/٩٠١	٢٢١لسنة٩٤		١٥,٠٠		
١٦	٠١١٠٠٨٩٤١٤	عقد خدمات إستشاريه هندسيه للإشراف على التنفيذ (إدارة التشييد)	٣/٩٠١	٢٢٣لسنة٩٤		١٥,٠٠		
١٧	٠١١٠٠٨٩٤١٥	الشروط العامه لعقد أعمال المقاولات (نموزج إسترشادى)	٢/٩٠١	٢٢٢لسنة٩٤		٢٠,٠٠		
١٨	٠١١٠٠٨٩٤١٦	عقد تصميم وتنفيذ (بتمويل من المالك)	٥/٩٠١	٢٤٦لسنة٩٩	الأعمال	٢٠,٠٠		
١٩	٠١١٠٠٨٩٤١٧	عقد مشترك خدمات إستشاريه هندسيه للدراسات والتصميمات والإشراف المستمر على التنفيذ	٤/٩٠١	١٦٥لسنة٩٧		١٥,٠٠		
٢٠	٠١١٠٠٨٩٤١٨	مواصفات بنود أعمال الخرسانه ذاتية الدمك	———	٣٦٠لسنة٢٠٠٧		٣٥,٠٠		
٢١	٠١١٠٠٨٩٤١٩	المواصفات الفنية للقطاعات المصنعة من UPVC	———	٣٦٠لسنة٢٠٠٧		٢٥,٠٠		
٢٢	٠١١٠٠٨٩٤٢٠	المواصفات الفنية لصناعة الخرسانه في الأجواء الحارة	———	٣٦٠لسنة٢٠٠٧		٢٠,٠٠		
٢٣	٠١١٠٠٨٩٤٢١	المواصفات الفنية للخرسانه الجاهزة عادية الوزن والإشتراطات الفنية والبيئية لمحطات الخلط	———	٣٦٠لسنة٢٠٠٧		٢٥,٠٠	٦٠٥,٠٠	إجمالي بنود الأعمال
		إجمالي الكودات والملاحق والمعاجم ومواصفات بنود الاعمال	**٤١١٠,٠٠**					

أولاً : تخفض الأسعاربنسبة ٥٠% لطلبة الجامعات والمعاهد الحكومية المصريه بخطاب معتمد من الكليه أو المعهد وأيضاً من رئيس مجلس إدارة المركز القومي لبحوث الإسكان والبناء .

ثانياً : الدفع نقداً بخزينة المركز أو بشيك باسم المركز القومى لبحوث الإسكان والبناء ٠

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أحمد يوسف
مخازن المركز القومي لبحوث الإسكان والبناء

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Appendix D List of Sustainable Design Tools

Table 2 List of Sustainable Design Tools (Single and Dual aspects) [Name, Type, and Country) (Fowler and Rauch 2006)

Sustainable Design Tool	Type	Sustainable Design Tool	Type	Sustainable Design Tool	Type
Green Building Advisor (US)	Catalogue	Environmental Profiles of construction materials, components and buildings (UK)	Database of LCA information	"Green" Hotels Association (US)	Hotels/ Lodging
Energy Star	Energy analysis	Quest	Policy choice tool	Coalition for Environmentally Responsible Economies (CERES) Green Hotel Initiative (US)	Hotels/ Lodging
Energy Certification for Buildings (Finland)	Energy analysis	BM Bau Building Passport (Germany)	Product specification guide	Green Globe 21 (US)	Hotels/ Lodging
BSEA 1.0 (Finland)	Energy Analysis	The Movement for Innovation (M4i)	Construction & Design Safety	Green Leaf Eco-Rating Program (Canada)	Hotels/ Lodging
NEN 2916/5128, NPR 2917/5129 (Netherlands)	Energy Modeling Software	EcoProP	Requirements management system	Green Rating Program (Africa)	Hotels/ Lodging
SIMBAD (Finland)	Energy Modeling Software	Costing Reference Model	Residential	Green Seal Certification (US)	Hotels/ Lodging

Sustainable Design Tool	Type	Sustainable Design Tool	Type	Sustainable Design Tool	Type
EDIP (Denmark)	Environmental assessment of products	Super E-House Program (Canada)	Residential	HVS International ECOTEL Certification	Hotels/ Lodging
Environmental Classification of Properties	Environmental impact assessment	AccuRate (Australia)	Residential	Sustainable Ecotourism Rating (Costa Rica)	Hotels/Lodgin g
Papoose (Finland)	Environmental impact assessment	Alameda County (CA)	Residential	Vermont Green Hotels in the Green Mountain State	Hotels/Lodgin g
Envest	Environmental impact assessment tool	BASIX Building Sustainability Index (Australia)	Residential	Green Rating Initiative (Ethiopia)	Industrial
EcoEffect (Sweden)	Environmental Impact Software model	BERS (Australia)	Residential	Green Rating of Indian Industry	Industrial
ISO 14001	Environmental Management System	Build a Better Clark (Clark County Washington HBA)	Residential	Sustainable Project Appraisal Routine (SPEAR)	Industrial
MRPI Netherlands	Environmental product declaration	Build A Better Kitsap Home Builder Program (Kitsap, WA HBA)	Residential	Global Reporting Initiative	Industrial Reporting
Cities for Climate Protection Software	GHG emissions inventories tool	National Association of Home Buildings (NAHB) Green Guidelines	Residential	BEAT 2000 (Denmark)	Life Cycle assessment tool
City of Santa Monica Green Building & Construction Guidelines	Guideline	Built Green Alberta (Canada)	Residential	BRI LCA (Japan)	Life Cycle assessment tool

Sustainable Design Tool	Type	Sustainable Design Tool	Type	Sustainable Design Tool	Type
ECDG – Japan	Guideline	Built GreenTM (MBA of King and Snohomish Counties, WA)	Residential	Eco Indicator (Netherlands)	Life Cycle assessment tool
Green Building Program (Austin, TX)	Guideline	Built GreenTM Colorado (HBA of Metro Denver)	Residential	EcoInstall (Netherlands)	Life Cycle assessment tool
National Packages Sustainable Building (Netherlands)	Guideline	California Green Builder Program	Residential	EcoPro (Germany)	Life Cycle assessment tool
NYC High-Performance Building Guidelines	Guideline	Chula Vista (CA) GreenStar Building Incentive Program	Residential	EcoQuantum (Netherlands)	Life Cycle assessment tool
Seattle Sustainable Building Action Plan and Built Smart (Seattle, WA)	Guideline	City of Boulder Green Points (CO)	Residential	LCA-House (Finland)	Life Cycle assessment tool
Tokyo Metro Green Building Program	Guideline	City of Frisco (TX) Green Building Program	Residential	LCAiT (Sweden)	Life Cycle assessment tool
NatHERS (Australia)	Residential	County of Santa Barbara Innovative Building Review Program (CA)	Residential	Legoe (Germany)	Life Cycle assessment tool
New Mexico Building America Partner Program	Residential	Earth Advantage Home (US)	Residential	OGIP (Switzerland)	Life Cycle assessment tool

Sustainable Design Tool	Type	Sustainable Design Tool	Type	Sustainable Design Tool	Type
(HBA of Central New Mexico)					
Novoclimat (Quebec, Canada)	Residential	Earth Advantage Program (Portland General Electric)	Residential	REGENERS (Finland)	Life Cycle assessment tool
R-2000 (Canada)	Residential	EarthCraft House (Greater Atlanta, GA HBA)	Residential	TAKE-LCA (Finland)	Life Cycle assessment tool
Schenectady HBA Green Building Program (NY)	Residential	EarthCraft House (US)	Residential	TEAM (Finland)	Life Cycle assessment tool
SeaGreen (Seattle)	Residential	EcoHomes (UK)	Residential	Athena Model (Canada)	Life Cycle assessment tool
Southern Arizona Green Building Alliance	Residential	EnerGuide Houses Program (Canada)	Residential	BEES (US)	Life Cycle assessment tool
Super E House Program (Canada)	Residential	Energy Rated Homes of Colorado	Residential	GaBi 4	Life Cycle assessment tool
Super Good Cents and Natural Choice Homes	Residential	Energy Star (US, Canada)	Residential	KCL-ECO	Life Cycle assessment tool
The BREEAM Green Leaf for Multi-Residential Buildings (Canada)	Residential	Evergreen Building Guide (Issaquah, WA)	Residential	LISA (Austrailia)	Life Cycle assessment tool

Sustainable Design Tool	Type	Sustainable Design Tool	Type	Sustainable Design Tool	Type
The Green Builder Program (NM)	Residential	FirstRate (Australia)	Residential	Umberto	Life Cycle assessment tool
Vermont Built Green	Residential	G/Rated (Portland, OR)	Residential	Solution Spaces (Canada)	Life Cycle cost and impact of urban development forecasting tool
Western North Carolina Green Building Council	Residential	Green Building Program, Austin Energy (TX)	Residential	Equer (France)	Life Cycle simulation tool
HERS (US)	Residential	Green Built Home (Wisconsin Environmental Initiative)	Residential	Environmental Choice Program	Materials assessment method
Home Builders Association of Greater Kansas City (MO)	Residential	Green Built Program (HBA of Greater Grand Rapids, MI)	Residential	MMG (Netherlands)	Materials assessment method
HomeRun (Canada)	Residential	Green Home Designation (Florida Green Building Coalition)	Residential	SIA 493 (Switzerland)	Materials checklist
Hudson Valley HBA Green Building Program (NY)	Residential	Green Points Building Program (Boulder, CO)	Residential	Hawaii BuiltGreenTM	Residential
Multifamily Green Building Guidelines (Alameda County, CA)	Residential	Green Building Rules and Regulations in Dubai	Guidelines	Health House Advantage Certification (US)	Residential

Appendix E BREEAM New Construction 2014 Category Weightings

Table 3 BREEAM New Construction category weights (BRE 2014)

Categories	Weighting	Index	Criterion	Max. credits	%
Management	12%	Man1	Commissioning	2	2.18%
		Man 2	Constructors Environmental and Social Code of Conduct	2	2.18%
		Man 3	Construction site impacts	4	4.36%
		Man 4	Building user guide	1	1.09%
		Man12	Life Cycle Cost Analysis	2	2.16%
Heath and Well Being	15%	H0a 1	Daylighting	1	1.07%
		Hea 2	View out	1	1.07%
		Hea3	Glare control	1	1.07%
		Hea 4	High frequency lighting	1	1.07%
		Hea 5	Internal and e:<ternal lighting levels	1	1.07%
		Hea 6	Lighting zones and control	1	1.07%
		Hea7	Potential for natural ventilation	1	1.07%
		Hea 6	Indoor air quality	1	1.07%
		Hea9	Volatile Organic Compounds [VOC)	1	1.07%
		Hea 10	Thermal comfort	2	2.14%
		Hea 11	Thermal zoning	1	1.07%
		Hea 12	Microbial contamination	1	1.07%
		Hea 13	Acoustic performance	1	1.07%
Energy	19%	Ene 1	Energy efficiency	15	11.87%
		Ene 2	Sub-metering of substantial energy use	1	0.79%
		Ene 3	Submetering of high energy areas and tenancy	1	0.79%
		Ene 4	External lighting	1	0.79%
		Ene 5	Low-zero carbon technologies	3	2.36%
		Ene8	Lifts	2	1.56%
		Ene 9	Escalators and traveling walkways	1	0.79%

Categories	Weighting	Index	Criterion	Max. credits	%
Transport	8%	Tra 1	Provision of public transport	2	1.76%
		Tra 2	Proximity to amenities	1	0.69%
		Tra 3	Alternative modes of transport	2	1.76%
		Tra 4	Pedestrian and cyclist safety	1	0.69%
		Tra 5	Travel plan	1	0.69%
		Tra 6	Maximum car parking capacity	2	1.76%
Water	6%	Wat 1	Water consumption	3	2%
		Wat 2	Water meter	1	0.07%
		Wat 3	Major leak detection	1	0.67%
		Wat 4	Sanitary supply shut-off	1	0.67%
		Wat 6	Irrigation systems	1	0.67%
		Wat 3	Sustainable on-site water treatment	2	1.33%
Materials	12.50%	Mat 1	Material specifications (major building elements)	4	3.85%
		Ma1 2	Hard landscaping and boundary protection	1	0.96%
		Mal3	Re-use of building facade	1	0.96%
		Ma1 4	Re-use of building structure	1	0.96%
		Mats	Responsible sourcing of materials	3	2.66%
		Mate	Insulation	2	1.92%
		Ma17	Designing for robustness	1	0.96%
Waste	7.50%	Wst 1	Construction site waste management	3	3.21%
		Wst 2	Recycled aggregates	1	1.07%
		Wst 3	Recyclable waste storage	1	1.07%
		Wst 5	Composting	1	1.07%
		Wst 6	Floor finishes	1	1.07%
Land Use & Ecology	10%	LE 1	Re-use of land	1	1%
		LE 2	Contaminated land	1	1%
		LE3	Ecological value of site & protection of eco logical features	1	1%

Categories	Weighting	Index	Criterion	Max. credits	%
		LE4	Mitigating ecological impact	5	5%
		LE6	Long-term impact on biodiversity	2	2%
Pollution	10%	Pol 1	Refrigerant GWP - building services	1	0.63%
		Pol 2	Preventing refrigerant leaks	2	1.67%
		Pol 4	NOX emissions from heating source	3	2.5%
		Pol 5	Flood risk	3	2.5%
		Pol 6	Minimizing watercourse pollution	1	0.63%
		Pol 7	Reduction of night-time light pollution	1	0.63%
		Pol 8	Noise attenuation	1	0.63%
Innovation	10%	Inn 1	Innovations [1 credit per innovation, max. 10 credits)	10	10%
Total				**119**	**100.7%**

Appendix F BREEAM New Construction Non-Domestic 2014 Scope (BRE 2014)

Commercial	Offices	General office buildings Offices with research and development areas (i.e. category 1 labs only)
	Industrial	Industrial unit – warehouse storage/distribution Industrial unit – process/manufacturing/vehicle servicing
	Retail	Shop/shopping center Retail park/warehouse 'Over the counter' service provider e.g. financial, estate and employment agencies and betting offices Showroom Restaurant, café, and drinking establishment - Hot food takeaway
Public (non-housing)	Educational	Pre-school Schools and sixth form colleges - Further education/ vocational colleges Higher education institutions
	Healthcare	Teaching/specialist hospitals - General acute hospitals Community and mental health hospitals GP surgeries and Health centers and clinics
	Prisons	High-security prison Standard secured prison Young offender institution and juvenile prisons Local prison-Holding Center
Law courts	Law Courts	Law courts Crown and criminal courts County courts, Magistrates' courts, Civil justice centers Family courts Youth courts Combined courts
Multi-residential accommodation/Supported living facility	Residential institutions (long term stay)	Residential care home Sheltered accommodation Residential college/school (halls of residence) Local authority secure residential accommodation Military barracks
Other	Residential institutions (short term stay)	Hotel, hostel, boarding and guest house Secure training center Residential training center
	Non-residential institutions	Art gallery, museum Library Day center, hall/civic/community center Place of worship
	Assembly and leisure	Cinema Theatre/music/concert hall Exhibition/conference hall Indoor or outdoor sports, fitness and recreation center (with/without pool)
	Other	Transport hub (coach/bus station and above ground rail station) Research and development (category 2 or 3 laboratories - non-higher education)

Appendix G LEED New Construction (BD +C) version 4 Categories and Weights

Table 4 LEED New Construction (BD+C) v4 categories weightings (USGBC 2015)

	Category/Credit	Points
SS	Sustainable Sites	26
SS-P1	Construction Activity Pollution Prevention	R
SS-1	Site Selection	1
SS-2	Development Density and Community Connectivity	5
SS-3	Brownfield Redevelopment	1
SS-4.1	Alternative Transportation - Public Transportation Access	6
SS-4.2	Alternative Transportation - Bicycle Storage and Changing Rooms	1
SS-4.3	Alternative Transportation - Low-Emitting and Fuel-Efficient Vehicles	3
SS-4.4	Alternative Transportation - Parking Capacity	2
SS-5.1	Site Development - Protect or Restore Habitat	1
SS-5.2	Site Development - Maximize Open Space	1
SS-6.1	Stormwater Design - Quantity Control	1
SS-6.2	Stormwater Design - Quality Control	1
SS-7.1	Heat Island Effect - Nonroof	1
SS-7.2	Heat Island Effect – Roof	1
SS8	Light Pollution Reduction	1
WE	Water Efficiency	10
WE-P1	Water Use Reduction by 20 %	R
WE-1.1	Water Efficient Landscaping: reduction of domestic water consumption by 50%	2
WE-1.2	Water Efficient Landscaping: no use of domestic water	2
WE-2	Innovative Wastewater Technology	2
WE-3	Water Use Reduction by 30% / 35% /40 %	4

EA	Energy & Atmosphere	35
EA-P1	Fundamental Commissioning of Building Energy Systems	R
EA-P2	Minimum Energy Performance	R
EA-P3	Fundamental Refrigerant Management	R
EA-1	Optimize Energy Performance	19
EA-2	On-site Renewable Energy	7
EA-3	Enhanced Commissioning	2
EA-4	Enhanced Refrigerant Management	2
EA-5	Measurement and Verification	3
EA-6	Green Power	2
MR	Materials & Resources	14
MR-P1	Storage and Collection of Recyclables	R
MR-1.1	Building Reuse - Maintain 55% of Existing Walls, Floors, and Roof	1
MR-1.1	Building Reuse - Maintain 75% of Existing Walls, Floors, and Roof	1
MR-1.1	Building Reuse - Maintain 95% of Existing Walls, Floors, and Roof	1
MR-1.2	Building Reuse, Maintain 50% of fit-out	1
MR-2.1	Construction Waste Management. 50% of all waste is recycled	1
MR-2.2	Construction Waste Management, 75% of all waste is recycled	1
MR-3.1	Materials Reuse, 5%	1
MR-3.2	Materials Reuse, 10%	1
MR-4.1	Recycled Content, 10%	1
MR-4.2	Recycled Content, 20%	1
MR-5.1	Regional Materials, 10%	1
MR-5.2	Regional Materials, 20%	1
MR-6	Rapidly Renewable Materials	1
MR-7	Certified wood	1

IEQ	Indoor Environmental Quality	15
IEQ-P1	Minimum Indoor Air Quality Performance	R
IEQ-P2	Environmental Tobacco Smoke (ETS) Control	R
IEQ-1	Outdoor Air Delivery Monitoring	1
IEQ-2	Increased Ventilation	1
IEQ-3.1	Construction Indoor Air Quality Management Plan-During Construction	1
IEQ-3.2	Construction Indoor Air Quality Management Plan- Before Occupancy	1
IEQ-4.1	Low-Emitting Materials - Adhesives and Sealants	1
IEQ-4.2	Low-Emitting Materials - Paints and Coatings	1
IEQ-4.3	Low-Emitting Materials - Flooring Systems	1
IEQ-4.4	Low Emitting Materials Composite Wood & Agri-fiber Products	1
IEQ-5	Indoor Chemical and Pollutant Source Control	1
IEQ-6.1	Controllability of Systems – Lighting	1
IEQ-6.2	Controllability of Systems - Thermal Comfort	1
IEQ-7.1	Thermal Comfort – Design	1
IEQ-7.2	Thermal Comfort – Verification	1
IEQ 8.1	Daylight and Views - Daylight 75% of the Surface	1
IEQ 8.2	Daylight and Views - Views, 90 % of the Surface	1
ID	Innovation & Design	6
ID-1	Innovation in Design	5
ID-2	LEED Accredited Professional	1
RP	Regional Credits	4
RP-1	Regional Priority	4

Appendix H Assessment Fees for LEED NC BD+C version 4

LEED New Construction Building Design and Construction version4 fees (USGBC 2015)

Building Design and Construction Fees	Organizational Level or Non-members	Silver, Gold & Platinum Level Members	Member Savings
Registration	$1,200	$900	$300
Precertification Review (optional, LEED Core and Shell only)			
Flat fee (per building)	$4,250	$3,250	$1,000
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000		
Combined Review: Design & Construction			
Project gross floor area (excluding parking): < 50,000 sq ft.	$2,750	$2,250	$500
Project gross floor area (excluding parking): 50,000-500,000 sq ft.	$0.055/sf	$0.045/sf	$0.01/sf
Project gross floor area (excluding parking): > 500,000 sq ft.	$27,500	$22,500	$5,000
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	+ $10,000		
Split Review: Design			
Project gross floor area (excluding parking): < 50,000 sq ft.	$2,250	$2,000	$250
Project gross floor area (exclud. parking): 50,000-500,000 sq ft	$0.045/sf	$0.04/sf	$0.005/sf
Project gross floor area (excluding parking): >500,000 sq ft	$22,500	$20,000	$2,500
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000		
Split Review: Construction			
Project gross floor area (excluding parking): < 50,000 sq ft.	$750	$500	$250
Project gross floor area (excluding parking): 50,000-500,000 sq ft	$0.015/sf	$0.01/sf	$0.005/sf
Project gross floor area (excluding parking): >500,000 sq ft.	$7,500	$5,000	$2,500
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000		
Appeals			
Complex credits	$800/credit		
All other credits	$500/credit		
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	+ $500/credit		
Formal Inquiries			
Project CIRs	$220/credit		

Appendix I CASBEE for Building (New Construction (weighting coefficient)

Table 5 CASBEE for Building (New Construction) weighting coefficient (IBEC 2014)

Main criteria category	**Weighting coefficient**	**#**	**Criteria category**	**Weighting coefficient**	**#**	**sub-criteria**	**Weighting coefficient**
LR1 Energy	40%	1	Building thermal load	30%			
		2	Natural Energy utilization	20%			
		3	Efficiency of Building Service System	30%	3.1	HVAC system	45%
					3.2	Ventilation system	15%
					3.3	Lighting system	30%
					3.4	Hot Water supply system	5 %
					3.5	Elevators	5 %
		4	Efficient Operation	20%	4.1	Monitoring	50.00%
					4.2	Operation & management system	50%
LR2 Resources & Materials	30%	1	Water Resources	15%	1.1	Water saving	40%
					1.2	Rainwater & greywater	60%
		2	Reducing Usage of Non-renewable resources	63%	2.1	Reducing usage of materials	7 %
					2.2	Continuing use of existing building skeleton etc.	24%
					2.3	Use of recycled materials as structural frame materials	20%
					2.4	Use of recycled materials as non-	20%

Main criteria category	Weighting coefficient	#	Criteria category	Weighting coefficient	#	sub-criteria	Weighting coefficient
						structural materials	
					2.5	Timber from sustainable forestry	5%
					2.6	Reusability of components and materials	24%
		3	Avoiding the Use of Materials with Pollutant Content	22%	3.1	Use of materials without harmful substances	32%
					3.2	Avoidance of CFCs and halons	68%
LR3 Offsite environment	30%	1	Consideration of Global Warming	33.3%			
		2	Consideration of Local Environment	33%	2.1	Air pollution	25%
					2.2	Heat island effect	50%
					2.3	Load on local infrastructure	25%
		3	Consideration of Surrounding Environment	33%	3.1	Noise, vibration & odor	40%
					3.2	Wind damage & sunlight obstruction	40%
					3.3	Light pollution	20 %
Q1 Indoor Environment	40%	1	Noise & Acoustics	15%	1.1	Noise	40%
					1.2	Sound insulation	40%
					1.3	Sound absorption	20%
		2	Thermal Comfort	35%	2.1	Room temperature control	50 %

Main criteria category	Weighting coefficient	#	Criteria category	Weighting coefficient	#	sub-criteria	Weighting coefficient
					2.2	Humidity control	20%
					2.3	Type of air conditioning system	30%
		3	Lighting & Illumination	25%	3 1	Daylighting	30%
					3.2	Anti-glare measures	30%
					3.3	Illuminance level	15%
					3.4	Lighting controllability	25%
		4	Air Quality	25%	4 1	Source control	50%
					4.2	Ventilation	30%
					4.3	Operation plan	20%
Q2 Quality of Service	30%	1	Service Ability	40%	1.1	Functionality & usability	40%
					1.2	Amenity	30%
					1.3	Maintenance management	30%
		2	Durability & Reliability	31%	2.1	Earthquake resistance	48%
					2.2	Service life of components	33%
					2.3	Reliability	10%
		3	Flexibility & Adaptability	29%	3.1	Spatial margin	31%
					3.2	Floor load margin	31%
					3.3	Adaptability of facilities	38%
Q3 Outdoor Environment on site	30%	1	Preservation & Creation of Biotope	30%			
		2	Townscape & Landscape	40%			

Main criteria category	**Weighting coefficient**	**#**	**Criteria category**	**Weighting coefficient**	**#**	**sub-criteria**	**Weighting coefficient**
		3	Local Characteristics & Outdoor Amenity	30%	3.1	Attention to local character & improvement of comfort	50%
					3.2	Improvement of the thermal environment on site	50%

Appendix J CASBEE Certification fees

Table 6 CASBEE Certification Fee Table (as of September 2014) (electronic mail from the Secretary of Japan Green Build Council/Japan Sustainable Building)

. For a large scale building (total floor area is 500 sq.m. and more) (unit: JPY)

Note: This table is for Institute for Building Environment and Energy Conservation, IBEC, and applied to Buildings in Japan only. Fee tables are varied according to the certification

Total Floor Area (sq. m.)	No. of building types*	Fee	Tax	Total
Under 10,000 sq.m.	One	600,000	48,000	648,000
	Two types	780,000	62,400	842,400
	Three types	960,000	76,800	1,036,800
	Four types& more	1,140,000	91,200	1,231,200
From 10,000 sq.m. to 50,000 sq. m	One	750,000	60,000	810,000
	Two types	975,000	78,000	1,053,000
	Three types	1,200,000	96,000	1,296,000
	Four types and more	1,425,000	114,000	1,539,000
More than 50,000 sq.m.	One	900,000	72,000	972,000
	Two types	1,170,000	93,600	1,263,600
	Three types	1,440,000	115,200	1,555,200
	Four types and more	1,710,000	136,800	1,846,800

** If it is a re-certification, the fee is 70 percent of the above.

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2. For a detached house (small scale individual house)

	Number of	Fee	Tax	Total
Detached house*	-	80,000	6,400	86,400

* It shall be assessed by CASBEE for Home (Detached House) Assessment fees are not included. That supposed to be paid directly to a CASBEE accredited professional who is in charge of the assessment from the client.

Appendix K The Pearl Rating System for Estidama. Building Rating System Design and Construction version 1.0

The Pearl rating categories (The Pearl Rating System for Estidama, 2010)

	Categories	Points	Ratio%	Brief Description of the category
1	Integrated development process	10	6	Encouraging cross-disciplinary teamwork to deliver environmentally and quality management work throughout the life of the project
2	Natural systems	14	9	Conserving, preserving and restoring the region’s critical natural environments and habitats
3	Livable communities	38	23	Improving the quality and connectivity of outdoor and indoor spaces
4	Precious water	37	23	Reducing water demand and encouraging efficient distribution and alternative water sources
5	Resourceful energy	42	26	Targeting energy conservation through passive design measures, reduced demand<comma> energy efficiency and renewable sources
6	Stewarding materials	18	11	Ensuring consideration of the ‘whole-of-life’ cycle when selecting and specifying materials
7	Innovating practice	3	2	Encouraging innovation in building design and construction to facilitate market and industry transformation
Total		162	100	158 points + 3 innovating PRACTICE

Appendix L GSAS Design and Build Certification - Categories and Weights (GSAS 2015)

Table 1 – Urban Connectivity

UC	URBAN CONNECTIVITY	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
UC.1	Proximity to Infrastructure	1.42%	1.49%	0.00%	2.10%	1.42%	1.64%	1.66%	1.72%
UC.2	Load on Local Traffic Conditions	1.78%	1.87%	4.00%	2.62%	1.78%	2.05%	2.07%	2.15%
UC.3	Public Transportation	1.28%	1.34%	2.88%	1.89%	1.28%	1.48%	1.49%	1.55%
UC.4	Private Transportation	0.38%	0.00%	0.00%	0.00%	0.38%	0.00%	0.45%	0.46%
UC.5	Sewer & Waterway Contamination	1.07%	1.12%	0.00%	0.00%	1.07%	1.23%	1.24%	1.29%
UC.6	Acoustic Conditions	0.26%	0.27%	0.58%	0.38%	0.26%	0.30%	0.30%	0.00%
UC.7	Proximity to Amenities	0.68%	0.72%	1.54%	1.01%	0.68%	0.00%	0.80%	0.83%
UC.8	Accessibility	1.14%	1.19%	0.00%	0.00%	1.14%	1.31%	0.00%	0.00%

Table 2 - Site

S	SITE	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
S.1	Land Preservation	0.90%	0.9%	1.91%	1.03%	0.95%	1.05%	0.95%	0.95%
S.2	Water Body Preservation	1.20%	1.2%	2.55%	1.38%	1.27%	1.41%	1.27%	1.27%
S.3	Habitat Preservation	0.90%	0.9%	1.91%	1.03%	0.95%	1.05%	0.95%	0.95%
S.4	Vegetation	0.72%	0.72%	1.53%	0.83%	0.76%	0.84%	0.76%	0.76%
S.5	Desertification	0.72%	0.72%	1.53%	0.83%	0.76%	0.84%	0.76%	0.76%
S.6	Rainwater run off	0.60%	0.6%	0.00%	0.69%	0.63%	0.70%	0.63%	0.63%
S.7	Heat Island Effect	0.30%	0.3%	0.00%	0.34%	0.32%	0.35%	0.32%	0.32%
S.8	Adverse Wind conditions	0.45%	0.45%	0.00%	0.52%	0.47%	0.00%	0.47%	0.47%
S.9	Noise Pollution	0.30%	0.3%	0.00%	0.00%	0.32%	0.35%	0.32%	0.32%
S.10	Light Pollution	0.40%	0.4%	0.00%	0.00%	0.42%	0.00%	0.42%	0.42%
S.11	Shading of adjacent properties	0.45%	0.45%	0.00%	0.52%	0.47%	0.53%	0.47%	0.47%
S.12	Parking Footprint	0.60%	0.6%	0.00%	0.69%	0.63%	0.70%	0.63%	0.63%
S.13	Shading	0.27%	0.27%	0.57%	0.31%	0.28%	0.32%	0.28%	0.28%
S.14	Illumination	0.36%	0.36%	0.00%	0.41%	0.38%	0.42%	0.38%	0.38%
S.15	Pathways	0.36%	0.36%	0.00%	0.41%	0.38%	0.42%	0.38%	0.38%
S.16	Mixed Use	0.45%	0.45%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 3 - Energy

E	ENERGY	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
E.1	Energy Demand Performance	5.20%	5.20%	5.42%	5.20%	5.20%	5.20%	5.20%	5.20%
E.2	Energy Delivery Performance	5.20%	5.20%	5.42%	5.20%	5.20%	5.20%	5.20%	5.20%
E.3	Fossil Fuel Conservation	3.64%	3.64%	3.79%	3.64%	3.64%	3.64%	3.64%	3.64%
E.4	CO2 Emissions	4.55%	4.55%	4.74%	4.55%	4.55%	4.55%	4.55%	4.55%
E.5	NO_x,SO_x & particulate Matter	5.42%	5.42%	5.64%	5.42%	5.42%	5.42%	5.42%	5.42%

Table 4 - Water

W	WATER	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
W.1	Water Consumption	16 %	16 %	16 %	16 %	16 %	16 %	16 %	16 %

Table 5 - Materials

M	MATERIALS	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
M.1	Regional Materials	1.45%	1.45%	2.57%	2.29%	1.45%	2.29%	1.45%	1.45%
M.2	Responsible Sourcing of Materials	1.70%	1.70%	3.00%	2.67%	1.70%	2.67%	1.70%	1.70%
M.3	Recycled Materials	0.73%	0.73%	1.29%	1.14%	0.73%	1.14%	0.73%	0.73%
M.4	Materials Reuse	1.21%	1.21%	2.14%	1.90%	1.21%	1.90%	1.21%	1.21%
M.5	Structure Reuse	1.45%	1.45%	0.00%	0.00%	1.45%	0.00%	1.45%	1.45%
M.6	Design For Disassembly	1.45%	1.45%	0.00%	0.00%	1.45%	0.00%	1.45%	1.45%
M.7	Life Cycle Assessment (LCA)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 6 – Indoor Environment

IE	INDOOR ENVIRONMENT	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
IE.1	Thermal Comfort	1.37%	1.37%	0.00%	0.00%	1.37%	1.92%	1.66%	1.50%
IE.2	Natural Ventilation	1.83%	1.83%	4.53%	4.27%	1.83%	2.56%	2.21%	2.00%
IE.3	Mechanical Ventilation	1.83%	1.83%	0.00%	0.00%	1.83%	2.56%	2.21%	2.00%
IE.4	Illumination Levels	1.37%	1.37%	0.00%	0.00%	1.37%	1.92%	1.66%	1.50%
IE.5	Daylight	1.83%	1.83%	4.53%	4.27%	1.83%	2.56%	2.21%	2.00%
IE.6	Glare Control	1.37%	1.37%	0.00%	0.00%	1.37%	0.00%	0.00%	1.50%
IE.7	Views	1.37%	1.37%	0.00%	0.00%	1.37%	0.00%	0.00%	0.00%
IE.8	Acoustic Quality	1.37%	1.37%	3.40%	3.20%	1.37%	1.92%	1.66%	1.50%
IE.9	Low-Emitting Materials	1.83%	1.83%	4.53%	4.27%	1.83%	2.56%	2.21%	2.00%
IE.10	Indoor Chemical & Pollutant Source Control	1.83%	1.83%	0.00%	0.00%	1.83%	0.00%	2.21%	2.00%

Table 7 – Culture and Economic Value

CE	CULTURE AND ECONOMIC VALUE	Commercial	Core & Shell	Single Residential	Group Residential	Education	Mosques	Hotels	Light industry
CE.1	Heritage & Cultural Identity	8.13%	8.13%	8.75%	8.13%	8.13%	8.13%	8.13%	0.00%
CE.2	Support of National Economy	4.88%	4.88%	5.25%	4.88%	4.88%	4.88%	4.88%	13.00%

Appendix M TARSHEED Categories' Credits

	ENERGY	%
	ENVELOPE	15.00%
E01	WINDOW TO WALL RATIO	2.00%
E02	EXTERNAL WINDOW SHADING	2.00%
E03	ROOF INSULATION	2.00%
E04	EXTERNAL WALLS INSULATION	2.00%
E05	BASEMENT OR FLOOR SLAB INSULATION	1.00%
E06	LOW-E COATED GLASS	1.50%
E07	HIGHER PERFORMANCE GLASS	1.50%
E08	AIR TIGHTNESS	3.00%
E09	COOLING	25.00%
E10	HEATING	5.00%
E11	HOT WATER	10.00%
E12	LIGHTING	20.00%
E13	APPLIANCES	15.00%
E14	SMART METERS	2.00%
E15	THE KILL SWITCH	1.00%
E16	EFFICIENT ELEVATORS	4.00%
E17	EXTERNAL LIGHTING AND CONTROLS	3.00%
E18	RENEWABLE ENERGY	
		100.00%
	WATER	**%**
	INDOOR	79.61%
W01	SHOWERHEADS*	27.86%
W02	KITCHEN SINK FAUCETS*	15.92%
W03	LAVATORY FAUCETS*	15.92%
W04	WATER CLOSETS*	19.90%
	IRRIGATION	20.39%
W05	REDUCE GRASS	10.19%
W06	IRRIGATION EFFICIENCY	10.19%
	ADD ON	
W07	GREY WATER / AC CONDENSATE / RAINWATER	
	*UPC and IPC code	**100.00%**

	HABITAT	%
	OUTDOOR	**42%**
H01	READY-MIX CONCRETE	5%
H02	REFLECTIVE TILES FOR ROOF AND OUTDOOR PAVING	10%
H03	REFLECTIVE PAINT FOR EXTERNAL WALLS	5%

H04	SHADED PARKING	10%
H05	BICYCLE RACKS	2%
H06	ORGANIC FRUITS AND VEGETABLES GARDEN	8%
H07	OUTDOOR LIGHTING FULL CUTOFF	2%
	MATERIAL	**34%**
H08	PROPER DISPOSAL OF CONSTRUCTION WASTE	5%
H09	RECYCLING CONSTRUCTION WASTE	2%
H10	WASTE SEGREGATION AT SOURCE	10%
H11	PRODUCE YOUR OWN COMPOST	2%
H12	LOCAL FLOORING	8%
H13	LOCAL CERAMIC	5%
H14	RECYCLED CONTENT	1%
H15	MATERIAL REUSE	1%
	INDOOR	**24%**
H16	ENTRYWAY SYSTEM	3%
H17	LOW VOC PAINTS	10%
H18	WINDOWS FOR LIVING SPACES	10%
H19	KITCHEN EXHAUST	1%
		100%

Appendix N LEED Building Design and Construction (New Construction) version 4 (USGBC 2014)

1. Sustainable Sites category: Light Pollution Reduction

Model Lighting Ordinance zones and the maximum lighting percentage (USGBC 2014)

TABLE 2. Maximum percentage of total lumens emitted above horizontal, by lighting zones

MLO lighting zone	Maximum allowed percentage of total luminaire lumens emitted above horizontal
LZ0	0%
LZ1	0%
LZ2	1.5%
LZ3	3%
LZ4	6%

2. Water Efficiency category: Outdoor Water Use Reduction

Percentage reduction from base case and possible points (USGBC 2014)

TABLE 1. Points for reducing irrigation water

Percentage reduction from baseline	Points (except Healthcare)
50%	1
100%	2

3. Water Efficiency category: Indoor Water Use Reduction

Possible points according to water use reduction (USGBC 2014)

TABLE 1. Points for reducing water use

Percentage reduction	Points (BD+C)
25%	1
30%	2
35%	3
40%	4
45%	5
50%	6

4. Materials and Resources category: Building Lifecycle impact reduction credit

Impact categories for reduction (USGBC 2014)

Select at least three of the following impact categories for reduction:

- global warming potential (greenhouse gases), in CO_2e;
- depletion of the stratospheric ozone layer, in kg CFC-11;
- acidification of land and water sources, in moles H+ or kg SO_2;
- eutrophication, in kg nitrogen or kg phosphate;
- formation of tropospheric ozone, in kg NO_x or kg ethene; and
- depletion of nonrenewable energy resources, in MJ.

Appendix O Case Study Energy Consumption Calculations

The following tables represent the energy consumption in the ten different apartments per each floor. Variations are due to apartment area and use.

Table 1 – Apartments number 1, 2, and 3.

Flat 1				**Flat 2**				**Flat 3**			
	Watts	Nos	Total Watts		W	Nos	Total Watts		W	Nos	Total Watts
Light	100	60	6000	Light	100	60	6000	Light	100	60	6000
Light	50		0	Light	50		0	Light	50		0
Light	24		0	Light	24		0	Light	24		0
AC	1800	1	1800	AC	1800	1	1800	AC	1800	1	1800
AC	2400	2	4800	AC	2400	2	4800	AC	2400	2	4800
AC	2800	1	2800	AC	2800	1	2800	AC	2800	1	2800
AC	4900	1	4900	AC	4900	1	4900	AC	4900	1	4900
13 A Plug	200		0	13 A Plug	200		0	13 A Plug	200		0
15 A Plug	500		0	15 A Plug	500		0	15 A Plug	500		0
20A Plug	1000	5.3	5300	20A Plug	1000	5.3	5300	20A Plug	1000	5.3	5300
Heater	1200	2	2400	Heater	1200	2	2400	Heater	1200	2	2400
WM	1000		0	WM	1000		0	WM	1000		0
Exhaust Fan	100		0	Exhaust Fan	100		0	Exhaust Fan	100		0
		Total =	**28 KW**			**Total =**	**28 KW**			**Total =**	**28 KW**

Table 2 - Apartments number 4, 5, and 6

Flat 4				**Flat 5**				**Flat 6**			
			Total				Total				Total
	W	Nos	Watts		W	Nos	Watts		W	Nos	Watts
Light	100	60	6000	Light	100	60	6000	Light	100	60	6000
Light	50		0	Light	50		0	Light	50		0
Light	24		0	Light	24		0	Light	24		0
AC	1800	1	1800	AC	1800	1	1800	AC	1800	1	1800
AC	2400	2	4800	AC	2400	2	4800	AC	2400	1	2400
AC	2800	1	2800	AC	2800	1	2800	AC	2800	1	2800
AC	4900	1	4900	AC	4900	1	4900	AC	4900	1	4900
									1300	1	1300
13A Plug	200		0	13 A Plug	200		0	13A Plug	200		0
15A Plug	500		0	15 A Plug	500		0	15A Plug	500		0
20A Plug	1000	5.3	5300	20A Plug	1000	5.3	5300	20A Plug	1000	5.3	5300
Heater	1200	2	2400	Heater	1200	2	2400	Heater	1200	2	2400
WM	1000		0	WM	1000		0	WM	1000		0
Exhaust Fan	100		0	Exhaust Fan	100		0	Exhaust Fan	100		0
		Total =	**28 KW**			**Total =**	**28 KW**			**Total =**	**26.9 KW**

Table 3 - Apartments number 7, 8, 9, and 10

Flat 7				**Flat 8**				**Flat 9**				**Flat 10**			
			Total				Total				Total				Total
	W	Nos	Watts		W	Nos	Watts		W	Nos	Watts		W	Nos	Watts
Light	100	60	6000	Light	100	72	7200	Light	100	72	7200	Light	100	36	3600
Light	50		0	AC	3900	1	3900	AC	3900	1	3900	Light	3900		0
Light	24		0	AC	1300	1	1300	AC	1300	1	1300	Light	1300		0
AC	1800	1	1800	AC	1800	1	1800	AC	1800	1	1800	AC	1800	1	1800
AC	2400	1	2400	AC	2400	3	7200	AC	2400	3	7200	AC	2400		0
AC	2800	1	2800	AC	2800		0	AC	2800		0	AC	3100	1	3100
AC	4900	1	4900	AC	4900	1	4900	AC	4900	1	4900	Ac	4900	1	4900
AC	1300	1	1300												
13A Plug	200		0	13A Plug	200		0	13A Plug	200		0	13A Plug	200		0
15A Plug	500		0	15A Plug	500		0	15A Plug	500		0	15A Plug	500		0
20A Plug	1000	5.3	5300	20A Plug	1000	6.4	6400	20A Plug	1000	6.4	6400	20A Plug	1000	2.8	2800
Heater	1200	2	2400	Heater	1200	3	3600	Heater	1200	3	3600	Heater	1200	2	2400
WM	1000		0	WM	1000		0	WM	1000		0	WM	1000		0
Exhaust Fan	100		0	Exhaust Fan	100		0	Exhaust Fan	100		0	Exhaust Fan	100		0
		Total=	**26.9 KW**			**Total=**	**36.3 KW**			**Total=**	**36.3 KW**			**Total=**	**18.6KW**

Table 4 - Total base case energy use in the building

Total Load in the first floor		=	**285**	**KW**
Service Corridor per Floor		=	3.6	kW
			288.6	kW
1	For 4 Floors	=	1154.4	kw
2	Basement Lights	=	18	kw
3	Power and Motors	=	37	kw
4	Mechanical and Ventilation	=	7.8	kw
5	Roof Lights	=	5.2	kw
6	Power & Motor	=	12	kw
Traditional	**Grand Total**	**=**	**1234.40**	**KW**

Table 5 – Building's common areas base case and improved case

Common areas	**%**	**Base case KW**	**Improved case KW**
Light	20%	7.44	1.488
A/C and Ventilation	45%	16.74	13.392
Elevators	35%	13.02	10.416
Total (Common areas)	**100%**	**37.2 KW**	**25.296 KW**

Table 6 - Comparison between base case and improved case energy use

Base case		**Improved case**	
Item	Load in KW	Item	Load in KW
Light conventional	240.00	Light LED	48
Power	268.00	POWER	268
Heater	105.6	Solar heater	10
AC R22	583.6	AC R410	466.88
Service/common areas	37.2	Service/common areas	25.296
Total	**1234.4 KW**	**Total**	**818.176 KW**

Therefore, 818.176/1234.4= 0.662. Thus, the saving is 1-0.662=0.337 → 33.7%