Article

Toward Sustainable Healthcare Facilities: An Initiative for Development of “Mostadam-HCF” Rating System in Saudi Arabia

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Abstract: Saudi Arabia vision 2030 emphasizes the applications of sustainability concepts in all aspects of life in Saudi society. Accordingly, the Mostadam rating system for existing and new buildings was recently launched to achieve appropriate, sustainable building standards. In the medical field, sustainable healthcare facilities are an extension of the concept of sustainable buildings in terms of important sustainable healthcare parameters. Therefore, the sustainable development of healthcare facilities has great impacts on growing economic, social and environmental issues, which, in turn, improve Saudi society’s public health. Moreover, the COVID-19 pandemic has further exposed the urgent need for sustainable healthcare facilities to control the outbreak of such dangerous pandemics. Accordingly, the retrofitting of the existing healthcare facilities and the shift toward new sustainable ones have become an important objective of many countries worldwide. Currently, the concepts related to sustainable healthcare facilities are rapidly varying their scopes toward wider perspectives. Therefore, a new local rating system for healthcare facilities based on the potential and resources of sustainable healthcare facilities in Saudi Arabia should be developed. The present paper investigates the development of a new version of the Mostadam rating system, known here as “Mostadam-HCF”, in relation to the local Mostadam rating system and in accordance with the LEED version 4.1 (BD + C: Health-care). This important step can help the existing and the new healthcare facilities in Saudi Arabia to obtain, firstly, national accreditation and, consequently, to be internationally accredited. Moreover, the initiative of sustainable healthcare facilities can also help in fighting the current COVID-19 pandemic and the other possible future viruses in Saudi Arabia.

Keywords: LEED rating system; Mostadam rating system; sustainable healthcare facilities; Saudi Arabia

1. Introduction

Healthcare facilities are considered the most important constructions worldwide [1]. Such facilities affect the health and well-being of each person as well as the public health of our communities [2]. However, healthcare facilities can have negative environmental impacts due to failure to apply sustainability standards in all of their various sectors [3]. This can lead to negative side effects on people’s public health.

Sustainability initiatives for healthcare facilities introduce significant environmental and financial benefits that can help medical systems thrive, now and in the future [4].

Therefore, one of the newest trends in the medical facilities sector is obtaining certification for sustainability from an international and recognized assessment tool, e.g., the Leadership in Energy and Environmental Design (LEED) rating system [5]. The sustainability certification process allows the comparison of features of the healthcare facility and its performance against a set of standardized criteria in order to improve project efficiency, reduce overall costs and improve the patient experience.
As hospital construction projects continue to rise, health administrators are increasingly looking to incorporate green initiatives and environmentally friendly practices into the design, construction, and management of healthcare facilities. This transition to sustainable healthcare facilities is largely focused on reducing hospitals’ carbon footprints and incorporating renewable energy sources, e.g., solar energy [6,7].

Concerns about hospitals’ environmental impacts have made the healthcare sector one of the most visible settings for the green building movement. Moreover, with the magnitude of responses to COVID-19 and the consequences for health systems and economies, proactive action by the research community is critical for alleviating future pressures on health systems and ensuring that services remain high-quality, accessible, and sustainable [8]. These pressures will be concentrated on the demand for and supply of healthcare services. In order to solve the above problems, it is required to establish new healthcare facilities or therapeutic facilities that are equipped with special specifications and requirements where sanitary isolation work is done for those who are proven to be infected with highly dangerous infectious viruses or people who are proven to be infected with the virus and do not yet have symptoms of the disease. This procedure can greatly limit the outbreak of COVID-19 or any infectious viruses [9].

This type of newly proposed healthcare facility belongs to what is currently widely spread and known as sustainable/green hospitals or sustainable/green healthcare facilities, considered one of the four initiatives of the Hospital 2020 movement worldwide. The sustainable healthcare facility is defined as a healthcare facility that has taken the initiative to have one or more of the required elements for sustainable healthcare buildings [10]. These elements range from choosing an environmentally friendly site, utilizing sustainable and efficient designs, using sustainable building materials to applying renewable energy systems [11]. Moreover, green outdoor environments at healthcare facilities should be considered an important item in the sustainability of all medical facilities [12].

In a comparison between green hospitals with non-green hospitals with respect to patient revenue and operating expenses, it was found that green hospitals had higher facility running costs and invested more on plant operations than non-green hospitals. Although the green hospitals in this study received more revenue, the earnings were not sufficient to justify the high operating costs [13].

2. Problem Statement

As Saudi Arabia vision 2030 adopts the comprehensive development standards in all fields in Saudi society, recently, in 2019, the "Mostadam" evaluation service was launched for existing and new buildings to achieve sustainable building standards in a way that is appropriate for the privacy and principles of Saudi society [14]. According to the importance of sustainable buildings in Saudi Arabia, the investment in sustainable buildings in Saudi Arabia has become the third largest investment in this sector in the world. Its kingdom seeks to be the largest investor in the world in the sustainable buildings sector.

Mostadam has three different rating systems, which focus on residential buildings, communities, and commercial buildings. Two important elements were included for each rating system: one is for design and construction, and the other is for operational and existing. The categories of Mostadam are miscellaneous and include the following: site sustainability; efficient energy and water use; region and culture; health and comfort; materials and waste transportation and connectivity; and policies and maintenance. Unfortunately, the international standards for sustainable hospitals and green healthcare are not included in Mostadam, although the environmental impacts of sustainable hospitals make the healthcare sector one of the most prominent settings for the green building transition.

In Saudi Arabia, there are 10 healthcare projects registered from 2011–2020 in different LEED versions; however, none of these projects were certified until now [15]. That may be attributed to the inconvenience of LEED rating systems to the local conditions. Therefore, a new local rating system for healthcare projects in Saudi Arabia should be included in Mostadam. As a result of the current circumstances of the existence of the COVID-19
pandemic, accreditation of public health facilities and hospitals has become a necessary matter to fight the spread of infection in these facilities [16]. Moreover, it is an important step to nationally certify the existing healthcare projects in order to obtain the international sustainability certification.

3. Literature Review

An environmentally sustainable health system, according to the World Health Organization, is one that “improves, preserves, or restores health while minimizing harmful impacts on the environment and maximizing resources to preserve and enhance it, to the advantage of current and future generations’ health and well-being.” Environmental sustainability in the healthcare sector can be achieved when resources are used as effectively as possible without compromising patient care quality.

Environmentally friendly healthcare facilities are important because they reduce emissions and help to preserve the environment. The following section provides an overview of eco-friendly green healthcare facilities, as well as the challenges that they face.

Most of the previous investigations have been directed toward investigations of different areas for improving environmental sustainability in healthcare facilities. Such areas of improvement include a different goal framework, which encompasses the following: energy efficiency, reduced water consumption, improved transportation, reduced waste, sustainable design and use of buildings, environmental leadership, safer chemicals, sustainable and healthy food and purchasing of sustainable products [17]. In the following section, a review of the most important sustainable categories is presented.

3.1. Energy Efficiency

Healthcare facilities consume a lot of energy. These facilities can minimize energy usage by using an energy-efficient-building envelope, lighting, air conditioning systems, and so on. The literature review of such a topic in healthcare facilities can be seen in [18–27]. The main topics discussed are the energy consumption analysis, application of energy management system, energy saving techniques, energy efficient policy, assessment of heating and cooling systems, and the investigation of the influence of building orientation, shading devices, and roof solar. It can be seen that there is a lack of investigations related to renewable energy applications in healthcare facilities.

3.2. Location of Healthcare Facility

For nearly four decades, the operations research community has focused on the position of healthcare facilities (HCFs) as one of the most relevant strategic concerns in healthcare systems, disaster management, and humanitarian logistics. Most of the recent investigations related to such issues try to bring considerations to the complexity in solving problems concerning the location of healthcare facilities by employing an advanced, multi-criteria decision analysis (MCDA) method, either integrated with geographic information system (GIS) [28] or based on an improved genetic algorithm [29]. Different approaches and strategies were also discussed in [30–36]. However, the literature review shows that there is still a lot of space for more practical healthcare facility location problems to be studied, as well as the emergence of new optimization models and solution methods in healthcare facility location planning.

3.3. Water Efficiency

Water management system is generally a very important issue in building constructions and especially in healthcare facilities, due to the huge amount of water consumed for their daily operations [37,38]. However, few papers can be found in the literature related to the water-management systems in the healthcare facility [39–41]. Therefore, more research work is required to evaluate the existing water efficiency in existing and newly constructed healthcare facilities, according to the sustainability of water management.
systems. Moreover, further research findings about the relation between opportunistic waterborne pathogens and construction activities are required.

3.4. Materials and Resources

Since healthcare facilities are considered one of the building types for which the standards of sustainability should be applied in the materials used and waste management; therefore, the previous studies devoted to this group are considered general and cover the building sector in general [42–44].

3.5. Indoor Environmental Quality

The category of indoor environmental quality has received great attention and extensive investigation due to its great importance in healthcare facilities [45]. This category plays also a significant role in achieving occupant comfort and their productivity in healthcare facilities [46,47]. Most of the previous investigations were directed either to the definition of the physical characteristics of the indoor environment, which can affect health and wellbeing in healthcare facilities, and their assessment methods, [48–51] or to the review and analysis of state-of-the-art research [52,53]. The future studies in such an area are currently directed toward the application of evidence-based design principles in healthcare facilities to improve occupant health and productivity as well as the sustainable design [54].

4. Rating Systems for Sustainable Healthcare Facilities

The definition of sustainable or green healthcare facilities can be defined in a similar way to the general definition of sustainable buildings/hospitals according to the Office of the Federal Environmental Executive (OFEE). “Sustainable hospitals can be defined as the practice of designing, constructing, operating, maintaining, and removing buildings in ways that conserve natural resources and reduce pollution” (OFEE, 2003). This definition is fully applicable to healthcare facilities at all stages of design, construction, and operation. Moreover, a sustainable movable healthcare unit is a hospital unit, usually of a small size and limited facilities, for immediate care of illnesses and injuries, and applies most of the sustainability concepts.

According to the Green Guide for Healthcare (GGHC), the opportunities to enhance environmental performance of the sustainable healthcare construction is identified in the following domains: site selection, water conservation, energy efficiency, recycled and renewable materials, low emitting materials, alternative transportation, daylighting (the use of natural light in a space to reduce electric lighting and energy costs), reduced waste generation, local and organic food use, and green cleaning materials.

Moreover, the U.S. Green Building Council (USGBC), which is a non-profit organization based in Washington, D.C., develops and administers (2008) the Leadership in Energy and Environmental Design (LEED) rating system. The GGHC and LEED may be distinguished from each other through their mode of administration.

The Global Green and Healthy Hospitals (GGHH) is an international network of hospitals, healthcare facilities, health systems, and health organizations dedicated to reducing their environmental footprint and promoting public and environmental health. By January 2018, GGHH had 983 members in 51 countries on 6 continents, representing the interests of over 32,300 hospitals and health centers. All these members use innovation, ingenuity, and investment, to transform the health sector and foster a healthy sustainable future.

In general, sustainable building rating systems have gained popularity worldwide for the development of sustainable buildings started from different countries, including the U.K., the U.S. and Italy, as BREEAM, LEED and ITACA systems, respectively [55].

Similar to the green building rating systems, there are a number of rating systems dedicated for the healthcare facilities, e.g., LEED Healthcare, BREEAM Healthcare, U.K. 2008 and Joint Commission International (JCI), Illinois 1994 [56].

Recently, many countries, including those in the developing world, developed their own ranking systems for green buildings as well as healthcare facilities based on site
sustainability, energy and water use, indoor air quality, material selection, waste reduction, and creativity for improved environmental results. The sole aim of these systems is to reduce negative effects on the environment, e.g., the Indian Green Building Council (IGBC) launched the IGBC Rating System [57], and Mostadam rating system in Saudi Arabia [14].

In general, it was observed that in the past five years, there have been several initiatives taken by countries for the transition of traditional hospitals toward sustainable hospitals by applying one or more of the sustainability categories, e.g., improving energy efficiency or the use of a solar water-heating system. Existing hospitals may apply for LEED in order to obtain the LEED certification. The number of green hospitals obtaining the LEED certifications is slowly increasing and range between existing hospitals or those that are newly constructed.

4.1. LEED Healthcare Certified Facilities

The Leadership in Energy and Environmental Design (LEED) rating system, offered by the U.S. Green Building Council (USGBC), has become the most widely renowned and used certification system for sustainable buildings, including sustainable hospital buildings. LEED started as a tool to promote sustainable buildings by creating parameter standards and aimed to increase awareness of the benefits of sustainable buildings.

The first version of LEED was introduced in 1998 and was launched in 2000, and consequently the movement took off. This version is known as LEED New Construction (NC) v1.0 for LEED certification of green buildings. In 2005, LEED NCv2.0 and v2.2 in 2005 were introduced. In 2009, LEED v3 was released and became a major success in the sustainable buildings sector. In 2013, LEED v4 was introduced by considering the analytical framework developed for 2009 and applied a new set of criteria that was developed especially for the built environment.

It should be pointed out that the first hospital to be certified, according to LEED, was the Boulder Community Foothills Hospital in 2003, achieving the LEED Silver certificate. Thereafter, the USGBC decided that a rating system to make certification more accessible for healthcare projects is required. Consequently, in 2010, a new LEED healthcare rating system was approved by USGBC. From 2013 until now, LEED rating systems were continuing developed. Nowadays, the rating system title has a new name: LEEDv4 BC + D: Healthcare, which was published in July 2019. To date, LEED has grown to encompass more than 127 certified hospitals [5]. It is very important to emphasize that LEED-certified sustainable hospitals must have an optimal green healthcare environment that values the specific criteria that influence the health of patients, patients’ wellbeing and patients’ recovery periods. Consequently, in a comprehensive analysis of such certified hospitals [5], it was concluded that most of the LEED-certified hospitals with high total scores may be sustainable buildings; however, such hospitals do not have an optimal green healthcare environment. Moreover, sustainable buildings in different countries are designed and constructed, according to the country climatic conditionings; consequently, the assessment criteria for these sustainable buildings should be different [58].

The main aims of the LEED rating system can be classified into five primary categories [15]. However, in the different LEED-version rating systems, some secondary items can be seen in the rating system, according to the developments occurred. Moreover, there are four levels of certification for buildings in the LEED rating system: Certified, Silver, Gold, and Platinum. The number of points earned by each sustainable building can determine the level of LEED certification. Table 1 shows the LEED categories with the total score of different LEED rating systems and the levels of certifications.
Table 1. Comparable credits for different LEED rating systems.

| No | Category (Base Category *) | Version 3 | Version 4 | Version 4.1 BD + C: Healthcare |
|----|-----------------------------|-----------|-----------|-------------------------------|
| 1  | Integrative process         | 0         | 1         | 1                             |
| 2  | Location and Transportation | 0         | 16        | 9                             |
| 3  | Sustainable site *          | 26        | 10        | 9                             |
| 4  | Water efficiency *          | 10        | 11        | 11                            |
| 5  | Energy and atmosphere *     | 35        | 33        | 35                            |
| 6  | Materials and resources *   | 14        | 13        | 19                            |
| 7  | Indoor environmental quality * | 15      | 16        | 16                            |
| 8  | Innovation and Design Process | 6        | 6         | 6                             |
| 9  | Regional priority           | 4         | 4         | 4                             |
|    | Total Points                | 110       | 110       | 110                           |

Project Certificate Total Points earned
Certified 40–49
Silver 50–59
Gold 60–79
Platinum 80–110

4.2. Mostadam Rating System Development

Saudi Arabia vision 2030 adopts comprehensive development standards in all fields in Saudi society. To achieve such standards, many initiatives and programs have been launched to achieve the concept of sustainability in meeting the present needs without compromising the requirements of future generations. Therefore, the “Future of Saudi Cities” program was recently launched, which seeks to develop a new vision for a sustainable urban future and provide environmentally sustainable cities by expanding the construction of sustainable buildings. In addition, the “Mostadam” evaluation service was recently launched for existing and new buildings to achieve sustainable building standards in a way that is appropriate with the privacy and principles of Saudi society [14].

Table 2 illustrates the main categories, credit title, and credit points of the Mostadam rating system for residential buildings. It should be pointed out that this rating system cannot deal with healthcare facilities in its current state. Therefore, the main objective of the present work is the development of a new rating system for the evaluation of sustainable healthcare facilities and is called, hereafter, “Mostadam-HCF”. The developed rating system is based on the original Mostadam rating system and similar to LEED-version 4.1 BD + C: Healthcare; however, it is appropriate for the privacy and principles of Saudi society.

Table 2. Mostadam rating system for residential buildings.

| Item No. | Category | Credit Title | Core Keystone Credit Points | Optional Credit Points | Total Points per Category |
|----------|----------|--------------|-----------------------------|------------------------|---------------------------|
| 1        | Transportation and Connectivity | 1. Electric Vehicle Provisions | 1                          | 1                       |                           |
|          |          | 2. Access to Public Transportation | 2                          | 2                       |                           |
|          |          | 3. Access to Amenities | 2                          | 2                       |                           |
|          |          | 4. Home Office | 1                          | 1                       |                           |
|          |          | 5. Individual Sustainable Transport | 1                          | 1                       |                           |
| 2        | Site Sustainability | 1. Sewage, Flood and Rainwater Management | 1                          | 1                       |                           |
|          |          | 2. Ecological Assessment and Protection | 2                          | 2                       |                           |
|          |          | 3. Construction Environmental Management | 1                          | 1                       |                           |
|          |          | 4. Ecological Enhancement | 2                          | 2                       |                           |
|          |          | 5. Heat Island Effect | 1                          | 1                       |                           |
|          |          | 6. Light Pollution | 1                          | 1                       |                           |
Table 2. Conts.

| Item No. | Category                      | Credit Title                                      | Core Keystone Credit Points | Optional Credit Points | Total Points per Category |
|---------|-------------------------------|---------------------------------------------------|-----------------------------|------------------------|---------------------------|
| 3       | Water                         | 1. Indoor Water Performance                       | 3                           | 7                      | 24                        |
|         |                               | 2. Outdoor Water Performance                      | 2                           | 8                      |                           |
|         |                               | 3. Alternative Water Solutions                     | 3                           | 3                      |                           |
|         |                               | 4. Water Metering                                 | 1                           | 1                      |                           |
| 4       | Energy                        | 1. Energy Performance                             | 5                           | 10                     | 27                        |
|         |                               | 2. Systems Commissioning                           | 1                           | 1                      |                           |
|         |                               | 3. Envelope Commissioning                          | 1                           | 1                      |                           |
|         |                               | 4. Energy Metering                                 | 1                           | 1                      |                           |
|         |                               | 5. Energy Efficient Appliances                     | 1                           | 1                      |                           |
|         |                               | 6. Renewable Energy                                | 7                           | 7                      |                           |
|         |                               | 7. Ozone Impact                                    | 1                           | 1                      |                           |
| 5       | Materials and Waste           | 1. Non-Polluting Insulation Materials               | 1                           | 1                      | 4                         |
|         |                               | 2. Construction Waste Management                   | 2                           | 2                      |                           |
| 6       | Health and Comfort            | 1. Outdoor Thermal Comfort                         | 2                           | 1                      | 14                        |
|         |                               | 2. Indoor Thermal Comfort                          | 1                           | 1                      |                           |
|         |                               | 3. Ventilation                                     | 1                           | 1                      |                           |
|         |                               | 4. VOCs and Low-Emitting Materials                 | 2                           | 2                      |                           |
|         |                               | 5. Access for All                                  | 1                           | 1                      |                           |
|         |                               | 6. Daylight and Visual Comfort                     | 2                           | 2                      |                           |
|         |                               | 7. Acoustics                                       | 1                           | 1                      |                           |
|         |                               | 8. Indoor Air Quality                              | 1                           | 1                      |                           |
|         |                               | 9. Active Residents                                | 1                           | 1                      |                           |
|         |                               | 10. Outdoor Space                                  | 1                           | 1                      |                           |
| 7       | Education and Innovation      | 1. Mostadam Guide                                  | 2                           | 2                      | 4                         |
| 8       | Region and Culture            | 1. Thriving Economy                                | 2                           | 2                      | 7                         |
|         |                               | 2. Heritage and Culture                            | 2                           | 2                      |                           |
|         |                               | 3. Vibrant Society                                 | 1                           | 1                      |                           |
|         |                               | 4. Regional Focus                                  | 2                           | 2                      |                           |
| 9       | Policies, Management and Maintenance | 1. Residential Waste Management                | 1                           | 1                      | 4                         |
|         |                               | 2. Sustainable Procurement                         | 1                           | 1                      |                           |
|         |                               | 3. Building Performance Monitoring                  | 2                           | 2                      |                           |

5. Research Methodology

The research methodology adopted in the present work is based on the detailed comparison between the LEED V4.1 rating system, which is designed for healthcare facilities, and the current state of the Mostadam rating system. A set of so-called base categories for healthcare facilities is defined in both rating systems and the individual, and the total points are compared. Through such a comparison, the new Mostadam rating system for health care facilities, called Mostadam-HFC, is developed. The development is based on the potential and the resources of the sustainable healthcare facilities in Saudi Arabia.

In order to describe the potential of sustainable healthcare facilities in Saudi Arabia, some base LEED credit categories were chosen. These credit categories can be considered the most important items in the LEED rating systems. As shown in Table 3, the total points of these base categories for all LEED rating systems are more than 80. Consequently, the achievement of high score in such categories can lead to an accredited healthcare facility with a high level of certification.

It should be pointed out that the sustainable site includes the assigned point for the item Location and Transportation in all LEED versions. Moreover, it can be noticed that the large difference between LEED V3 and LEED V4.1 can be seen in the category of sustainable site. This difference is almost distributed over the other categories with the emphasis on the Material and Resources category in LEED V4.1. In the following sections, these base categories are discussed in details and their potential in Saudi Arabia are also explored.

An important comparison for the base categories of healthcare facilities in LEED V4.1 and the Mostadam rating system is illustrated in Figure 1. The base categories in the
Mostadam rating system are given other titles, as shown in Table 3; however, the physical meaning of such base categories is still retained.

Table 3. Total points of the base categories items in different versions of LEED rating system compared with Mostadam rating system (Base Category *).

| No. | Base Categories Items * | Base Categories Items * (Mostadam) | Total Points | LEED Version 3 | LEED Version 4 | LEED Version 4.1 BD + C: Healthcare | Mostadam Rating System |
|-----|--------------------------|-------------------------------------|--------------|---------------|---------------|-------------------------------------|-------------------------|
| 1   | (SS) Sustainable site *  | Site Sustainability *               | 26           | 10            | 9             | 9                                   | 9                       |
| 2   | (WE) Water efficiency * | Water *                             | 10           | 11            | 11            | 27                                  | 24                      |
| 3   | (EA) Energy and atmosphere * | Energy *               | 35           | 33            | 35            | 35                                  | 27                      |
| 4   | (MR) Materials and resources * | Materials and Waste*               | 14           | 13            | 19            | 19                                  | 4                      |
| 5   | (IEQ) Indoor environmental quality * | Health and * Comfort               | 15           | 16            | 16            | 16                                  | 14                      |
|     | Total Points             |                                     | 100          | 83            | 90            | 90                                  | 78                      |

![Figure 1](image-url) Comparison of the rating system points for LEED-V4.1 and Mostadam rating system.

It can also be seen that most of the LEED V4.1 categories exceed the corresponding ones in the Mostadam rating system, except that of Indoor Environmental Quality for which both rating systems show nearly equal points. However, in our previous research [14], it was indicated that the Mostadam rating system improves indoor thermal comfort evaluation or more and the indoor environmental quality evaluation, compared to LEED v4.1. The other base categories scales of the Mostadam rating system should be changed to be nearly equal to those of LEED V4.1 in order to be suitable for application in rating healthcare facilities in Saudi Arabia. Otherwise, a new version of Mostadam should be provided for healthcare facilities. This is the motivation of the present work, and it is called the Mostadam-HCF rating system. The development of the Mostadam-HCF rating system in Saudi Arabia is also motivated by the high potential and resources in different regions of Saudi Arabia as will be explained in the following section.
5.1. **Potential of Sustainable Healthcare Facilities in Saudi Arabia**

According to the base categories described in the previous section, the potential and the resources required for sustainable healthcare facilities in Saudi Arabia are explained.

5.1.1. **Sustainable Sites**

The site selection of the healthcare facility and its environment are considered one of the important various aspects of the certification process of healthcare facilities. The total points for this category are equal when comparing LEED V4.1 and the Mostadam rating system. The site selection of the healthcare facility usually occurs during the initial planning and construction phases of the project.

A good site of healthcare facility should have the following qualities:

1. Be selected according to the study and analysis of the regional context, including the future plans for the surrounding area.
2. Recognize the ecological integrity of the site and identify credits relevant to patient wellbeing.
3. Simply connect to the natural world and the respite places.
4. Take advantage of the local microclimate conditions, such as (solar and wind energy, shading, natural ventilation and daylight systems).
5. Be away from high-pressure electrical lines.
6. Be away from valleys (storm-water run-off) or be near dams and wells.
7. Have organized car parks to facilitate entry and exit traffic.
8. Have safe and easy access to the site with the presence of road signs.
9. Prevent intrusions on patient privacy.
10. Enable easy access by healthy transportation modes.
11. Lessen the ripple effect of the building on the surrounding community.
12. Maintain the surrounding environment and the ecological footprint of the region and restore site biodiversity.
13. Reduce the light, audio and visual pollution.
14. Be close to major water, electricity, gas supply lines and sewage.
15. Have the opportunity to enjoy nature’s attractive atmosphere during the right atmosphere, away from the hustle and bustle of the city.

In Saudi Arabia, there are many suitable places that can achieve the above criteria; however, the guide, conditions and requirements should be prepared from the partners involved by cooperation with Saudi Ministry of Health. Figure 2 shows some beautiful landscapes in different regions of Saudi Arabia. Therefore, in order to encourage good sustainable site selection in Saudi Arabia, the total points should be increased in the Mostadam rating system from 9 to 15 points.

![Figure 2. Conts.](image-url)
5.1.2. Water Efficiency

It is well known that healthcare facilities are classified as intense energy- and water-use buildings. Healthcare facilities use 2.1 times more energy per square foot than commercial buildings and use 80–150 gallons of water per bed per day [30]. This is in comparison with the average municipal water consumption in Saudi Arabia (around 270 litres ≈ 70 gallons per capita per day), which is considered very high water consumption. Recently, Saudi Arabia, through the ministry of Environment, Water and Agriculture, launched a program for drastic reduction in water use. This program aims to reduce daily per capita consumption to 200 L by 2020 and to 150 L by 2030. Consequently, sustainable healthcare facilities should be water-efficient buildings by following the water strategies described in LEED for indoor use, outdoor use, specialized uses and metering.

A good, water-efficient healthcare facility should comply with the following:

1. Use water conserving fixtures.
2. Install automatic faucet sensors.
3. Use low consumption flushing fixtures.
4. Use treated grey (sewage) water for irrigation and horticulture.
5. Have rainwater harvesting systems.
6. Install a number of Tube wells.
7. Use treated water in flush tanks in toilet.
8. Use Reverse Osmosis (RO) technology and water coolers for drinking water.
9. Install a Sewage Treatment Plant (STP) with sufficient capacity.
10. Use underground water for flushing systems.

It should be pointed out that normal treatment plants and sewage systems may be unable to adequately remove the toxic materials produced from the healthcare facility, and consequently, special care should be considered regarding that important issue.

According to the Mostadam rating system, this category has sufficient total points, and it can remain as it is without change.

5.1.3. Energy and Atmosphere

Sustainable healthcare facilities can be defined similar to sustainable buildings, which are responsive to local climate conditions with optimized energy performance. In the LEED rating system, atmosphere is combined with energy; this implies the protection of the community from contaminant airborne releases. In other words, the achievement of an energy-efficient healthcare facility means good surrounding atmospheric conditions. Therefore, it is important to assure a comfortable healthy indoor and outdoor environment to support patient recovery with significantly reduced energy demand. This can only be achieved by increasing reliance on renewable energy systems along with applying an electric energy management system. Additionally, in the LEED rating system, this category received the maximum points: nearly 35 points for all versions. This indicates...
the importance of such a category in the LEED rating system. Therefore, a wide range of previous investigations regarding energy-efficient, sustainable healthcare facilities can be found in the literature [31].

A good, energy-efficient healthcare facility should comply with the following:
1. Have installed a Solar Hot Water System (SHWS) for washing, bathroom use, and other services.
2. Replace used fuel from diesel to compressed natural gas (CNG).
3. Use renewable energy sources, e.g., solar and wind, for power generation.
4. Have large windows with increased exposure to daylight, considering the appropriate window-to-wall ratio (WWR).
5. Use appropriate glazing specifications.
6. Include the exterior solar shading systems in architectural design.
7. Apply different modern passive daylighting systems, e.g., light tubes and translucent concrete.
8. Apply the concepts of passive solar building design, e.g., building orientation.
9. Use the modern design of windcatchers to obtain natural ventilation for thermal comfort process.
10. Apply the building energy-efficiency standards.
11. Incorporate energy-saving material in the building envelope.
12. Insulate the interior walls with nano-phase change materials.
13. Use low energy windows.

According to the high potential of renewable energy in Saudi Arabia, i.e., solar and wind energy, it can be suggested that the total score should be increased from 27 to 35 points in the Mostadam rating system.

5.1.4. Materials and Resources

Healthcare facilities can easily earn credits from the materials and resources category, according to LEED rating system V4.1 (about 20 points). This can be simply achieved by utilization of local, natural construction green materials, free from volatile organic compounds, which may be emitted from building materials and fabrics. In general, sustainably sourced materials and products should be implemented.

A well-sourced material and resources healthcare facility should comply with the following:
1. Use recycled and rapidly renewable construction materials and resources.
2. Use low-emitting green cleaning materials.
3. Incorporate energy-saving material in the building envelope.
4. Use low-cost and durable materials and resources.
5. Implement sustainable furniture and medical furnishings.
6. Avoid persistent bio-accumulative and toxic polybutylene terephthalate (PBT) chemicals, (e.g., lead, cadmium and copper).
7. Have a wide range of eco-friendly and green building materials (e.g., bamboo and cork floor, recycled steel, and green concrete).

Recently, a new framework for environmentally sustainable building materials in Saudi Arabia was investigated; for more details, one can see [32]. Therefore, an increase in the total points in the Mostadam rating system should be estimated, from 4 to 10 points.

5.1.5. Indoor Environment Quality

In general, all the LEED rating systems stress upon the importance of the indoor environment quality in healthcare facilities in order to reduce the health sector’s carbon footprint. The desire to create a healthy indoor environment for building occupants is considered one of the main aims of the green healthcare facilities movement. Moreover, healthcare facilities are a type of building that deal with sensitive, sick and vulnerable people. In healthcare facilities, indoor pollutants can be caused by various interior factors,
such as building materials, human activities and interior fittings. Therefore, and considering the amount of time humans in healthcare facilities spend indoors on a daily basis, the indoor environment quality (IEQ) received renewed recognition and research in recent decades, as the IEQ of such facilities have a direct impact not only on the wellbeing and recovery progress of patients, but also on nurses, doctors and other staff’s satisfaction. Most of the recent investigations argued the importance of daylight on the physiology and psychology of patients, along with its effects on patient recovery [33]. In enclosed spaces, indoor pollutants are the result of building materials, human activities and interior fittings.

A good indoor environment quality healthcare facility should comply with the following:

1. Reduce volatile organic compound emissions and other contaminants.
2. Contain indoor air quality monitoring.
3. Control indoor chemical and pollutant sources.
4. Enhance natural daylight and natural view facilities.
5. Reduce indoor acoustic environment level.
6. Consider color selection sustainability in interior spaces.
7. Ensure a medium range of indoor relative humidity (40–60%) for better health and productivity.
8. Have efficient natural ventilation systems.

Recently, great attention has been given to the indoor environment quality and its effects on human thermal comfort. In general, additional thermal comfort standards, such as the ASHRAE Standard, should be taken into account in the improvement process of IEQ in healthcare facilities. As mentioned above, the Mostadam rating system has many strength points regarding IEQ when compared with LEED V4.1; therefore, it is enough to increase the total points of the category from 14 to 16 points, similar to that of the LEED V4.1 system.

6. Results and Discussion

From the above discussion, a new Mostadam Rating System for healthcare facilities can be developed. The new model is known in the present work as Mostadam-HCF. The following table, Table 4, shows the total points of such a new rating system in Saudi Arabia and the percentage increases compared with LEED Version 4.1 BD + C: Healthcare.

**Table 4.** Total points of the base categories items in the developed Mostadam-HCF rating system (Base Category *).

| No. | Base Categories Items * (Mostadam) | Total Points Mostadam-HCF | Points/Percentage Increase Compared with LEED Version 4.1 BD + C: Healthcare |
|-----|---------------------------------|--------------------------|--------------------------------------------------------------------------------|
| 1   | Site Sustainability             | 15                       | 9                                                                            +67%                                           |
| 2   | Water                           | 24                       | 11                                                                           +118%                                          |
| 3   | Energy                          | 35                       | 35                                                                           0%                                              |
| 4   | Materials and Waste             | 10                       | 19                                                                           −0.47%                                         |
| 5   | Health and Comfort              | 16                       | 16                                                                           0%                                              |
|     | Total Points                    | 100                      | 90                                                                           +0.11%                                         |

From the above table, it can be concluded the following important remarks and comments:

- **R1.** The total points of the category Site Sustainability is increased in Mostadam-HCF by about 67% over the corresponding one in LEED Version 4.1 BD + C: Healthcare.
- **C1.** This increase is logical due to the diverse, beautiful landscapes in different regions of Saudi Arabia.
- **R2.** The total points of the category Water is also increased in Mostadam-HCF by about 118% over the corresponding one in LEED Version 4.1 BD + C: Healthcare.
- **C2.** This increase reflects the important strategic plans adopted by Saudi Arabia for water management and conservation during recent periods.
• R3. The total points of the category Materials and Waste is reduced by about 47% from the corresponding one in LEED Version 4.1 BD + C: Healthcare.
• C3. This reduction reflects that this group receives little importance in Saudi Arabia, due to the current use of sustainable materials in the green buildings industry.
• R4. The total points of the categories Energy, and Health and Comfort are the same as those in LEED Version 4.1 BD + C: Healthcare.
• C4. This reflects the importance of such categories in both rating systems and in relation to sustainable healthcare facilities.

Generally, it can be summarized that the Mostadam-HCF rating system can be considered a developed version of the LEED V4.1 rating system for healthcare facilities; however, it includes the potential and available resources of Saudi Arabia regions and the relevant issues of Saudi vision 2030. More concentration is given to Mostadam-HCF for the water category as well as renewable energy applications.

The certification system of the developed Mostadam-HCF can be the same as the current Mostadam rating system for residential buildings (Mostadam-RB), as the total points are equal in both rating systems.

Table 5 shows the certification level used by the current Mostadam rating system, given here as Mostadam-RB; this can be also used by the developed Mostadam-HCF rating system for healthcare facilities in Saudi Arabia.

Table 5. Certification levels awarded from current Mostadam-RB and the developed Mostadam-HCF rating systems.

| No. | Certification Levels Awarded by Mostadam-RB and Mostadam-HCF | Total Points |
|-----|-------------------------------------------------------------|--------------|
| 1   | Green                                                       | 20–34 points |
| 2   | Bronze                                                      | 35–49 points |
| 3   | Silver                                                      | 50–64 points |
| 4   | Gold                                                        | 65–79 points |
| 5   | Diamond                                                     | 80–100 points |

7. Conclusions

Recently, in order to provide innovative healthcare services, the transition to sustainable healthcare facilities has become urgently required. Sustainable healthcare facilities have a direct impact not only on the wellbeing and recovery progress of patients, but also on staff satisfaction, the surrounding environment and the community. In the present paper, a comprehensive review for the development of LEED rating systems, including healthcare facilities, was introduced and compared with the currently applied Mostadam rating system in Saudi Arabia. The potential for transition toward healthcare facilities in Saudi Arabia was presented. Some important categories and items for obtaining healthcare LEED certification for Saudi Arabia healthcare facilities were suggested. Finally, a newly developed Mostadam-HCF rating system was presented, according to the huge potential and resources of sustainable healthcare facilities in Saudi Arabia. In general, Saudi Arabia, due to its high sustainability potential, has the motivated power to be one of the important and leading countries in providing sustainable healthcare services, globally. This is considered one of the main pillars for achieving Saudi Arabia vision 2030. The future work is the application of such a rating system (Mostadam-HCF) for distressed healthcare projects in Saudi Arabia.

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