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Adjustment of the Indoor Environmental Quality Assessment Field for Taif City-Saudi Arabia

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Abstract: Along with the global concern of the Environmental Assessment of Buildings, the Kingdom of Saudi Arabia (KSA) had recently used its system, Mostadam, to provide a suitable method to assess its buildings environmentally. Nevertheless, Mostadam still cannot be used for all Saudi Arabia regions without having misleading results, which is due to its various internal regions with their various characteristics. Taif city has its unique environmental characteristics, which affect all the environmental buildings' assessment fields. This research aimed to adjust the Indoor Environmental Quality (IEQ) field of Mostadam according to Taif characteristics. The research analyzed Taif characteristics that have an impact on the IEQ field, which are mainly related to the occupants' different comfort needs and health requirements. Then, according to an analytical methods, authors proposed some changes to adjust Mostadam IEQ field according to these characteristics. The research resulted in an obvious difference between the resulted IEQ items weights and formulation versus the origin one of Mostadam, which proves the need for such adjustment to achieve a fair and trusted assessment to achieve the utmost credible assessment results when assessing buildings environmentally in Taif. It is recommended to adjust other assessment fields similarly later on, and then globally.

Keywords: environmental building rating systems; green buildings; indoor environmental quality; spatial variables; Mostadam

1. Introduction

Environmental Building Rating Systems (EBRSs) have been released over the years and developed permanently in line with different demands and advances. Countries that were not pioneers in having their building rating systems had to choose from several assessment options to follow up with the

global attention of the environmental building's assessment. Several types of research encouraged the use of local systems that would assist better for achieving local goals than other, different assessment options [1–4]. This paper extends the debate of how credible the different assessment options are, to the debate of how credible is the use of a local rating system over the same country different regions.

According to Saudi Arabia, 2030 vision; Architectural and urban fields must be oriented to achieve sustainability with the highest degree of efficiency; thus, the highest degree of credibility and accuracy is required. Mostadam, the Kingdom of Saudi Arabia's (KSA) EBRs was developed to apply the sustainable principles of buildings and urban design locally, and to achieve the KSA vision 2030 [5]. Believing that the use of Mostadam is the best choice, there are still question mark on the credibility of its results among the KSA different regions with their different characteristics. There are several variables that control the production of the EBRs versions; the spatial, time, and building type variables. When focusing on the spatial variables it is very clear that they are not committed to countries borders, as the country borders are not environmental boundaries, and cannot be unified among the same country, as there may be wide spatial variables differences internally. One can find more similarities between regions in different countries than for the same country [6]. Spatial variables affect the environmental building's assessment in different ways, such as affecting the assessment items' estimation weights and their formulation. A previous research has discussed the way of integrating the common global variables' influence for each EBRs to focus then on the specific spatial variables impact to adjust its versions for the different internal country's regions [7]. Another research has proven the capability of adapting the Green Pyramid Rating System (GPRS), which is the environmental assessment method of Egypt, to correspond with the different Egyptian regions' characteristics with its great diversity, in order to get the utmost appropriate, fair, and accurate assessment scores according to the different spatial variations [8].

Considering its importance, the paper focused on the Indoor Environmental Quality (IEQ) assessment field to be adjusted, as most people spend around 90% of their time indoors [9]. Note that this assessment field shows clearly the effect of the spatial variables on the assessment items and that other assessment fields could be adjusted similarly later on. Different ways of assessing the IEQ field have been recently developed, and they could be integrated by the building rating systems assessment to achieve the utmost credible results, such as the use of the computation of zone-level ventilation requirement based on actual occupancy, and the plug and lighting load information [10].

The rest of the paper is organized to conclude the environmental assessment options of buildings in KSA to choose from, which ended to choose Mostadam as the most preferable option, then searching the credibility of Mostadam to assess buildings among KSA internal regions, which ended by an expected answer of its impossibility. Then, the main Taif city characteristics that could affect the assessment criteria of the IEQ field were presented, and their effect on the IEQ items' weights and formulation were determined for both current Mostadam versions. Finally, the research illustrated a proposed way to adjust the Mostadam's IEQ field to fit Taif characteristics and highlighted the differences between the origin and the adjusted assessment field that certainly give different assessment results, which means that the non-adjusted version could lead to final misleading assessment results. As a conclusion, the paper emphasized the significance of considering the spatial variables of the same countries' regions within their local EBRs and discussed the way of adjusting Mostadam to be compatible with the specific spatial aspects of Taif city, to achieve higher results credibility when assessing its buildings.

2. Material and Methods

In preparing an adjustment proposal of the IEQ assessment field of Mostadam, to comply specifically with Taif city characteristics, first, there was a need to prove the preference and advantages of using Mostadam versus other environmental building assessment options for the KSA. A comparative analysis was used to do so. Second, there was a need to prove the preference and advantages of adjusting Mostadam to comply with the different KSA internal regions. A comparative analysis of

the internal spatial KSA aspects was used to do that, too. Third, all Taif city characteristics that may affect the IEQ assessment field were gathered and analyzed regarding their impact and relation to the different IEQ items in Mostadam. Thus, an analytical method was used. Fourth, for both Mostadam rating Systems—residential and commercial—the assessment items' weights and formation were adjusted according to the authors' proposed changes that could help a better environmental assessment of buildings in Taif, relying on its analyzed characteristics. A logical reasoning method was used to suggest the proposed changes in the IEQ items' weights and formations. Finally, the resulting changes of the IEQ field as a whole were presented to conclude the dissimilarity from the original one, as well as the importance of that field adjacent to achieve a more credibility and fair assessment results towards the achievement of its goals.

3. Environmental Assessment of Buildings

Green building (GB) could be defined as an integrated process; aiming to minimize or neglect negative influence on the environment among the whole building life cycle, taking into consideration the occupants' well-being, by providing them with efficient healthy spaces [11,12]. The World Green Building Council (World GBC) is an international network of GB councils. It reclaims that those different green buildings cannot be the same across the world due to the various countries and regions characteristics and priorities that shape the GB methods, such as climate conditions, traditions, cultural, social, and historical backgrounds, deferent building ages, and special environmental, and economic properties. Around the world, EBRs have emerged to determine the environmental principles for buildings. They are used in issuing assessment certificates to confirm buildings' adherence to the environmental issues based on specific classifications. Approximately, more than 600 EBRs were estimated globally, along with the increasing environmental concern [7,12].

4. Environmental Assessment Options of Buildings in KSA

As not being within the first EBRs producing countries' wave, several building assessment options were available for the KSA to choose from, and it experienced some of them before producing its own. These options start from the use of the existing international rating system as it is, until the production of its local one. In the following is a review of these options briefly.

4.1. Using International Green Building Rating Systems

The first EBR, the "Building Research Establishment Environmental Assessment Method" (BREEAM) was released and developed from the Building Research Establishment (BRE) in the United Kingdom in 1990. The next was the most recognized and extended method, the "Leadership in Energy and Environmental Design" (LEED), which was released from the U.S. Green Building Council (USGBC) in the United States of America in 1998, and was applied in 2000. Several other EBRs were produced from other countries later on. There are various obvious differences among the different EBRs due to the different limitations, cultures, potentials, and practices of each produced country [7,11]. Although BREEAM was the first issued rating system and has certified buildings that are nearly seven times more than those for LEED, and account for 80% of the total certificated projects around the world, LEED is considered the most adaptable system for green project assessment, as used in 160 countries versus 77 countries for BREEAM [11,12]. From the USGBC site, statistics showed that, in 2020, there were 877 LEED-certified projects in KSA. (<https://www.usgbc.org/projects>)

Both BREEAM and LEED were used out of their producing countries despite their different regional, climate, culture, etc., characteristics because the used green assessment standards could be the local equivalent standards or the international standards. For example, BREEAM permits equivalents to the International Organization for Standardization (ISO) 7730:2005 to be used to assess the thermal comfort category [12]. But researchers indicated that they are not convenient to the Middle East's requirements and properties, as they could not be the preferable standard that may comply with its local context and decide some credits, indicators, categories, and items weights [1].

4.2. Using Equivalent Green Building Rating Systems

The equivalent rating systems are those modified from the original international systems according to specific requirements for the countries they are designed for, such as LEED India and LEED Canada [6]. For the gulf region, several equivalent EBRs emerged; in 2008, BRE Global had launched BREEAM Gulf for the Gulf region. BREEAM was already being applied to several projects there, then the information received from those projects had been used to form the assessment process, norms, and scoring of the BREEAM Gulf to be suitable for local cultural diversities, climate situation, and building practices [13]. The USGBC had also produced LEED Emirates to be used at the UAE as an equivalent version of its original one, considering local differences [14]. Another option that could be taken as a solution to produce an equivalent rating system is the use of the Sustainable Building Tool (SBTool), a generic building performance assessment framework that is created to be modified by other local organizations. Its idea relies on using common values that can be exchanged with local values by national experts to set the appropriate performance levels. It can be used by regional authorized organizations, to establish a rating system to suit their regions and building types and to provide more consistency in the assignment of weighting points [15]. But none of the gulf countries used that option.

4.3. Using Regional Green Building Rating Systems

Different countries, including the Gulf countries, tended to extract their regulations, codes, and rating systems to respond to their local characteristics and contexts [1]. Any produced EBRs from a gulf country can be considered a regional EBRs for the KSA. Some of these countries were pioneers in developing their own EBRs, such as the UAE to achieve Abu Dhabi's 2030 vision by being one of the global sustainable cities, as well as by producing the Pearl Rating System (PRS)—also called Estidama tool—in 2008 [1,14]. Pearl had combined the most rating systems in use (LEED and BREEAM) but was a locally convenient system with national priorities [1,3]. Similarly, other gulf countries had caught up with the environmental assessment of buildings flow, such as the Qatar Sustainability Assessment System (QSAS) in Qatar in 2009 and the Oman Building Environmental Certification (OMBEC) in Oman in 2017. KSA used some of these EBRs, such as the use of the QSAS in 2013, for a number of its buildings [2,3].

4.4. Producing Local Green Building Rating System: Mostadam

KSA had taken a vital step towards its environmental building assessment by developing its own EBRs, Mostadam, which was launched in 2019 by The Ministry of Housing to support the aspirations of the KSA vision 2030. Mostadam refers to the Saudi Building Code (SBC) and is designed to comply with the existing legislation. Thus, other rating systems have to be adapted to Saudi standards, but Mostadam can be used directly. It also complies with geographical aspects and local priorities. Mostadam started with a green building rating system for residential buildings, then for non-residential/commercial buildings, and residential communities [5,15].

5. Credibility of Environmental Assessment Options to Assess Buildings in KSA

When choosing any of the environmental assessment options to assess buildings, the debate lies in these options' results reliability. When the international EBRs were developed, they were formed for their establishment countries, and they included specific criteria inspired by their countries' specific regulations or standards. Thus, they cannot practically be applied in other countries without having misleading results. Doan et al. (2017) covered the various researches done for the main rating systems and concluded that BREEAM and LEED have a global considerable number of green-certified buildings, but, when analyzing the overall aspects, scores, categories, and assessment criteria to compare between the local and international rating systems, the results show considerable differences. While some international rating systems are more concerned with environmental sustainability categories, other

local rating systems are more concerned with social and economic aspects categories, as each of the compared systems assigned the plurality possible score to the local priorities [12].

The credibility of sustainable assessment results cannot be solely achieved by the use of equivalent EBRs' adaptations. For instance, Energy efficiency has the highest category weight in the LEED and BREEAM rating systems even when adapted to other countries with their different priorities [12]. And despite the fact that the two previous systems have equivalent systems to the gulf region, BREEAM Gulf and the LEED Emirates, major differences had appeared between both of them, which indicated the effect of the producing countries on the resulted priorities even after adaptations [6].

The use of regional EBRs does not solve the countries' diversities, even with their many requirement similarities. Despite the fact that most regional systems share most of their aims and main priorities, there are differences in categories and items weighing according to the specific local requirements, properties, and internal regions characteristics, which always makes the local rating systems the utmost credible assessment option [1].

After passing through the previous options, it could be concluded that none of them could be used without a lack of results credibility and that it is important to achieve assessment methods' variation among countries due to the local variables affecting the assessment components and weights. So, the production of local-based rating systems with a comprehensive consideration of sustainability issues of a specific country is always needed as a vital step to a responsive sustainable assessment. This step ensures the application of best building environmental practice that should be different from other countries according to each local properties and circumstances. It helps to fulfill the desired degree of sustainability according to local aspects and is expected to perform much better to serve building performance and assessment [1,4,6,8,12].

6. Credibility of Mostadam to Assess Buildings among KSA Internal Regions

The assessment fields and items credits in the different EBRs are used to ensure the building's commitment to the environment, and to assess the environmental performance efficiency of buildings. The use of the same rating system among the different country regions will lead to inaccurate results similarly as was discussed for using a global EBRs among different countries. Therefore, each rating system should be formed and edited to match the special characteristics and conditions of each specific internal region by modifying the different items' weights and formulation through specialized groups and academics [8]. Likewise, Mostadam cannot fit the building environmental requirements among all KSA internal regions with their different characteristics and variations and, thus, cannot give credible and accurate results. Therefore, and because of the great variety in the internal country characteristics, there is a demand to include the effect of the different spatial variables on the building's assessment for producing a more compatible version to achieve the highest reliability and credible assessment, and to get the utmost fairness and accuracy results [6].

The KSA is a country of 200 million square kilometers representing about 80% of the Arabian Peninsula. It has been divided into different internal regions according to different features basis. It has a climate that ranges from semiarid, to a hyper-arid climate; therefore, it was divided according to the climatic features by different divisions. One of these divisions was three climatic zones, and according to these zones, the Saudi Building Codes (SBCs)—which Mostadam depends on—had determined its energy-saving requirements upon [16–18]. But, including the climatic differences within the Energy assessment field of Mostadam by relying on the SBCs is not the only way to include the KSA diverse characteristics of its internal regions.

It should be noted that adjusting an existed local rating system for its internal regions is much preferable, accurate, and easier than starting from scratch, especially when considering the importance of the country's internal regions' compatibility in their main assessment priorities and issues [8]. For example, it was logical to generally raise the weight of the Energy assessment field in Mostadam versus other assessment fields because, in the hot–arid climates context, the KSA was classified within the ten countries with the highest energy consumption per capita in 2014. It was also classified as one

of the most ten CO₂-emitting countries in the world in 2013, and the primary energy consumption per capita is over three times higher than the world average. Besides, generating electricity consumes about one-third of the KSA daily oil production. Electricity consumption is annually increasing by about 5–8%; thus, probably the oil production and oil consumption will be equivalent by 2035. Remarkably, about 80% of the total electricity that the Saudi Electricity Company generates daily is consumed by the building sector. Air Conditioning systems consume about 50% of the buildings' sector electricity consumption [19] and defer among different KSA regions and cities, which means that, although there should be an overall concern among the KSA by the energy conservation, this concern should be connected by the climatic characteristics, which differs among its internal climatic zones.

7. Taif City Characteristics Effect on Mostadam Assessment Fields

Taif city stands about 1800 m above sea-level on the eastern slopes of the Al- Sarawat Mountains, and it lies about 167 km south-east of Jeddah and about 90 km south-east of the Holy City of Makkah, as shown in Figure 1. Taif has a hot desert climate; however, its summer climate is much preferable than in other Kingdom parts. In summer, people go to the city to enjoy the weather, as it is a popular tourist destination among Saudis, with its beautiful scenery and unique relaxed atmosphere [16,20]. When considering Taif's unique characteristics to adjust Mostadam, all assessment fields' weights should be changed to comply and express its special requirements. The following is a proposal for adjusting the assessment fields' estimating weights of the Mostadam residential version.



Figure 1. Location of Taif city on Kingdom of Saudi Arabia (KSA) map. (<https://www.lonelyplanet.com/maps/middle-east/saudi-arabia/>).

- The 'Policies, Management, and Maintenance' Assessment field weight may stay as it is, without increasing or decreasing. Considering that Taif's solid waste product is considered low in comparison to other KSA cities, and although the capability to recycle solid wastes in Taif is low, the city has an efficient solid waste collection system [16,21].

- The 'Energy' Assessment field weight may be decreased. Considering that KSA has diverse climatic regions that are sometimes considered three and sometimes five climatic regions, each of them has very different climatic characteristics and relative energy demands, with cooling demands ranging between 40% and 71%, and different cooling and heating degree days [19]. Psychometric charts could be used to show the effect of the climatic characteristics on achieving thermal comfort in the internal building spaces, thus the need for cooling and heating requirements. The Psychometric charts of both Taif and Riyadh cities in KSA show the number of comfortable hours when using only passive and natural solutions, which are sequentially 67% and 34%, as shown in Figure 2, noting that the comfortable hours without the passive solutions are sequentially 19.2% and 8.1%, so the Energy assessment field should stay of high weight among KSA cities, but it could be higher in Riyadh and other cities than in Taif [22].

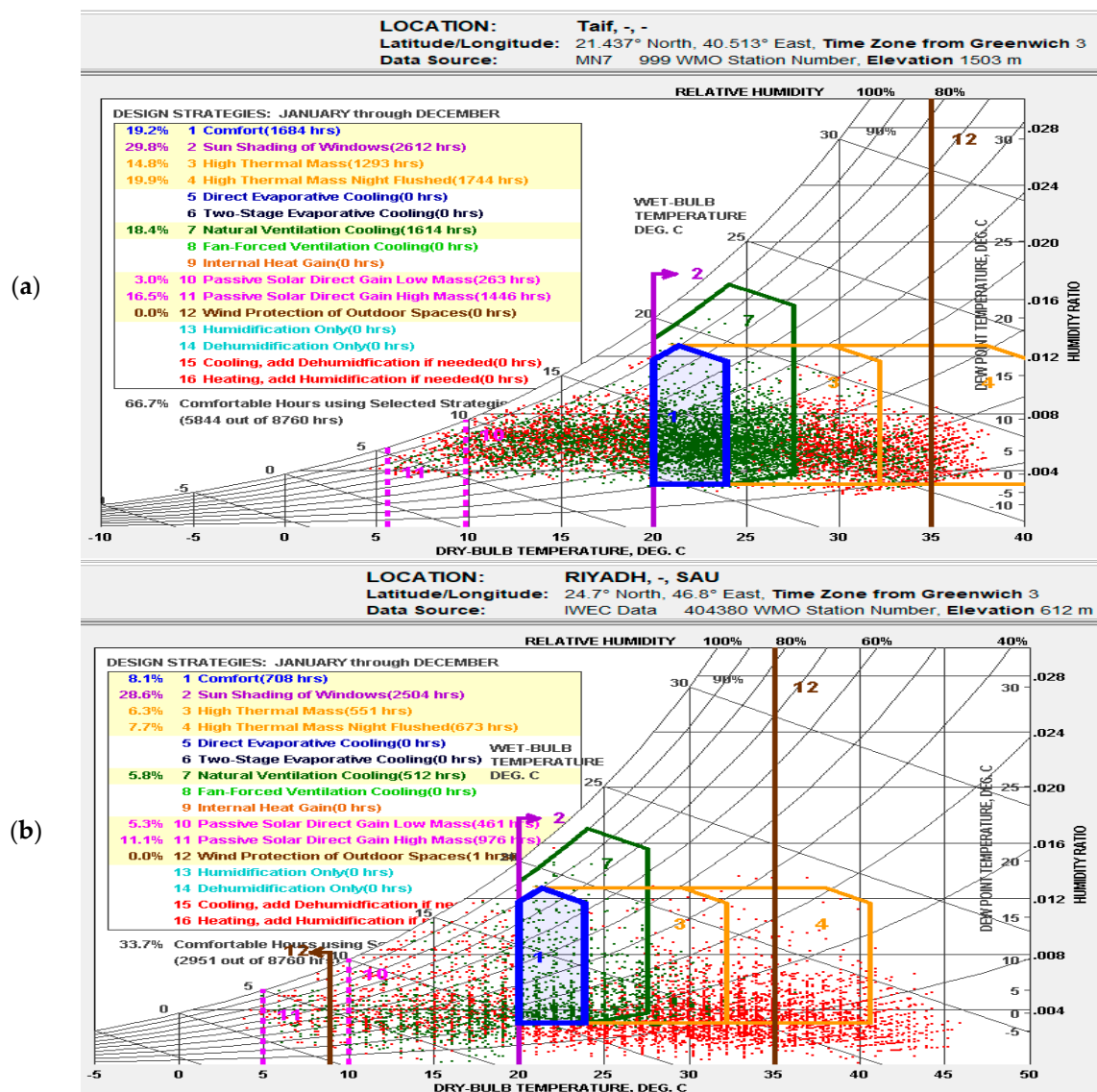


Figure 2. (a) Psychometric charts of Taif and (b) and Psychometric charts of Riyadh cities showing the number of comfortable hours with passive and natural solutions [22].

- The 'Water' Assessment field weight may stay as it is or increased: to encourage the utilization of wasted rainwater in that region, considering that KSA is an arid area and one of the world's driest countries that lacks permanent water-bodies, and uses its oil resources to provide potable water by operating its desalination plants. It also has the third-highest per capita fresh-water

consumption in the world [23]. The Jeddah-Makkah-Taif area is the most water deficit area in the Western Region; in this area, desalinated water provides about 90% of domestic water needs [24]. In Taif, the growing concern of agricultural and landscaping in that region due to its unique soil compared to other KSA cities increases pressure on the limited water reserves, considering its reliance on the non-renewable groundwater. Besides, in the future, the available water resources can be further affected by the impacts of climatic change [25].

- The 'Health and Comfort' Assessment field weight may be increased, and the reasons and ways for that is the main concern of this research, which are discussed in the next sections.
- The 'Education and Innovation' Assessment field weight may stay as it is because of the exceptional attention that must be given to raising realization of sustainability all over the KSA, to apply the Saudi Vision 2030 goals regarding people's awareness of sustainability [26].
- The 'Site Sustainability' Assessment field weight may be increased, noting that 1.2% of the KSA land area is woodland, and about 80% of it scattered throughout the Sarawat mountain range in the south-western region where Taif is. These forests have been undergone intensive grazing, severe cut, misuse, and different humanitarian activities [27]. The Taif forests inventory demonstrated that they are suffering from degradation, represented by the low ability of natural renewal of the main forest species, the gaps diffusion in forest cover, a high irregular trees rate, the reduction of the most larger trees, remarkable eroded soil, die-back and die-off of trees, insects break out, decreasing the number of tree species, loss of some wild animals species with an increase in the number of monkeys, increase in urbanization and accompanying activities, the spread of recreation areas, and others [27].
- The 'Transportation and Connectivity' Assessment field weight may stay as it is because there are equal exposed problems among the different KSA cities regarding that issue, like the climate, the hot deserts, and the high mountain—where Taif city is—where each have different but equally challenging problems [28].

8. Indoor Environmental Quality (IEQ) Assessment Field

IEQ is a concept that is affected by psychosocial and physical aspects and controls the health, comfort, and productivity of the occupants. The effects of IEQ on human health are significant, ranging from minor distractions and performance decrease to major diseases and health deterioration [29–31]. IEQ had been always a main assessment field in the EBRs since they appeared, and it is one of the core common fields for all. It concerns the achievement of different human comfort needs within the building's internal spaces, including the quality of indoor air, ventilation rate, thermal comfort, visual comfort, acoustical comfort, physiological comfort, drinking water, and other different human needs that should be achieved, and the reduction of ergonomics, micro-organisms, Hygiene, odors, electromagnetic radiation, and other pollutants. Achieving these human needs is a major role of buildings, as people spend about 90% of their lives within buildings, which makes the quality of the indoor environment affect the human directly, for whom the buildings are mainly constructed [12,32,33]. However, the awareness of green buildings demand is increasing, ensuring the desired level of IEQ is often not given the worthy care, and buildings rated as 'green' do not guaranty their cope with the desired IEQ level, especially if given an approximately low assessment weigh in the EBRs, such as in LEED and BREEAM, which presents only around 14.6% and 15% of its total weight sequentially [4,31].

9. Taif City Characteristics Related to the IEQ Assessment Field

The IEQ assessment field in the EBRs is one of the obvious assessment fields that shows the importance of its variance among different places; therefore, it is one of the assessment fields that researchers should focus on to study its compatibility when considering a building rating system adjustment to be used among several regions [7]. To assess buildings in Taif city environmentally, several unique characteristics are leading to some concerns and constraints that should be included to

form the IEQ assessment field of its buildings. In the following, the main Taif's characteristics that are affecting the IEQ assessment field in the Mostadam Rating system 'Health and Comfort' are presented.

9.1. Climatic Conditions

In the KSA, there is a great deal of divergence in terms of climatic aspects [34]. A simplified way is used to divide the KSA into three climatic zones: Areas that have dry hot climates, e.g., central and northern regions, and some cities in the Western and Eastern regions; areas that have hot, humid climate, e.g., cities located on the Red Sea coast (western or southern region) or cities along the Arabian Gulf coast (eastern region); and Upland region that has the heaviest rain and its temperature range between 21–28 °C in summer and 10–12 °C in winter [17,35]. But, a more accurate classification classifies the KSA into five populated climatic zones that could be presented by main cities: Khamis Mushait, Jeddah, Riyadh, Guriat, and Dhahran [34]. Taif city is in the highland climatic zone according to the first classification, and, in the Subtropical (Khamis Mushait) zone, according to the second one. The daily temperature range average (°C) for the annual cycle for the Highland zone is shown in Figure 3, and the five climatic zones and their climatic parameters are shown in Figure 4 and Table 1.

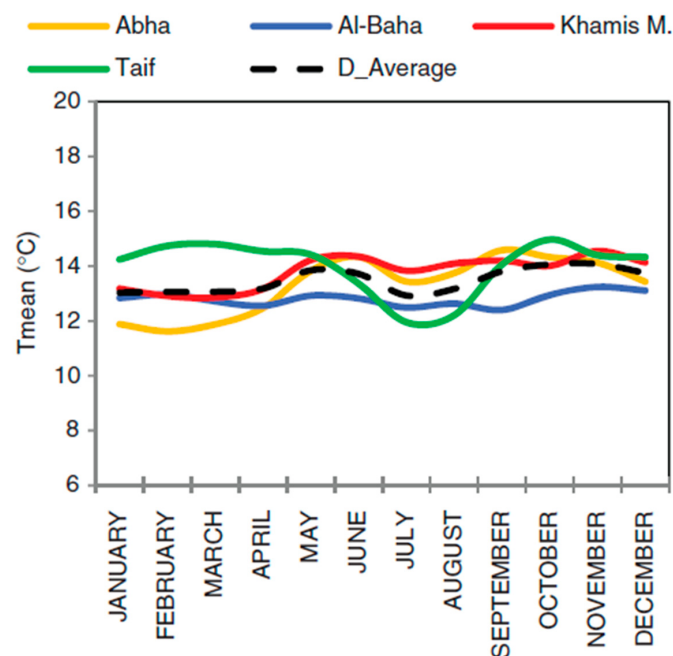


Figure 3. The daily temperature range average (°C) for the annual cycle for the Highland zone [36].

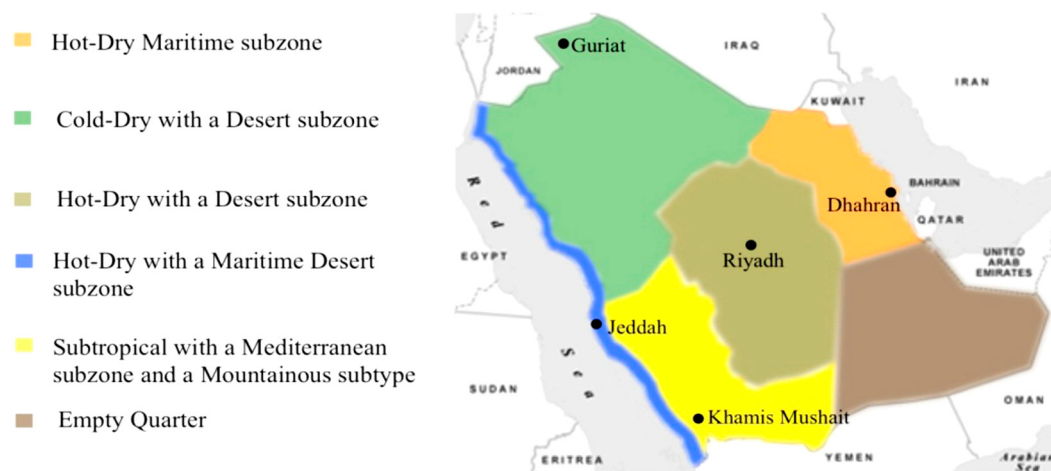


Figure 4. The division of five climatic zones in the KSA [34].

Table 1. The climatic parameters for the five climatic zones in the KSA, noting that Taif city is located in the Subtropical (Khamis Mushait) zone [34].

Climatic Represented Location	Geographic Coordinates			Air Temperature			Relative Humidity			Wind Speed			Global Solar Radiation		
	Latitude (°N)	Longitude (°E)	Elevation (m)	Minimum (°C)	Maximum (°C)	Mean (°C)	Minimum (%)	Maximum (%)	Mean (%)	Minimum (m/s)	Maximum (m/s)	Mean (m/s)	Minimum (W/m ²)	Maximum (W/m ²)	Mean (W/m ²)
Dhahran	26.3	50.1	22	5.0	45.7	25.8	19	99	57	0	5.7	0.9	0	990	195
Guriat	31.3	37.4	502	−3.3	43.9	19.8	12	100	40	0	16.3	4.2	0	1053	235
Riyadh	24/7	46.8	583	2.2	43.7	25.1	10	91	32	0	11.9	3.1	0	1049	252
Jeddah	21.5	39.2	33	13.9	41.7	27.9	37	100	65	0	11.2	2.6	0	1035	257
Khamis Mushait	18.3	42.7	2051	2.7	34.3	18.9	17	100	51	0	12.4	3.1	0	1127	289

Grey color indicates the zone that the case study is related to.

9.2. Precipitation Conditions

Generally, precipitation increases with higher altitude. In all seasons, the south-western region (Taif, Baha, Khamis Mushait, Abha, and Gizan) receives rainfall with a maximum in spring (44.29%). Nearly 80% of the total KSA precipitation occurs through months from November to May. The other period occurs through the summer season. This region is also characterized by sleet precipitation occurrence during rainy times (June, July, and August) [37,38]. Although the impact of climate change on the average warming is expected to be low in the south-western regions (0.2–0.4 °C) during the summer for the year 2041, the annual total rainfall shows an increase in moisture ranging between 20 and 30%, which results in more periodic or acute hurricanes that increase the bacteria, mold, and building dampness [20,39–41].

9.3. Topography Conditions

The KSA has differences in topography in different parts of the KSA, whether it is mountains, valleys, desert, or coastal areas. Taif is within the Sarwat Mountains region and characterized by the mountains' topography characteristics. Different topographies resulted in the emergence of different building materials, different quality of soil, and diversity of traditional building designs and urban styles among the KSA [35].

9.4. Some Health Problems Conditions

In the following, some main health problems conditions related to Taif city are presented.

9.4.1. Sleep Disorders and Excessive Daytime Sleepiness (EDS)

Sleep disorders are an important health problem in KSA. In Taif city, there was a significant increase in sleep disorders and EDS versus other KSA areas. Even among Taif itself, the incidence of sleep disorders and EDS was higher in the high-altitude areas versus areas with less altitude. Such a problem can be related to Taif's generally high altitude, which is associated with a considerable decrease in oxygen concentration in the atmosphere. This may affect breathing patterns and lead to sleep disorders. People living at high altitudes usually experience problems, like waking frequently, having arousals, and daytime somnolence. The periodic breathing that usually appears in most people at high altitudes could be determined as the main cause of sleep disturbances [42]. Sleep disorders might cause numerous medical health problems, impaired daytime functioning, and critical consequences on

patients' health and quality of life. Although some sleep disorders are more difficult to cure, most can be easily controlled with sufficient medication [43]. Research on the sleep disorders and EDS in Taif University students showed that the incidence of sleep disorders and EDS was more common in the high altitude areas, such as Al-Muhammadiyah and Al-Hada (1953 m and 1785 m above the sea level), compared to lower altitude areas, such as Al-Hawiah (1435 m above the sea level), as shown in Figure 5 [42].

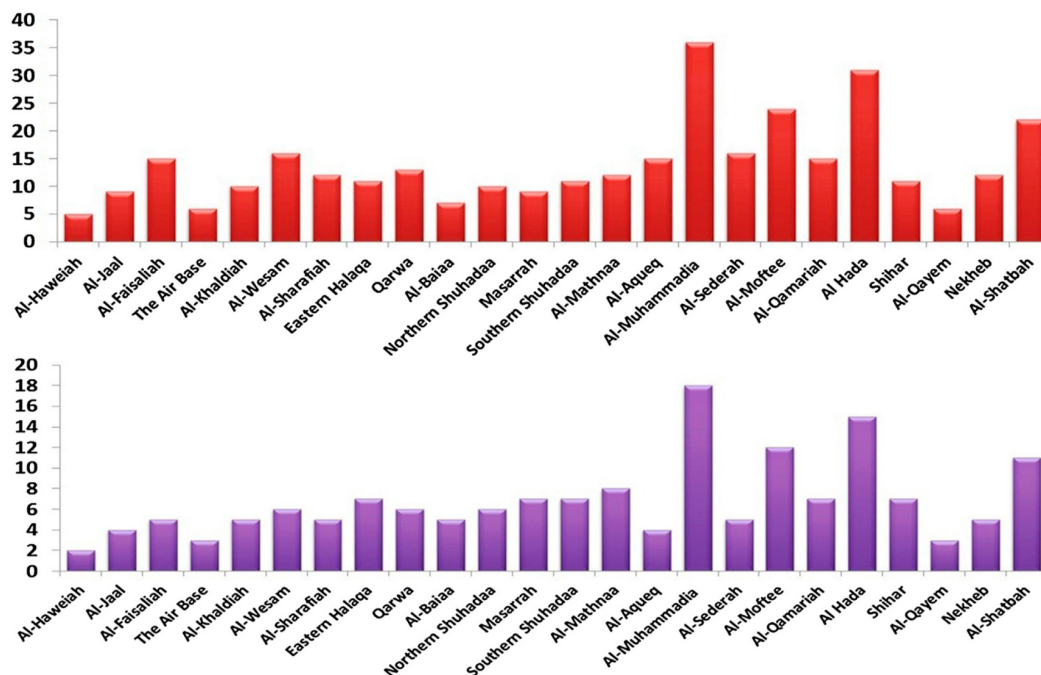


Figure 5. The prevalence of sleep disorders (**above**) and Excessive Daytime Sleepiness (EDS) (**below**) among Taif University students, according to residence [42].

9.4.2. Asthma

Asthma extension has risen worldwide, and environmental factors have an important role in the etiology of the disease. Asthma prevalence is generally low in the Middle East, although high ratios have been recorded in the KSA among 16- to 18-year-old adolescents. The prevalence of asthma and asthma-related symptoms are affected by the high altitude; therefore, Taif is clearly illustrated for that disease. Although the mountain climate can adjust the respiratory function and bronchial responsiveness of asthmatic subjects, Hypoxia, hyperventilation of cold and dry air, and physical exertion might worsen asthma or promote bronchial hyperresponsiveness [44].

9.4.3. Allergies

Prevalence of allergic diseases in Taif city, such as urticaria, allergic rhinitis with or without other comorbidities, and atopic dermatitis, is well known, and they are all affected by the high altitude. Allergies are one of the most serious health problems of poor Indoor Air Quality (IAQ), as well as poor ventilation [31,44,45].

9.4.4. Heart Failure

High altitude is considered a risk factor in decompensating heart failure. Hypoxia occurring with the raise in altitude leads to several modifications in the cardiovascular and pulmonary systems by activating the chemoreceptors in the Sympatho-adrenergic system to provide adequate oxygen to the organs. Barometric pressure lowers with the altitude raise, resulting in a partial oxygen pressure decrease and lowering the ability of tissues to use oxygen. As a result of the hypoxic setting, the human

body tries to compensate for this situation by increasing blood flow, respiratory rate, hemoglobin, and hemo-concentration [46].

9.4.5. Lymphoblastic Leukemia

Saudi Cancer Registry ranked leukemia as the 5th type of cancer cases of both genders in KSA. The most diagnosed type of leukemia was the Precursor B-cell lymphoblastic leukemia, followed by Precursor cell lymphoblastic leukemia. The western region including Taif city is considered the highest rate in precursor cell lymphoblastic leukemia with a percentage of 21.5% [47]. Indoor air pollution from heating sources and dust, as well as passive smoking and magnetic field exposure, are some causes of childhood leukemia risk [48].

9.4.6. Polycythemia

In Taif, the number of secondary polycythemia patients is raising significantly, and most of those patients are males that share one fact: they are all heavy smokers [49].

9.5. Some Pests and Insects Rates

An investigation on rose plants (*Rosa damascene trigintipetala*), which were cultivated extensively at Taif, observed that there are individuals of *Lygus* species during the flowering period, which forms the first detection of this species in KSA. In the future, it is expected that this invasive insect pest could be a main, critical pest in the Taif or nearby regions in KSA. Its biological parameters, when feeding is on broad bean pods and/or rose flower buds, and these two food sources are cultivated at Taif and easily obtainable [50].

The mosquito fauna in the western coastal area in KSA distribution shows that a number of the species in both Taif and Tabouk reported the highest (13 species, 68.42%). This may be attributed mainly to climate prevailing in them of being much cooler during the summertime than it is in other parts of KSA. There are a variety and abundance of different mosquito species, among which several vectors of diseases mainly lymphatic filariasis, Rift Valley fever, malaria, and dengue fever [51]. Noting that Taif is one of the vitality cities of the KSA and close to the holy city of Mecca, where millions of pilgrims reach every year, and all year round, then, Taif represents an important spot to be a malaria focus in the KSA [52].

9.6. Some Noise Condition

Taif is relatively a quiet city in terms of traffic and population compared to other KSA cities, like Riyadh and Jeddah [53]. On the other hand, some environmental phenomena, such as thunderstorms, make it roaring in moments. In general, thunderstorm frequency does not defer in any compatible way with precipitation. Annual thunderstorms are most frequent over the south-western parts of the KSA and decrease generally towards the east and the west. The southern region in general, especially the cities of Taif, Abha, and Al-Baha, has shown the utmost numbers of a thunderstorm through days all year round, as shown in Table 2 and Figure 6. Besides, this variation shows a tendency for the rising frequency with time [37,54].

Table 2. Comparison of the annual average thunder days (Td/yr) and the seasonal average for some main KSA cities [54].

Cities	Total Average Td/yr				
	Summer	Autumn	Winter	Spring	Annual
Riyadh old	0.25	1.0	4.46	10.0	15.75
Makkah	2.89	9.9	2.95	3.7	19.47
Jeddah	1.17	4.0	1.92	1.8	9.00
Taif	16.86	29.6	6.55	43.0	96.00

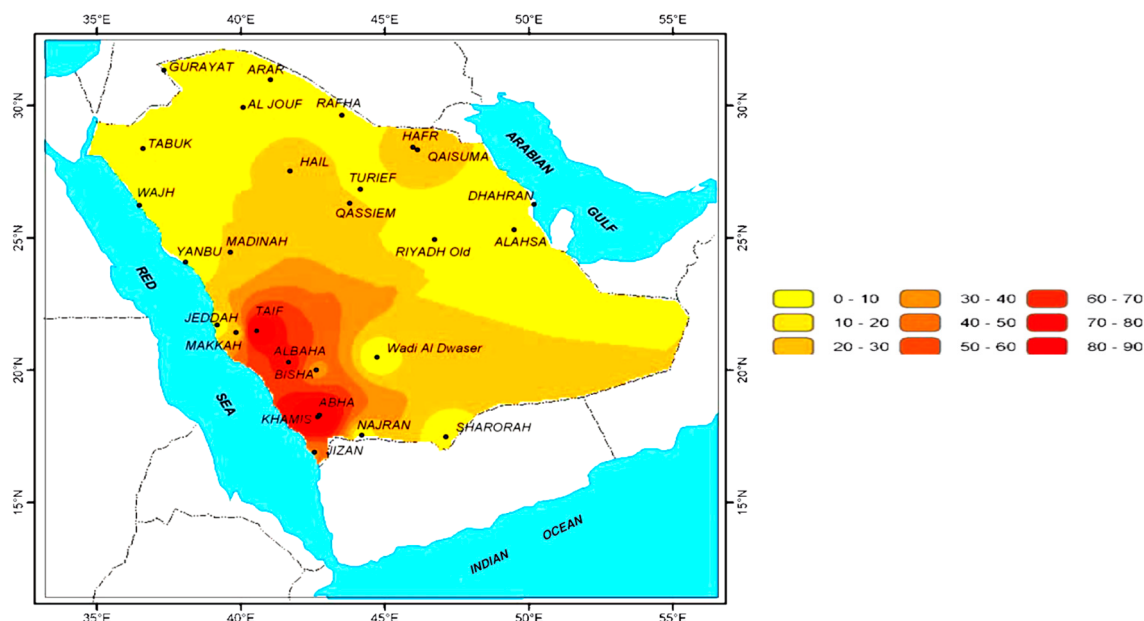


Figure 6. The annual average thunderstorm distribution in color contours in thunderstorm days per year [54].

9.7. Ions Concentration Condition

Air ions are formed when sufficient energy displaces an outer electron from a molecule of one of the common gases. Under normal conditions, there is a small difference between positive and negative ions at the lower levels of the atmosphere. Electrical discharges can cause the formation of ions in the atmosphere. This requires a high electric field that generally occurs in the disturbed weather inside or in the vicinity of lightning and thunderstorms [55]. Bursts in the concentration of intermediate ions were also found during lightning and rain episodes [56]. As previously mentioned, Taif is considered one of the cities with the greater numbers of thunderstorm days all year round, which results in induced air ions concentration increase after the occurrence of thunderstorms and lightning.

9.8. Wind Direction

Taif's wind rose, in Figure 7, shows how wind speed and direction are typically distributed at Taif city. The brown ring (outermost) represents the hour's ratio when the wind arrives in each direction. On the blue (next) ring, the radial bars' height and color represents the temperature average of the wind coming from each direction. The next ring represents the humidity average, in which the light green is presenting comfortable. The three triangles in the inmost ring represent the maximum, average, and minimum velocity of the winds from different directions. Thus, it is noted that the northern and the eastern directions are the ones that receive winds within the comfort zone range and that the northern direction has the most hour percentage all year round [22].

9.9. Water Quality

Taif is highly dependent on groundwater for water consumption. Groundwater contamination is considered one of the essential fields of attention in several regions, notably those areas with restricted provides like Taif. Many prospected sources can cause chemical and microbial contamination in groundwater. A study was done for the water of the open well in the Taif region concluded that 95% of collected samples' qualities (biological, chemical, and physical) lie below the required standards. Several wells are polluted with potassium (K) and phosphorus (P). Potassium and phosphorus are important fertilizers used in agricultural land for plant growth and development, so these wells may be used for agriculture, as Taif is one of the famous places for agriculture within the KSA, and these

wells are nearby the agricultural lands. Taking into consideration that poor water quality causes 80% of human health problems, it is to blame for the spread of infectious diseases [57].

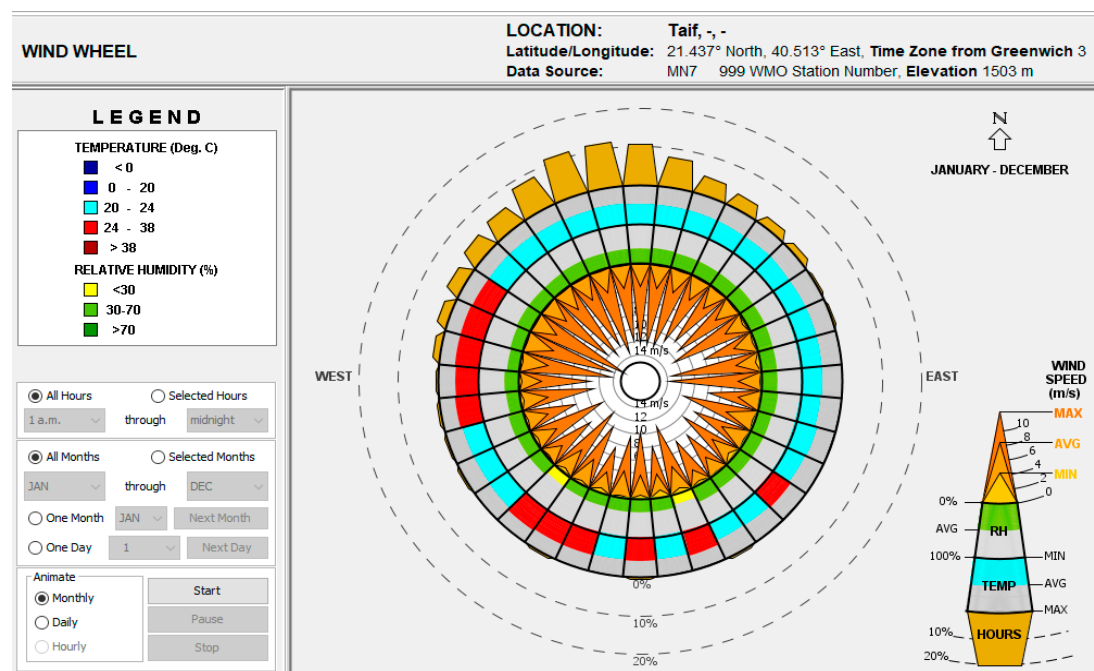


Figure 7. The annual wind rose of Taif city [22].

9.10. Flora

The Taif area is the richest area of biodiversity in the KSA. It has the utmost plant diversity, with about 74% of the total plant species of the KSA, mainly due to the greater rainfall. In the following, some of Taif's main flora characteristics are presented.

9.10.1. Medicinal Plants

About 63.2% of total recorded species (165 species) in Taif are medicinal. This means that the Taif region has a significant number of medicinal plants; some are used in folk medicine or known to have medicinal value. Over the years, large virgin land areas have been overturned into agricultural lands, which resulted in the vanishment of many wild species, including medicinal plants. Today many medicinal plants face extinction or severe genetic loss. In Taif, limited data about the medicinal plants as natural resources for potential use by the local inhabitants of this region is available [58].

Note that the preliminary results of a study on behalf of the World Health Organization (WHO) have confirmed that the individuals' number using medicinal plants is great and, on the increase, even among young people. Plants do not only provide humans with food and fiber but also cure them of several fatal diseases. Medication by herbs was the sole way against a lot of diseases. But, the vanishment of the medicinal plants from their natural habitats has hidden results. Those traditional doctors, or herbalists, usually have a long and inherited experience. The erosion of such remarkable genetic resources and their deterioration is linked to the disappearance of knowledge and traditional experience and, then, a loss of precious intellectual feature rights [58].

9.10.2. Roses

Taif-roses is a famous rose type that cultivated in the Taif region and famous for its deep and strong fragrance in the Arabian World. That was one of the main reasons to choose Taif to be a touristic destination besides its cultural and artistic diversity and its moderate climate. It earned the name of 'Arabia's Rose', ever since roses started to be cultivated in the Ottoman era. Taif-roses have a significant

part in the national economy for their considerable value in the medicinal use besides the manufacture of perfumes, exportation of their oil to the Arab countries, and ornamentation [45,59].

10. Effects of Taif City Characteristics on the Mostadam IEQ Assessment Field

The assessment fields in the EBRs can be adjusted to comply with specific regional conditions by modifying their items' estimation weights, formulation, evaluation levels, and scores [6]. In this research, the IEQ assessment field in the Mostadam is adjusted according to Taif characteristics by modifying the items' estimation weights and formulation.

10.1. Adjustment of Mostadam Credit Points Weights According to Taif Characteristics

Credit points given to each assessment item represent the estimation weights of these items and expressing their importance degree [6].

In the Mostadam 2019 residential version, the offered credit points to its IEQ assessment field 'Health and Comfort' are 14 points out of the total 100 system points; thus, considering the third highest assessment field after the Energy and water assessment fields, it consists of ten main assessment items, two of which are keystones (mandatory), which are: HC01-Outdoor Thermal Comfort (2points) and HC02-Indoor Thermal Comfort (2 points), while the rest of the eight assessment items are optional credit points: HC03-Ventilation (1 point), HC04-VOCs and Low-Emitting Materials (2points), HC05- Access for All (1 point), HC06- Daylight and Visual Comfort (2points), HC07-Acoustics (1 point), HC08-Indoor Air Quality (1 point), HC09-Active Residents (1 point), and HC10-Outdoor Space (1 point) [60].

In the Mostadam 2019 Commercial Buildings version, the offered credit points to its IEQ assessment field 'Health and Comfort' are 28 points of the total 130 system points, four of which are keystones, which are: HC01-Outdoor Thermal Comfort (1point) and HC02-Indoor Thermal Comfort (3 points), HC03-Ventilation (1 point), HC04-Water Quality (2 points), and HC05-Smoke Control (1 point). The other items are optional credit points: HC06-Outdoor Space (1 point), HC07-Daylight and Views (2points), HC08-Indoor Lighting (2 points), HC09-Acoustics (2 points), HC10-Indoor Air Quality (3 points), HC11-VOCs and Low-Emitting Materials (2points), HC12-Active Lifestyle (2 points), HC13-Access for All (1 point), HC14-Car Park Pollutant Control (1 point), HC15-Safety and Security (2 points), and H16-Indoor Vegetation (2 points) [5].

In the following, the proposed modified weights and reasons for modifications are presented.

10.1.1. Outdoor Thermal Comfort

It is proposed to decrease the credit points of this item in the Residential (R) version from 2 to 1 (noting that it is already a 1 point in the Commercial (C) version) because Taif city is considered a moderate climate city with a mean temperature of 18.9 °C, as previously discussed [34].

10.1.2. Indoor Thermal Comfort

It is proposed to decrease the credit points of this item in the C version from 3 to 1 because, in the Energy Assessment Field of Mostadam Rating System, there is a requirement of installing the external envelope specifications according to the latest SBCs, currently, SBC 601 and 602 (The SBC 601 and 602 codes were set to conserve energy in non-residential and residential buildings, and they have determined the required thermal transmittance values for each zone of the Saudi Arabia zones, as distributed in these codes, obligating buildings to not exceed them. It is noted that Taif city as a part of the highland zone got higher thermal transmittance values than those cities in the other two zones. This means that is easier to be achieved [17,18,61], relying on the heat transfer coefficients. This requirement is under the energy performance item, which is a keystone item and should be accomplished in the Energy assessment field [5,60]. So, if a building certainly fulfills this item, then it will properly accomplish the internal thermal comfort easily in Taif city, taking into consideration its pleasant climatic conditions compared to other KSA cities, as previously discussed.

10.1.3. Daylight and Views

It is proposed to increase the credit points of this item in the C version from 2 to 4:

One added point goes to the daylight requirement because Taif has a significant increase in sleep disorders and EDS compared to other KSA cities, as previously discussed, and various studies have found the validation of bright light therapy as a treatment of sleep disorders. Allowing special bright light tubes to insert into the existing wall- and ceiling-mounted fixtures may provide a practicable and affordable solution to bringing more illumination to many inhabitants simultaneously [42,62].

One added point goes to the Views requirement because it is necessary to focus on providing views, taking into account Taif's mountainous nature and the possibility of blocking the users' vision and connectivity with nature, as well as taking into account Taif's artistic diversity nature that could be benefited from, compared to other KSA regions [59].

10.1.4. Acoustics

It is proposed to increase the credit points of this item in the R version from 1 to 2, and, in the C version, from 2 to 3, because Taif was found to have the greatest concentration of thunderstorm days all year round, which reaches an average of 96 T/y [54].

10.1.5. Ventilation

It is proposed to increase the credit points of this item in the R and C versions from 1 to 3, the added points go to the natural ventilation requirement because many Taif health problems are related to the decrease in partial oxygen pressure due to its high altitudes, such as asthma, allergies, and heart failure problems. So, ensuring good natural ventilation rates will help to avoid the occurrence or the increase in these problems [44,46]. Natural ventilation also reduces the internal humidity in different spaces, which is the main reason for the mold growth and dust mites that may cause indoor allergens and irritants, and may raise the incidence of asthma [41]. It can also help the pest control needed in Taif especially in the flowering periods [63]. Note that lower natural ventilation rates raise the concentration of some indoor contaminants and might lead to exceedingly the indoor humidity levels especially during cold weather [40]. The increase of the credit points is also due to the concentrations of the high ions after the frequent thunderstorms' occurrence in Taif, as previously discussed, and the need for good natural ventilation to prevent its accumulation and enclosure in the internal spaces, which affects the human radiological balance.

10.1.6. Indoor Air Quality

It is proposed to increase the credit points of this item in the R version from 1 to 2, and, in the C version, from 3 to 4, besides decreasing the credit points of the IAQ test report concentration of air contaminants requirement in the C version from 2 to 1. The previous requirement decrease is proposed because Taif does not suffer from more acute particulate pollution than many other urban areas, unlike Riyadh and Jeddah for instance, noting that indoor air pollution is a combination of the contribution of the outdoor sources and indoor sources [64]. As for the 2 added points in R version and the 2 resulted points in C version (1 added + 1 obtained from an existing requirement), one goes for the proposed added requirement of preventing the exposure to the electromagnetic field, as discussed in the next section of the research, and one for the proposed added requirement of installing mosquito nets and avoid the accumulation of stagnant water, as also discussed in the next section of the research.

10.1.7. Smoke Control

It is proposed to increase the credit point of this item in the C version from 1 to 2, to increase the focus on controlling the smoking in the city's buildings, in line with the increasing number of secondary polycythemia patients for smokers in Taif, as previously discussed [49].

10.1.8. Outdoor Space

It is proposed to increase the credit points of this item in the C version from 1 to 2, to increase the concern for the planted spices in the outdoor spaces that are related to health and comfort. The added point can be given to encourage the cultivation of some specific plants that help to raise the quality of the outdoor and indoor spaces through the smell it gives, such as the Taif roses, noting that achieving good odors is equally to reducing bad odors for the GBs. [65] Or the added point can be given to encourage the cultivation of medicinal plants to raise the health of occupants through their benefits. Taking into consideration Taif's land abilities to plant such spices, and its previous richness of them, note that, today, many medicinal plants face extinction or acute genetic loss, with no conservation action being taken for most of the endangered medicinal plant species, and most knowledge on their use being related to traditional societies, whose extinction is now under threat, with too much focus on discovering new drugs and too little focus on the troubles related in the use of traditional medicines by local people [58].

10.1.9. Access for All

It is proposed to increase the credit points of this item in the C version from 1 to 2 because of the mountainous nature of the Taif land that makes the challenge of achieving those item requirements more difficult, thus more weight, than other KSA topographical regions.

10.1.10. Indoor Vegetation

It is proposed to decrease the credit points of this item in the C version from 2 to 1 because it is better in Taif to encourage the outdoor vegetation, rather than the indoor vegetation, to utilize the rainfall in that region. Green walls could also be used.

10.2. Adjustment of Mostadam Items Formulation According to Taif Characteristics

In the Mostadam Rating System, the IEQ 'Health and Comfort' assessment field includes several assessment items with several intents to achieve the comprehensive goal of that field, which are ensuring occupant health, wellbeing, and overall satisfaction with their surroundings, and these items aims are as follows.

For both Residential and Commercial versions:

- Outdoor Thermal Comfort: To improve outdoor thermal comfort and encourage more active lifestyles.
- Indoor Thermal Comfort: To improve building energy efficiency, improve thermal comfort via system calibration and testing, and provide occupants with control over their indoor environment.
- Daylight and Visual Comfort/Views: To maximize the use of natural light, minimize glare to improve occupant wellbeing, and visually connect to the outdoors to enhance health, productivity, and learning.
- Acoustics: To reduce noise disturbance, and improve occupant wellbeing by achieving low ambient sound levels in internal spaces.
- Ventilation: To ensure that all occupied spaces have adequate fresh air and to enhance the indoor environment and improve human comfort.
- Indoor Air Quality: To enhance the indoor environment by improving air-tightness and air quality.
- VOCs and Low Emitting Materials: To reduce the concentration of volatile organic compounds (VOCs) in the indoor environment, contributing to better indoor air quality and increased occupant welfare.
- Non-Polluting Insulation Materials: To encourage the use of insulation materials with a low impact on the environment and human health.

- Access for All: To ensure residents and visitors of all physical abilities have easy access to all building facilities [5,60].

In addition to the previous items, the Commercial version includes:

- Water Quality: To mitigate the risk of Legionella in water-based building systems and provide occupants with access to high-quality drinking water.
- Smoke Control: To minimize the exposure of building occupants and visitors to smoke and boost their health and well-being.
- Outdoor Space: To provide an outdoor space which gives building occupants and visitors a connection to nature, a sense of wellbeing, as well as encourage an active lifestyle.
- Indoor Lighting: Design buildings to enhance the visual comfort and productivity of building occupants through the provision of high-quality lighting and lighting controls.
- Active Lifestyle: To provide building occupants with opportunities for regular physical activity and exercise.
- Car Park Pollutant Control: To improve the air quality in enclosed car parks through optimum ventilation design and continuous measurement of pollutants.
- Safety and Security: To ensure that the planning and building design contributes to a safe and secure environment for occupants and visitors.
- Indoor Vegetation: To integrate indoor vegetation in interior design to improve the health and well-being of occupants, boost productivity while improving indoor air quality [5].

In the following, the proposed modified formulation of the Mostadam IEQ items for Taif city is presented.

10.2.1. Outdoor Thermal Comfort

It is proposed to modify this item in the R and C versions, by adding a requirement to avert the exposure of people in outdoor spaces to the high precipitation rate over the year. Note that it is an important concern for the outdoor spaces to provide the application of rain protection systems [65] and that Taif city has a precipitation rate that may cause a non-comfort feeling if not treated by proper protection methods when rainfall occurs, especially if it is accompanied by sleet, that occurs sometimes with rain at the Taif region [38]. It is also proposed to add a requirement in the R version, and putting more focus on it in the C version that is related to making use of collected precipitations water to cool the climate during the hot and un-humid days depending on the evaporation process, as Taif is considered a moderate humid city with a mean relative humidity of 51% [34]; so, cooling air using evaporation methods would be a proper solution to achieve thermal comfort, especially when considering the ability to benefit its precipitation rates over the year.

10.2.2. Indoor Thermal Comfort

It is proposed to modify this item in the R and C versions, by encouraging the passive solutions, such as insulating the walls of the external building, more than encouraging the active solutions, such as controlling the building's sensors, considering that Taif has a moderate climate that is easier to achieve thermal comfort within its buildings than other KSA cities, as well as considering the priority of applying the passive cooling and heating strategies in the GBs. An important step towards passive strategy is already considered in the Energy assessment field by requiring the achievement of the SBCs' u-values of the buildings envelope in the different KSA climatic zones, but approximately 70% of residential buildings in the KSA are not thermally insulated, while it would significantly improve performance if highly encouraged to be applied [66]. Besides, the evaporative cooling has been proven in some research to be a very attractive passive strategy to be applied in Taif, as it can provide enough cooling capacity, and it is considered to be an effective and low-cost solution in Taif city, especially when considering the high precipitation ratio that may be utilized in the buildings services [22,67].

10.2.3. Daylight and Views

It is proposed to modify this item in the C version, by adding some types of views that can be achieved through the windows, to ensure that the achieved views through the buildings avoid the obscuring high lands in Taif, as well as to take advantage of the amazing scenery of Taif's nature. Some types of views that are mentioned in the LEED v4 could be helpful, such as: 'multiple lines of sight to vision glazing in different directions at least 90 degrees apart, views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 7.5 m from the exterior of the glazing; and unobstructed views located within the distance of three times the head height of the vision glazing' [32].

10.2.4. Daylight and Visual Comfort (for R Version)/Views (for C Version)

It is proposed to modify this item in the R and C versions, by increasing the required minimum daylight illuminance in all spaces used early in the day. The increase should help people's internal "biological clock" produce an adenosine level in the body to help to stay awake in the morning and help to reduce sleep disorders and EDS in Taif city, which are high as previously discussed. The incoming light which is transduced by retinal ganglion cells is considered the main factor synchronizing circadian rhythm. A phase advance will occur if the person is exposed to light after the peak of melatonin rhythm or a minimum of core body temperature, usually in the early morning [42,68].

10.2.5. Indoor Lighting

It is proposed to modify this item in the C version, by increasing the total illuminance in all spaces used early in the day to produce an adenosine level in the body to help to stay awake in the morning. This is due to the same reason as modifying the previous item.

10.2.6. Acoustics

It is proposed to modify this item in the R and C versions, by adding a requirement of adding agricultural terraces, as they can, along with the application of rainwater harvest techniques, reduce external noises, such as the high concentration of thunderstorms in Taif, as they are an acoustical problem in that city, as previously discussed. Besides, according to the KSA national program towards the achievement of sustainable development goals of its 2030 vision, agricultural terraces have been rehabilitated, along with the application of rainwater harvest techniques in Taif, Baha, Asir, and Jazan. These terraces have agricultural and water objectives, leading to an abundance of output, as well as the creation of a conducive environment for the growth of agricultural activity and the provision of food [69]. This item is also proposed to be modified by adding a requirement of installing sound sensors on the building's facades and linking them by the nearest meteorological station, to give an appropriate warning to the occupants when a thunderstorm occurs and to apply pre-determined solutions in the buildings to achieve the proper sound levels for the different occupied spaces according to their functions. In that case, it should be considered to test the achievement of those levels during periods of thunderstorms using the pre-determined solutions.

10.2.7. Ventilation

It is proposed to modify this item in the R and C versions, by preferring passive ventilation ways and focusing on the natural ventilation rather than other ventilation types, such as applying differential pressure methods, and the use of windcatchers that are a traditional method of natural ventilation in the KSA [35]. Besides, providing automatic indication devices on all-natural ventilation openings meant to achieve the minimum opening requirements. An alarm must work when any of the openings are closed during occupied hours [32]. Natural ventilation has a special significance in Taif due to its high altitude and its moisture and biological characteristics, which increases the occurrence of some serious health problems, such as respiratory symptoms, allergies, asthma, and perturbation of the

immunological system, as previously discussed [31]. Besides, natural ventilation decreases the high concentration of ions after thunderstorms occurrence in Taif, which are of a high rate, as previously discussed. Management of moisture also requires appropriate monitoring of ventilation to avoid high humidity, condensation on surfaces, and excess moisture in materials [70].

It is also proposed to modify this item in the R and C versions, by adding a requirement of using appropriate filters for all air inlets into the building, to help pest management that is needed in Taif city, especially during the flowering periods, as previously discussed, besides their role as a curative of asthma and allergies [41].

10.2.8. Indoor Air Quality

It is proposed to modify this item in the R and C versions, by adding a requirement to prevent the use of some furniture elements that may cause a reduction in the IAQ, such as the moquette carpets, which are common and very widely used in residential buildings in the KSA. The moquette carpets are considered a sink for indoor air pollutants, which harm the occupants' health, especially when considering the high rates of asthma and allergies in Taif [29,31].

It is also proposed to add a requirement to prevent the exposure to an electromagnetic field beyond the range of 0–300 Hz because it is harmful to the human body and causes the possibility of health hazards, such as acute lymphoblastic leukemia in children. Noting that low-frequency electromagnetic radiation is common mainly indoors (due to computers, electrical appliances, microwaves, wireless devices, radio waves, and transformers, etc.) [31]. In addition, note that Leukemia in KSA is an important public health problem that causes deaths among young people, and that the western region, including Taif, showed the greatest rate in precursor cell lymphoblastic leukemia, as previously discussed [47].

It is also proposed to add a requirement to install mosquito nets or screens, to avoid the accumulation of stagnant water, and install permanent entryway systems, to capture dirt and particulates entering the building at regularly used exterior entrances [32]. The control of the mosquitos may reduce the transmission and spread of several diseases, such as malaria, noting that Taif has reported the highest number of mosquitos' species in the KSA in 2017 [51].

10.2.9. Smoke Control

It is proposed to add this item in the R version to decrease health problems associated with increased smoking rates in Taif, noting that this item already exists in the C version. The added item could be formulated to include compartmentalization of smoking areas, weather-strip all exterior doors and operable windows in the residential units to minimize leakage from outdoors, weather-strip all doors leading from residential units into common hallways, and minimize uncontrolled pathways for the transfer of smoke and other indoor air pollutants between residential units by sealing penetrations in the walls, ceilings, and floors and by sealing vertical chases [32].

10.2.10. Water Quality

It is proposed to modify this item in the C version, by providing drinking water based on rain collectors' process instead of wells. That is because of the high rainfalls rate in Taif, while it depends on wells for its drinking water, which need proper treatment before being used, and preferred to be used in agriculture rather than drinking; due to the wells water characteristics, considering that Taif is one of the well-known places for agriculture within Saudi Arabia [57].

10.2.11. Outdoor Space

It is proposed to modify this item in the C version, by preferring the outdoor spaces to be at the northern side of the buildings when there are no natural or mandatory obstacles for that. This modification helps to achieve the aim of this item and benefit the longest wind period and most moderate wind temperature, according to Taif wind rose, as previously shown. It is also proposed to

modify this item to include a preferable percentage of Taif roses in the outdoor space landscape to affect the smell comfort for users positively, as well as providing pleasant odors as expected in the city of roses.

It is also proposed to include a preferable percentage of Taif medicinal plants in the outdoor space landscape that occupants can use to improve their health, with instructions on the ways to use them. The consideration of public interest in the use of plants as medicines has been based on the hypothesis that the plants will be available continually. However, no planned efforts have been made to guarantee this, to face the threats posed by the increasing demand and population, nor to lower the destruction of plant-rich habitats [58].

10.2.12. Active Lifestyle

It is proposed to modify this item in the C version, by connecting the swimming pool option—already existed in that item—by the ability to take advantage of the wasted rainfall in Taif, whether directly, by using the water, or indirectly, by affecting the users' senses, such as the use of roof pool that allows water to fall from it into an internal pool for instance during rainy times.

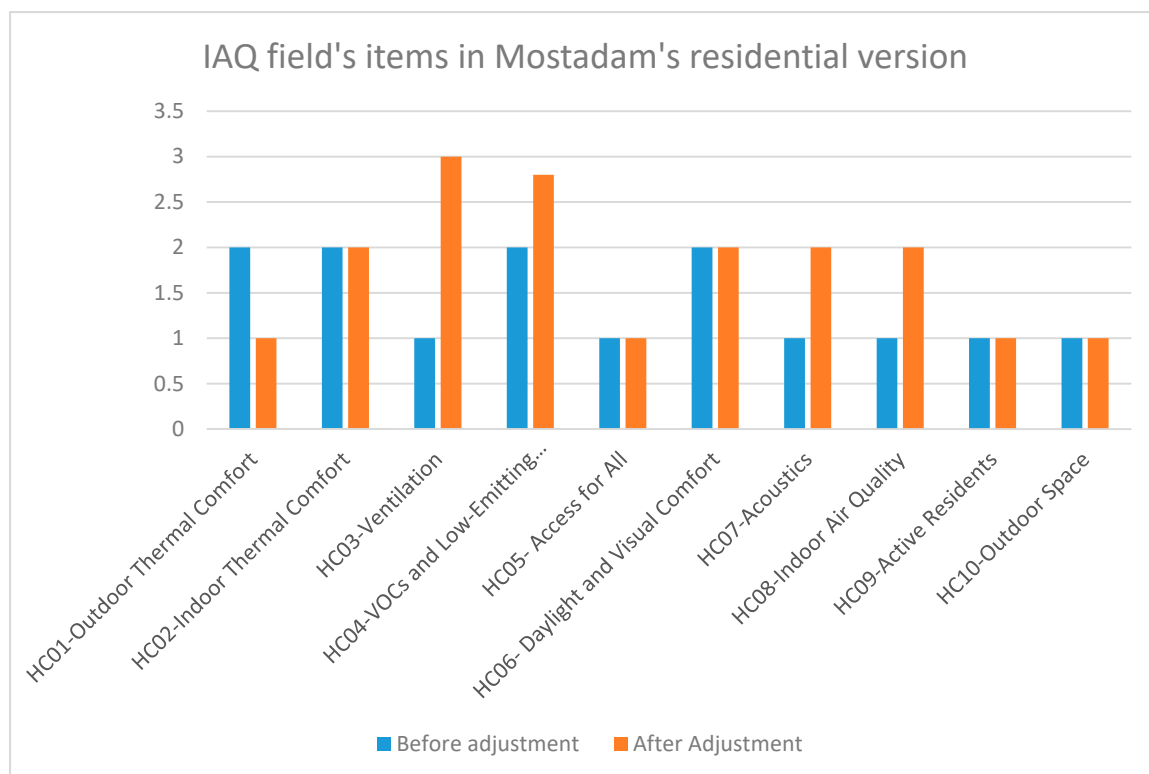
11. Results and Discussion

The research's main result was the ability and applicability of adjusting an existing assessment rating system of a country to be compatible with its different regions of different spatial characteristics. As country borders do not express environmental boundaries and do not include uniform characteristics between their ranges, they may, on the other hand, include several, and sometimes radically, different characteristics; therefore, they cannot be used in forming a one unified rating system for the whole country, or expect that a unified one can justly judge buildings efficiency over the country's different regions. On the contrary, it may lead to doubt the credibility and fairness of their assessment and comparison results. The research also presented several proposed adjustments and changes that are related to the specific characteristics of Taif city. These adjustments could be used to create a complete Mostadam version for Taif city, noting that adjusting other assessment fields may need to focus on some other city characteristics that are related to these fields. And it should be noted that changing the assessment field's weight will affect other fields' weights to keep the final total points as it is for all versions, to allow the comparison of buildings among cities. In the following, Table 3 and Figures 8 and 9, the proposed estimation weights of the IEQ items according to the research are presented, which lead to an increase in the IEQ assessment field weight in exchange for other fields weights, which is logical according to the many related problems to the IEQ field in Taif, as well as the ability to lower other assessment fields weights, such as the Energy field for Taif.

The research recommends those interested and specialized in the environmental assessment of buildings, as well as the institutions, to use these systems to give a priority for achieving the most credibility, as well as accurate results of the EBRs, especially when considering the global approach of providing them within the building permits. Thus, it is recommended to develop different versions of the local EBRs all over the world, and, for Mostadam, for the other different assessment fields, and different Saudi Arabia's regions, cities, and even for the different places in the same region, if needed, to achieve the utmost credible and assured results towards Green Buildings. For example, both al-Hada and al-Shafa zones, which are parts of Taif city, were intended to be natural reserves and have different characteristics from Taif itself [71]; then, they need their own rating systems. Green Building Councils all over the world are recommended to qualify experts to modify the EBRs and produce special versions for their different internal countries' spatial levels according to their characteristics, to ensure more credibility and accuracy of the assessment results.

Table 3. The proposed estimation weights of the Indoor Environmental Quality (IEQ) items of Mostadam Environmental Building Rating Systems (EBRS), according to Taif city characteristics.

IEQ Item in Mostadam	Credit Points Weights According to Taif Characteristics
Outdoor Thermal Comfort	R version from 2 to 1
Indoor Thermal Comfort	C version from 3 to 1
Daylight and Views	C version from 2 to 4
Acoustics	R version from 1 to 2, and in the C version from 2 to 3
Ventilation	R and C versions from 1 to 3
Indoor Air Quality	R version from 1 to 2, and in the C version from 3 to 4
Smoke Control	C version from 1 to 2
Outdoor Space	C version from 1 to 2
Access for All	C version from 1 to 2
Indoor Vegetation	C version from 2 to 1
Total	IEQ field in R version from 14 to 17, and in C version from 28 to 37

**Figure 8.** Proposed items' estimation weights adjustment of the IEQ field in the Mostadam residential version to be used fairly in Taif city.

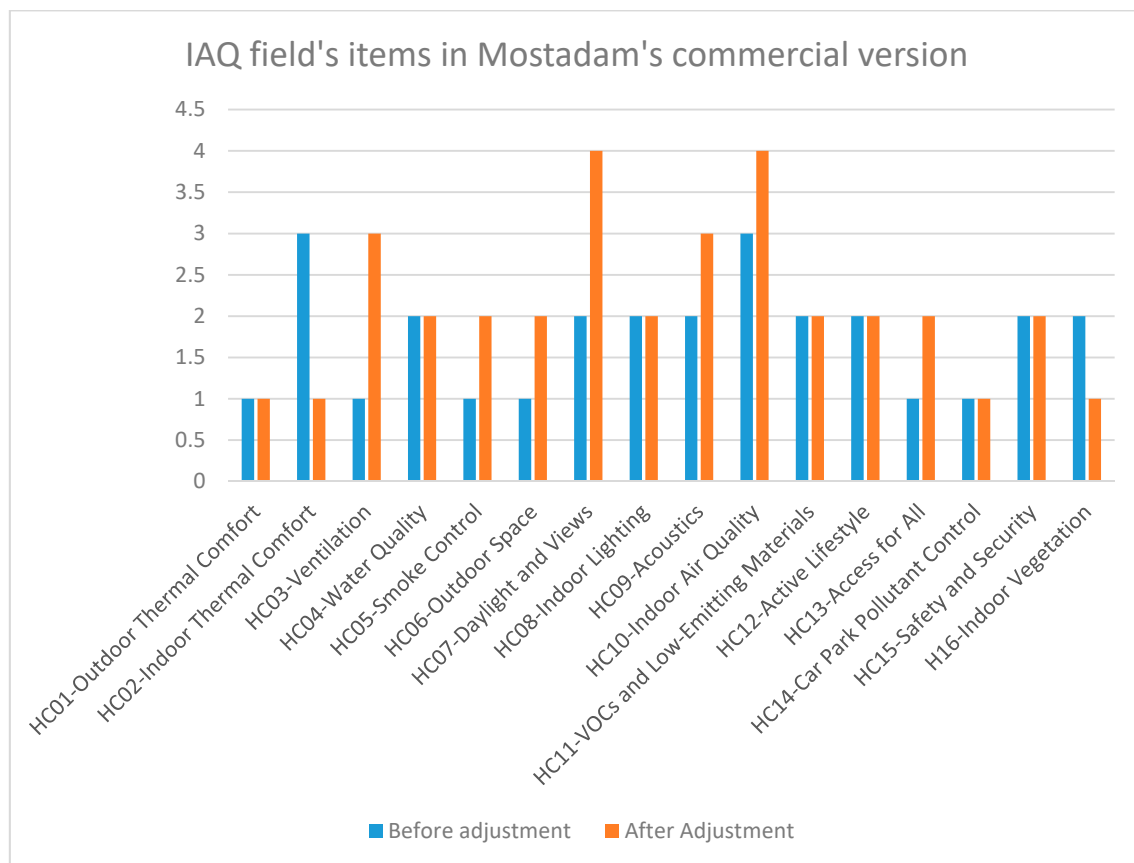


Figure 9. Proposed items' estimation weights adjustment of the IEQ field in Mostadam's commercial version to be used fairly in Taif city.

12. Conclusions

Environmental Building Rating Systems (EBRSs) were set and spread to ensure that buildings meet environmental standards. In KSA, to catch and keep up with the important global orientation, many options were available to be chosen from. KSA had already experienced some of them, such as the use of international and regional rating systems. A vital step was taken towards its environmental buildings assessment by developing its own system, Mostadam, which is considered the best credible and compatible option to assess KSA buildings. For similar reasons that are related to the spatial variables, it is highly recommended to adjust Mostadam for the different KSA regions to get the utmost reliable, credible, and fair assessment results. Spatial variables that affect the environmental assessment of buildings in KSA are very wide considering its area and diversity features. The research focused on adjusting the Indoor Environmental Quality (IEQ) assessment field in Mostadam named 'Health and Comfort', according to Taif's city characteristics. The importance of the IEQ field is clear when knowing that people spend most of their lives indoors. Spatial different characteristics that affect the IEQ in Taif in a different way from the other KSA cities were collected and analyzed, and these characteristics were either affecting human health or comfort, as these are the main concern of that assessment field. Taif characteristics were then used to adjust the Mostadam IEQ field through its items' estimation weights and formulation. The proposed adjustments and changes were presented and discussed, which emphasizes the importance of such adjustments, as well as helps to achieve more credible and fair results when using the adjusted IEQ field of Mostadam to assess buildings in Taif. The same way is recommended to complete a Mostadam version for Taif city, and likewise, all other KSA cities, and the whole world, according to their spatial variations.

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