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Green Airport building certification comparison: a practical approach for Airport Management

Betul Kacar[a], Eylem Turhan[b], Alper Dalkiran[c,d], and T. Hikmet Karakoc[e,f]

[a]Aviation Management, Cappadocia University, Nevsehir, Turkiye; [b]Civil Aviation, Eskisehir Technical University, Eskisehir, Turkiye; [c]School of Aviation Management, Suleyman Demirel University, Isparta, Turkiye; [d]Research and Development Department, International Sustainable Aviation and Energy Research Society, Eskisehir, Turkiye; [e]Faculty of Aeronautics and Astronautics, Eskisehir Technical University, Eskisehir, Turkiye; [f]Information Technology Research and Application Center, Istanbul Ticaret University, Istanbul, Turkiye

ABSTRACT

In this study, six certificates have proposed and three of them used by airport terminal building to analyze, measure, and score environmental damage were compared. Certifications handled in the study are LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), CASBEE (Comprehensive Assessment for Building Environmental Efficiency), SBTool (Sustainable Building Tool), ACA (Airport Carbon Accreditation) and Green Airport and Green Company certificates. As a result, this research gathered the most widely used certificates in the literature. In addition, the Green Airport and Green Company certificate, the first green airport certificate in Turkiye, was added to the study for comparison, which has been offered just for airports. Hong Kong International Airport's sustainability report was examined to determine how many points it would have received if it had applied for the most widely used LEED, BREEAM, and Green Airport and Green Company Certificates regarding the reported activities. The results have shown that the energy and atmosphere category is vital for all certification systems. Also, the study reveals that LEED gets 89.09 over 100 points, BREEAM 93.1 over 100 points, and Green Airport 75 over 100 points which display BREEAM to get a higher environmental response. This study aims to guide green building practices to decision-makers, which has become necessary in many countries. Employees and managers want to know the quality and quantity of sustainable tasks or planning at airports.

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Green building rating systems; Airports; Airport terminals; green building certification; sustainability; sustainability applications

1. Introduction

The concepts of sustainability and sustainable development have relevance in scientific research about environmental issues, policies linked to environmental management, and industrial and agricultural production (Ruggerio 2021). Resource use and emissions resulting from population and economic growth have amplified the burden on the environment (Hermundsdottir and Aspelund 2021). It is related to the fact that this situation becomes riskier every day, the unconscious consumption of the natural resources we have with the idea that they will never run out and will not diminish, and the practice of compensating for this is insufficient. Also, ignorance of sustainability issues in any organization leads to substantial financial losses and market reputation (Jamwal et al. 2021). Some factors motivate industries to take sustainable measures. Certification verifies the accomplishment of green goals and can be a valuable marketing tool for owners and design-construction teams through the process of developing a sustainable building (Florez-Perez 2019).

Studies on sustainability often lead us to the report titled "Our Common Future," published by the United Nations and written by the Brundtland Commission. According to Choy, the definition of sustainability is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" the publication "Our Common Future," published by the Brundtland Commission in 1987, influenced development ideas uniquely (2015). The concept of sustainability has been defined as "reducing the impacts by the aviation" in terms of the boundaries of the subject. Industries are now looking for the adoption of new technologies which can fulfill the sustainability requirements (Jamwal et al. 2021). Since the aviation industry is one of the leading industries in the use of technology, various studies are carried out to meet these requirements in the planning, design, and operation stages of the airport's construction. According to Ferrulli (2016), designing an airport means evaluating the factors limiting the traffic capacity at the airport and their effects on the environment at different scales and making analyses and evaluations at many levels in line with this purpose. This analysis and evaluation methods have been put forward by various countries and organizations worldwide. Using tools to evaluate the sustainability of buildings throughout their life cycle represents a pivotal point enabling the transition toward a sustainable built environment (Gonzalo, Jorge-Ortiz, and Bovea 2022). Authorities and organizations initiated the rating systems for green buildings to minimize/optimize the consumption of natural resources and control pollution (Doan et al. 2017). Owners or developers voluntarily submit their

CONTACT Betul Kacar betul.kacar@kapadokya.edu.tr Aviation Management, Cappadocia University, Nevsehir, Turkiye

buildings through a third-party evaluation process to validate the green strategies applied (Sartori et al. 2021). In order to promote the sustainable performance of the building sector, the widespread adoption of sustainable building materials has been considered one of the most promising ways toward this endeavor (Chen et al. 2021). However, no consensus has yet been reached on the optimal procedure for assessing performance so that results can guide decisions toward sustainable building renovations (Jiménez-Pulido, Jiménez-Rivero, and García-Navarro 2021). A green building uses energy and water more efficiently, reduces waste generation and pollution, and minimizes consumption of all other resources to protect the planet without compromising all stakeholders' health, comfort, cost, safety, and satisfaction (Varma and Palaniappan 2019). The criteria that green building rating systems use can vary according to the socio-economic status of each country, organizational cultural characteristics, ownership of sustainable energy resources, and the attitude of managers and employees.

Researchers observe that the green building rating schemes are not homogeneous in terms of main features (Mattoni et al. 2018). These green rating systems vary in scope and complexity but are generally designed to provide guidance, scoring, and potential rewards for using sustainable best practices (Diaz-Sarachaga, Jato-Espino, and Castro-Fresno 2017). In the light of this information, the study aims to guide decision-makers who want to engage in sustainable activities at airports but do not know where to start. In this sense, with the green building rating certificates (LEED, BREEAM, CASBEE, SBTOOL, Green Airport, and Green Company) introduced in detail, decision-makers will be able to decide which certificate is suitable for their businesses. They will be able to predict how many points they can get before applying for one of these certificates. This study will provide a foresight service to the enterprises in the aviation industry, where the competition is quite challenging. Also, it will facilitate the managers in planning, design, and operation in the decision-making stages.

In addition, the unique aspect of the study is to calculate how many points Hong Kong International Airport gets in a selected three certification systems. A building project can be regarded as sustainable only when all the different dimensions of sustainability environmental, economic, social, and cultural are taken into account (Mateus and Bragança 2011). These factors were influential in Hong Kong International Airport's selection for this study. For the study to serve as a guide, the first step was to research literature on "green building rating systems." Then, these certificates are explained chronologically, and certificate enforcement principles are illustrated under each certificate description.

One of the factors limiting the study's outcome is that the exact scores for each of the certificates are different, and some do not have a point calculation system. Due to this limitation of the study, the total scores of the three certificates assumed to be applied by Hong Kong Airport were equalized to compare them more reliably. Also sustainability reports of the airports pulished by a frame of facts and figures, which has been a problem to assess between the criteria of the certifications.

2. Detailed certification appraisals

Six certification systems have been determined to use as green building certificates for airports, which are widely used worldwide. The overlap between the certification systems has been described in terms of scope. The essential differences from each other have been highlighted on a narrow scale.

2.1. BREEAM certification

BREEAM- Building Research Establishment Environmental Assessment Method is the first green building rating system globally, created and operated by BRE (Building Research Establishment) in the United Kingdom. Suzer (2019) study emphasized that BREEAM has a reward system that encourages buildings that reduce the social, economic, and environmental impacts caused by building users through rewards. Like the other certificates discussed, the BREEAM certificate has different variants in many areas. Each of these areas is shown in Figure 1.

2.2. LEED Certification

LEED- Leadership in Energy and Environmental Design, is a green building rating certification program developed by US Green Building Council (USGBC). One of the common features of LEED and similar green building rating systems discussed in this study is to predict the effects of buildings on the environment. To inspect them within the standards they have determined and thus raise the awareness of the individuals, the public, and the municipalities in charge of the buildings (Greer et al. 2019). LEED Certification was first released in 1993 as LEED 1.0. This certificate had visions such as protecting structures in areas with designated infrastructure and foundations, protecting agricultural areas, and protecting wildlife ("LEED Rating System" 2021). It is the most well-known and adopted system, acceptable in over 165 countries and territories for evaluating sustainable buildings worldwide. (Liu, Chen, and Chou 2019).

LEED is a point-based system, and different green features will earn different points. The standards of the LEED certificate are shown in Figure 2. ("LEED Rating System" 2021).

2.3. SBtool Certification

SBTool- Sustainable Building Tool was established by an international initiative for a sustainable built environment (IISBE). IISBE is an international nonprofit organization whose general aim in international entrepreneurship is to actively complete policy and direction and grow in the right direction to speed up the movement to a sustainable built environment. Known as GBTool- Green Building Tool when it was first released, the certificate is now called SBTool, and it was established in 1998. SBTool is constantly making improvements regarding the

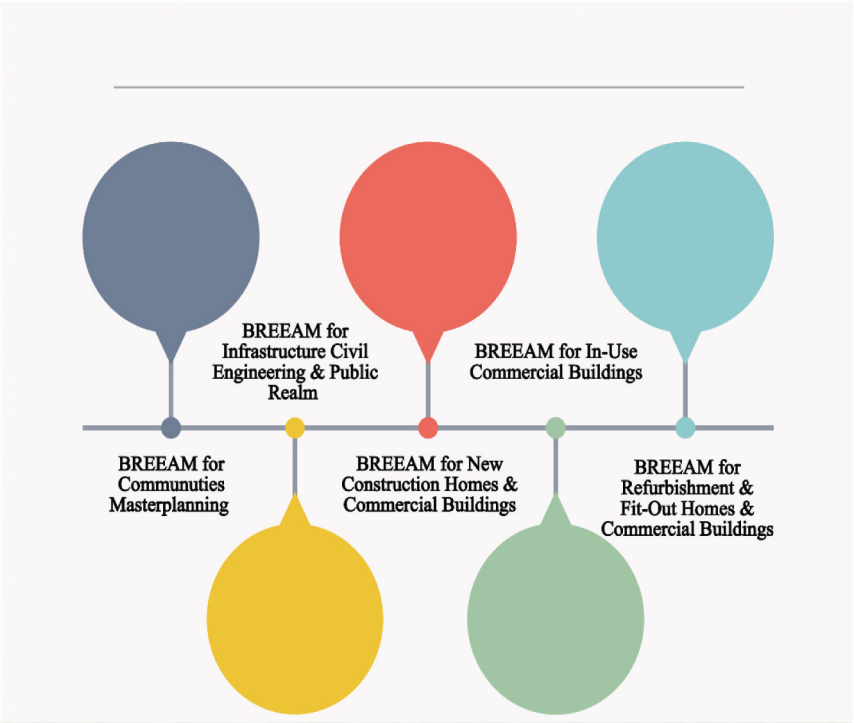

Figure 1. The standards of the BREEAM certificate (Technical Standards 2021).

Figure 2. The standards of the LEED certificate.

evaluation of buildings of all types. Their specific goal is to map out the current activities. They can get information about the Stakeholder-Based Evaluation- SBE and scale-up and the expected standards established and increase SBE awareness amongst international buildings and the construction community. They take action on topics not covered by existing

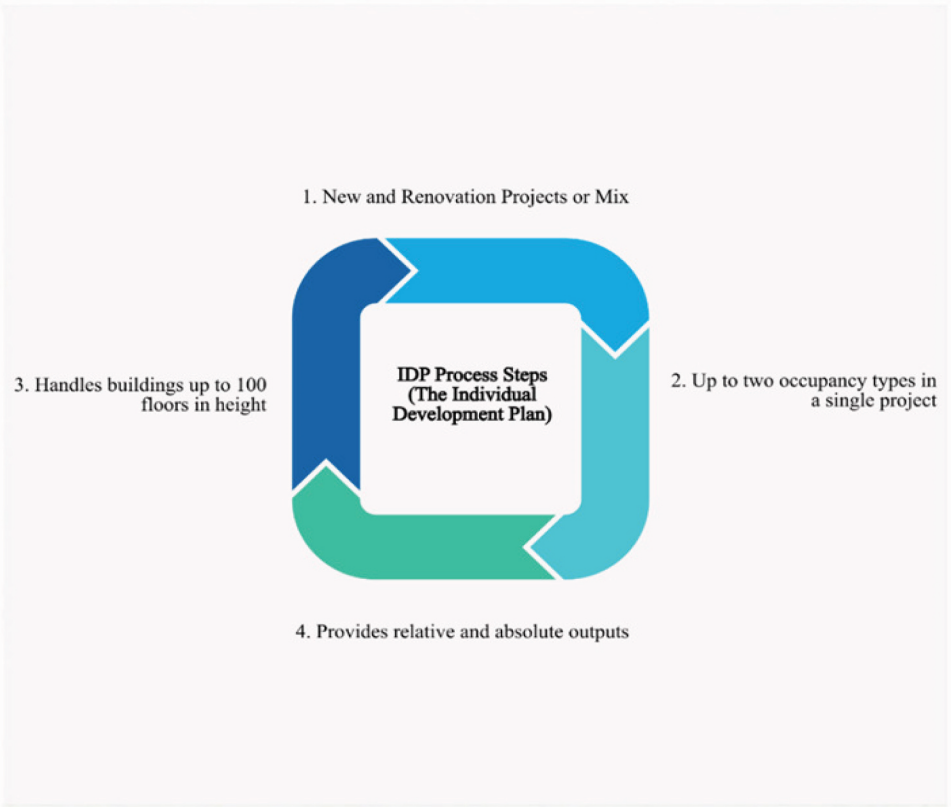

Figure 3. The evaluation process of the SBTool certificate.

organizations and networks. They have active chapter organizations in the Czech Republic, Italy, Spain, Israel, Portugal, Taiwan, Korea, and the IISBE Canada process ("SBTool and SNTool" 2021). SBTool certificate contains the Individual Development Plan (IDP) process. As shown in Figure 3, this plan manages all four main phases. These stages, per the order in the image, are as follows. Includes "New and renovation projects or a mix" in the first place, "Up to two occupancy types in a single project" in second place, "Handles buildings up to 100 floors in height" in third place, and "Provides relative and absolute outputs" in last place (Airports & CO_2 2021).

2.4. CASBEE Certification

The Comprehensive Assessment System for Built Environment Efficiency (CASBEE) Certificate is also used to evaluate the environmental performance of buildings of various types, like the other articles discussed in the article. CASBEE is a rating tool based on the Building Environmental Efficiency (BEE) ("CASBEE" 2021). It is crucial to understand the BEE definition to understand better the use and implementation of the CASBEE Rating System. The Building Environmental Efficiency definition is used by measuring the value of the services and products within various criteria. CASBEE is a method for evaluating and rating the environmental performance of buildings.

In the CASBEE rating system, we first encounter two significant factors. The first of the factors is the "Built Environment Quality," denoted by "Q." It represents the living amenities for the users of the related building. The second factor is "The Built Environment Load," denoted by "L." Negative aspects of the environmental effects of the building are shown by expression. There are specific criteria for Q and L (Please see Figure 4).

The assessment components of the CASBEE are:

- Q-Quality (Built Environment Quality): It evaluates the interior of buildings for building users.
- L-Load (Built Environment Load): It evaluates the outside of the building.
- The easily understandable form of the formula is given in Eq. (1); (Visa et. al 2020)

$$BEE = \frac{Q}{L} \tag{1}$$

CASBEE has a "main sheet" that includes the first inputs such as building name, number of floors, building type, and $LCCO_2$ calculation during the assessment phase. The Assessment Results Sheet shows the Q (Environmental Quality of the building), L (Environmental Load Reduction of the building), BEE (Built Environment Efficiency), and $LCCO_2$ emission rates ("Contributes to the stability" 2021). It is possible to attain these results in graphics and numerical formats in the ultimate form.

2.5. ACA Certification

Airport Carbon Accreditation Program (ACA) is a global carbon management program for airports. The Airport Carbon Accreditation program launched in 2009 by Airports Council International (ACI) Europe aims to reduce airport carbon

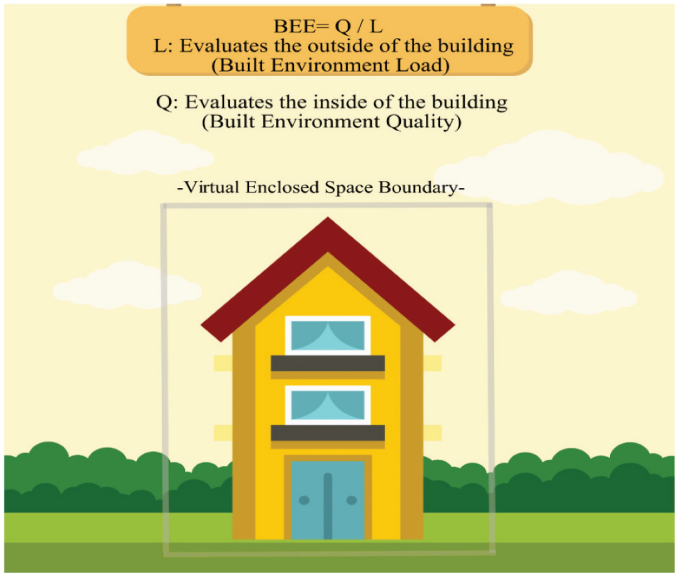

Figure 4. The basic principle of the CASBEE certificate (modified from CASBEE website.).

emissions and, ultimately, neutralize their carbon footprint (Postorino and Mantecchini 2014). It independently evaluates and recognizes managing airports' efforts to reduce CO_2 emissions (Airports & CO_2 2021). The ACA program is administered by the (ACI), the global association of airport operators.

The program can be implemented for all airports of any size. The program comprises six levels, as shown in Figure 5. Airports can choose to participate in the program at any level, provided they meet the entry requirements. The ACA program includes measuring and managing an airport's environmental impact. The goal is carbon neutrality or net-zero emissions (Airport Carbon Accreditation 2021).

2.6. Green Airport and Green Company Certification

Efforts have been started by the General Directorate of Civil Aviation (GDCA), an authority in aviation in Turkey. To reduce and, if possible, eliminate the harm organizations operating in airports cause to the environment and human health. The Turkish Standards Institute and GDCA conducted a joint study in this context. Businesses that meet the specified requirements are granted a "Green Company Certificate" by GDCA. "Green Airport certificate" will be issued to that airport if all businesses in an airport receive a "Green Company Certificate." The basic principle of the Green Airport and Green Company certificate is shown in Figure 6.

During the negotiations with the GDCA administration, it was concluded that the certification project ended this year and that several studies would be introduced in the coming years to cover all airports in Turkey. Regardless of the current existence of the certificate, the certificate has some good details on behalf of Turkish Civil Aviation. According to the GDCA Service tariff, there is a 20% discount on the extension fees of the authorization certificates, licenses, and certificates that it will pay. Suppose Airport Operators and other service providers at airports meet all requirements. In that case, the airport is given the title "Green Airport" by GDCA, and all institutions and

Figure 5. The levels of the ACA certificate.

Figure 6. The basic principle of the Green Airport and Green Company certificate.

organizations that meet the requirements receive a 50% discount on the fees for permits issued by GDCA (Green Airport Project 2021).

3. Method

The certificates, which are generally introduced in the introduction section chronologically, are examined in Table 1 based on some distinguishing features such as the country of origin, the information by how many countries they are used, criteria and standards, and scoring systems. By presenting each certificate's qualitative and quantitative features in a single table simultaneously, it is desired to provide users with the opportunity to make a clearer and more understandable comparison.

According to Table 1, one of the most remarkable data shared in the table is the substance of the ACA certificate, which has been included in the "Energy and Atmosphere" category. Although the "Energy and Atmosphere" category is among the criteria of each certificate and has similar characteristics, the "Compensation for residual emissions with reliable offsets" contained in the ACA certificate is not a criterion found in other certificates. It is, therefore, stated explicitly in Table 1. This factor, which can be explained as calculating and reducing the emissions caused by devices used to reduce the number of emissions, is a critical factor that increases the quality of the service to issue green building certificates. Turkey's "Green Airport and Green Company" certificate also has the "Pollution & Anti-icing" criteria, which other certificates do not. Studies conducted to calculate and reduce the effects of the anti-icing components, which are often used in aircraft, both add authenticity to the certificate and provide a different angle to the impurities caused.

LEED and BREEAM are the two most widely used certificates in this study. Green Airport and Green Company certificates were compared with some standard criteria. More quantitative comparison was made by calculating their scores. In order to compare and equalize the weights between categories, three mentioned certificates with similar content were aligned. Then the weight of each certification's total score was calculated. The categories associated with this context are:

- Category "Integrative Process" from LEED certificate; Category "Governance" from BREEAM certificate, and Category "General Considerations" from Green Airport and Green Company
- Category "Materials and Resources" from LEED certificate; Category "Resource and Energy" from BREEAM certificate, and Category "Fuel Management and Management of De-icing/Anti-icing Activities" from Green Airport and Green Company
- Category "Energy and Atmosphere" from LEED certificate; Category "Land Use and Ecology" from BREEAM certificate and "Waste Water, Dangerous Goods and Mixtures, Air Pollution Management" from Green Airport and Green Company

Table 1. The comparison of 6 Green Rating Systems in the world.

Evaluation System	CASBEE	SBTool	LEED	BREEAM	Green Airport and Green Company	ACA Carbon Accreditation
Country	Japan	Canada	USA	UK	Turkey	Brussels, Belgium
Organizations	IBEC	IISBE	USGBC	BRE	GDCA	ACI EUROPE
Flexibility	1 Country	9 Country	167 countries	89 countries	1 Country	46 Country
First Version	2004	1998	1993	1990	2013	2009
Latest Version	2016	2020	2016	2018	-	2019
Main Categories						
Location and Transportation			✓	✓		
Sustainable Sites	✓	✓	✓	✓		✓ * Footprint Measurement
Energy and Atmosphere	✓	✓	✓	✓ * CO_2 Emissions	✓	✓ * Compensation for residual emissions with reliable offsets
Materials and Resources	✓	✓	✓	✓	✓ * Waste & Fuel	
Indoor Environmental Quality	✓	✓	✓			
Health and Wellbeing				✓		
Innovation in Design			✓	✓		
Water Efficiency		✓	✓	✓ * Surface Water Runoff	✓ * Wastewater	
All other evaluation categories		Service Quality		✓ * Waste & Pollution	✓ * Pollution & Anti-icing	✓ * Carbon management
Noise		✓			✓	
Awareness and Education		✓	✓		✓	✓
Regional Priority		✓	✓			
Ensuring Company Regulations and Updates			✓	✓	✓	✓
Rating approach			Additive credits	Pre-weighted categories	Assessment	
Certificate Levels	C (poor), class B-, class B+, class A, and class S (excellent)	Bronze quality 40–60% Silver quality 60–80% Gold quality over 80%	Certified : 40 to 49 pt. Silver : 50 to 59 pt. Gold : 60 to 79 pt. Platinum : 80 to 110 pt.	Acceptable :★ Pass:★★ Good:★★★ Very Good:★★★★ Excellent:★★★★★ Outstanding:★★★★★★	Putting together the necessary documents to issue a certificate.	Level1: Mapping Level2: Reduction Level3: Optimization Level4: Neutrality Level5: Transformation Level6: Transition
Issued certifications	+540	Information not available	96.275* * : Buildings	2.313.475* * : Buildings	113* *: Air companies	Over 500 Airports

Table 2. The main categories and scores of the Green Airport and Green Company certificate.

Green Airport and Green Company	
Categories	Scores
Waste Water Management	11.11
Management of De-icing/Anti-icing Activities	11.11
Waste Management	11.11
Management of Dangerous Substances and Mixtures	11.11
Air Pollution Management	11.11
Management of Fuels	11.11
Staff Education	11.11
Environmental Noise Management	11.11
Other Evaluation Criteria	11.11
Total	100

Table 3. The main categories and scores of the BREEAM certificate.

BREEAM	
Categories	Scores
Governance	9.30
Social and Economic Wellbeing	42.7
Resource and Energy	21.6
Land Use and Ecology	12.6
Transport and Movement	13.8
Total	100

Table 4. The main categories and scores of the LEED certificate.

LEED	
Categories	Scores
Integrative Processes	1
Location and Transportation	18
Water Efficiency	12
Energy and Atmosphere	38
Materials and Resources	14
Indoor Environmental Quality	17
Innovation	6
Regional Priority	4
Total	110

- Category "Indoor Environmental Quality" from LEED certificate, Category "Social and Economic Wellbeing" from BREEAM certificate, and Category "Environmental Noise Management" from Green Airport and Green Company

In the next stage, a simple mathematical method was preferred when performing the calculation. Accordingly, the total score is 100 in BREEAM and 110 in LEED. In order to make an accurate comparison, it was preferred to give each score with a percentage account. The criteria and scores of BREEAM and LEED certificates are shown in Tables 3 and Table 4. The weight values of BREEAM certificate categories are not included in the calculation since they are already given at the base of 100. The simple mathematical method used to calculate the Integrative Process Category's Weight of LEED is to write the fraction 1/110 in the denominator 100. As a result of the transaction, the value found for the Integrative Process Category's Weight was 0.90/100. When the same calculation was made for the Materials and Resources Category of LEED, a value of 12.72/100 was found. The same method found 34.54/100 for the Energy and Atmosphere category and 15.45/100 for the Indoor Environmental Quality category.

The criteria scores of the Green Airport and Green Company certificate are not determined by the DGCA, the decision-making body, and the certificate is given according to whether the requirements are fulfilled. In light of this information, to make an accurate and consistent comparison with LEED and BREEAM, all Green Airport and Green Company certificate criteria are aimed to be scored based on 100 points, just like other certificates. For this purpose, each criterion of the Green Airport and Green Company certificate, which has nine criteria, was considered equal and evaluated as 11.11 points by dividing 100 by 9 (Please see Table 2).

The weight of the "Integrative Process" category selected from these categories in the total scoring of the LEED certificate was calculated, and the 0.90-index value was found. This category corresponds to "Governance" in the BREEAM certificate. The index value was already given at 9.30 points. In the calculation made for the "General Considerations" criterion of the Green Airport and Green Company certificate, the score was 11.11 points. The weight of the "Materials and Resources" category is selected from these categories. The total scoring of the LEED certificate was calculated and found as 12.72 points. In the same calculation made for this category, which corresponds to "Resource and Energy" in the BREEAM certificate, the index value was 21.6 points. In the calculation made for the "Fuel Management and Management of De-icing/Anti-icing activities" criterion of the Green Airport and Green Company certificate, the score was 11.11 points.

The weight of the "Energy and Atmosphere" category selected from these categories in the total scoring of the LEED certificate was calculated, and the 34.54-index value was found. In the same calculation made for this category, which corresponds to "Land Use and Ecology" in the BREEAM certificate, the index value was 12.6 points. In the calculation made for the "Waste Water, Dangerous Goods, and Mixtures, Air Pollution Management" criterion of the Green Airport and Green Company certificate, the score was 11.11 points. The weight of the "Indoor Environmental Quality" category selected from these categories in the total scoring of the LEED certificate was calculated, and the 15.45-index value was found. In the same calculation made for this category, which corresponds to "Social and Economic Wellbeing" in the BREEAM certificate, the index value was already given at 42.17. In the calculation made for the "Environmental Effects" criterion of the Green Airport and Green Company certificate, the score was 11.11. Table 5 shows the values of each criterion, selected as typical in all three certificates and calculated to equal 100 points in total.

4. An airport simulation estimation

This part of the study was completed based on the sustainability report published on the Hong Kong Airport website. According to Li and Loo (2016), Hong Kong Airport was relocated from Kai Tak Airport to Chek Lap Kok Airport to increase its capacity, mitigate noise pollution around the old

Table 5. The common categories and scores of 3 certificates.

Certificates	Green Airport and Green Company	LEED	BREEAM
Common Criteria			
Process Related Procedures	General Considerations	Integrative Process	Governance
Score	11.11	0.90	9.30
Energy and Resources Usage	Fuel Management and Management of De-icing/Anti-icing Activities	Materials and Resources	Resource and Energy
Score	11.11	12.72	21.6
Resource Use and Environment	Waste Water, Dangerous Goods and Mixtures, Air Pollution Management	Energy and Atmosphere	Land Use and Ecology
Score	11.11	34.54	12.6
Environmental Effects	Environmental Noise Management	Indoor Environmental Quality	Social and Economic Wellbeing
Score	11.11	15.45	42.17

airport, create job opportunities, and promote land development. In this way, the airport contributed to sustainability. In the article, Lam talks about Hong Kong Airport's strategies to deal with waste management and says that by 2021, the total waste generation at the terminal could reach a recycling rate of 50% (Lam et al. 2018).

The selected airport's 2020–2021 sustainability report has been examined in detail. With the explanation of the notes taken from here, different sustainability practices that they can apply at airports are presented to the readers. Then, an answer was sought as to how many points the selected airport would have received if it had applied for the LEED and BREEAM certificates, which are widely used globally, and the Green Airport and Green Company certificates. In the next part of the study, the scoring systems of these three certificates were compared to each other so that the comparison could give more accurate results.

4.1. Three Green Airport certification application on Hong Kong International Airport

4.1.1. LEED certificate's criteria

The points that Hong Kong International Airport will obtain if it applies for the LEED Certificate are shown in Table 6. The "Integrative Process" credit supports integration in the early design phase, where the homeowner can achieve their sustainability goals and needs. In this context, AAHK-Airport Authority Hong Kong addresses sustainability issues and improves Hong Kong International Airport (HKIA)'s overall sustainability performance through engagement with its stakeholders and collaboration with airport business partners. We can assume that the airport will get 1 point from the first category of LEED Certificate.

Various studies have been carried out to ensure that passengers and employees at the airport can benefit from more comfortable transportation services based on the project's location. These studies are as follows:

- 3 Runway systems to meet long-term traffic needs,
- New land-use opportunities that leverage Hong Kong International Airport's geographical advantage and proximity to the Hong Kong-Zhuhai-Macao Bridge,
- They were capitalizing on the growth potential of the Greater Bay Area and expanding their catchment area ("Hong Kong International Airport 2021).

In the light of the information given, we can assume that the airport will also get 18 points from the "Location and Transportation" category of the LEED certificate. According to the information obtained from the sustainability report, the airport stated that it did not carry out any specific studies on water efficiency but still participated in various studies related to water conservation. In this case, it will not be able to get points from the "Water Efficiency" category of the relevant certificate. In 2020/21, they organized the Carbon Reduction Award Scheme, biannual technical working group meetings, and sector-based benchmarking initiatives as part of an airport-wide carbon reduction program ("Hong Kong Report" 2021, page 130). They are devising a carbon reduction goal for 2035. This long-term target will reduce emissions in absolute terms and align with the Hong Kong Government's 2050 carbon neutrality goal. They promoted other environmental initiatives in 2020/21. For example, they extended the Smart-to-Charge electric vehicle recharging system to the airfield ("Hong Kong Report" 2021, page 28). After these activities, we can say that the airport will receive 38 points in the "Energy and Atmosphere" category. There are policies regarding the efficient and effective use of energy, water, and other raw materials at the Hong Kong Airport. They launched a five-day safety awareness program in August 2020. Under these circumstances, we can assume that Hong Kong Airport will receive 14 points.

The airport declares that low-emission materials and technical tools are used to improve indoor air quality and enable employees to work in a more productive atmosphere. This approach shows that the airport can get 17 points from the relevant category of the LEED certificate. In April 2020, they

Table 6. Compliance of Hong Kong Airport with LEED certification criteria.

LEED		Hong Kong Airport's Status	Predicted Score
Categories	Scores	Yes or No	
Integrative Processes	1	Yes	1
Location and Transportation	18	Yes	18
Water Efficiency	12	No	0
Energy and Atmosphere	38	Yes	38
Materials and Resources	14	Yes	14
Indoor Environmental Quality	17	Yes	17
Innovation	6	Yes	6
Regional Priority	4	Yes	4
Total	110		98

launched the 5 G service at the Check-in Hall, Meeters and Greeters Hall, and Baggage Reclaim Hall. In addition to deploying different autonomous cleaning robots to make cleaning and disinfection a more efficient and productive operation, they have also applied automation and robotic solutions in other airport operations. With all these examples, we can predict that the airport will receive 6 points from the Innovation category of LEED. Finally, within the scope of the regional priority category, the airport carried out various activities to develop regional civil aviation. They also organized virtual job fairs and webinars to promote job opportunities and careers in the aviation industry and attract recruits.

The airport can get 4 points from the category related to these studies. As a result of matching the information provided by the airport and the LEED certificate, we can predict that the airport will receive an average of 98/110 points if it applies to the LEED certificate. This rating is based on the available information of the LEED certification and the sustainability report provided by the airport and is an estimate only. The total points that LEED Certified buildings can earn can be 110 points. In addition, buildings that achieve more than 80 points are eligible for LEED Platinum status. There is four certification status for LEED Certificate. "Certified" status for buildings that can collect 40–49 points; "Silver" status for buildings that reach 50–59 points; Buildings with a score between 60 and 79 are given the "Gold" status, and finally, buildings with a score above 80 are eligible for the "Platinum" status. As a result, we can say that if Hong Kong Airport applies for the LEED certificate with its current studies, it will deserve the Platinum LEED certificate.

4.1.2. BREEAM certificate's criteria

The points that Hong Kong International Airport will obtain if it applies for the BREEAM Certificate are shown in Table 7. Since it is known that the BREEAM certificate's Governance category is similar in content to the LEED certificate's Integrative Process category, explaining the airport's work on this issue will reduce the work repetition. The interpretation we can make here is that if the airport applies for a BREEAM certificate, it will get 9.30 points in this category.

In August 2020, a virtual "Wellness Weeks" campaign was held to encourage Hong Kong Airport staff to maintain a healthy lifestyle ("Hong Kong Report" 2021, page 74). They continued developing their talent during the year and preparing for future challenges. They completed a 12-month leadership development program for high-potential middle managers in July 2020. These studies prove that the airport will get 42.7 points from BREEAM's "Social and Economic Wellbeing" category. The government has adopted a waste-to-resources recycling strategy to support a circular economic model. Hong Kong Airport also made some Artificial reef (AR) deployment pilot tests. About 100 artificial reef units were deployed in waters to the west of Hong Kong International Airport's South Runway in June and July 2021 ("Hong Kong Report" 2021, page 61). With all these efficient efforts to use resources, the Hong Kong airport can get 21.6 points in the "Resource and Energy" category. They also recognize their responsibility to avoid and minimize adverse impacts on ecology and biodiversity relating to the operation and development of Hong Kong Airport. They also have to ensure that their activities do not harm the essential ecological assets on or near Hong Kong International Airport. We can say that Hong Kong airport can get 12.6 points from the "Land Use and Ecology" category with all these efficient efforts to protect ecology and to use land logically. BREEAM's "Transport and Movement" categories are similar to LEED's "Location and Transportation" category. In the light of this information, we can say that the airport will get half of the total score in this category, namely 6.3 points. As a result of matching the information provided by the airport and the BREEAM certificate, we can predict that the airport will receive an average of 93/100 points if it applies to the BREEAM certificate.

Table 7. Compliance of Hong Kong Airport with BREEAM certification criteria.

BREEAM		Hong Kong Airport's Status	Predicted Score
Categories	Scores	Yes or No	
Governance	9.30	✓	9.30
Social and Economic Wellbeing	42.7	✓	42.7
Resource and Energy	21.6	✓	21.6
Land Use and Ecology	12.6	✓	12.6
Transport and Movement	13.8	✓	6.9
Total	100		93.1

4.1.3. Green Airport and Green Company certificate's criteria

The points that Hong Kong International Airport will obtain if it applies for the Green Airport and Green Company Certificate are shown in Table 8. Since it is known that the "General Considerations" category is similar in content to the BREEAM certificate's Governance category and LEED certificate's Integrative Process category, explaining the airport's work on this issue will reduce the work repetition. The interpretation we can make here is that if the airport applies for Green Airport and Green Company certificates, it will get 12.5 points in this category.

Table 8. The current compliance of Hong Kong Airport with Green Airport and Green Company certification criteria.

Green Airport and Green Company		Hong Kong Airport's Status	Predicted Score
Categories	Scores	Yes or No	
General Considerations	12.5	✓	12.5
Waste Water Management	12.5		0
Waste Management	12.5	✓	12.5
Management of Dangerous Substances and Mixtures	12.5		0
Air Pollution Management	12.5	✓	12.5
Management of Fuels	12.5	✓	12.5
Staff Education	12.5	✓	12.5
Environmental Noise Management	12.5		0
Other Evaluation Criterias; -Innovation -Updates about innovations	12.5 (Each subcriteria is 12.5/2 points)		12.5
Total	100		75

The airport does not have a current study on the "Waste Water Management" category, so it will not receive points from the "Waste Water Management" category of the Green Airport and Green Company certificate ("Hong Kong Report" 2021, page 58). According to the information from the sustainability report of Hong Kong Airport, "Management of De-icing /Anti-icing Activities" does not apply to Hong Kong Airport. De-icing/anti-icing is not required due to the climate of Hong Kong Airport's geographic location. Therefore, this criterion was not included in the evaluation. At Hong Kong Airport, practices such as making a "Digitalized Baggage Containerization Report" are carried out concerning digitalization ("Hong Kong Report" 2021, page 42). This reporting helps staff store papers in digital media with tablets without having to fill in the papers one by one manually. Up to 500,000 pieces of paper could be saved per year.

As a result of the study, the airport will get 12.5 points from the "Waste Management" category of the Green Airport and Green Company certificate. Since the airport has no activity in the "Management of Dangerous Substances and Mixtures" category, the score it will get is calculated as 0. As per Green Airport Design and Construction Strategy, design consultants must identify the opportunities for environmental efficiencies at the scheme design stage for eligible projects. Considerations related to associated life cycle benefits may improve energy efficiency and minimize air pollutants also carbon emissions. With these data taken into account during the design phase, the airport's "Air Pollution Management" category score will be 12.5. The Airport Authority of Hong Kong is supportive of the use of Sustainable Aviation Fuels and maintains a watching brief on the sector. The Airport Authority of Hong Kong will work with airlines seeking to use Sustainable Aviation Fuels to enable uptake. The score airport will get from the "Management of Fuels" criteria will be 12.5 points ("Hong Kong Report" 2021, page 50). In March 2021, they published their eight-sustainability report, which features interviews with airport staff that explain how sustainability is a part of everyday work at Hong Kong Airport. The report was prepared per the GRI-Global Reporting Initiative's standards.

The earned point that the airport, which attaches great importance to the training of its personnel, will receive from the "Staff Education" criteria again be 12.5. Since the airport has no activity in the "Environmental Noise Management" category, the score it will get is calculated as zero points. The innovative part of this study is to simulate the airport data to explain mentioned certificate. With this information, the airport may receive 12.5/2 points from the innovation title in the sub-criteria of the "other criteria" title. In addition, securing and controlling the innovative works with various company policies shows that the last sub-criteria, "Updates about innovations," is fulfilled. Therefore, it can be said that 12.5/2 points will be obtained from this criterion. Although nine criteria have been determined in this certificate, the "Management of De-icing/Anti-icing Activities" criterion does not comply with Hong Kong Airport due to its geographical and climatic features. Therefore, it is not included in the calculation. Therefore, the calculation was made for Green Airport, and the Green Company certificate had eight criteria as 12.5 points. This value is obtained by dividing the value of 100, which is determined as the total value for the certificates, by 8, the number of criteria. In the light of this information, the current table used to apply the sustainability activities of Hong Kong Airport to the Green Airport and Green Company certificate is as follows. As a result of matching the information provided by the airport and the Green Company & Green Airport certificate, we can predict that the airport will receive an average of 75/100 points if it applies for the Green Airport and Green Company certificate.

5. Results and discussion

In the literature, there are studies of authors who have made various suggestions about sustainability. While most of them focused on areas with negative outputs in the industrial sense, most of them conducted research specific to airports. Dalkiran (2018) indicates the necessary steps for the sustainability of the construction of airports prior to their operation. The author states that the concept of sustainability, which started with the planning phase, will continue with the design phase and that these two phases are critical in the design of an airport. In this study related to sustainability, certificates were examined and mainly included in the literature.

Liu has discussed LEED, BREEAM, GBTool, and EEWH (ecology, energy saving, waste reduction, health), Taiwan's local building rating system (Liu, Chen, and Chou 2019). In his study, Seinre et al. used a method to evaluate five buildings in Estonia with LEED and BREEAM certificates (Seinre, Kurnitski, and Volla 2014). While emphasizing the features of the CASBEE certificate, Shamseldin also compared it with the LEED and BREEAM certificates (Shamseldin, 2016). On the other hand, Ugur examined two buildings in Turkey entitled to receive the Gold and Premium levels of LEED certificates only within the scope of this certificate (Ugur and Leblebici 2018). In general, it was seen that the authors tested the applicability of certificates locally.

The graphic that can be created according to Table 5, in which the criteria calculations are made again by determining the specific titles of the LEED, BREEAM, and Green Airport and Green Company certificates mentioned in the method section, is as in Figure 7. As seen from the graphic, while BREEAM emphasizes environmental impacts and social improvement, LEED gives the highest score in the criterion in which resource use and the environment are integrated. Similarly, the certificate that gives the highest priority to the details of energy and its use is BREEAM. On the other hand, Green Airport and Green Company was the certificate that emphasized the studies and procedures related to the process.

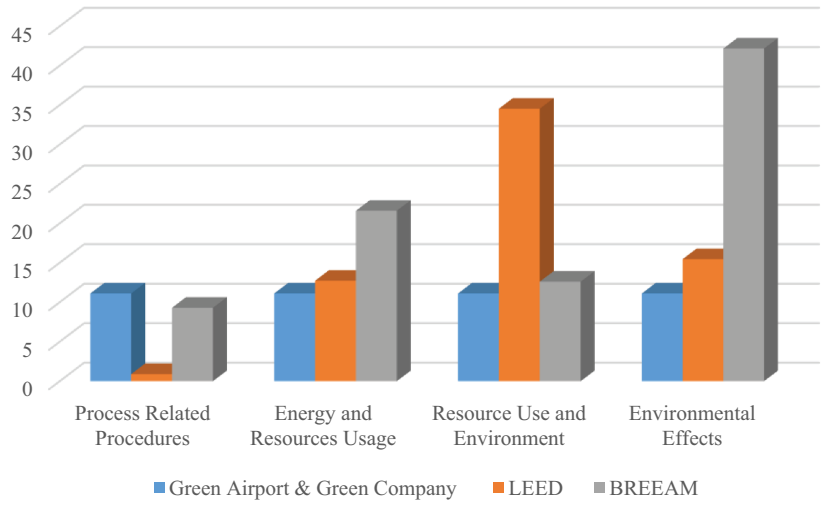

Figure 7. Comparison of weights of the selected categories in the total score of three certificates

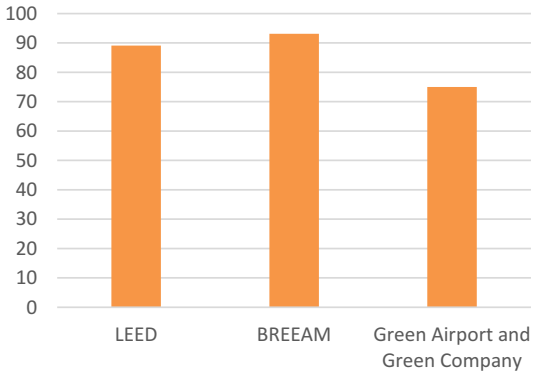

Figure 8. HKIA's points for the 3 default certificates applied.

When applying the certificates to the airport, all applicable criteria were included in the calculation and applied without equalizing the total scores. Accordingly, the Hong Kong International Airport applying for the LEED certificate received a score of 98 out of 110 points. It was concluded that the airport applying for the BREEAM certificate received 93.1 points out of 100 points. The airport applying for the Green Airport and Green Company certificate received 75 out of 100 points. For the reliability of the final comparison to be made, a simple mathematical calculation was used to equate the total score of the LEED certificate with a total score of 110 to 100 points. When this score of Hong Kong International Airport, which gets 98 points out of 110 points, is calculated in the denominator of 100, which is the total score of BREEAM, the airport's score is 89.09/100.

In the light of the results drawn from this, if the airport has applied for three certificates and the total score obtained for these three certificates is 100, the points it will get areas in Figure 8. The comments that can be made by looking at this graph can be as follows: The estimated lowest score from the Green Airport and Green Company certificate may be the lack of fully established criteria scoring. In addition, the fact that the airport receives almost identical scores from BREEAM and LEED certificates can be given as a reason for these certificates to have an intimate understanding of criteria and scoring.

6. Conclusion

Environment, society, and economy are the three pillars of sustainability, and the majority of sustainability rating systems have been developed in line with those pillars (Awadh 2017). For this purpose, a detailed examination of the introduced certificates was made within the framework of these pillars. After a detailed examination of the green building rating certificates, a simple simulation may help decision-makers, managers, and employees. Airports to apply for the certification program can issue a more precise idea. As the transformation of the economies of the developed world toward service industries intensifies, it can be expected that the investments in office and other commercial buildings will grow correspondingly (Junnila 2004).

This study aimed to achieve an approach that has not been done in this area of the literature before. This way aims to add originality to the study and create a guide for certificate users and decision-makers. It is known that sustainability is a subject of academic interest, especially in aviation. For this reason, the practice of "assuming an airport's application for certificates," which is the striking point in this study, can be further developed and applied in different studies. It may be suggested to researchers to strengthen the technical side of the study by conducting

academic studies in this field. What is meant by this is that it is more challenging to do the implementation part manually than with the help of a computer. Therefore, researchers can achieve more efficient results in comparing certificates they will carry to an electronic environment and calculating how many points a building will get if it applies for a certificate.

Nomenclature

BRE	Building Research Establishment
SBE	Stakeholder-Based Evaluation
Q	Quality
L	Load
GRI	Global Reporting Initiative
GDCA	General Directorate of Civil Aviation
IDP	Individual Development Plan
AAHK	Airport Authority Hong Kong
ACA	Airport Carbon Accreditation Program
ACI	Airports Council International
AR	Artificial Reef
BEE	Building Environmental Efficiency
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
EA	Energy & Atmosphere
HGBTool	Green Building Tool
HKIA	Hong Kong International Airport
IDP	The Individual Development Plan
IEQ	Indoor Environment Quality
IISBE	International Initiative for a Sustainable Built Environment
$LCCO_2$	Life Cycle Carbon Dioxide
LEED	Leadership in Energy and Environmental Design
RE	Resource & Energy
RP	Regional Priority
SBTool	Sustainable Building Tool
USGBC	US Green Building Council

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