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SUSTAINABLE DESIGN FOR THE FUTURE: A COMPARATIVE STUDY OF GREEN BUILDING CERTIFICATION CRITERIA

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Abstract. This article examines reflections in architecture, a universal concept of sustainability. Mankind has been consumer-oriented for a very long time and as a result, it has started to face certain crises. Depletion of limited resources, climate change and mountains of non-recyclable waste are the main problems. The interest in the concept of sustainability has increased as a result of people's awareness of the problems listed. Therefore, lots of different disciplines interact with this approach. One of the branches with which it interacts is design. The materials, fittings and alternative methods used in design provide complementary contributions to architecture. At this point, the concept of sustainable design, which defines approaches that focus on the search for solutions to environmental problems, is a model that is sensitive to the environment and improves the quality of the living space. This paper presents a traditional topic discussing the problem of building that are consumer-oriented which leads to different environment crisis. Thus, the study encourages the application of sustainability in building through conserving energy, preserving water, using sustainable materials and creating interior space quality. This article comparatively evaluates the concept of sustainable design in existing green building certificates. Green building certificates and criteria were scanned to see the place of the concept of sustainable design in green international framework. Green building certificates have been selected from countries that can be considered pioneers in different parts of the world. In the score distribution observed in the table, the first four criteria have been identified and they are listed as follows: Energy, Water, Material and Interior environmental quality. A field study was carried out in which suggestions were developed taking these criteria into consideration and recommendations were made within this scope. Case study area Amsterdam Nature and Environment Learning Center (NME) is undocumented but with eco-friendly potential was chosen to see how information from documentation and examples could be used.

Keywords: *Energy conservation, green building certificates, interior environmental quality, international sustainable standards, preserving water, sustainability design.*

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1. Introduction

After meeting the physiological needs necessary for human survival, the need to feel safe comes second (Maslow, 1943). The need for shelter, which forms the basis of the need to feel safe, is one of the biggest factors in the development of architecture and interior architecture. Throughout history, individuals have produced places to shelter themselves and designed the interior space in line with their needs. Although there are many factors affecting the design of the living space, living in a space enabling healthy conditions is the most fundamental right of individuals. For this reason, the concept of

sustainability of the habitable environment is highly studied. Although sustainability is perceived as bringing some restrictions, creativity is increased and future generations are enabled to be led as environmentally friendly designers.

Global problems such as climate crisis, waste problems and resource depletion are growing day by day, jeopardizing the lives of future generations. As Yeang stated at the SASBE conference in Delft, sustainable design needs to become a standard in our lives and architects and designers have a great responsibility here (Yeang & Lehmann, 2009).

The word "sustainability" is heard in many different fields today. The global ecosystem is something for which we all share the responsibility of protecting. Choices like resource efficiency in design, reducing energy and use of local material use support these concepts. Sustainable cities, sustainable architecture and interior design are specialised fields that aim to create a healthy urban environment. The right location decisions, resource efficiency in design, reducing energy use and the use of local materials support this concept (Han, 2023).

The concept of energy has a great experience in different disciplines and architecture is one of these disciplines. One of the most prominent factors in sustainable buildings is energy and all the other factors are linked to energy. The choice of material used in the design depends on the preference of the designer, architect and interior designer. The designer should make this choice not according to their individual wishes but in accordance with the physical conditions of the design. It should not be forgotten that buildings are designed as permanent products. For this reason, material plays an important role in determining the life of this structure (Bulhaz, 2020).

According to the research, it has been determined that green buildings increase the productivity of the users. The factors that are important for indoor quality in certificate programs can be listed as follows: thermal comfort, indoor air quality, lighting and daylighting, visual quality and acoustic performance. Looking at the general principles, it can be said that the grading is mostly based on mechanical aspects (Horr *et al*., 2016).

A value of sustainable design is that all building systems are integrative in the economic, social and environmental spheres. It is about reducing energy waste while recognizing how this contributes to other contexts (Mersal, 2021). Reducing the energy needs of buildings is part of this awareness. The right choice of materials and design criteria increase energy efficiency in buildings. Choosing low-energy materials does not mean compromising the durability or performance of buildings. On the contrary such material choices contribute to sustainable development and increase the energy efficiency of buildings (Güner *et al*., 2017). Moreover, when the 2030 targets are considered, sustainable structures are seen as fundamentally important for a clean future, addressing the critical issues of today (Goubran *et al*., 2023). Energy is recognized as a prominent factor for sustainability; however, when sustainability in design is considered, it cannot be discussed as pertaining to just one factor. In connection with the emergence of the concept, sustainability is a whole with other factors (water, materials, interior design). Since its relationship with design is also multifaceted, it does not seem right to emphasize only one criterion. For this reason, the hypothesis of the study is constructed as "the concept of sustainable design is a holistic concept and establishes its relationship with design through energy, water, material and interior space".

As discussed in the hypothesis, sustainability is a holistic approach. Reducing energy and water use should continue not only during the construction phase but also during the periods when the building interacts with the user. For this reason, the designs and mechanical solutions made in the interior spaces, which are the user's living space,

are directly related to energy, water and material criteria. In addition, although the quality of the interior space is mostly handled under mechanical solutions, the user's perception of beauty should not be discarded.

A comprehensive analysis of globally registered certificates, bringing together key requirements and providing detailed information. Building on these findings, proposals were developed on how non-certified buildings can be registered for green certifications. The significance of these certificates in maintaining ecological balance is aimed to be emphasized and the requirements are intended to be made more accessible through architectural design. Through a case study, aim to demonstrate how these requirements can be seamlessly integrated.

In the research, Sustainable design certificate programs that have developed principles for sustainable design from different regions of the world were examined. Among the listed criteria, the first four common criteria of each certificate were analyzed and brought together in a table. In addition to commonalities and differences, it was found that energy, water, material and indoor quality criteria have an important place in the certificates. For this reason, three certificates with these four principles in the top four criteria were selected. High scoring examples of the selected certificates were selected. While selecting the examples, it was not considered as a criterion such as having the same function, but it was important that they had high scores. The aim here is to observe how the high score and the reflection of the same first four criteria are constructed on real buildings.

2. Method and Materials

In this study, the relationship between architecture and design sustainability is mentioned. It is aimed to determine what factors that make a space sustainable are within the scope of international standards. For this purpose, the study was designed in a structure descending from general to specific and the concept of sustainability was examined by looking at previous academic studies. Afterward, the sub-headings of the concept were examined and its effects on architectural and interior design scales were investigated.

Green building certificates and criteria were scanned to see the place of the concept of sustainable design in the international framework. Green building certificates have been selected from countries that can be considered pioneers in different parts of the world. Care was taken to select countries from different continents, especially Europe, America, Australia and Asia. These certification systems are listed by year of release. Then, a table was created showing the criteria and their score distributions. In the score distribution observed in the table, the first four common criteria have been identified and they are listed as follows: Energy, Water, Material and Interior environmental quality.

As a result of the examination of the selected certificates, LEED, Green Star and GRIHA certification systems with the same first four criteria were selected. High-score examples of three selected certificate programs were examined. Samples were analyzed and interpreted according to four selected criteria. The material and internal quality criteria observed in the samples are closely related to the energy and water criteria. In addition, it can be said that a relationship with sustainability is established in architecture through materials and interior space.

An existing structure that is undocumented but with eco-friendly potential was chosen to see how information from documentation and examples could be used. The

characteristics of the sample building, the company that designed the building and its architecture were researched through magazines. In the light of the information obtained, the structure was examined and interpreted on the four criteria observed from the certificate programs. If a certificate program were to be applied, what suggestions could be offered were considered and some approaches were developed. An estimated score was made at the end of all this compiled information. Along with these recommendations, it is envisaged that if three selected green building certificates were applied, the certificate degrees that could be obtained on average.

3. Sustainable Design

Problems have been brought about by developing technologies from the industrial revolution to the present. A growing desire for solutions to the problems likely to be faced in the future is being observed (Wang, 2021). Global warming, uncontrolled consumption of natural resources, declining biodiversity, air pollution and the disappearance of natural habitats such as forests are some of today's current problems (Aytis & Polatkan, 2010). The search for solutions to these problems, which started in the recent past, has led to the concept of sustainability. The concept first came to the agenda with the book "Sustainable Society" written by Dennis Pirages. The concept gained international importance and became an environmental movement with the "Our Common Future" report published by the World Commission on the Environment in 1987 (Tekeli, 2001).

It does not enough only talk theoretically about the sustainability concept. Practically needed some principles to mobilise states or companies and get easier that process. For this reason, nine principles of sustainable life were determined in the report "Caring for the World" made by the International Union for Conservation of the World (IUCN), the United Nations Environment Program (UNEP) and the World Wildlife Fund (WWF) in October 1991. These nine principles:

1. "Building a sustainable society.
2. Respecting and caring for the community of life.
4. Improving the quality of human life.
5. Conserving the Earth's vitality and diversity.
6. Keeping within the Earth's carrying capacity.
7. Changing personal attitudes and practices.
8. Enabling communities to care for their environments.
9. Providing a national framework for integrating development and conservation.
10. Creating a global alliance" (IUCN, UNEP, WWF, 1991).

Today's environmental problems have entered the lens of architecture. While architecture adds identity to cities, it also shapes the spaces we live in. For this reason, sustainable architecture can be defined as a concept that approaches the environment with respect and value, uses energy, material and water resources efficiently and aims to design living spaces for people by considering the potential of today to change the future (Sev, 2009).

'Every design decision (…) has environmental impacts, especially in space design" (Woolley *et al*., 2006). Sustainable design aims to increase the quality of the environment while increasing the quality of life of people. It is a kind of win-win method (Kim & Rigdon, 1998). When viewed from this perspective, buildings that are designed in a nature-sensitive manner also aim to maintain the welfare of the users without compromise.

Sustainable architecture should research and examine the land on which the building will be built and the surrounding resources and design according to its findings. A properly designed architectural structure integrates with the land and plays a complementary role. In the construction sector, wrong construction, destruction and use invite environmental problems. Sustainable architecture or, in other words, green architecture was born to prevent them. It is important to use local or recycled materials during the construction of the building. During use, the use of renewable energy and its destruction without harming nature when it completes its life cycle is necessary to maintain the ecological balance.

Certain characteristics are seen in a good instance of sustainable architecture. Efficient use of resources, life cycle, user comfort and aesthetic design. Things to consider in the construction process of the building start with the selection of land and continue from material preferences and production to energy-water savings.

Interior architecture should be based on a holistic design. Because it interacts with the built environment and with users inside the building. The sustainability concept has a big role in interior architecture. Since interior architecture is the area that experiences the most change, it is the area where waste production is the most intense. Partial demolitions such as users' needs and changes in areas for various reasons cause large waste generation (Celadyn, 2019). Therefore, adopting this eco-friendly design modal and designing spaces this way is essential for caring to balance ecologically.

It has so many reasons for the rise of refuse on interior architecture. User demand, renovations for areas that need to be renovated, frequent changing of equipment and possible accidents that may occur are examples of these. Because they are continually active, it is normal for users to request modifications or alterations. But every change has helped to increase waste mountain. In this case, the materials and products used in the changes must be sustainable.

4. Sustainable Design Standards

As the need for sustainable design practice multiplies itself, this area has emerged to need more specific determinants for maximum efficiency. Throughout time, certain standards have emerged which help states, companies and designers. These standards are important for designers and users who want to know about the structures of the built places, with this being the main idea in today’s world, all countries determine some design standards. The concept of sustainability aims to reduce the carbon footprint while maximizing the aesthetics, cost and comfort of buildings (Bjørberg & Salaj, 2023).

In the study, certificates from various regions of the world were selected to see what the common criteria of green building certificates are. Care was taken to select certificates from each region as America, Europe, Asia, Arabian Peninsula and Australia. The certificates were sorted by year of issue. The criteria of the certificates were then converted into a hundredths system. The criteria and scores of each program are given in the table. As seen in Table 1, the certificate programs have common and different aspects.

According to Table 1, Energy, Water, Indoor Quality and Materials are the common features with the highest rate. The three certificates that capture this similarity, LEED, Green Star and GRIHA, are discussed in detail.

Table 1. Sustainable design standards taken from different continents of the world and ranked by year of release. Criteria scores are converted to percentile system and added

EXIT YEAR& COUNTRY	CERTIFICATE PROGRAM	CRITERIA	POINTS	EXIT YEAR & COUNTRY	CERTIFICATE PROGRAM	CRITERIA	POINTS
1990 United Kingdom	BREEAM New Construction	Management Health & Wellbeing Energy Transport Water Materials Waste Land Use & Ecology Pollution	12% 15% 19% 8% 6% 12,5% 7,5% 10% 10%	2007 Germany	DGNB New Constructions	Environmental Quality Economic Quality Socio- Cultural and Functional Quality Technical Quality Process Quality Site Quality	25% 25% 25% 10% 10% 5%
1996 France	HQE	Energy Environment Health Comfort	25% 25% 25% 25%	2007 Türkiye	B.E.S.T. Various 1.8	Integrated Green Project Management Land Use Water Use Energy Use Health & Wellbeing Material and Resources Use Residential Life Operation and Maintenance Innovation	1% 11% 11% 23% 13% 11% 11% 9% 2%
1998 USA	LEED V4.1 Building Design and Construction	Location and Transportation Sustainable Sites Water Efficiency Energy and Atmosphere Material and Resources Indoor Environmental Quality Innovation Reginal Priority	15% 9% 10% 30% 12% 15% 6% 4%	2007 India	GRIHA V2019	Sustainable Site Planning Construction Management Energy Efficiency Occupant Comfort Water Management Sustainable Building Material Life Cyle Costing Socio-Economic Strategies Performance Metering and Monitoring Innovation	11% 4% 17% 11% 15% 11% 5% 8% 7% 5%
2003 Avustralia	Green Star Design & Built v1.3	Management Indoor Environment Quality Energy Transport Water Materials Land Use % Ecology Emissions Innovation	13% 16% 20% 9% 11% 13% 13% 5% 9%	2008 United Arab Emirates	PEARL Design & Construction Version 1.0	Intagred Development Process Natural Systems Liviable Buildings Precious Water Resourceful Energy Stewarding Materials Innovating Practice	14% 18% 9% 18% 9% 23% 9%
2005 Singapore	Green Mark New Non-residental Buildings v1.1	General Architectural Exterior Architectural Interior Mechanical Electrical Landscape Smart FM	8% 12% 23% 20% 12% 12% 14%				

LEED

LEED is a certificate system created by the U.S. Green Building Council (USGBC). It helps to evaluate and rate green buildings. The certificate has degrees that are labeled as Certified, Silver, Gold and Platinum. All degrees require certain scores. Certified over 40 points are considered as Certified, for Silver certification over 50 points are needed, for Gold over 60 points and for Platinum over 80 points are mandatory. To get a LEED

certification some basic requirements are expected. The primary four requirements are listed below in Table 2.

Table 2. LEED scores for the same first four criteria (LEED v4.1 BD+C)

LEED Top Four Evaluation Criteria	Point
Energy and Atmosphere	30%
Indoor Environmental Quality	15%
Material and Resources	12%
Water Efficiency	10%

Green Star

Green Star is a green building system created by the Green Building Council of Australia in 2003. Just like the other certification programs, the Green Star certificate has certain standards and levels. Green Star certification is based on 4, 5 and 6-Stars certifications. 4 Stars over 15 points, 5 Stars over 35 and 6 Stars over 70. The same first four criteria, as stated in Table 3, may be observed.

Table 3. Green Star scores for the first four common criteria (Green Star - Design & AS Built v1.3)

Green Star Top Four Evaluation Criteria	Point
Energy	20%
Indoor Environment Quality	16%
Materials	13%
Water	11%

GRIHA

GRIHA is an Indian green building certification system. As with other certification programs, it aims to protect the life cycle and ensure energy reduction. GRIHA grades their certification from 1 to 5-star certificates. 1 Star between 25-40, 2 Star between 41-55, 3 Star 56-70, 4 Star between 71-85 and 5 Star between 85-105. It was created in 2007 and has ten criteria. The first four common criteria can be seen below in Table 4.

Table 4. Scores of the same first four criteria of GRIHA (GRIHA V2019)

GRIHA Top Four Evaluation Criteria	Point
Energy Efficiency	17%
Water Management	15%
Occupant Comfort	11%
Sustainable Building Materials	11%

Above are the four criteria that the three certificates have in common: Energy, Water, Indoor Quality and Materials. Energy and water criteria are usually highly rated in all certification systems because they are overused and valuable in many areas. For example, the energy or water used in the production of the material affects different factors such as the energy and water to be used in the building. It can be concluded, as seen in example, that these criteria can be considered the basis for sustainability. Although energy and water criteria have a wide range and impact, they alone will not be sufficient for a sustainable environment. Although energy and water are criteria that affect all other standards, their relationship with design is established through materials and indoor environmental quality. In this context, sustainability in relation to design builds a bridge between materials and interior design criteria.

To establish the relationship between architecture and sustainability, this aim needs to be embodied and embedded in the design. Therefore, since materials and interiors are the main parts of architecture, the relationship with sustainability is established through these two criteria. In this context, it can be said that no single criterion can form the foundation of sustainable design. Sustainable design is a holistic approach and cannot be addressed in a single area. Therefore, the criteria can be ranked in order of importance, but it cannot be said that one is chosen and the others are not needed. Looking at all these evaluations, it can be said that each criterion contributes to the development of this eco-friendly model. Therefore, since materials and interior design are the main parts of architecture, the relationship with sustainability is built on these two criteria. All the information shows us that the criteria help to develop the eco-friendly system.

5. Examples with International Standards

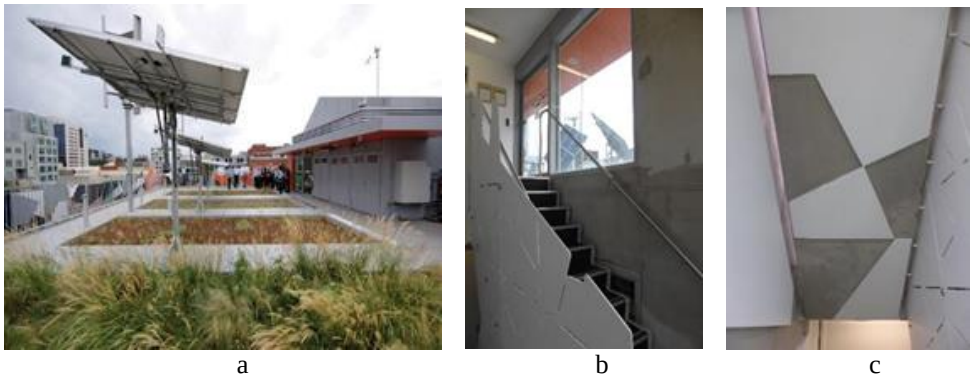
In this part of the study, the high scoring projects of the three selected certificates are evaluated. While selecting the sample projects, the criterion of belonging to the same function was not taken into consideration, it was important that they received high scores. In the examples, the reflection of the four criteria that stand out in the three certificates was examined. The environmentally friendly solutions in the projects and how they relate to the design were examined. After the examination, the data of the three examples were itemized and their common and different features were evaluated with the help of Table 5. First, the Pixel Building, which has two certificates, was analyzed. These certificates are LEED and Green Star. The second example is BASF Türkiye Innovation Center which has LEED certificate. The last example is the British School from the GRIHA certification system. In this study, the environmentally friendly solutions of the examples are evaluated.

Pixel Building - LEED Platinum and 6 Star Green Star Certification

Located in Melbourne, Australia Pixel Building has LEED Platinum and Green Star 6 Star certificates. The building is a zero-carbon office, producing its own energy and water as a whole which makes the building self-sufficient. The most important element that draws attention to the building at first glance is the facade design made from colored and recycled material. The panels, as seen below, serve as both a canopy and a water treatment. The panels in different forms surrounding the glass mass add color to the interior with the help of reflected lights as seen in Figures 1 (a,b).

a b

Figure 1. Pixel building and facade images
Source: https://www.archdaily.com/190779/pixel-studio505?ad_medium=gallery; https://stephenvaradyarchitraveller.com/2018/02/11/melbourne-pixel-building-australia



a b c

Figure 2. Pixel Building, roof and interior design images
Source: http://civilarchitectureconstruction.blogspot.com/2019/03/pixel-building-studio505-australia.html; https://stephenvaradyarchitraveller.com/2018/02/11/melbourne-pixel-building-australia/

Panels collect rainwater on the roof and filter and purify it. Clean water is also used in offices, WC and any other area where water is needed. At the same time, the building has solar and wind panels for getting energy on the roof. The roof with the green area has been serving one more than function as seen in the Figure 2a.

Concrete, which is the main material of building, is a special material in which carbon is reduced by half. Material and recycling were not contented only with this and a special anaerobic system was designed to reduce waste generation.

Facade panels' angular form has been continued throughout the interior space as seen in Figures 2b and 2c. For example, ceiling walls and stair railings. Continuing movement in the wall and ceiling don't completely cover the area. In this way the main material, concrete, joins the design. The building's shape is a rectangle and one edge had a designed blind facade. WC, storage, stairs and cellular offices are positioned on the blind facade side. So, the area had been used effectively and the other three facades had been designed to be glass.

a b

Figures 3. Pixel Building, interior images
Source: http://civilarchitectureconstruction.blogspot.com/2019/03/pixel-building-studio505-australia.html; https://stephenvaradyarchitraveller.com/2018/02/11/melbourne-pixel-building-australia

The building has a plan to be an open office. Additionally, the effects of the facade panels' shape can be seen in the furniture and interior space, as shown in Figure 3a,b. In this way, the building's holistic design is demonstrated. The interior space had been

designed properly with a new generation working style. Facades on the contrary interior design had been constructed in basic and white color. But circulations and break room areas had been highlighted with color. Although the building is not a very large structure, the interior space is well utilized. Sustainable design is not just about the efficient use of energy and water. It needs to serve user comfort and aesthetic perception.

BASF Türkiye Innovation Center - LEED GOLD

BASF is a well-known firm in the chemistry industry. The firm attaches importance to the sustainable concept in the studies. Also, the firm's working space has been designed to attach importance to the sustainable concept like the products they produce. In this context, it received LEED Gold certification with the Innovation Center built in 2020. Built in Technopark Istanbul campus, the building is an R&D building where the company carries out laboratory studies. It is designed in a form integrated with the building island where it is located. In the general design, the building is designed as two masses, the staircase acts as a connection between the masses.

It is seen that an outer shell is created with the mesh preference on the facade. It is observed that the main mass with large glass behind the mesh is preferred white color like the outer shell as seen in Figure 4a,b. There are green areas in front of the masses. By landscaping, the immediate surroundings can be greened even more beautifully. The desire for the building to be environmentally friendly from the beginning and the progress in line with the principles has earned the company LEED Gold Certificate.

a b

Figure 4. BASF Inovation Center building and inside
Source: https://www.arkiv.com.tr/proje/basf-inovasyon-merkezi/11570

All processes from the design to the construction of the project were planned and built in accordance with LEED certification criteria. When the use of water is examined, one of the important criteria, water consumption provides 50% water saving according to EPA (Environmental Protection Agency) standards thanks to the efficient fixtures used in the space. Water consuming equipment has an Energy Star standard. In this way, water and energy savings are achieved.

The building also pays attention to energy criteria. Design and technical solutions are presented by considering the (American energy efficiency standard) criteria in mechanical areas such as lighting, ventilation, heating-cooling systems. The focus is on minimizing consumption while taking user comfort into account. Luminaires are monitored with energy monitoring systems, thus aiming to prevent possible wastage. From installation to user use, energy systems are inspected in accordance with LEED's Commissioning (Installation and Commissioning) requirements. Preventing unnecessary energy expenditures also minimizes costs.

When it comes to material criteria, more than 20 of the materials used have EPD certificates. EPD (Environmental Product Declaration) is a certificate given to products that have minimal impact on the environment from the production stage. More than 25% of the materials in the office are recycled. There are also waste collection areas on each floor to encourage users.

The proportions of materials with harmful compounds such as paint, primer and adhesives used in interior spaces have been adjusted in accordance with international limits. Energy saving is aimed to be achieved by giving heating-cooling systems to individual control. Based on ASHRAE 62.1.2012 standards, healthy and comfortable indoor air quality is among the priority criteria. In addition, it has been tried to utilize daylight at maximum level in interior design. As seen in Figure 10, more than 75% of the users are designed to receive daylight from where they sit and have a view towards the view.

a b

Figure 5. BASF Inovation Center interior photos
Source: https://www.arkiv.com.tr/proje/basf-inovasyon-merkezi/11570

In the design of the space, it can be considered that an industrial style has been adopted due to the building's function as an innovation center. In addition to the open ceilings seen in Figure 5b, the choice of industrial materials such as concrete and plexi, which are easy to clean, supports this opinion. Although the general color predominance is grey and white, it is observed that various colors are used to define the space. In addition to connecting the two buildings, the staircase creates a sculptural center in the middle. There are also occasional uses of color in the office areas. As in Figure 5a, it is seen that materials such as felt that can provide sound insulation for user comfort are also used.

A new generation working environment with a well-planned layout is designed. By using vibrant colors in the design, the monotony of the space is prevented. The space is balanced with rhythmic and calm forms that complement each other. Break areas, work areas and meeting areas are defined with colors and materials as in Figure 5a,b. It offers office experience that combines two contrasts that are both focusing and relaxing for the users. In this way, while the energy of the employees is kept high, there is no tiring movement.

The British School - Five Star GRIHA Certification

Located in New Delhi, India the British School has 5-star GRIHA Certification. The building's design vision is “An International education with an Indian soul”. Not 5 trees were destroyed in the field during construction conversely 292 local trees have been

planted for contributing to climate. At the same time while construction continued, precautions were taken about air pollution.

It was thought some strategies for reducing dependence on the mechanical systems were taught during building use. The first is the traditional passive method without air conditioning to reduce and control the energy use of 50 percent of the school. The other is the building is designed in a courtyard architecture to remain shaded throughout the year. Also, in the living areas, 62% get light with daylight because of the building windows' frequent and wide. Therewith, the project's interior lighting and HVAC system of more than 30% have been produced with renewable energy.

a b

Figure 6. The British School facade images
Source: https://www.archdaily.com/891016/the-british-school-morphogenesis?ad_medium=gallery/

The building's hot water needs are met with solar panels. Moreover, efficient luminaires were preferred for saving on water. When the architecture of the building is examined, spaces have been created by extracting masses from a large rectangle. Courtyards have turned into great break spaces with elevation differences and greens. If the building plan is examined, it can be seen that the interior spaces are well-organized and that the relationships between the spaces have been carefully considered. The awning above the swimming pool located in one of the courtyards is functional and aesthetic. It also helps the building to have a holistic design that looks like Figures 6a,b.

a b

Figure 7. The British School interior and facade images
Source: https://www.archdaily.com/891016/the-british-school-morphogenesis?ad_medium=gallery/

In material preferences, importance is given to sustainability. Of the floor materials, more than 70% are quota stone and terrazzo. Besides has also been used materials like low-energy plaster and bison sheet. Materials and white color in the facade continue indoors as seen Figures 7a,b. As well as some areas were emphasized with living colors or materials. For instance, the reception is highlighted by wood materials on the wall and ceiling. The building's stair and balcony railings are made of metal material. The building being close-knit with nature provides the users with living areas of peace. Also, the light passing in the perforated plaster on the facade offers a visual feast in the courtyard as seen Figures 8a,b. The British school is a good instance where nature and architecture balance each other. At the same time, it has been designed with a holistic approach according to sustainability criteria.

a b

Figure 8. The British School Images
Source: https://www.archdaily.com/891016/the-british-school-morphogenesis?ad_medium=gallery/

Evaluation of Samples

The instances were compared in terms of energy, water, interior space quality and material criteria in Table 5 below. As can be seen, the examples' dynamics vary. The solutions produced by BASF Türkiye Innovation Center for interior space quality criteria and the solutions produced for Pixel Building are different. If the same instances are examined again, BASF Innovation Center doesn't have the Pixel Building's self-sufficient system. Also, the British School's relationship with nature and architecture is absent from the other two instances. The approach of architects, interior architects and designers who deal with the project changes the way the criteria are applied. For instance, BASF Innovation Center designers preferred recyclable materials while The British School designers preferred natural materials. In another instance, Pixel Building gathered rainwater to meet the water needs while the other two spaces also preferred efficient luminaires to save water. As a result, different solutions to the same problem are observed in the instances.

All these things show us it is not always easy theoretical knowledge forward to practice. Problems such as economic problems, wrong planning, a firm or designers do not consider sustainability causing a disruption process to theoretical knowledge forward to practice. If the states and firms may encourage it, people might be interested in the eco-friendly model.

Table 5. The three selected samples were analyzed for the same first four criteria

CRITERIA	Pixel Building LEED Platinum, 6 Star Certification	BASF Türkiye Innovation Center LEED Gold	The British School 5 Star GRIHA Certification
ENERGY	• Solar and wind panels	• Daylight sensor • Energy Star certification	• Traditional passive cooling method
WATER	• Facade panels that filter rainwater	• Efficient luminaire selection	• Efficient luminaire selection
INTERIOR SPACE QUALITY	• Games of light • Open office • Spacious and bright interior • Emphasis color selections in Break-Forward areas • Soft angular form movement in interior and furniture • Holistic design	• New generation working environment open office • Vivid and dynamic design • Floor-Ceiling projections • Panel that creates semi-privacy • Workstation	• Games of light • A concept in the Full-Empty relationship • Small courtyards • Dynamic-Color interior design • A holistic design that does not cut the relationship between architecture and nature
MATERIAL	• Facade panels recycled material • Glass and steel material on the façade • Plastic and wooden materials in fittings • Low carbon special reinforced concrete material	• 20% of the space is recycled material in the interior • Fabric material and company's own production of melamine resin • More than 20 'Environmental Product Declaration' (EPD) certificates for materials	• Low energy gypsum bison sheet • Quota stone and terrazzo for floor • Wood material for places that need emphasis, such as stairs, balcony railings

By examining these certified buildings, the first four common criteria of the selected green building certificates were evaluated on the examples. In the examples, the methods used to make the building environmentally friendly were examined. It is easier and more accurate to provide these conditions from the construction of a new building. However, today there are already many building stocks. Considering the energy and cost loss of demolishing and rebuilding buildings, it is important to look at what can be done with existing buildings and what can be reconsidered. In the light of this information, a building that does not have a certificate but has potential in terms of some environmentally friendly criteria has been selected.

6. Case Study Nature and Environment Learning Center in Amsterdam

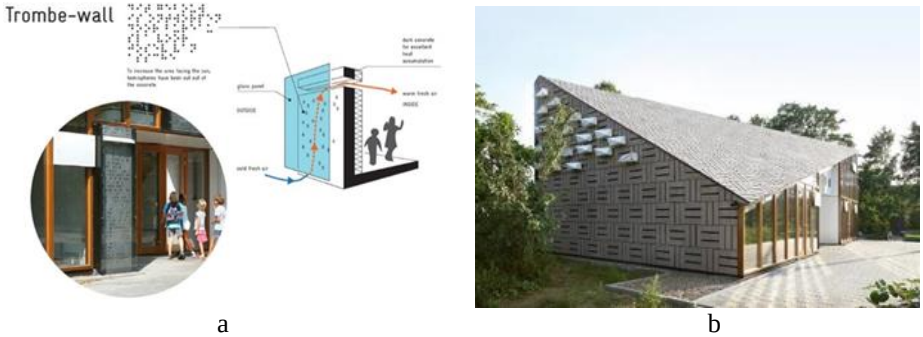
Located in Amsterdam, Netherlands, Nature & Environmental Learning Center's purpose is to help children learn by experiencing nature and the environment. The building was designed by the Bureau SLA architecture firm. The learning center founders said they wanted to see sustainable values in the building from the Bureau SLA. Then, the firm designed this structure where nature, architecture and people interact.

The first aim of building design is zero energy. That reason, the building's energy is filled with solar panels. Has been considered that gathering daylight could be a problem because the building direction is not exactly looked south. That problem resulted in the rectangle shaped roof's cross, edges downloaded to the downside and it emerged that

iconic roof design. The inclination is contributing to the design while solving the gathering daylight problem. The aesthetic inclination due to functionality at the same time helps the children for they see the solar panels. These functions are important because of the founders' requests that children see sustainable values. Wood slats and the solar panels had placed at the same inclination on the roof. Therefore, the roof cover features a holistic design, as seen in Fıgure 9a,b.

a b

Figure 9. Images of the building
Source: https://www.archdaily.com/778961/nature-and-environment-learning-centre-bureau-sla?ad_medium=gallery/



a b

Figure 10. Passive heating-cooling system' demonstration and birdhouses
Source: https://www.archdaily.com/778961/nature-and-environment-learning-centre-bureau-sla?ad_medium=gallery/

Energy recovery in the heating and cooling systems of the building is designed in collaboration with the façade design. The south facade also features glass, followed by a gap and then concrete material. These wall systems have been recognized as Trombe walls after Félix Trombe. The system provides passive heating and cooling. Located perforated concrete behind the glass gathers coming daylight and lets in the warm fresh air with air circulation. Or the interior space stays chilly because the warm fresh air circulation won't let in if closing the vents in the interior space. And the building's heating is provided with daylight, so it doesn't release CO_2. The form following the function helps the building facade's aesthetic appearance. The problems help emerge iconic designs with good solutions. The building's other long facade is almost all designed with glass. In this way, the interior space lets in plenty of daylight. And the building's other two short facades are designed with wood mosaics. The white boxes integrated with the facade are birdhouses as seen in Figures 10a,b. There are 21 birdhouses, 20 for swallows and 1 for bats.

If the interior plan is examined, it can be seen that the building has been designed symmetrically. Both sides of the ground floor are a classroom as seen in Figure 11a,b. The middle area is the entrance, WC and circulation place. Also, the first floor has a canteen and office. The materials are left in their raw state, allowing the user to make direct contact with them. When examining the material choices in the building, it is evident that they follow a life cycle, including wood mosaics, roof tiles, lacquer, concrete and ceramic tiles, as seen in Figures 1a and b.

a b

Figure 11. Building interior images
Source: https://www.archdaily.com/778961/nature-and-environment-learning-centre-bureau-sla?ad_medium=gallery

a b

Figure 12. Building interior images
Source: https://www.archdaily.com/778961/nature-and-environment-learning-centre-bureau-sla?ad_medium=gallery

The concrete appearance in the floor and ceiling presents a loft atmosphere. At the same time, the color choice has been made simple. The space gets plenty of daylight owing to big and continuous windows, so it doesn't need so many lighting fixtures. This point is important for reduced energy. It has been observed using wood material in the furniture as seen in Figures 12a and b. Children need not only the classroom but also a flexible environment in which they can move freely. Because of that, the Learning Center does not only attach importance to practice as much as theory.

It is very valuable to have an existing structure that they can experience and touch while teaching the children sustainable values. The building's energy, interior and materials integrity other than keeping the user in a relationship with nature is important for sustainable values. At the same time, it gave the answer to how iconic designs can be created with problems that seem to limit.

Suggestions Offered for The Building

The building may not have applied for certification programs because it is not too big. For that reason, if it had applied for a certification program what suggestion would be added has been contemplated. Besides, the relationship of energy, water, materials and interior space, which are the main layers of the study, was looked at.

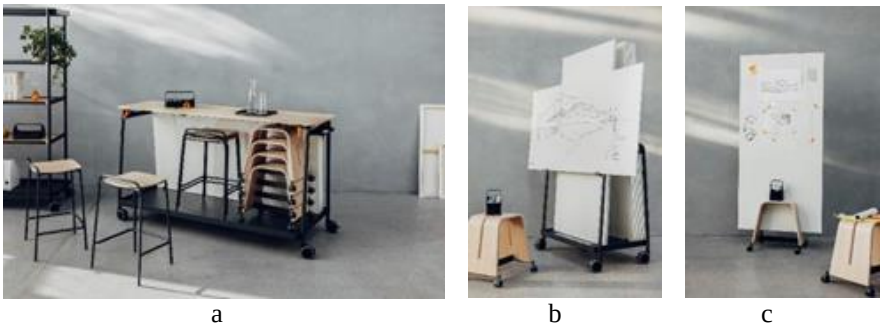
The building is a forward point about energy and is designed with a good solution. If a certification application were made, it can be predicted that it would score high due to those energy solutions. The land area also has used be an agricultural field, so it needs lighting. Besides, the land has a big area that, if used with lighting, might consume so much energy. For that reason, lightning's energy is fungible with wind turbines.

Water use is important because the land area is big. Upon this have been studied some ideas for water efficiency. It might be considered systems like gathering rainwater or greywater recovery for the garden and the wet areas inside the space. The gathered rainwater system is suitable for this roof with an iconic inclination. The important point is not to spoil the holistic design since the system was added later. Like solar panels completing the building, the gathering water system must be suitable for building design. As seen in Figure 13.

Figure 13. Illustration of a rain storage system in the form of birdhouses

The building's east facade is deemed suitable for the water tank. Water tank design might be made as birdhouses form for aesthetic appearance. In that way, the form might help a complementary design. At the same time, the fact that children see the water tank as they see the solar panels repeats the purpose of the building. Storage of the water helps with garden irrigation and the use of smart irrigation systems is important for reducing water use. And in the interior space change the armatures with efficient luminaires provide save water.

High-low overlapping footstools have been designed suitable for storage under the wheel table. At the same time, if the board is needed in the class, a footstool or table can be attached and after use, it can be stored under the wheeled table as well. Moreover, the products produced with recyclable materials wood and metal as seem Figures 14a,b,c.



a b c

Figure 14. Brunner modular furniture
Source: https://www.brunner-group.com/en-DE/products/details/boards_BO100 /

The furniture and the floor area they occupy, both during use and when not in use, are visible in the plan layout. In the first classroom, the distribution of space during a lesson or activity can be observed. In contrast, the second classroom illustrates the floor area occupied during non-use situations, facilitated by their modular system, as seen in Figure 15.

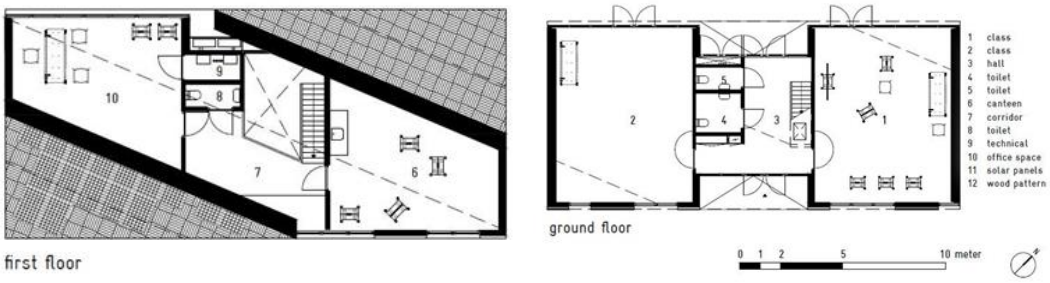


Figure 15. Plan view of modular furniture
Source: https://www.brunner-group.com/en-DE/products/details/boards_BO100;
https://bureausla.nl/project/natuur-milieu-educatiecentrum-amsterdam

Table 6. Existing features of the building and suggestions offered

CRITERIA	EXISTING FEATURES	SUGGESTIONS
ENERGY	• Solar Panels • Passive Heting-Cooling System	• Wind Turbine
WATER	• ----------	• Rainwater Storage System • Efficient Luminaire • Smart Irrigation System
INTERIOR SPACE QUALITY	• Simple and Understandable Plan Setup • Simple Interior Design • Bright and Fresh Environment	• Modular Furniture Choices for Flexible Interior
MATERIAL	• Natural and Recyclable Material Selections: Wooden Mosaic and Roof Tiles, Lacquer, Concrete, Ceramic Tiles	• Certificate Application for Materials

In addition, the possible placements of the furniture on the office and canteen floors are shown. The building has a simple and understandable plan design. Therewith flexible furniture provides a useful solution angle to function. Most of the building's construction materials are natural and recyclable, not to be after-life waste. It can be applied to cradle-to-cradle certification (C2C) to confirm materials.

Cradle to cradle is a system that encourages materials to be environmentally friendly. It evaluates the steps of a product's cycle by following it from the beginning to the last moment. In order to be certified, products must meet a number of criteria set by the program, such as product cyclicality, climate protection, water-soil management and many more (C2C Certified 2021).

In the table above, the existing features and the suggestions offered are itemized, as shown in Table 6. Suggestions were offered for the building with information from the analyzed instances. As stated at the beginning of the part, what kind of solutions could be offered to the structure if an application is made to a program is examined. When the building is considered with the added suggestions, the potential certification level that could be achieved can be estimated. Designing the existing building to be environmentally friendly, in alignment with its intended purpose and incorporating the added recommendations, can demonstrate that a high-level certificate can be achieved. If the LEED certification is considered, Gold or Platinum levels can be achieved. For Green Star, the building could receive a 5- to 6-star rating, while for GRIHA, a 4- to 5-star rating could be attained. Certification ranges considered for the building are estimates based on knowledge gained from the beginning of the study. When the certificate program is applied to the building, of course, changes in the certificate levels can be observed.

7. Conclusion

Sustainable design and architecture not only improve our living environments but also aim to create eco-friendly spaces. This study examined the key criteria affecting the sustainability of buildings and analyzed international green building certifications. The findings indicate that three of these certifications share common criteria, namely water, energy, indoor environmental quality and materials. This observation underscores the strong connection between sustainability and architecture. Solutions for these criteria were developed and analyzed within the context of the certification examples. As each case presented different solutions, these examples were compared using a table, with sustainable methods listed in itemized form.

While it is critical to consider these four criteria when constructing new buildings, it is equally important to address the vast number of existing buildings worldwide. Demolishing and rebuilding these structures would result in significant energy, water and financial losses. Therefore, an uncertified example was examined to demonstrate how existing buildings can be adapted to contribute to environmental sustainability. Small yet impactful suggestions were developed for the four criteria, offering guidance for future building designs and providing practical methods for making existing buildings more environmentally friendly with minimal impact on their surroundings.

The information obtained from this research proved valuable in analyzing the selected examples. The examples were evaluated according to the same four criteria used in green building certifications and in each case, the close relationship between sustainability and design was clearly evident. Design is not antagonistic to the environment; rather, it is in harmony with it. Today's buildings not only fulfill the basic need for shelter but also serve additional purposes such as comfort, entertainment and consumption. For this reason, creating human-centered, environmentally respectful and aesthetically pleasing products has become an inherent requirement in the design process from the outset. The fact that the four common criteria identified - energy, water, indoor environmental quality and materials - are central to this study further demonstrates the

interconnection between design and sustainability. While energy and water are of great importance in technical terms, interior quality and materials are the most critical criteria for designers. The buildings analyzed exhibit a balance between design and sustainability.

Upon completing the analysis, the application of the four criteria in various buildings became evident. Design concepts influenced by the natural environment and climate of the country, such as the design of the English School, highlight the beauty of limitations. The Pixel Building, which harnesses water and heat from nature to generate energy and BASF's office environment, developed in accordance with sustainability principles and emerging technologies, demonstrate that a better future is indeed possible.

Finally, the Nature and Environment Learning Centre provides a sustainable environment for its users, enabling them to experience these principles firsthand. The rainwater harvesting system incorporated into the building, along with modular furniture offering multiple functions, illustrates how existing structures can be adapted to align with sustainable principles and the four key criteria identified in this research. Given the current excess of buildings and the economic and physical factors that prevent large-scale reconstruction, this study emphasizes the need to present alternative solutions for such cases. It is possible to develop solutions that reconcile the functional requirements of a building with sustainability principles. Although large-scale changes are not always feasible, even small changes aimed at raising awareness can offer hope for future generations.

Further avenues for research are also suggested. In this study, four common criteria were selected; however, a more focused approach could involve narrowing the criteria to a single factor and analyzing its impacts in more detail. Alternatively, the number of criteria could be expanded for broader analysis. Another suggestion is to explore the reasons for variations in the order of importance of criteria across different regions, despite the shared commonalities. Furthermore, the potential relationship between these variations and geographical factors could be investigated.

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