Journal of Architectural Sciences and Applications
JASA 2024, 9 (1), 368-386
Research article
e-ISSN: 2548-0170
https://dergipark.org.tr/en/pub/mbud

Assessment of Ecological Landscape Design: A Case Study Applying LEED Certification Criteria to BTU Mimar Sinan Campus

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Abstract

Ecological design is an approach that is applied in campus areas. This study aims to determine the LEED certificate points achievable through proposed ecological landscape designs for campus areas. The v3-2009 version of the LEED certificate was used in the study. In this study, national and international articles, LEED scoring system was first examined. Within the scope of the information obtained, the point value of the study area was calculated for its current form based on the LEED certification system. New ecological landscape design study was proposed for the area and re-scoring was performed within the scope of this proposed project. After the total score that campus would receive from the LEED certificate and the score obtained from each category were determined. Through the ecological campus planning approach developed in this study, the campus's certificate score increased from 10 to the 'Silver certificate' level, totalling 50 points.

Keywords: *Planting design, ecological design, energy and water efficiency, green certification, LEED.*

Ekolojik Peyzaj Tasarımının Değerlendirilmesi: LEED Sertifikasyon Kriterlerinin BTÜ Mimar Sinan Yerleşkesine Uygulandığı Bir Örnek Olay Çalışması

Öz

Ekolojik tasarım kampüs alanlarında uygulanan bir yaklaşımdır. Bu çalışma, kampüs alanları için önerilen ekolojik peyzaj tasarımlarıyla elde edilebilecek LEED sertifika puanlarının belirlenmesini amaçlamaktadır. Çalışmada LEED sertifikasının v3-2009 versiyonu kullanılmıştır. Bu çalışmada ilk olarak ulusal ve uluslararası makaleler, LEED puanlama sistemi vb. çalışmalar incelenmiştir. Daha sonra elde edilen bilgiler kapsamında çalışma alanının LEED sertifikasyon sistemi esas alınarak mevcut haliyle puan değeri hesaplandı. Daha sonra alana yönelik yeni ekolojik peyzaj tasarım çalışması önerilmiş ve önerilen bu proje kapsamında yeniden puanlama yapılmıştır. Daha sonra kampüsün LEED sertifikasından alacağı toplam puan ve her kategoriden alınacak puan belirlendi. Bu çalışmada geliştirilen ekolojik kampüs planlama yaklaşımı sayesinde kampüsün sertifika puanı 10'dan 'Gümüş sertifika' düzeyine çıkarak 50 puana yükseldi.

Anahtar kelimeler: *Bitkisel tasarım, ekolojik tasarım, enerji ve su verimliliği, yeşil sertifika, LEED.*

Citation: Aksoy, O. & Erken, K. (2024). Assessment of ecological landscape design: A case study applying LEED certification criteria to BTU Mimar Sinan Campus. *Journal of Architectural Sciences and Applications*, 9 (1), 368-386.
DOI: https://doi.org/10.30785/mbud.1461004

Received: *March 29, 2024 –* ***Accepted:*** *May 30, 2024*

1. Introduction

Along with the global decrease in biological capacity, many threats such as global warming and a decrease in arable land, potable water and natural energy resources are occurring (Obata, Agostinho, Almeida & Giannetti, 2019). To minimise these effects, different professional disciplines have come together and developed solutions. One of these solution proposals is the use of ecological approaches. Ecological design is a concept that requires working with an interdisciplinary approach to support social, cultural, economic and technological processes, especially ecological processes while designing a vital environment that can be sustained without disturbing the natural balance despite nature in the natural environment (Ünal, 2014). The ecological design approach is applied in the building and its immediate surroundings, green areas, hospital structures and many other areas. Another application area of the ecological design approach is campus buildings. Ecological campuses focus on 'environmental sustainability', the 'ecological cycle' and being 'healthy' (Gomez & Derr, 2021). For example, Konya Food and Agriculture University has designed a green roof that can be described as ecological, also called "Green Pot" (Arat & Kaçar, 2020). In addition to the substantive connotations of 'energy conservation' and 'resource recycling', sustainable campuses integrate the common awareness of the community by breaking down barriers. For example, there are many ecological practices at Taiwan University. These ecological applications are such as seperation of garbage, recycling of resources and use of leaf litter as fertilizer by turning it into compost and expanding the use of solar energy (Yang, 2021).

Sustainability is often associated with ecology. However, the concept of sustainability has a broader perspective such as economy, politics and social issues in addition to ecology (Schiederig, Tietze & Herstatt, 2012). The concept of sustainability has been on the agenda of the world since the 1970s. Since the Stockholm Declaration in 1972, studies on sustainability have started and university institutions have been involved in studies in this direction since 1990 (Saygın & Ulusoy, 2011). This has led to the design of university campuses taking into account the principle of sustainability. The main purpose of sustainable design in campus areas is to mitigate the consumption of basic resources such as energy, water, and raw materials (Patel & Patel, 2012). Energy-efficient, water-efficient, waste-efficient and climate-efficient designs can be developed with ecological and sustainable design approaches for campus areas. There are some green certification systems within the supervision of all these approaches.

Numerous green certification systems worldwide evaluate green area, buildings and their nearby environments, thereby demonstrating how ecologically sound these designs are (Süzer, 2015). Leadership in Energy and Environmental Design (LEED) rating systems and the Building Research Establishment Environmental Assessment Method (BREEAM) are the world's leading certification systems (Erbıyık, Çatal, Durukan, Topaloğlu & Ünver, 2021). Other certification systems include the Green Standard for Energy and Environmental Design (G-SEED, South Korea), Green Star (Australia) and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE, Japan) (Caymaz & Başkaya, 2022; Erbıyık et al., 2021). Another certificate system is the SİTES certificate, which evaluates green areas (Sustainable Sites Initiative, 2014; SITES, 2023). For example, the SITES Silver-certified Minneapolis Convention Center Plaza is the first SITES project in Minnesota, and the first SITES-certified project at a convention center (SITES, 2023). Certifications serve an important role in providing information between stakeholders through simplified communication, minimising environmental impacts, completing sustainability assessment tools and introducing sustainability aspects early in the planning process (Süzer, 2015).

LEED is the most popular and widely used green building rating system worldwide. The LEED green building certification system was developed in 1998 by the United States Green Building Council (USGBC), a consensus-based nonprofit organisation (Uğur & Leblebici, 2018). The LEED certificate evaluates projects using different versions according to the nature of the area to be designed. Categories such as new constructions, schools, homes, commercial interiors and neighbourhood development are included under this certification system. The evaluation criteria and rating schemes of each category are different (Atasoy, 2020). However, in general, the evaluation criteria are examined in six categories. These categories are sustainable areas (SS), water efficiency (WE), energy performance (EA), materials and resources (MR), indoor environmental quality (IEQ) and innovative design (INNO) (Cidell, 2009). Projects that score 40–49 points after the evaluation are entitled to receive a certificate, while projects with 50–59 receive a silver certificate, those with 60–79 points receive a gold certificate and those with 80–110 points receive a platinum certificate (Gurgun, Polat, G., & Bayhan, 2016). LEED NC, v.3 was used within the scope of the present study and consists of five main categories. These categories include sustainable areas, WE, energy and atmosphere, MR and IEQ. Various criteria must be fulfilled under each relevant category, with specific points being awarded to each. The final score of the evaluated building is determined by summing the points earned. The higher the number of points earned, the higher the level of certification achieved. The possible scores that can be obtained from these five main categories correspond to a total of 100 points. There are two additional categories, innovation and regional priority, which can provide 10 bonus points to projects (Atasoy, 2020).

In this research, Bursa Teknik University (BTU) Mimar Sinan Campus located in Bursa province, which is under pressure with the urban texture of the western, south and northern parts, but still preserves its green texture, was determined as the study area. Many applications have been carried out within the scope of a sustainable campus in Mimar Sinan Campus. The present study aimed to evaluate how many points would be obtained if it was assumed that the LEED certificate was created with the discipline of landscape architecture in mind. In this context first stage, literature research was conducted. Two stages the current certificate point value of BTU Mimar Sinan Campus was determined by considering the v3-LEED 2009 version. Then, a new ecological landscape design proposal was developed for the area while considering these data and the headings in the LEED certification. Final stage, the scores obtained from all ecological applications were revealed and it was determined which certificate could be obtained with these applications. There are many studies in the literature evaluating ecological campuses. Many of these studies were evaluated by the Green Metric system. However, in these studies, only the current state of the campus and its score were determined. This study is unique in that it evaluates campuses according to the LEED certification system and develops a new ecological design proposal for the area. This study is important in terms of evaluating the campuses according to a new certification system other than the Green Metric certificate and showing the low scores obtained due to the LEED certificate being created with more architecture in mind. In addition, the outcomes of this study are valuable as they reveal that landscape should be considered as an important factor in the evaluation of university campuses in the future versions of the LEED certificate. The methods and outputs of this study set an example for the development of an ecological campus model in accordance with international standards in campuses in Türkiye and other developing countries.

2. Material and Method

2.1. Study Area

The study area was Bursa Technical University (BTU) Mimar Sinan Campus, which is located within the provincial borders of Bursa, with an area of 211,257 m^2 (Figure 1). In the western part of the area, there is Safety Street, with Eflak Street in the southern part, Ankara Yolu Street in the northern part and Hacivat Stream in the eastern part.

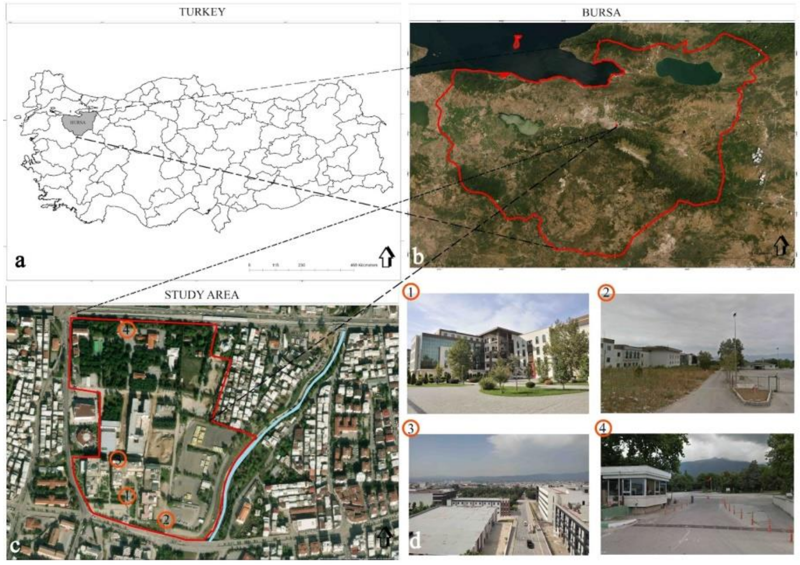

Figure 1. Location of BTU Mimar Sinan Campus in Türkiye (a, b) (Google Earth, 2022), the points where images 1–4 were taken (c) (Google Earth, 2022) and images of the study area (d) (Photograph: Onur AKSOY, 2022)

2.1.1. Data collection

In the study area, elevation, aspect and slope mapping was conducted by considering the Türkiye digital elevation model (DEM) data. The study area is located at an altitude range of 136–228 m asl. As a result, plant species selections for campus plant design were made according to the known altitude values. Slope analysis was also performed using DEM data and it was observed that the slope of the area varied between 7 and 10%. Aspect analysis was conducted using the same data. In this manner, suitable plant species were selected while considering these aspects and the desire to reduce the energy consumption of buildings. The soil structure of the campus area is colluvial, moderately eroded and consists of Class II soils (TSA, 2022). All topographic data in the study area is important in terms of guiding the designs in the campus areas where ecological landscape design will be conducted. In addition, a map showing the soil condition of the area was also created. In the plant design project to be proposed for the area, plant species selection was made in accordance with the soil type. When the water present in the area was examined, it was noted that Hacivat Stream is located on the eastern border of the area.

2.1. Method

The ecological landscape design project and evaluation study, which was conducted on BTU Mimar Sinan Campus while considering the LEED certificate, consisted of four stages (Figure 2). In the first stage, national and international literature data on the subject, applied project examples and landscape studies of all sizes were examined. In addition, various books, articles, herbarium surveys and notes and photographs taken during field studies on natural plants of Bursa were also examined at this stage. In the second stage, the current certificate point value of BTU Mimar Sinan Campus was determined by considering the v3-LEED 2009 version. The reason for using the v3-2009 version of the LEED certificate is that the company that provides the LEED certificate in Türkiye was called and received the opinion that it was appropriate to use this version. Company officials use this version in the evaluation of campuses in Türkiye. When determining the score values, the criteria determined by Council UGB (2009) and Haselbach (2010), Gurgun et al. (2016), Erbıyık et al. (2021) were considered. In addition to these criteria, natural data (i.e., topography, slope, aspect, elevation, soil, water, flora and climate) and structural data (transportation and existing structures) in BTU Mimar Sinan Campus were also examined.

Then, a new ecological landscape design proposal was developed for the area while considering these data and the headings in the LEED certification scoring criteria. At this stage, structural and plant suggestions related to ecological landscape design proposed for the area were put forward. In the third stage, BTU Mimar Sinan Campus was then re-scored with the created ecological landscape design. The reason for using the v3-2009 version of the LEED certification in this study is that this version is more suitable for the ecological landscape design of campus areas. In addition, to evaluate the study area, applications in the structural category that were not under the jurisdiction of landscape architecture (but in the 'Necessary' category) in the LEED certificate were scored assuming that they already exist. During the final stage, the scores obtained from all ecological applications were revealed and it was determined which certificate could be obtained with these applications.

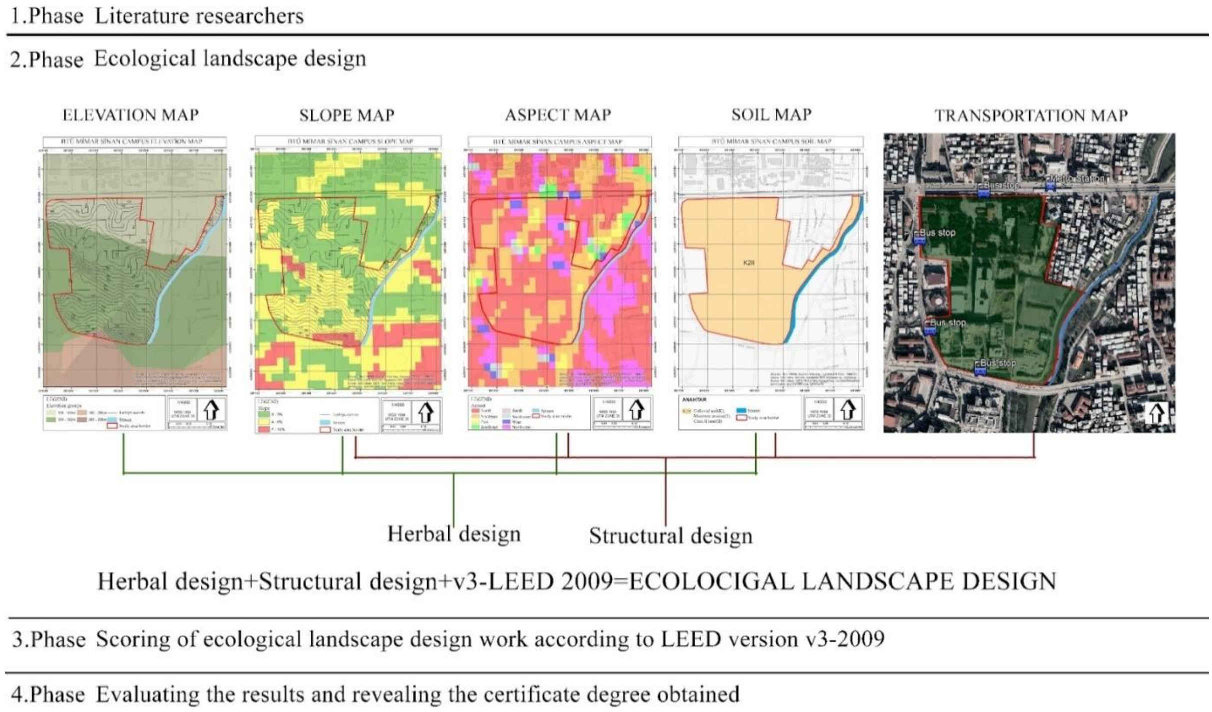

Figure 2. Study workflow chart (Aksoy, 2022)

3. Results and Discussion

3.1. The LEED Score of BTU Mimar Sinan Campus Before Ecological Landscape Design

Considering the 6 categories (sustainable areas, water efficiency, energy performance, materials and resources, indoor environmental quality, and innovative design) included in the v3-LEED 2009 version by Council UGB (2009) and the titles under these categories, the current score value has been determined. In determining and evaluating all these score values, interviews and technical reports held at BTU Construction Works Department were taken into account. In line with the examinations made in the study area, it was determined that the current LEED value of the area is 10 points. A breakdown of point values is presented as follows: Site selection (1 point); Brownfield redevelopment (1 point); Public transportation access (6 points); Innovative wastewater technologies (2 points). It was determined that BTU Mimar Sinan Campus could not obtain any certificate from the LEED certification system based on this point value. This point value of Mimar Sinan Campus is due to the fact that ecological approaches are not taken into account in building and landscape planning. Mimar Sinan Campus received a low score from the LEED certificate due to the lack of bicycle paths, inadequate bicycle parking areas, and lack of ecological design approaches regarding rainwater, waste, and energy efficiency. Figure 3 shows the parking areas, floors, roofs and open green area system before the ecological landscape design at Mimar Sinan Campus.

Figure 3. The situation of BTU Mimar Sinan Campus (Google Earth, 2022) before the ecological landscape design (Photograph: Onur AKSOY, 2023)

3.2. Ecological Landscape Design at BTU Mimar Sinan Campus

The BTU Mimar Sinan Campus ecological landscape design, which was performed while considering the natural and structural area analyses and the seven main titles in the v3-LEED 2009 version, is presented in Figure 4. This design work was conducted with structural and plant solutions that reflect the ecological characteristics of the area. Within the scope of structural design, suggestions for applications such as parking lots, bicycle paths, water collection areas, flooring and urban reinforcement elements were developed. Within the scope of planting design, natural plant use, rain gardens, rooftop and vertical gardens, wind shielding, drought-resistant grass use and biolamb were proposed. Applications were also proposed for the field.

Figure 4. The situation of BTU Mimar Sinan Campus after the ecological landscape design (Aksoy, 2022)

3.2.1. Sustainable sites

The sustainable sites category was evaluated out of 26 points (Table 1). The score value of the area before the ecological landscape design was 8 points. While 4 points of this value were obtained via planting design applications, 7 of these points (Figure 12) were obtained due to the location of the area and structural applications. With the ecological landscape design proposed for BTU Mimar Sinan Campus, 19 points were obtained from the title of 'Sustainable Areas'.

Table 1. Point values obtained from the sustainable areas category and its sub-headings before and after the ecological design

v3-LEED 2009 Categories		**Category weights**	**Point value before design**	**Point value after design**
Sustainable Sites		26 points	8 points	19 points
Prereq 1	Construction Activity Pollution Prevention			
Credit 1	Site Selection	1	1	1
Credit 2	Development Density and Community Connectivity	5		
Credit 3	Brownfield Redevelopment	1	1	1
Credit 4.1	Public Transportation Access	6	6	6
Credit 4.2	Bicycle Storage and Changing Rooms	1		1
Credit 4.3	Low-Emitting and Fuel-Efficient Vehicles	3		3
Credit 4.4	Parking Capacity	2		2
Credit 5.1	Protect or Restore Habitat	1		1
Credit 5.2	Maximise Open Space	1		1
Credit 6.1	Quantity Control	1		1
Credit 6.2	Quality Control	1		
Credit 7.1	Non-roof	1		1
Credit 7.2	Heat Island Effect—Roof	1		1
Credit 8	Light Pollution Reduction	1		

In this category, the first structural application made within the scope of ecological landscape design was to minimise the number of parking lots in the area. The parking areas designed in the area have been designed while considering the parking regulations of Türkiye (2018) (see Annex 1). The working area is 211.257 m^2. In Annex 1 of the parking regulations, one parking lot is recommended for an area of 200 m^2 for university buildings. According to this article, a parking area for at least 1,057 people is needed in the study area. In the newly proposed ecological landscape design, an outdoor parking lot for 269 people, a parking lot for 53 hybrid vehicles, an indoor parking lot for 150 people and 555 parking lots should be provided in an area outside the campus, if required. Overall, 53 of these parking areas are reserved as shared parking areas. Additionally, a 310-person bicycle parking lot has been proposed for the study area. Shower cabins are also recommended in the immediate vicinity of the bicycle parking lots if there is space in the building.

Under this category, planting applications made within the scope of ecological landscape design are also included. Within the scope of ecological landscape design, the amount of green space in the study area has been increased by creating rooftop gardens (Figure 5), rain gardens, xeriscape gardens and natural plant areas. Except for the existing trees in the study area, a new planting design has been proposed for the entire area. With the new ecological design approach, 98,511 m^2 (approximately 58.07% of the area) of open green area was created. Among these open green areas, the area covered by the rooftop gardens is 24,168 m^2. The area covered by the buildings in this area is 46,821 m^2. Succulent plant species indigenous to Bursa were proposed for 51.61% of the roof area.

Figure 5. Recommended green roof application before and after the work area (Aksoy, 2022)

Apart from the ecological landscape design, due to the current location of the area, a point value was obtained from the sustainable areas category based on examinations made of the area according to the soil map of Türkiye II Class land (TSA). According to the results of the Google Earth program and measurements made in the field, Hacivat Stream is located in an area approximately 70 m from the buildings. In the 'Red Book of plants of Türkiye ', Ekim et al. (2000) assigned 1 point value from the title of 'field development' under this category since there were no living creatures from the threatened or endangered categories. Additionally, according to the 1996 zoning plan for the area, it has been used as a primary and high school education area as well as a public space from 2003–2006. Today, the area is used as a public space. Within the scope of this data, the area was not previously polluted and is not currently polluted. It is also considered that it is in a class of agricultural land; thus, 1 point was obtained from the title of 'brownfield redevelopment'. Due to the location of the area, the final point value obtained from the sustainable areas category originated from the 'Public transport access' heading. In line with the measurements made at BTU Mimar Sinan Campus, the existing north entrance is 150 m away from the metro station. In addition, the bus stops on Eflak Street and Safety Street are 30 m away from the campus. Thus, it achieved 6 points under the title of 'public transportation access' under the sustainable areas category.

3.2.2. Water efficiency

The current point value of this category before the ecological landscape design was 2 points (Table 2). This point value was obtained due to the existing water-saving faucets in the building. After the ecological landscape design was applied, the point value of this category increased to 6 points (Figure 12). These scores were obtained through planting design applications. In this context, the first planting application recommended for the area is rain gardens.

Table 2. Point values obtained from the water efficiency category and its sub-headings before and after the ecological design

v3-LEED 2009 Categories		Category weights	Point value before design	Point value after design
Water Efficiency		10 points	2 points	6 points
Prereq 1	Water Use Reduction—20% Reduction			
Credit 1	Water Efficient Landscaping	2–4		4
Credit 2	Innovative Wastewater Technologies	2	2	2
Credit 3	Water Use Reduction	2–4		

Many rain gardens (Figure 6) have been proposed for the area within the scope of the study. These applications are generally applied in the middle refuge, parking lot and areas where the slope decreases. While designing the rain gardens, the selected species were chosen according to the requirements of the zones. Water-loving plant species were used in the first zone, moderately water-loving plants were used in the second zone and drought-resistant plant species were used in the outer zone. Additionally, natural species that can best adapt to the ecology of the area were selected. The plant species used in the rain garden are presented in Table 3. These species were selected from the natural species of Bursa flora while considering the study conducted by Uncapher & Erskine (2012).

Table 3. Natural plant species recommended for the rain gardens of BTU Mimar Sinan Campus

Trees	Bushes	Herbaceous species
Acer campestre	*Erica arborea*	*Bellis perennis*
Celtis australis	*Salix cinerea*	*Carex pendula*
Populus alba	*Vaccinium myrtillus*	*Iris orientalis*
Ulmus glabra	*Viburnum opulus*	*Primula vulgaris*

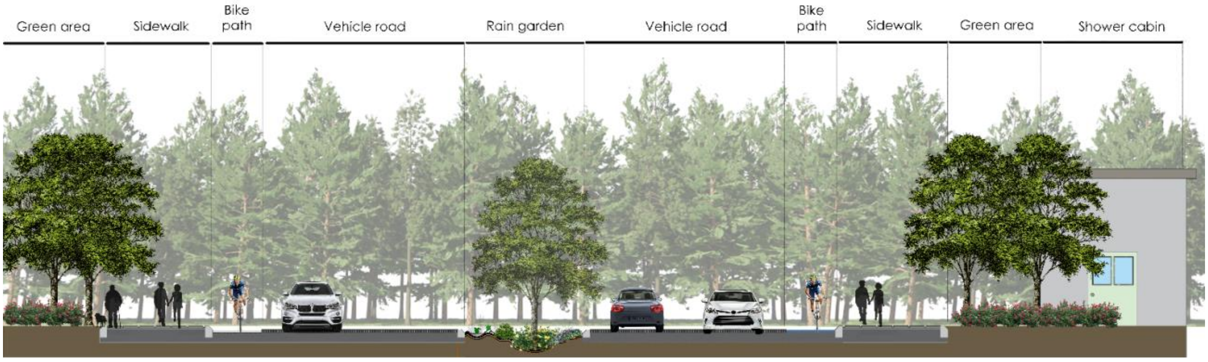

Figure 6. Rain gardens proposed for the medians of BTU Mimar Sinan Campus (Aksoy, 2022)

The second planting application recommended for the area is xeriscape gardens. According to Hilaire et al. (2008), with the correct application of xeriscaping, savings of up to 76% can be achieved in terms of outdoor water consumption. Additionally, drought-resistant plant species were used in the proposed water towers (Figure 7). The plant species used in xeriscape applications are listed in Table 4. These include plant species listed by Davis (1965–85), which were used in xeriscape applications by Williams (2013) and belong to the natural flora of Bursa.

Figure 7. Proposed water collection towers in front of E block at BTU Mimar Sinan Campus (Aksoy, 2022)

Table 4. Natural plant species recommended for xeriscaping at BTU Mimar Sinan Campus

Trees	Bushes	Herbaceous species
Cercis siliquastrum	*Pyracantha coccinea*	*Achillea millefolium*
Fraxinus ornus	*Arbutus unedo*	*Cistus laurifolius*
Malus sylvestris	*Genista lydia*	*İberis spruneri*
Tilia argentea	*Vitex agnus castus*	*Salvia argentea*

Natural plant species were used in all planting practices recommended in the study area (except the use of plants that produce their own energy and plants that shine throughout their life cycles). Overall, a 42.121 m^2 grass area is proposed for the study site. Within the scope of ecological plant design, the grass mixture proposed for the area was created by considering the species naturally found in the region and low water consumption. Finally, passive rainwater harvesting system area of 4,712 m3 was proposed. The proposed water collection area (Figure 8) is designed to meet the irrigation water needs of outdoor plants. The passive rainwater harvesting system requires no additional pump power and no complex filtration systems (Kucukkaya, Kelesoglu, Gunaydin, Kilic & Unver, 2021).

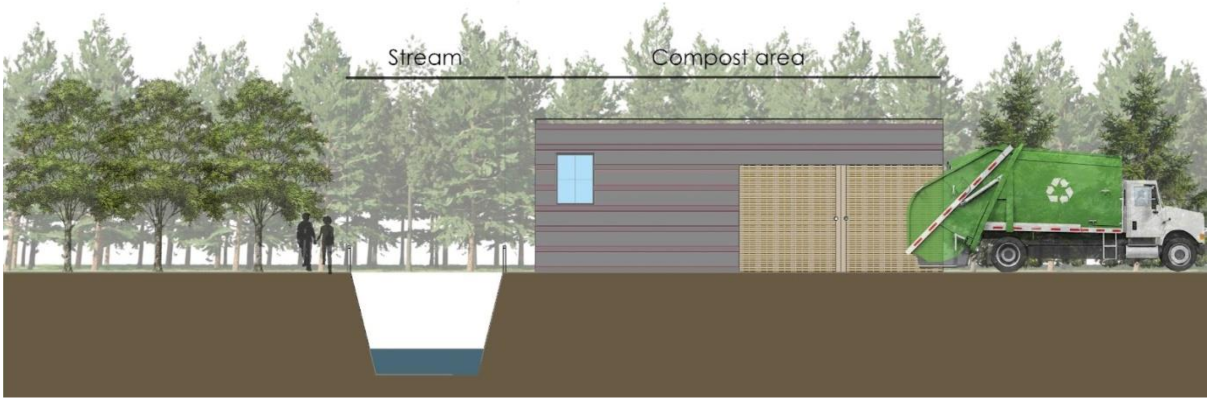

Figure 8. Recommended compost and water collection area (Aksoy, 2022)

3.2.3. Energy and atmosphere

Before the ecological landscape design was made in the area, no points were obtained from the energy and atmosphere category. However, the score for this area increased to 17 (Table 5) with the vertical garden and roof gardens recommended in the ecological landscape design. While 17 points of this value were obtained with vegetative applications (Figure 12).

Table 5. Point values obtained from the energy and atmosphere category and its sub-headings before and after the ecological design

v3-LEED Categories		**Category weights**	**Point value before design**	**Point value after design**
Energy and Atmosphere		**35 points**	**0 points**	**17 points**
Prereq 1	Fundamental Commissioning of Building Energy Systems			
Prereq 2	Minimum Energy Performance			
Prereq 3	Fundamental Refrigerant Management			
Credit 1	Optimise Energy Performance	1–19		17
Credit 2	On-Site Renewable Energy	1–7		
Credit 3	Enhanced Commissioning	2		
Credit 4	Enhanced Refrigerant Management	2		
Credit 5	Measurement and Verification	3		
Credit 6	Green Power	2		

Windbreak, vertical garden and roof gardens have been proposed to save energy in the area. Vertical gardens on the north-northwest and south-southwest façade (i.e., the dominant wind directions of BTU Mimar Sinan Campus), rooftop gardens on the upper parts of the buildings and vegetative screening on the building facades have been proposed. *Hedera helix* was used as the plant species in vertical gardens. The specific leaf area (SLA) of the species is c. 200 $cm^2\ g^{-1}$ in shade, but closer to 100 $cm^2\ g^{-1}$ in sun. Typical leaf characteristics are: lamina area c. 50 cm^2; lamina volume c. 1.4 cm^3; foliar water content is relatively high at c. 230 g H_2O 100 g^{-1} leaf dry mass (65–70% wet mass), although declining from juvenile to mature plants (Metcalfe, 2005). Considering the studies of Aşkın (2014) and Esin (2001) with all of these applications, it was predicted that 40% energy savings could be achieved. Thus, 17 points were obtained from this topic.

3.2.4. Materials and resources

In this category, the site has no current LEED score (Table 6). Materials were separated and stored with the recycling bins recommended for outdoor environments within the scope of LEED. In addition, the reinforcement elements used were recycled and procured from local materials. After these studies, the point value of the area was increased to 4 points (Figure 12).

Table 6. Point values obtained for the materials and resources category and its sub-headings before and after the ecological design

v3-LEED Categories		Category weights	Point value before design	Point value after design
Materials and Resources		14 points	0 points	4 points
Prereq 1	Storage and Collection of Recyclables			
Credit 1.1	Maintain Existing Walls, Floors and Roof	1–3		
Credit 1.2	Maintain 50% of Interior Non-Structural Elements	1		
Credit 2	Construction Waste Management	1–2		
Credit 3	Material Reuse	1–2		
Credit 4	Recycled Content	1–2		
Credit 5	Regional Materials	1–2		2
Credit 6	Rapidly Renewable Materials	1		1
Credit 7	Certified Wood	1		1

Except for 8 buildings in the Mimar Sinan Campus, which is the study area, only the concept design of 18 buildings is available. The materials to be used before the construction of these buildings have not been determined. However, the most important feature of the LEED certificate that distinguishes it from other certification systems is that it applies to the certification system before construction, after construction and during the construction phase. However, architectural applications were not included in the scope of the study. When the booklet in the LEED v3-2009 version is examined, it is stated that Regional Material Use is equivalent to the SITES v2 credit or component (USGBC, 2023). From this point of view, we can also think of this title as outdoor flooring. This suggests that the existing impermeable floors planned to be built in the area in the future will be removed and the use of regional materials will be used instead. In this context, it is recommended to use regional materials in the outdoor floor coverings planned to be built in the area in the future. In addition, it is recommended to replace the existing impermeable flooring materials with regional materials. The flooring materials recommended for the study area are naturally found in the area (e.g., Gemlik diabase, Uludağ granite, travertine and marble materials). Floors created using these materials are designed to provide an underground water supply. In addition, a distance map of the mines (Figure 9) from which the material used in the area was extracted was created in the ArcGIS environment. When the topographic thresholds are not considered, it is evident that the furthest mine supply distance for granite material is between 60–70 km, while the closest mine is Gemlik diabase for marble material. As a result, a value of 2 points was obtained for this title. The building materials of all reinforcement elements used in the area have been designed by considering recyclable and naturally site-specific materials. Within the study area, outdoor wood items include bamboo flooring, garbage cans made of linen, pergolas made of wood and geotextiles, seating units made of wood and stone materials, and lighting units constructed of wooden materials. These materials are rapidly renewable. In this manner, recycling which is an important component of ecological landscape design has been implemented in campus areas.

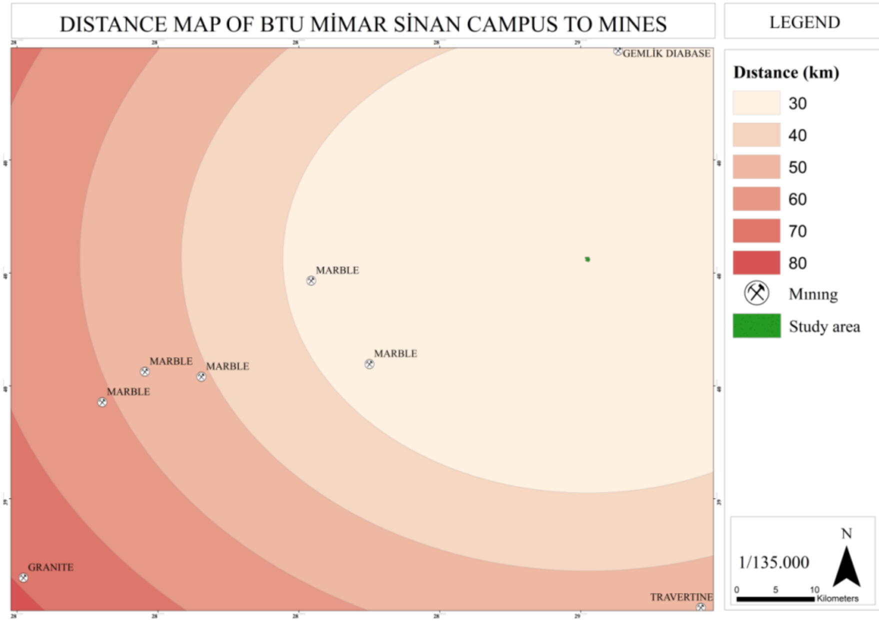

Figure 9. Distance map of the campus to mines (Aksoy, 2024)

The recommended wood materials were obtained from companies certified by the Forest Stewardship Council (FSC) in accordance with their principles and criteria. In this context, 1 point was obtained from this title. A compost processing facility (Figure 7) is proposed for the southeast of the area. By using the proposed compost processing facility, tree, branch, leaf, kitchen and grass residues can be converted into compost. This compost is planned for use as organic fertiliser for plants.

3.2.5. Indoor environmental quality (IEQ)

The IEQ category includes strategies for improving indoor air quality and accessing natural daylight and views while also improving acoustics (Council UGB, 2009; Haselbach, 2010). However, since the applications under this category cover architectural applications, the point value could not be obtained (Figure 12).

3.2.6. Innovation and design

In the examinations conducted at the BTU Mimar Sinan Campus, it was observed that there is currently no study in the field that can be considered innovative. The following aspects can be described as innovative in the ecological landscape design proposed under LEED: self-watering soil (Karagöz & Yücel, 2020), plant species that produce their own energy (Murray et al., 2016), plants that glow at night (Patel & Ashwini, 2022) and biolamb (Horvath & Tóth, 2005). With these applications, the score for this category was increased to 4 points (Table 7).

Table 7. Point values obtained for the ınnovation and design category and its sub headings before and after the ecological design

v3-LEED Categories		Category weights	Point value before design
Innovation and Design Process		**6 points**	**4 points**
Credit 1.1	Innovation in Design: Specific Title	1	1
Credit 1.2	Innovation in Design: Specific Title	1	1
Credit 1.3	Innovation in Design: Specific Title	1	1
Credit 1.4	Innovation in Design: Specific Title	1	1
Credit 1.5	Innovation in Design: Specific Title	1	
Credit 2	LEED Accredited Professional	1	

The first application that can be considered innovative in the study area is the application of 'biolamb' (Figure 10). Since the study area in Yıldırım District is close to an industrial zone, the air quality is low. The 'biolamb' (Horvath & Tóth, 2005) proposal is an ecological application that has been used for trial purposes in the campus area. These devices clean polluted air with algae growing within them and have been used in an attempt to improve air quality in the campus area.

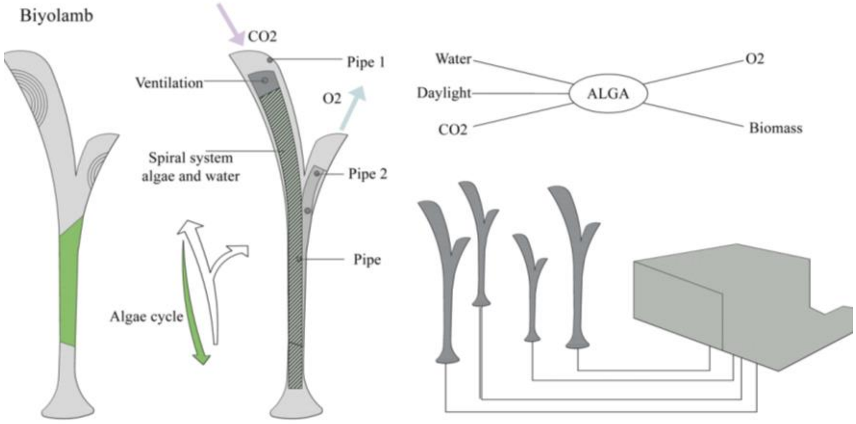

Figure 10. Working principle of the biolamb application proposed for the BTU Mimar Sinan Campus (Horvath &Tóth, 2005)

Another application is the use of plants that produce their own energy. This type of system, which works by using the energy stored in soil which contains nutrients and microorganisms secreted by plants during their growth (Murray et al., 2016)—was placed in certain parts of the study area for trial purposes. Compost material created from branches, bark, leaves and grass waste in the gardens will be constantly supplied to these areas. In this manner, the continuity of nutrients in the soil will be ensured. Plants that glow throughout their lifetime (Patel & Ashwini, 2022) are suggested for entrances and heavily used areas for trial purposes. The last application that can be considered innovative within the scope of ecological landscape design in the area is the 'self-irrigating soil' application. This new soil mixture can draw water from the air and distribute it to the plants. This soil mixture can expand the arable land map and reduce agricultural water use. In this method, highly moisture-absorbing gels (Figure 11) are used to draw water from the atmosphere to the soil. When the soil reaches a certain temperature, the gels release water to be given to the plants (Demitri et al., 2013). In a similar study, Karagöz & Yücel (2020) tested this method on Euonymus japonicus 'Aureomarginatus'. In this study, the authors attempted to reduce the amount of water consumption by using super-absorbent polymers. As a result of the study, water use was reduced by 45%, while labour costs were reduced by 48%. This study was applied to four parcels for trial purposes in the field.

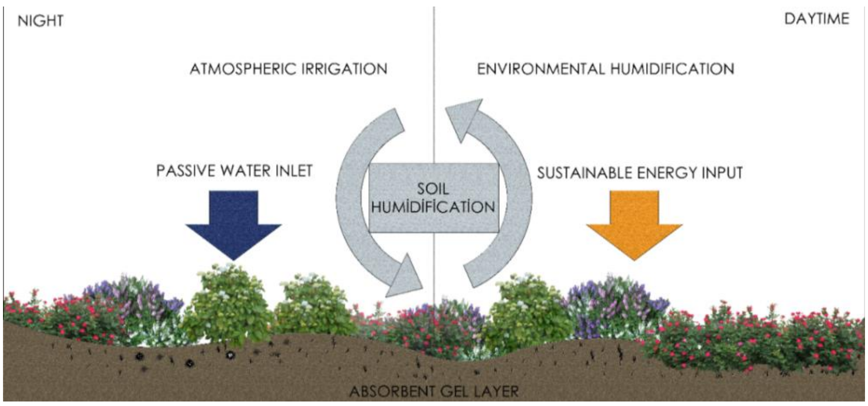

Figure 11. 'Self-irrigating soil' proposed for BTU Mimar Sinan Campus (Aksoy, 2022)

3.2.7. Regional priority

No point value could be obtained for this category within ecological landscape design. This is due to the inability of the design to meet the appropriate spatial criteria and the fact that the LEED certificate was created while considering areas within the borders of the USA.

3.3. Scoring BTU Mimar Sinan Campus After Ecological Landscape Design According To the LEED Scoring System

Although the score value for BTU Mimar Sinan Campus before the ecological landscape design was 10, a total of 50 points were obtained from the LEED certification when the ecological landscape design based on the natural and structural area was analyzed and v3-LEED (2009 version) was applied. This point value corresponds to a 'Silver Certificate' from the LEED certification.

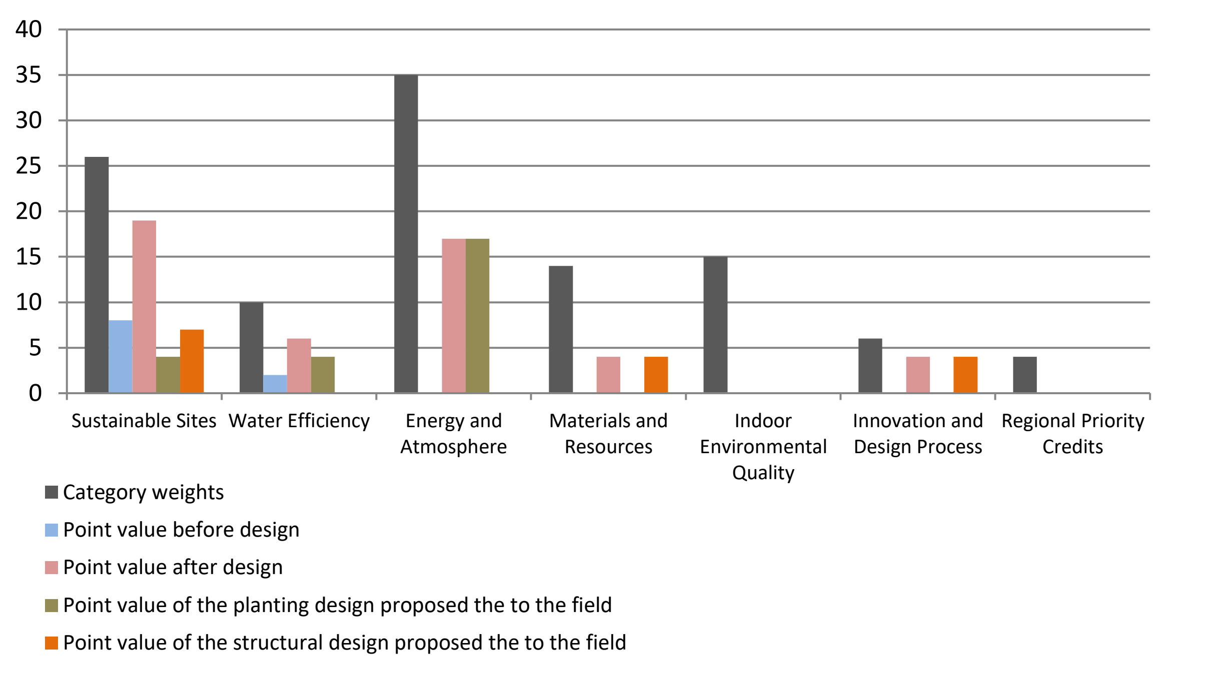

Figure 12. Point values for seven main titles in v3-LEED (2009 version) at BTU Mimar Sinan Campus. Values obtained before and after the ecological design and from the structural and planting applications in the designs (Aksoy, 2024)

As a result of the study carried out at BTU Mimar Sinan Campus by taking into account the v3-LEED (2009 version), structural and natural data in the area, it was determined that the study could receive a Silver Certificate. These score values were obtained with ecological landscape design applications made in the area. In the study area, applications were made in many categories such as water, energy, transportation, close environment, waste and materials. Similar applications to these applications were made at the Eisenhower Memorial. The Eisenhower Memorial is a conservation area in Washington, Columbia, USA. The area has obtained a Gold certificate in LEED certification. Many applications have been made in the area, such as the use of alternative transportation vehicles, reducing the parking capacity, increasing open green areas, rainwater management applications, green roofing, energy-efficient designs and regional flooring materials and the use of certified wood (USGBC, 2023). Other studies were obtained at the gold-certified University of Hawaii UHH Student Srvcs, the gold-certified Warszawa Business Garden, the gold-certified University of Hawaii WO Library, the platinum-certified BG Wroclaw Building 7 and the silver-certified Inonu University Student Life Center in Türkiye (USGBC, 2023). All these practices are important in ecological and sustainable design studies on campuses.

With the ecological practices to be carried out on the campuses; Many benefits are provided, such as saving water and energy, reducing the urban heat island effect, combating disasters, increasing biodiversity and creating a healthy and livable environment. According to a study by Song (2022), planted rooftop gardens can absorb 15 to 90% of available rainwater and rain gardens can reduce runoff by 25–69%. According to studies conducted by Erken (2021) and Wolf (2004), the use of natural plant material in the landscape protects existing natural vegetation while preserving water and enhancing its quality.

The energy problem concerns the campus areas as well as the whole world. In this context, while planning university campuses, design proposals that provide minimum energy savings should be made. This makes the energy title in many certification certificate systems such as LEED, BREEAM, SITES, Green Metric an important tool for campus and other areas. However, structural material is not the only alternative for energy saving in LEED certification. Energy savings can be achieved in plant material. According to Kern, Antoniolli, Wander, Mancio, & González (2016), among 21 certified LEED buildings, the results for 18 show savings of only 1% below the expected value, rather than the 27% promised at the certification stage. Another study investigated the energy performance of 100 LEED buildings and concluded that these buildings use 28 to 35% more energy on average than non-certified buildings (Kern et al., 2016). According to Panagopoulos (2008), urban tree planting can provide a 25% reduction in net cooling and heating energy use in urban landscapes. According to Aboelata & Sodoudi (2019), trees and vegetation can reduce indoor energy consumption by increasing outdoor thermal performance and reducing urban heat islands. Also, urban trees can reduce energy use from air conditioning by 20%. Regarding energy reduction, lawns lower the outdoor air temperature and therefore reduce the energy demand of buildings by 0.2–0.5%. In this study, the authors attempted to save energy by using plant material that is not in the energy and atmosphere title of the LEED certificate. The cost of plant material is low when compared to other structural applications and its efficiency is high in terms of energy saving. According to a study by Feng & Hewage (2014), covering a building envelope with green vegetation (e.g., a green roof or vertical garden) is considered a sustainable practice in terms of energy savings. According to studies conducted by Aşkın (2014) and Esin (2001), heating and cooling cost savings of 20–40% can be achieved with herbal applications in campus areas. According to Feng and Hewage (2014), by planting plants in urban areas, a 25% reduction in cooling and heating energy use can be achieved in urban areas.

Many of the university's environmental sustainability actions are limited in scope and focus mostly on reducing resource consumption, waste generation and carbon emissions, rather than rethinking existing processes and reorienting sustainability strategies (Mendoza, Gallego-Schmid & Azapagic, 2019). Recycling of solid waste is important in terms of reducing the negative effects on the environment (Saygın & Ulusoy, 2011). In this context, solid waste and plant residues are recycled in university campuses and suitable solid wastes are reused as reinforcement elements (El Ouaqoudi et al., 2015) while plant material is used as compost (Mendoza et al., 2019). In addition, studies have proven that there are some benefits such as water purification, reduction of traffic noise, Urban Heat Island (UHI) reduction and recycling of waste materials, thanks to the permeable flooring material (Guan et al., 2021).

LEED certification also conducts auditing studies on ecological and sustainable transportation practices for university campuses. Ecological campus practices such as shared vehicle use, increasing hybrid vehicle use, bicycle access, increasing public transportation access and increasing parking areas are important in campus sustainability. For example, WSU Riverpoint Biomedical Campus has obtained a silver certificate by applying for many of the above-mentioned titles (USGBC, 2023). Finally, reducing the UHI effect by increasing open green spaces on university campuses, reducing CO_2 emissions (Zhang et al., 2014) and providing habitat areas for wildlife. For example, Whirlpool Downtown Campus has obtained a platinum certificate for campus sustainability with many applications such as green roofs, increasing open green spaces and preventing light pollution (USGBC, 2023).

All applications made within the scope of LEED certification are important for the sustainability of the campus and its immediate surroundings. Because, within the scope of green certification studies, it can be ensured that the balance of protection and use, the development of an effective system to cope with the problems occurring on a global scale, the evaluation of the campus and its immediate surroundings according to a certain classification, and the supervision of planning, design and management by expert and academic committees. There are some limitations in the scope of the study. For example, it could be possible to evaluate the area according to the SİTES certificate, but the SİTES certificate only evaluates green areas. Within the scope of this study, the building and the green area were evaluated together in the area. Another limitation in the LEED certificate is that almost all of the applications recommended in the energy and atmosphere category include structural applications. In the study, although not in the LEED certificate, point values were obtained by considering planting practices in the title of optimizing energy use. In this context, the use of plant materials should be increased, especially in areas where open green areas such as campus areas are considered together. Another limitation of the LEED certificate is the 'education' title in the Greenmetric certificate in campus areas. As a result, landscape planning, design and management issues for different versions of the LEED certificate, which evaluates campus areas, should be rethought by considering the academy and sustainable campus studies.

4. Conclusion and Suggestions

In the BTU Mimar Sinan Campus, an ecological landscape design study was conducted for the area while considering the v3-LEED (2009 version). Although the current point value for the area was 10 before the design study was conducted, this value was increased to 50 with the ecological landscape design study. This score corresponds to the 'Silver Certificate' of the LEED certification. Overall, 30 points of this score were realised through planting applications. Considering this score, it was concluded that the ecological landscape characteristics of the area can be increased with the proposed planting design. A score of 11 was obtained through the proposed structural applications, which have a lower score output than the outdoor herbal applications. This score was obtained from areas such as irrigation, waste, energy and transportation. The reason for not obtaining a higher score than the LEED certificate is that the certificate was created with the architectural infrastructure in mind. Since it is an architectural certificate, no points could be obtained by improving indoor air quality. As a result, the BTU Mimar Sinan Campus could not receive any certificate in its current form; however, with the proposed ecological landscape design, it could obtain a 'Silver Certificate' by achieving 50 points in the LEED certification system. An important step can be taken in terms of cost and sustainability by encouraging the use of the structural and plant applications of landscape architecture in this certificate system, which can be achieved by investing a large amount of labour and money in architecture.

Acknowledgements and Information Note

No assistance was received from any institution or organization in the study. The article complies with national and international research and publication ethics. Ethics committee permission was not required for the study. This article was produced from MSc thesis.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

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