ARCHITECTURAL SCIENCES AND SUSTAINABLE APPROACHES: UNIVERSITY CAMPUSES

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PREFACE

Dear Professors and Colleagues,

We are pleased bring to life that Architectural Sciences and Sustainable Approaches: University Campuses, which was published as an e-book by IKSAD Publishing House with the editors Assoc. Prof. Dr. Ertan DÜZGÜNEŞ and Assoc. Prof. Dr. Sultan Sevinç KURT KONAKOĞLU.

Architectural Sciences and Sustainable Approaches: University Campuses; will address issues such as architectural design of university campuses, sustainability and environmental impact and offers a broad perspective from an academic perspective. Nowadays, universities are not only educational institutions, but also play leading roles in sustainability and environmental adaptation. Also they are a place for education, research and they encourage environmentally sensitive design and management practices by adopting sustainability principles. Therefore, we believe that this book will be a guiding resource for the future planning, design and management of university campuses by addressing these issues comprehensively and will contribute to producing greener, more livable and more effective solutions.

With the valuable contributions of our chapter authors working in the professional disciplines of landscape architecture, architecture, city and regional planning, urban design and sustainability, we have completed Architectural Sciences and Sustainable Approaches: University Campuses book study has been completed with 22 book chapters. We would like to thank you, our esteemed authors, for their contributions to the preparation of the book.

We would also like to thank the editorial board and IKSAD Publishing House. We wish to continue this process we have started in the coming years.

In addition, we would like to express our sincere appreciation to Prof. Dr. Atila GÜL, the book coordinator of IKSAD Publishing House, for his guidance and support throughout the publication process.

We hope that our book '***Architectural Sciences and Sustainable Approaches: University Campuses'*** will be helpful to the readers.

Best regards.

01.10.2024

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1. Introduction

One of the biggest problems faced by all humanity today is the negative effects of economic growth on ecological systems. While economic growth increases the well-being of societies on the one hand, on the other hand, it causes environmental disruption and consumption of natural Resources (Amaral, Martins & Gouveia 2015). Similarly, the increase in technological developments and industrialisation to provide for the needs of an ever-increasing population has brought along an unplanned urbanisation (Kayapınar Kaya, Dal & Aşkın, 2019). However, problems such as environmental pollution, rapid depletion of natural resources, unconscious release of wastes into nature, release of toxic gases from production into the atmosphere, etc. have been among the issues worthy of discussion all over the world.

Since the early 20th century, environmental and ecological movement debates have become an important national and international policy issue (Kayapınar Kaya, Dal & Aşkın, 2019; Keirstead & Leach, 2007). Awareness on the subject has been tried to be created and action plans have been brought to the agenda. Thus, concepts such as "sustainable", "ecological", "environmentally friendly" have started to take place in our daily lives. The concept of "sustainability", which was first mentioned in the international arena in 1970, was defined as protecting the environment and ensuring ecological balance (Ağı Günerhan & Günerhan, 2016; Kayapınar Kaya, Dal & Aşkın, 2019). However, the concept of "Sustainable Development" came to the agenda at the development congress organised by the United Nations in Brazil in 1992 and became internationally recognised thanks to the Brundtland Report (World Commission on Environment and Development, 1987).

The term "sustainability" is nowadays frequently used in all areas of human activity related to the use and management of resources (Kutlu & Bekar, 2023). The key role of higher education institutions in the transition to a more sustainable society, which have significant environmental impacts at both the building and planning scales, has been recognised and emphasised for many years (Sonetti, Lombardi & Chelleri, 2016). Institutions of Higher Education have a special social responsibility for the development of society, in particular for the training of future leaders and for raising public awareness of Sustainability (Amaral, Martins & Gouveia, 2015).

University campuses include education buildings, social and cultural facilities, libraries, student dormitories, restaurants, dining halls, sports halls, etc., which serve many different functions and include significantly large systems. Therefore, the activities carried out on campus cause a large amount of energy and resource utilisation and generate waste. Therefore, universities, which are defined as key centres for innovation and environmental education in cities, should not only apply the concept of sustainability to build and use their infrastructure, but also promote it by including it in their curriculum courses. Universities have important responsibilities to ensure the necessary generational behavioural change to adopt more sustainable attitudes in daily life (Amaral et al., 2015; Sonetti et al., 2016; Yoshida, Shimoda & Ohashi, 2017).

According to the definition of sustainable university in the literature, universities should have environmental, economic and social concerns in all their activities and have the obligation to be an example to the society (Amaral et al., 2015). Accordingly, a university should minimise the negative environmental and social impacts that arise from the use of resources (Velazquez, Munguia, Platt & Taddei, 2006); protect the health and well-being of people and the ecosystem; have a responsibility to use the knowledge produced at the university to address the ecological and social challenges we face now and in the future (Cole, 2003); transfer to society efforts to conserve energy and resources, reduce waste, and promote social justice and equity (Alshuwaikhat & Abubakar, 2008). Furthermore, it is recommended to establish a university-wide sustainability committee to set and approve sustainability policies, goals and objectives in line with the sustainability mission. In addition, networking and collaborating with other universities to share their approaches and practices on sustainability are among the responsibilities of a sustainable university (Too & Bajracharya, 2015).

The first step towards university sustainability was taken in 1972 when the Declaration of the United Nations Conference on the Human Environment addressed the issue of sustainability in higher education (Amaral et al., 2015). Since then, many universities have voluntarily signed declarations declaring their commitments and have applied the necessary tools to achieve sustainability (Leal & Wright, 2002). Especially since 1990, the work of universities on sustainability has gained momentum, unions and societies have been formed, declarations and conditions have been signed (Ağ Günerhan & Günerhan, 2016). In recent years, measurement systems that evaluate the environmental performance of universities have been developed and have become widespread. Evaluation systems such as Green League, Environmental and Social Responsibility Index, UI GreenMetric are examples of international indices developed in this context. Among these, the UI GreenMetric index is the first developed and most widely used.

Universitas Indonesia (UI) launched the world university rankings in 2010, called UI GreenMetric. This initiative was launched with the aim of creating an online survey that would target universities around the world and reveal their sustainability policies. Factors such as increasing environmental problems in higher education institutions, water scarcity, rapid depletion of energy resources, decrease in biodiversity, and deterioration of ecological balance have been effective in the emergence of the model (Kayapınar Kaya, Dal & Aşkın, 2019). Thanks to this metric, information and experience sharing is provided among the universities participating in the ranking, and it is possible for universities to see their weaknesses and strengths. The rankings are largely based on the concepts of environment, economy, equality and teaching (UI GreenMetric Guidline, 2023). Within the framework of these concepts, categories and indicators were determined to evaluate the sustainability performance of universities. The UI GreenMetric index consists of 6 main categories and 53 sub-indicators. The main categories are Settings and Infrastructure (SI), Energy and Climate Change (EC), Waste (WS), Water (WR), Transportation (TR), Education and Research (ED) (Table 1).

Table 1. UI GreenMetric Evaluation Criteria, Points and Weights

No	The Criteria	Score	Weight
1	Settings and Infrastructure (SI)	1500	%15
2	Energy and Climate Change (EC)	2100	%21
3	Waste (WS)	1800	%18
4	Water (WR)	1000	%10
5	Transportation (TR)	1800	%18
6	Education and Research (ED)	1800	%18
Total		10.000	%100

Institutions of Higher Education have important responsibilities in encouraging and raising awareness of the society on any subject. For this reason, creating awareness for academics, students and employees in these institutions should be among the priority steps. Creating awareness is possible only if the physical environment in which they are located provides the necessary conditions. Therefore, university campuses should be shaped in line with sustainability principles and this philosophy should be adopted by all individuals. Similarly, attempts should be made to put forward practices that will set an example for each other among universities, to follow the developments in the world and to strive to be better. From this point of view, the aim of this study is to reveal the sustainability approaches applied in university campuses based on the UI GreenMetric index, which is an important evaluation tool worldwide. It is aimed to provide a guiding and exemplary guide to other universities that strive to become sustainable campuses with this determination study carried out specifically for the universities that are among the best in the world rankings.

2. Material and Method

This study, which aims to reveal sustainable approaches in university campuses, is designed with a descriptive design. Firstly, a literature review on sustainability and sustainable campus designs was conducted. Then, the university campuses to be analysed in the study were determined. These campuses were analysed and finally the study was concluded with the evaluation phase (Figure 1).

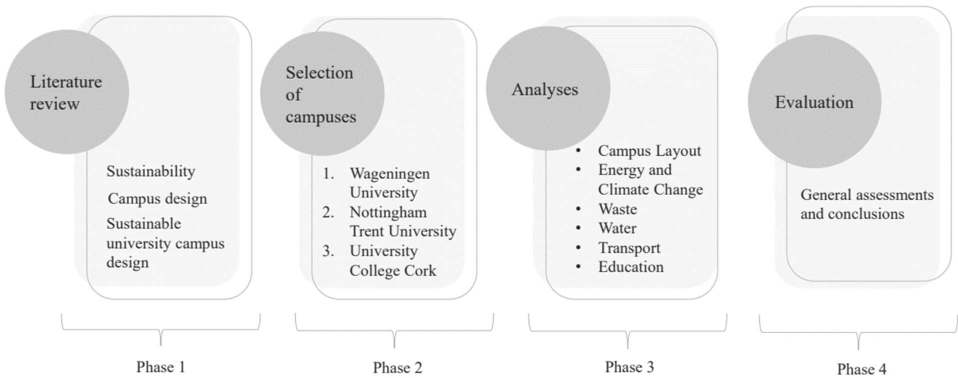

Figure 1. Research design

The UI GreenMetric ranking, which aims to promote the sustainability efforts of universities and evaluates their environmental sustainability performance, was taken into consideration in the selection of campuses. Since the data and all other necessary information used in this ranking are obtained from the UI GreenMetric ranking table and the databases of the universities, its reliability is high. Although there are many universities located in different geographies in the UI GreenMetric ranking, it is rich in diversity. Based on all these, in line with the study objectives, 3 campuses with the most data were determined among the top 10 universities ranked in the world in 2023 (Table 2). These campuses were analysed according to the criteria in the UI GreenMetric measurement and evaluation system.

Table 2. Selected Universities

	**University Name:** Wageningen University & Research **Country:** Netherlands **Date of Foundation:** 1876 **First Year in UI GreenMetric Ranking:** 2011
	**University Name:** Nottingham Trent University **Country:** England **Date of Foundation:** 1843 **First Year in UI GreenMetric Ranking:** 2015
	**University Name:** University College Cork **Country:** Ireland **Date of Foundation:** 1845 **First Year in UI GreenMetric Ranking:** 2014

3. Findings and Discussion

Wageningen University

Wageningen University in the Netherlands has been named the world's most sustainable university 7 times in a row according to the UI GreenMetric ranking. With its mission to explore the potential of nature to improve the quality of life, the university is the world's greenest university. In this context, the university ranks first in the UI GreenMetric Sustainable Universities world ranking with 9,500 points out of 10,000 points as of 2023.

The University achieved a score of 1350 under the first of the UI GreenMetric assessment criteria, "Setting and Infrastructure (SI)". Approximately 40% of the university's land area is green, and the campus has important ecological components such as wooded shores and ecological connectivity zones (URL-1) (Figure 2).

Figure 2. Green spaces and waterways at Wageningen University (URL-1)

The campus area consists of nature gardens, flower meadows, mixed vegetation of grasses, shrubs and trees, and ponds with gently sloping banks (URL-1) (Figure 3). Management plans are created for the regular maintenance of green areas, waterways and pond areas on the campus and for the maintenance of other green species.

Figure 3. Flora at Wageningen University (URL-1)

On the other hand, various sustainable maintenance techniques such as steaming weeds are used to combat invasive plant species on campus. On the other hand, in the university, which focuses on fauna management as well as plant species, various harmful organisms such as oak caterpillars are subject to environmental control and are under control so that they do not adversely affect the lives of other living things living in the immediate vicinity. In addition, action plans are formulated for all kinds of construction activities planned to be carried out in the campus area in order to balance the negative impact on the habitats of all other living things, especially the sparrow hotels and bat boxes located on the campus.

The University's score for the "Energy and Climate Change (EC)" criterion is 1825. All buildings on the university campus have been constructed in accordance with BREEAM guidelines to support environmental sustainability. Each building on campus focuses on a different aspect of sustainability depending on its function. Solar panels are located on the roofs of all suitable buildings on the campus and over 30,000 square metres of solar panels are currently used on the campus. Thus, renewable energy production is provided (URL-2) (Figure 4).

Figure 4. Various applications for energy efficiency at Wageningen University (URL-2)

By using smart control technology, energy consumption on campus is reduced by approximately 30% and LED lighting is preferred in all buildings. On the other hand, the university aims to reduce gas consumption by 85% in 2025 compared to 2018 and plans to realise this through heat and cold storage sources on campus. At the same time, it saves energy by fixing the heating of the buildings to 19 degrees in winter. In particular, thermal storage technology is used in a few of the buildings on the Wageningen Campus, contributing to the reduction of energy costs and energy efficiency. On the other hand, the university prioritises sustainable maintenance and material alternatives and uses sustainable roofs, paints and window frames (URL-2). In addition, in order to encourage the use of stairs instead of lifts in university buildings, lifts are placed in areas that are not easily visible in the building.

In the university, which scored 1,800 points in the "Waste (WS)" criterion, a sustainable purchasing policy is implemented as much as possible to reduce waste. Considering the life cycle of the material, sustainable materials are prioritised at the university. In other words, in addition to whether the material is reusable or not, attention is paid to be environmentally friendly from the production stage. At the same time, the unit at the university circularises its operations to keep the amount of waste to a minimum. At the university, which cares about reusing waste, opportunities to utilise existing waste are sought. In addition to these, studies are carried out on environmentally friendly raw materials to reduce the amount of waste at the university. Plastic wastes generated in laboratories and other units of the university campus are utilised in workshops organised with various collaborations. In Wageningen Campus, wood materials are used in many different areas from car park paving to outdoor furniture (Figure 5). They are made from Accoya, an environmentally friendly material made from soft pine wood produced in New Zealand (URL-3).

Figure 5. Various practices for waste management at Wageningen University (URL-1)

In another UI GreenMetric criterion, "Water (WR)", the university has a score of 1000. The university reduces water use in various ways. Grey water is used instead of drinking water in all possible buildings on campus. In addition, the cooling systems in the buildings are adjusted to consume less water from there. The university has waterways, which form an important part of the ecological water system in Wageningen (Figure 6). Thus, rainwater is collected in Wageningen canals via waterways (URL-4). In addition, while regulating the water level on the campus, it is aimed to support the development of flora and fauna in the ponds or in the immediate vicinity.

Figure 6. Waterways at Wageningen University (URL-1)

The university received a score of 1750 in the heading "Transportation (TR)". Visitors and students are encouraged to choose a more sustainable transport alternative such as bicycles, buses or trains in addition to their personal vehicles. There are areas within the campus where individuals can purchase electric bicycles. On the other hand, the network of bicycle paths on the campus is interconnected with the bicycle networks around the university. For public transport connections, the university works with the local municipality and other transport companies. In addition, in order to reduce the use of vehicles for transport, the digital working system, which allows working independently from place and time, is frequently used at the university. On the other hand, various shared transport alternatives have been developed at the university through the "Mobility as a Service" project (MaaS). Individuals who need a car come together and use shared electric cars for transport (URL-5).

It is possible to charge cars or bicycles with electric charging areas located at various points on the campus (Figure 7). Established in 2013, the first charging stations are now more than 129 points with increasing demand. At these points, individuals can also charge their phones or laptops. Visitors and students driving cars also use a solar-powered tyre pump to inflate their tyres for free at certain points on campus. In addition to saving fuel, this reduces CO_2 emissions.

Figure 7. Electric charging areas at Wageningen University (URL-4)

The university scored 1775 points in the last category of the UI GreenMetric ranking, "Education and Research (ED)". At the university, many researchers from different disciplines such as ecologists, soil scientists, technologists, economists, behavioural scientists, etc. are working on biodiversity for a more sustainable environment. Global biodiversity, climate issues, sustainable innovative material studies are just a few of the studies carried out in the field of education (URL-5).

Nottingham Trent University

The university in the England is one of the most sustainable universities in the world, which has been selected consecutively in recent years according to the UI GreenMetric ranking. In this context, it ranks 2nd in the UI GreenMetric Sustainable Universities world ranking as of 2023. UI GreenMetric received 9475 points out of a total evaluation score of 10,000 points.

The University scored 1375 points under the heading "Setting and Infrastructure (SI)", the first of the UI GreenMetric evaluation criteria. Spread over 260 hectares of campus, various practices are carried out to protect the biodiversity of green areas and to ensure that future generations can benefit from them. All lands on the campus are managed by expert teams and there are more than 25 different plant species throughout the campus. At the same time, some of the plants grown in the gardens on campus are used to make natural dyes in the Waverly Natural Dye Garden. In addition, "Home Farm" areas have been designed with a series of log piles to create a home for various animal species in the wooded areas on campus. At the same time, wildlife is supported on campus and 107 species are monitored and recorded with various observations through the "iNaturalist Biodiversity Monitoring" project launched in 2022. On the other hand, the existing ponds in the campus area have been improved in cooperation with Natural England (Figure 8).

With the improvement of the existing ponds, the population of salamander fish living in the lake has increased (URL-6).

Figure 8. Green spaces and ponds at Nottingham Trent University (URL-6)

Living green walls and roof gardens are another common practice on campus. These surfaces, which provide an additional habitat for wildlife in the campus area, also improve air quality and reduce the need for air conditioning by absorbing heat naturally. Plant species include bluebells and euonymus. The Boots roof garden stands out with its planting areas where students and staff can socialise and protect biodiversity (URL-7) (Figure 9).

Figure 9. Vertical and rooftop gardens at Nottingham Trent University (URL-7)

The score obtained by the university in the "Energy and Climate Change (EC)" criterion is 1850. Vertical and rooftop gardens on the campus are among the practices that contribute to energy efficiency as well as biodiversity. These applications, which reduce the need for air conditioning, also play an important role in energy efficiency by reducing energy costs. The annual electricity consumption of the university was reduced by 2,848,322 kWh with the Building Management System (BMS), which controls various infrastructures such as heating, cooling, lighting, power and security systems of the buildings on the university campus. On the other hand, the university meets a significant portion of the energy it needs from various on-site renewable sources such as photovoltaic panels and biomass boilers (Figure 10). In addition to this, the "Net Zero Carbon" project is another practice in which the university is gradually reducing its carbon footprint as much as possible and aims to zero it by 2040 (URL-6).

Figure 10. BMS system in Nottingham Trent University buildings (URL-6)

The University's score in the "Waste (WS)" category, which is a UI GreenMetric criterion, is 1800. Various practices are carried out with waste management providers at the university regarding the waste generated. The teams aim to contribute to circular use by reusing or recycling most or a large part of the waste generated from activities. The "WARP-It" study is one of the university's waste management practices. It is a web-based platform for the redistribution and saving of unused furniture. In this way, approximately 8,000 kg of waste material was diverted from landfill sites as well as 40,000 Euro cost savings in one year. At the idle Worm Farm on the Brackenhurst campus, plant fertiliser and compost are produced using recyclable waste and paper scraps. In this way, a large number of unused and waste paper-based waste materials have been put into use. In addition, various food wastes and oils are collected and recycled at the university's catering outlets, some of which are used as takeaway packaging. The other part is processed at the Colwick Anaerobic Digestion Plant to generate electricity. In addition, instead of being sent to landfill, the University's landfill sands are used to produce a lighter weight concrete. These concretes are also used in various areas such as garden pavements and bicycle paths. On the other hand, various artistic works are carried out at the university to draw attention to reduce plastic addiction and waste recycling, and the work titled "Plastic Person" has been the most prominent among them (URL-8) (Figure 11).

Figure 11. Waste management practices at Nottingham Trent University (URL-9)

In another UI GreenMetric criterion, "Water (WR)", the university has a score of 1000. The university aims to reduce water use by 8% as of 2018 and to consume less water each year than the previous year. Regular trainings and awareness-raising activities are organised for students and staff on water saving and conscious use of water at the university. In addition, water saving practices are carried out with simple arrangements by installing adapters to the taps. It is predicted that 60-80% water saving will be achieved when sensors are placed on approximately 600 taps on all campuses. Maintenance programmes that extend the life of the water infrastructure in the long term and optimise water performance in various building services are implemented throughout the university. In addition, it has been determined that approximately 6,000 cubic metres of water is consumed due to water leaks on campus, and work is underway on a major repair project by replacing the problematic sections of the networks with medium density polyethylene pipes (URL-10).

The score obtained by the university from the "Transportation (TR)" criterion is 1750. Under this criterion, practices that support a sustainable and active life are carried out at the university. In this context, 111 standard bicycles and 12 e-bikes were lent to students and staff throughout the university. In addition, there are 906 bicycle spaces on the campus and they are open to the use of every individual who uses bicycles (Figure 12). "Cycle to Work" application has been initiated on the campus and efforts are made to encourage cycling by organising discount campaigns on bicycles and accessories. In addition, there are 32 electric vehicle charging points on campus. In relation to the use of public transport, with the "Go2 Uni4 Bus Service" application at the university, trips are organised every ten minutes, which facilitates transportation between the university campuses. There are also car sharing applications with the companies that the university cooperates with in order to reduce the carbon footprint, save money economically, and reduce local congestion and pollution (URL-11).

Figure 12. Transport applications at Nottingham Trent University (URL-11)

The score obtained by the university in the UI GreenMetric criterion "Education and Research (ED)" is 1675. There are many research and development activities within the university for sustainability and a more livable future. Modern greenhouses with automatic air conditioning used for academic research, vertical farming units for sustainable natural food production are some of them (URL-12) (Figure 13).

Figure 13. Various educational activities at Nottingham Trent University

University College Cork

University College Cork in Ireland was founded in 1845. In 2007, they launched the Green Campus Programme, a "student-led, research-led, research-informed and practice-focused" programme to drive the transition to sustainability on campus and in the community (Figure 14). The Green Campus is a seven-stage programme with a continuous improvement cycle. Within this programme, campuses are re-evaluated every three years by external experts. Aiming to continuously improve its environmental performance, the university has received nearly 40 awards, ratings and rankings in sustainability with the contribution of this programme. In this context, UI ranks 6th in the GreenMetric Sustainable Universities world ranking as of 2023. UI GreenMetric received 9425 points out of a total evaluation score of 10,000 points (URL-13).

Figure 14. Illustration from workshop with Green Schools committees as part of 10-year celebrations (URL-13)

The University achieved a score of 1250 under the first of the UI GreenMetric criteria, “Setting and Infrastructure (SI)”. University College Cork’s estate comprises of 295,000 m² of buildings, 86 hectares of grounds and property and approximately 149 individual buildings. There are 451 species of flora and fauna on the campus. Two-thirds of the campus is green space, with a total of 2.3 km of woodland. Activities are organised on the campus to raise awareness of biodiversity and to contribute to the development of biodiversity locally. In 2019, funding was received to develop the campus as an “Open Arboretum” under the “Living Laboratory” programme. In this context, the University College Cork Arboretum has a collection of over 2500 trees in an area of approximately 42 acres across the campus. The collection includes approximately 120 different tree species. This open arboretum is also used as a workshop and training area to raise public awareness of biodiversity and sustainability issues (URL-14) (Figure 15) .

Figure 15. Use of the campus as a training area (URL-13)

The university has achieved a score of 1875 in the Energy and Climate Change (EC) criterion. University College Cork became the first university in the world to achieve the ISO 50001 standard for Energy Management. The university's Saver Saves Scheme is the first of its kind in Ireland and empowers building users to save energy in their own spaces and reinvest the savings in environmental projects. A team is being established within the department/school to run the programme locally. Projects are being implemented to increase the building's efficiency with the support of the university's energy manager. The programme has saved over 300,000 KWh of electricity by 2020. The university has received government funding for two large-scale decarbonisation projects. The O'Rahilly Building Heat Pump project was completed in 2022 and has reduced the building's energy-related carbon emissions by 40%. The Enterprise Centre Deep Retrofit project is ongoing and is expected to reduce building emissions by over 60%. Lighting and heat pump improvements have been made across the site, while solar power has been installed in some buildings. The approach across the campus is to move from gas heating to electricity or more renewable energy sources. As a ‘Living Laboratory’, different approaches are being tested at different sites to determine which will work best for the campus. Regulations require that all new buildings and major refurbishment projects across the university meet Near Zero Energy Building (NZEB) requirements, achieve a minimum A3 Building Energy Rating and BREEAM Excellent standards. Sustainability is considered at every stage of the project, from conceptual to construction and operation. The orientation and form of the building as well as the materials to be used are chosen at the concept stage and specified to give the most sustainable design for the purpose and location of the building. Designers are also tasked with achieving and/or incorporating as many Passive House Institute principles as possible into the building design. The new Student Hub Building, which was officially opened in May 2022, achieved BREEAM Excellent and was designed to maximise daylight and natural ventilation (URL-13; URL-14).

University College Cork has achieved a score of 1800 on the UI GreenMetric “Waste (WS)” criterion. Significant steps have been taken across the university in terms of waste management and waste reduction. Campaigns have been launched across the campus to reduce the use of single-use plastic products. Disposable cups have been phased out in many buildings on campus. The use of reusable plates, cups and serving items has been encouraged. Mini dishwashers have been installed to sterilise staff and students’ reusable individual items. Similarly, a soft drink dispenser has been installed in the main campus restaurant. These practices have reduced the use of single-use cups by almost one million units per year and plastic bottles by more than 70,000 units per year across the campus. In addition to single-use products, the restaurant kitchens have also started using the “Positive Carbon” tool to reduce food waste (URL-13; URL-15).

Positive Carbon is a total food waste monitoring solution designed to register different food waste types being disposed of. With this tool, food waste has been reduced by approximately 20%. A swap store has been established for university students' used and thrown away or collected items. Thanks to this store, students can access many products such as furniture, personal items, etc. at affordable prices, and products that meet their needs can be reused instead of being wasted. In addition, graduate theses have been transferred to digital media in order to reduce paper waste. It has been determined that approximately 400,000 pages of paper are saved per year with this application. Although important steps have been taken in terms of waste reduction, it is aimed to do more work to increase recycling rates at the university (URL-14).

The university has a score of 1000 from another UI GreenMetric criterion, “Water (WR)”. The main water consumers throughout the university are cafes, restaurants, toilet systems, fountains, research laboratories and deionized water production facilities. A comprehensive study on water usage was conducted across the campus in 2019. The measures taken in this context are as follows (URL-13):

- Embedding water conscious behaviour in the campus community through education & awareness.
- Upgrading to water efficient facilities including sensor technology & dual flush.

- Installation of water flow restrictors on tap outlets and sensor technology.
- Comprehensive underground leak detection & remediation program.
- Installation of metering and alarming systems to identify any leakage, excess consumption.
- Auto water shut offs to match building opening times.
- Use of grey water reuse systems for toilet flushing. For example, grey water from GSHP in the Western Gateway Building feeds WC Tanks with an average of 10m3 per day.
- Use of rainwater harvesting for toilet flushing, plant watering and use in glasshouse facilities.

The measures implemented have seen a 38% absolute reduction in water usage based on a 2019 baseline.

University College Cork achieved a score of 1700 in the “Transportation (TR)” criterion. In order to reduce transportation costs at the university, distance education is being implemented as much as possible in addition to face-to-face education. A new indoor bicycle parking area with 70 spaces was opened in June 2022. 3 self-service pumps/repair stations have been created. The aim of the e-bike project carried out at the university was to provide staff with e-bikes for a trial period, allowing staff to determine whether cycling is a suitable method of travel for commuting to work. Over 180 staff members trialled the bikes with more than 15 then going on to purchase an e-bike through the Government “Bike to Work Scheme” administered through University College Cork. Work continues to encourage public transport or cycling in order to reduce car dependency on daily or weekly trips from outside the campus (URL-13; URL-14; URL-15) (Figure 16).

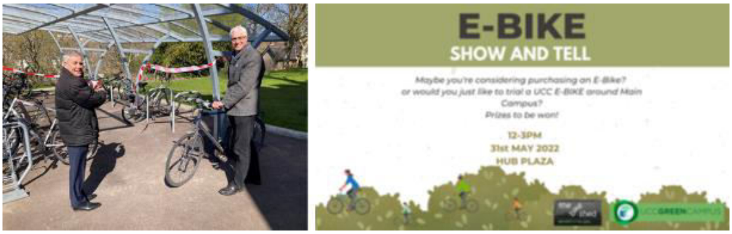

Figure 16. Cycling at university (URL-13)

It received 1800 points under the title of “Education and Research (ED)”, which is the last criterion of the Green Metric program. Activities are carried out at the university to encourage students, staff and society to be active citizens for sustainability, and to facilitate the development and empowerment of future leaders in the field of sustainability through learning and teaching activities. The “Learning and Teaching with the SDGs Digital Badge Course”, which was launched in May 2022, aims to inform teaching staff about sustainable development goals, help them identify connections between their modules and goals, and facilitate the integration of sustainable development goals into curricula. Similarly, open discussions are organized to identify obstacles to sustainable development goals and potential collaborative solutions through workshops and workshops (URL-13).

4. Conclusion and Suggestions

Universities play a key role in encouraging society towards a sustainable life thanks to their teaching and leadership power and their ability to conduct research activities towards a sustainable future. Therefore, as a requirement of this responsibility, they are expected to convey the basic principles of sustainability to society through both their physical environmental conditions and the curriculum they offer. In this context, the indexes developed to evaluate the environmental performance of higher education institutions around the world have enabled universities to approach sustainability activities more consciously. The practices of the universities examined within the scope of this study in line with the UI GreenMetric evaluation criteria are summarized in Table 3.

Table 3. Sustainability Practices at Universities

UI GreenMetric Kriterleri	**Applications Made**		
	Wageningen University	**Nottingham Trent University**	**University College Cork**
Setting and Infrastructure (SI)	• Rich vegetation and ponds • Green area maintenance plan • Measures against invasive plant species • Action plans to protect living spaces	• More than 25 plant species • Design of "Home Farm" areas • "iNaturalist Biodiversity Monitoring" project • Improvement of existing ponds • Vertical garden and roof garden applications	• 451 species of flora and fauna, more than 2,500 trees • "Living Laboratory" program • Use of the campus as a workshop and training area
	1350 p / 1500 p	**1375 p/ 1500 p**	**1250 p/ 1500 p**
Energy and Climate Change (EC)	• All buildings comply with BREEAM criteria • Solar panels • Smart control technology • Thermal storage technology • Winter temperature	• Building Management System for energy saving • Photovoltaic panels and biomass boilers • "Net Zero Carbon" project	• Compliance with ISO 50001 standards • "Saver Saves Scheme" program • The O'Rahilly Building Heat Pump project • Use of solar energy

	stabilization system		• Compliance with Near Zero Energy Building (NZEB) requirements for new buildings, minimum A3 Building Energy rating and BREEAM Excellent standards
	1825 p / 2100 p	**1850 p/ 2100 p**	**1875 p/ 2100 p**
Waste (WS)	• Sustainable material use • Waste management plan • Evaluation of waste plastics • Use of wood materials	• Waste management plan • “WARP-It” project • Production of plant fertilizer and compost from waste • Production of packaging from waste • Use of waste in electricity generation • Use of waste casting sand in concrete production	• Elimination of single-use plastic • Use of the “Positive Carbon” tool to prevent food waste • Opening of a swap shop • Delivery of theses digitally
	1800 p / 1800 p	**1800 p / 1800 p**	**1800 p / 1800 p**
Water (WR)	• Grey water usage • Rainwater collection with waterways	• Regular training for students and staff on water saving • Water saving and sensor faucets	• Sensor taps, double-chamber siphons • Water flow restrictors • Measurement and alarm system that detects leaks and excessive

			consumption • Automatic water shut-off • Recycling of grey water • Rainwater collection system
	1000 p / 1000 p	**1000 p / 1000 p**	**1000 p / 1000 p**
Transportation (TR)	• Encouraging the use of bicycles and public transport • E-bike purchase points on campus • Mobility as a Service project • Electric vehicle charging stations	• Providing bicycles to students and staff • "Cycle to Work" application • Electric vehicle charging stations • "Go2 Uni4 Bus Service" application • Car sharing applications	• Encouraging distance learning • Covered bicycle parking spaces • E-bike project • Encouraging public transport
	1750 p / 1800 p	**1750 p / 1800 p**	**1700 p / 1800 p**
Education and Research (ED)	• Many researchers from different disciplines conduct studies on sustainability.	• Research and development studies on sustainability	• Training courses for raising awareness among students and staff • Workshops and workshops
	1775 p / 1800 p	**1675 p / 1800 p**	**1800 p / 1800 p**

According to the UI GreenMetric 2023 ranking, the top ten universities received very high scores in all categories, and especially full scores in the "Waste" and "Water" criteria. In schools with rich vegetation, campuses are provided to host workshops and events like laboratories. Important activities are carried out in universities for energy saving. Sensitivity is shown in terms of compliance with the criteria of standards and certification systems. In the "Waste" category, applications aimed at reducing waste and evaluating existing waste brought full points to universities. Similarly, the recycling of both rainwater and gray water, measures taken to reduce water use, etc. also allowed them to reach full points in the "water" category. Applications regarding transportation on campuses are mostly aimed at encouraging bicycle use and public transportation. In the "Education and Research" category, projects carried out by researchers at the university, workshops and training provided to both students and staff are the prominent applications.

Universities should carry out their activities with the awareness of being an example not only for students but also for the whole society. Therefore, higher education institutions should be encouraging and supportive with the pioneering practices they develop for environmental problems, which are one of the most important problems of our age. The sustainability practices presented in this study are among the most important benefits aimed by the study, as they are guiding for universities both around the world and in our country.

It is considered that in order for university campuses in Turkey to achieve more successful results, it would be beneficial to produce various projects for energy efficiency, to invest in renewable energy sources in campus design, and to expand recycling programmes for the transformation of waste. On the other hand, it is suggested that educational activities to increase environmental awareness should be organised and courses to raise awareness should be included in the education programme. In addition, it is thought that more effective strategies on water use and waste management will be of great importance in promoting a sustainable campus culture. These initiatives will contribute to the higher ranking of universities in Turkey in the UI Green Metric ranking.

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Importance of Multifunctional Space Design on University Campuses

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1. Introduction

The university, which is the fundamental unit of higher education institutions, consists of affiliated faculties, colleges, conservatories, vocational schools, and institutes, along with their subdivisions (URL-1). The word university originates from the Latin term "universitas magistrorum et scholarium," which means "community of teachers and scholars." In the middle ages, it was used in the Western world to signify community, solidarity, and unity. Today, a university is defined as an institution that provides high-level education, scientific research, and publications through its faculties, institutes, colleges, and other subdivisions, equipping students with specific specializations (Alemu, 2018, p.211). Generally, a university represents unity and aims to produce universal knowledge in all fields and disseminate it. Historically, it has been a universal educational institution, thereby including students from various nations. Furthermore, universities can be described as institutions that absorb, develop, and spread the intellectual culture of society (URL-2).

The universal aim of universities is to conduct research, provide high-level education, produce knowledge, and disseminate it. The university has three primary functions: research, education, and public service (İflazoğlu Saban and Saban, 2016, p. 44). In 387 BC, the Greek philosopher Plato founded the Academy in the grove of Academos near Athens, where he taught philosophy, mathematics, and gymnastics (Doygun and Güleç, 2012, p. 1115) (URL-3) (Figure 1). The Library of Alexandria, although known as a library, became a significant scientific center that trained important scientists. Antioch, Harran, and Baghdad were centers where Muslim scholars translated and studied ancient Greek philosophy and are considered among the first universities (Saklı and Akdoğar Akbulut, 2017, p.10; Toksözlü Karaca and Önder, 2024, p. 28). The University of al-Qarawiyyin, founded as a mosque by Fatima al-Fihri in AD 859, is recognized as the oldest university in the world. Modern universities are considered to have originated from schools in the Christian tradition of the Middle Ages, with the University of Bologna (1088), the University of Paris (1150) and the University of Oxford (1167) being among the earliest examples (Hoque and Abdullah, 2021, p. 25).


Figure 1. Plato’s Academy (URL-4); A Medieval University Lecture and Genoa 1525 (URL-5)

When examining universities throughout history, their functions are seen as training highly qualified individuals with disciplined and productive thinking, contributing to the development of science and technology, solving national and global problems, providing free education to nurture rational and broad-minded generations, leading the spread and establishment of critical thinking, contributing to the development of basic sciences, conducting applied research, renewing and enriching existing knowledge and ideas, training personnel needed in professional fields and ensuring the renewal and intergenerational transfer of culture (Erdem, 2013, pp. 109-120).

To fulfil these functions, universities require various physical spaces, such as classrooms, laboratories, lecture halls, libraries, study offices, conference halls and recreational areas. Some universities are located within campuses, while others operate in individual buildings dispersed throughout cities. Therefore, based on their urban locations, universities can be classified as city or suburban universities (campuses) (Erçevik and Önal, 2011, p. 152).

It is important for universities to provide spaces for individual and collective use by students, academics, other staff, and the public. Lectures and practical works are conducted in classrooms and laboratories. They should be equipped with modern technologies and allow for flexible arrangements. Libraries should offer quiet study areas, group study rooms, digital resources and extensive book collections to meet students' research and learning needs. Cafeterias, student club rooms, outdoor seating areas and play areas where students can socialize are essential spaces for universities to perform their functions. Health centres and psychological counselling services should be provided to maintain physical and mental health of students. Silent and well-equipped individual study areas should be available for academic work and student counselling. Specialized areas equipped with advanced technology and security standards for advanced research, as well as spaces with the necessary technological infrastructure for academic and administrative meetings, seminars, conferences, and workshops, are also necessary. These diverse spaces help universities fulfil their academic and social roles. While providing suitable working and research environments for students and academics, universities also offer public spaces and services to the community, thereby integrating with society and contributing to social development. In recent years, due to insufficient physical space in universities, an increase in their duties and objectives, and a growing number of students and staff, multifunctional space designs have become prominent.

2. The Concept of Multifunctional Space

In architecture, a multifunctional space, as the name suggests, can serve multiple functions. Also known as “multipurpose space,” multifunctional spaces can be used for various activities and purposes, such as meetings, seminars, conferences, individual or group work, and other events. These spaces bring together multiple functions in the same area, sometimes simultaneously. Their adaptability allows communities to create spaces that serve various purposes and shape urban growth. Adapting primary interaction areas, such as conference rooms and workstations, enhances the efficiency of space usage. Multifunctional spaces are appropriate for integrating various functions in terms of both time and space. The concept of multifunctional space is not entirely new, and it can be found in traditional architecture. For example, the rooms in a traditional Japanese house are multifunctional spaces that derive, their identity from temporary users. These multifunctional spaces combine indoor and outdoor living areas with movable walls. Similarly, the rooms in traditional Turkish houses are also designed to be multifunctional. In a single room, functions such as sitting, entertaining guests, cooking, eating, sleeping, and even bathing are addressed. Due to the requirements of traditional living in various cultures, the multifunctional characteristic applied to architecture provides space flexibility (Voicu, 2023, p. 37). In contemporary architecture, the concept of multifunctional space offers users flexibility, time and space efficiency, cost-effectiveness, aesthetics, socialization, energy efficiency, and sustainability.

Multifunctional space design in universities and other public areas allows a single space to be used for multiple purposes. As mentioned above, these spaces stand out for their flexibility, adaptability, and versatility, which meet the different needs of various user groups. The basic principles of multifunctional space design include flexibility, multipurpose use, technological equipment, accessibility, comfort, and cost-effectiveness. Flexibility means that the space can be easily rearranged and adapted to different activities, while multipurpose use allows a single space to be used for various purposes, such as education, meetings, social events, and exhibitions, thus saving space and time (Banerjee and Goel, 2023, p. 185). Technological equipment requires spaces to have the necessary infrastructure for different uses. Accessibility and comfort aim to create spaces that are easily accessible and comfortable for everyone. A single space that serves multiple functions reduces the cost of creating separate spaces. These spaces can be arranged according to user needs, thereby improving the efficiency and comfort of daily life or workflow. Multifunctional spaces promote richer learning and social experiences by bringing different user groups together and encouraging interaction.

Multifunctional spaces include educational areas, meeting and conference rooms, social and relaxation areas, sports and recreation areas, and cultural and art spaces. Educational areas can be used for different classes and activities by being equipped with flexible furniture and technological infrastructure; while meeting and conference rooms should be designed to accommodate large group meetings, seminars, and social events. Social and relaxation areas can be used for both individual and group activities, and sports and recreation areas should be organized to host different sports and activities. Cultural and art spaces can function as both educational and social events. Considerations in the design of these spaces include the acoustics and lighting, storage and organization, and user feedback. Different events require appropriate acoustic arrangements and lighting options. To ensure flexible use of spaces, portable furniture and equipment should be chosen and sufficient storage space should be provided for these items. Improving and developing spaces based on user feedback is also important. These types of spaces provide suitable environments for various events and needs, allowing for both individual and collective use and enabling universities and other institutions to develop more dynamic and adaptive structures.

3. Examples of Multifunctional Space Design in Universities

In this section, examples of multifunctional space design and use in universities in Türkiye and around the world will be examined, and the findings will be presented under a separate heading.

The first example is a building designed by Rotterdam University in the Netherlands. The building, which houses a supermarket, modern classrooms, and workspaces on the ground floor, is designed as a flexible structure that can accommodate a “changeable program”. Designed by architect Paul de Ruiter, the university building is prominently positioned on a main axis, where indoor and outdoor spaces are combined as much as possible. Students and visitors have unobstructed access from the building to the atrium. One of the main design objectives is to organize the relationship between indoor and outdoor spaces on a human scale. Accessibility, transparency, a general overview, daylight, and visibility are key to this effort. Transparent facades provide both natural light and a connection to the surroundings. The use of plants and wooden elements in the interior creates a warm and pleasant ambiance for students and staff. The use of column-free wide openings creates spacious, unobstructed ground areas, making the building's layout clear, functional, and flexible. These factors contribute to creating a pleasant environment where students, staff, and visitors can work and relax. The use of biophilic design in the atrium and other plants and green walls in other areas gives the building a natural, refreshing appearance and feel. The five-story educational building, which has over 600 modern workspaces, has a flexible structure that provides space for replacement programs. Multipurpose areas within the building are arranged to allow individuals and groups conducting scientific work to work and rest overnight, if necessary. The stairs and landing areas, which serve as vertical circulation tools, also function as meeting and event spaces (Figure 2) (URL-6).

Figure 2. Multifunctional Spaces at Rotterdam University (URL-6, URL-7)

The Business School building at Rotterdam University was also designed to include multifunctional spaces. The landing areas and galleries are equipped with modular furnishings to accommodate gathering, resting, chatting, and watching TV (Figure 3).

Figure 3. Multifunctional Spaces at the Business School, Rotterdam University (URL-8, URL-9)

A design developed for the Norwegian University of Science and Technology as part of a master's thesis includes a multipurpose hall that aims to provide students with space for sports and other activities, protect them from the rain during rainy seasons, and shield them from the intense heat of the sun during warm months (Figure 4). The semi-open and semi-closed spaces serve students sitting and chatting in one corner and those playing basketball in another.

Figure 4. Multipurpose Space Designed for the Norwegian University of Science and Technology (URL-10)

The multipurpose hall designed by Atelier Régis Roudil Architectes is distinguished by its use of sustainable materials, specifically pine wood, for its structural and interior finishes. This design clearly demonstrates the architectural features, sustainability aspects, and integration with the local environment. Implementation reflects a sustainable approach that reduces the carbon footprint associated with construction and supports local industries. The multipurpose hall encourages social interaction and community engagement among users. Sustainable design principles foster a broader awareness of environmental responsibility among residents and visitors (Figure 5).

Figure 5. Multipurpose Hall Designed by Atelier Régis Roudil Architects (URL-11)

The multipurpose space at Samford Valley Steiner School has a significantly different design approach. The hall is built from waste timber. The structure connects indoor and outdoor spaces through spatial organization. The space can sometimes be used as a classroom, and at other times, the structure's walls can be opened as needed to create a stage, integrating with the green area in front of it to create a viewing and listening area (Figure 6).

Figure 6. Multipurpose Space at Samford Valley Steiner School (URL-12)

Historically, Latin American campuses have served the purpose of providing education to students. However, at Lima University in Peru, a multifunctional space has been designed where students can sit, relax, eat, exercise, and socialize in a central location. This design, recognized as a starting point for new participatory and collaborative forms of learning and teaching, features seating elements, while the atrium serves as a meeting and gathering place. The atrium also functions as a conference hall (Figure 7).

Figure 7. Multifunctional Space at Lima University, Peru (URL-13)

In the United States, while traditional classroom-based education continues, an educational approach involving team-based learning and collaboration is becoming increasingly common. Consequently, educational spaces have diversified. In addition to classrooms, circulation areas, such as atriums and halls, can be transformed into library environments using Wi-Fi. These spaces, with comfortable seating areas, enable project meetings, educational sessions, individual research, and study activities. They also provide a suitable environment for lunch or coffee. These areas are equipped with various technological devices such as portable tables, whiteboards, digital displays, and projectors. They provide a place for students to take breaks between classes without leaving the building, facilitate unexpected encounters with peers and faculty, and lead to enhanced study experiences. The combination of private and public spaces ensures collaboration as well as privacy. If relaxation areas include supportive materials like whiteboards, students can convert social areas into study areas. The use of furniture and lighting that can be adjusted or changed by students maximizes their comfort and desire to use the space. According to US universities' understanding, if students and educators can move furniture, to suit their needs, they can reposition it to create, a more engaging environment for the task at hand (URL-14). In this regard, George Washington University's Science and Engineering Hall provides opportunities for shared work, active learning, and socializing throughout the building, in addition to classrooms and laboratories (Figure 8).

Figure 8. Multifunctional Spaces at George Washington University (URL-14)

Hill College House at the University of Pennsylvania, designed by Eero Saarinen in 1960, is a university building that hosts approximately 520 students. The interior layout of the six-story stone building encourages a sense of community and social interaction through common use areas centrally located like a town square (Figure 9).

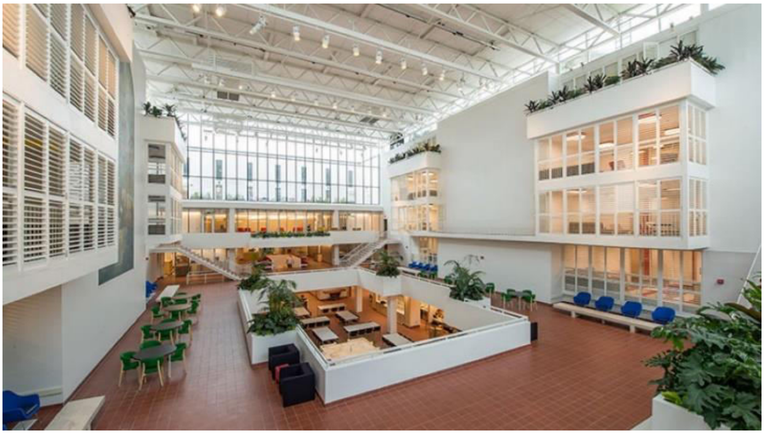

Figure 9. Multifunctional Space at Hill College House, University of Pennsylvania (URL-15)

Multifunctional spaces at Chapman University in California include seating areas, admissions offices, student clubs, and cafeterias. Adjacent to the faculty club on the third floor is a new rooftop terrace featuring potted plants, built-in seating areas, and an open living space centred around a fireplace. Flexibility and overlapping functions have shaped facility design. Movable walls and lightweight modular furniture that can be pushed aside to accommodate an audience enable the capacity to present larger events and concerts. The furniture is designed to be soft, yet durable, lightweight, portable, and inviting. Seating niches allow for group chats and studies. The building's multifunctionality extends outdoors, featuring multifunctional pergola areas that enhance usability and interaction (Figure 10).

Figure 10. Multifunctional Spaces at Chapman University, California (URL-16)

At the California Institute of Technology, part of the multifunctional space is used as a classroom, while students who wish to relax can listen to lessons from the relaxation area and students and staff who need a break can take a break at the coffee bar. If necessary, the classroom can be separated from the relaxation area using movable partition panels (Figure 11).

Figure 11. Multifunctional Space at California Institute of Technology (URL-17)

At Canadian University Dubai (CUD), the multifunctional space aims to allow students to hear and see the instructor and communicate, whether attending the class online or offline, thus producing hybrid learning solutions (Figure 12).

Figure 12. Multifunctional Space at Canadian University, Dubai (URL-18)

A multifunctional space designed by Beni Suef University features a semi-open pavilion for outdoor activities. This pavilion allows students and staff to sit and relax, eat, chat, and engage in cultural activities during their free time. It can also be used as an exhibition hall for art students to showcase their works (Figure 13).

Figure 13. Multifunctional Space Designed by Beni Suef University (URL-19)

Karen Blixens Plads, the urban square located between the buildings of the University of Copenhagen and the Danish Royal Library on the university's south campus's, was designed by the architectural firm Cobe, which emphasizes sustainable, innovative transportation applications. The project, which won the design competition held in 2014, features a large area that combines a public square and a university square and is divided into activity zones with small hills. The square, which serves as a meeting area for students and local residents, includes a high-capacity covered bicycle parking area and an open-air auditorium with seating for up to 1,000 people. Additionally, green areas that collect rainwater and facilitate its evaporation and return contribute to climate change adaptation (Figure 14) (URL-20). The multifunctional open space on this campus serves entirely for recreational purposes, helping to foster unity between the community and the university.

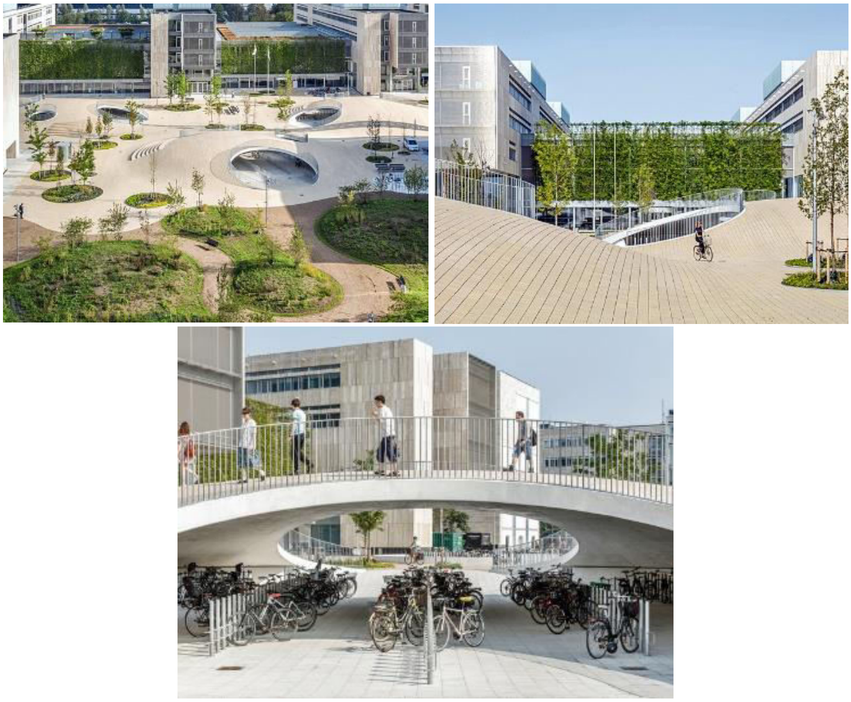

Figure 14. Karen Blixens Plads, Urban Square (URL-20)

The master plan designed by Sasaki in 2016 for the New University of West Java Project, with the mission of defining a new higher education pedagogy for Indonesia, has received two awards. Located in an agricultural region of Indonesia, the project is designed in harmony with the surrounding land with a sustainable approach. The design philosophy, based on collaboration, entrepreneurship, and a culture of participatory learning, aims to holistically support the development of students' minds, bodies, and spirits. The project envisions interconnected academic areas, housing, and student living spaces to form living-learning communities, thus keeping the campus core vibrant. Throughout the campus, recreational areas are spread over a wide area, guiding users without restriction, as shown in Figure 15 (URL-21).

Figure 15. The New University of West Java Project (URL-21)

At Istinye University in Istanbul, multifunctional spaces are designed with movable furniture to connect students and academic offices, in addition to being circulation and gathering areas (Figure 16).

Figure 16. Multifunctional Space at Istinye University, Istanbul (URL-22)

Multifunctional spaces at Koç University in Istanbul not only accommodate students' activities such as sitting, relaxing, chatting, and studying but also provide personal lockers for students in these areas. Multifunctional spaces separated from the main area with movable or fixed partitions can be transformed into classrooms or meeting rooms, ensuring auditory comfort (Figure 17 and 18).

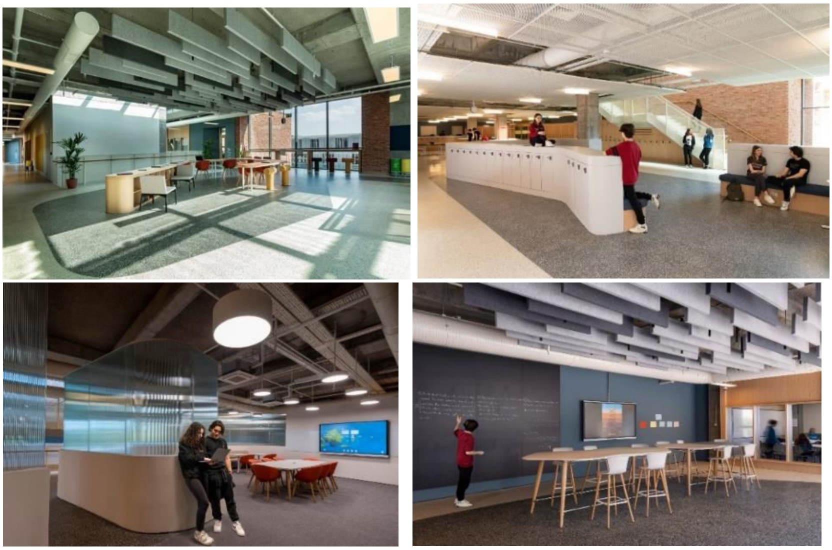

Figure 17. Multifunctional Space Designs at Koç University, Istanbul (URL-23)

Figure 18. Multifunctional Space Designs at Koç University, Istanbul (URL-24)

At Sabancı University in Istanbul, the multifunctional hall uses a staged arrangement with a movable steel construction platform and movable furnishing elements, allowing it to function as a tiered conference hall when needed (Figure 19). Undoubtedly, such examples are increasingly prevalent worldwide.

Figure 19. Multifunctional Hall at Sabancı University, Istanbul (URL-24)

4. Findings

The findings of the case studies are summarized in Table 1 as follows:

Table 1. Benefits of Using Multifunctional Spaces in Universities

BENEFITS	DESCRIPTIONS
Flexibility and Adaptability	Multifunctional spaces can be easily adapted to different activities and uses.
Cost and Space Efficiency	A single space that fulfils multiple functions reduces the cost of creating separate areas, thus reducing the amount of space.
Technological Equipment and Accessibility	Spaces with the necessary technological infrastructure for various uses and accessible areas that everyone can use comfortably.
Social Interaction and Community Engagement	Multifunctional spaces encourage different user groups to come together and interact. Users from different disciplines can come together and collaborate.
Aesthetics	These spaces should be aesthetically pleasing to serve as attractive centres.

Sustainability	These areas must conform to criteria of sustainable design. The consideration of energy efficiency should encompass the incorporation of many functions and technical equipment.
Time and Resource Efficiency	Multifunctional spaces allow various activities to be conducted in the same area, thereby saving time and resources.
User Satisfaction	Spaces that can be arranged according to user needs to enhance student and academic satisfaction.
Innovation and Creativity	Flexible and multifunctional spaces foster creative and innovative thinking.
Active and Collaborative Learning Environments	Multifunctional spaces support active learning and collaborative teaching methods, enabling students to learn more effectively.
Adaptation to Different Learning Styles	These spaces accommodate different learning styles, thus meeting individual learning needs of students.
Adaptation to Natural and Artificial Environmental Conditions	Multifunctional spaces designed as open, closed, or semi-open improve user productivity and enhance ergonomic conditions by properly regulating acoustics, natural and artificial lighting, and natural and artificial ventilation.
Scale	Such spaces can be designed on various scales, including a building, an atrium, a volume, a room, a pavilion, or a square. In other words, they can be created in a wide range of sizes.

5. Conclusion

The design of multifunctional spaces on university campuses is a crucial element that responds to the needs of modern educational institutions and adapts to future educational models. These spaces offer both students and academics flexibility, efficiency, and versatility, providing ideal environments for education, social interaction, and personal development. As observed in traditional architecture as well, these spaces have evolved to meet the current demands for sustainability and technological integration.

The examples reviewed in this study demonstrate that multifunctional spaces are not only significant for academic activities but also play vital roles in social, cultural, and recreational activities. Institutions in the United States, the Netherlands, Türkiye, Denmark, and Indonesia have begun to adopt innovative approaches to the design and use of such spaces.

These multifunctional areas not only facilitate the daily lives of students and academics but also strengthen the societal role of universities. Flexible spaces offer the ability to respond quickly and effectively to diverse needs. When equipped with sustainable materials and modern technologies, these spaces provide both environmental and economic benefits.

In conclusion, the design of multifunctional spaces on university campuses is a strategic approach that enhances the quality of educational and research activities while promoting social integration and cultural interaction. In the future, prioritizing user feedback, flexibility, and sustainability in the design of these spaces will ensure that universities remain dynamic and adaptive.

Multifunctional spaces help universities fulfil their academic and social roles. They provide suitable environments for students and academic study while offering open spaces and services to the community. The most important design factors include flexibility, accessibility, comfort, cost-effectiveness, and user feedback. Future designs should encourage the use of sustainable materials and the adaptation of spaces to meet user needs. In conclusion, multifunctional spaces are unprogrammed common and social spaces that enhance campus life and provide spaces for informal interactions among students and staff.

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The article complies with national and international research and publication standards.

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The Role of Green Infrastructure in the Planning and Design of Sustainable Campuses

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1. Introduction

The rapid urbanization movements observed during the Industrial Revolution resulted in the uncontrolled expansion of cities, accompanied by a lack of infrastructure. This results in a multitude of environmental issues, including climate change, global warming, the urban heat island effect, carbon emissions, and the loss of habitats and biodiversity. The construction pressure brought about by urbanization results in the destruction of topographical features, particularly natural drainage systems and underground ecosystems. In this context, the development of environmentally compatible sustainability policy has become a priority in order to ensure a healthy cycle in the whole of nature-human-society and to provide solutions to environmental problems.

The term 'sustainability' is derived from the word 'sustainable', which is defined as 'capable of being sustained at a certain rate or level' (Sustainability, 2024). Furthermore, it is defined as the transfer of resources currently in use to future generations without causing them harm (McDonough, 1992). The concept of sustainability ensures the responsible management of natural resources (Clayton & Radcliffe, 1996). The term 'sustainability in higher education' was first used in the Stockholm Declaration of 1972, which highlighted the interdependence between humanity and the environment in achieving environmental sustainability (Dawodu et al., 2022). Large institutions such as universities, which have historically been tasked with guiding and innovating society, can play an instrumental role in disseminating sustainable practices through their own sustainable and ecological policies. Consequently, sustainable and ecological campus practices have begun to proliferate rapidly across the globe (Foo, 2013; Lauder, Sari, Suwartha & Tjahjono, 2015; Tiyarattanachai & Hollmann, 2016). The concept of a green campus, or campus greening, is regarded as a fundamental aspect of sustainability in higher education (Filho, Nandhivarman, Golda & Mihaela, 2015). The advent of new planning and design approaches within the context of sustainable development on university campuses has led to the emergence of novel university models, which are increasingly being designated as 'green universities', 'sustainable universities', 'eco-campuses', 'green campuses', 'environmentalist campuses', 'sustainable campuses', 'smart campuses', 'environmentally friendly campuses' and 'climate-sensitive campuses' (Yapıcı, Oral, Yumuşak & Eren, 2021; Ak, 2022; Kurt Konakoğlu & Çelik, 2023).

The term 'sustainable campus' is used to describe higher education institutions that are self-sufficient, aim to minimize environmental, social and socio-economic negative impacts, and act as leaders in promoting sustainable living for society (Alshuwakhat & Abubakar, 2008; Klarin, 2018). The planning and design of sustainable campuses is feasible through the implementation of a comprehensive and long-term process. In this regard, a variety of measurement and evaluation methods and systems have been developed with the objective of determining the sustainability of campuses. These methods/systems seek to initiate the concept of sustainability at the micro scale, enhance public awareness, and disseminate the concept of sustainability. In the planning and design of sustainable campuses, it is recommended that the approach of supporting ecological processes, the landscape ecology approach and green infrastructure practices, including planning and design methods, be considered together (Alshuwakhat & Abubakar, 2008; Ak, 2022; Kurt Konakoğlu & Çelik, 2023).

The concept of infrastructure is typically conceived of in terms of grey infrastructure, encompassing elements such as roads, water networks, sewerage systems, power lines, and telecommunication networks. Additionally, built infrastructure, including hospitals, schools, and other structures, is also considered a form of infrastructure. In contrast to the conventional grey infrastructure approach, green infrastructure is designed to provide essential services for ecosystems, including clean air, water and food (Özeren, 2012; Gülgün Aslan & Yazici, 2016; Kavuran, 2022). Green infrastructure comprises natural life support systems, including integrated river networks, wetlands, wildlife habitats, greenways, parks and forests. These systems support natural ecological processes, ensure the sustainability of air and water resources, and enhance the quality of life of individuals (Benedict & McMahon, 2002). Another definition of green infrastructure posits it as a network of interconnected natural, semi-natural and cultural green spaces, designed and managed to provide ecosystem services that protect ecosystem values and functions (Benedict & McMahon, 2002; European Commission, 2013a; European Commission, 2013b). Green infrastructure represents a crucial instrument for enhancing the resilience of urban areas in the face of climate change. It is a widely employed strategy for the planning and design of sustainable urban environments and campuses (Ersöz, Ersoy Mirici & Sayan Atanur, 2022). In recent years, the term green infrastructure has been used to refer to a range of ecologically-oriented approaches, including green roofs, vertical gardens, street planting, rain gardens, rain ditches, cemeteries, parks, and all ecology-based approaches used to ensure the natural and cultural integrity of sports fields. Despite the diversity of these approaches, they all emphasize the interconnectedness of the built and ecological environments (Özdemir, 2009; Belfast City Council, 2020).

The integration of green infrastructure systems into spatial planning has emerged as a highly relevant and effective approach to enhancing the microclimate and mitigating the impacts of climate change, particularly the urban heat island effect. As posited by Benedict and McMahon (2006), the implementation of green infrastructure initiatives serves to reinforce the life support system, facilitate the formulation of sustainable policies, and exemplify the potential for harmonious coexistence between humans and the natural environment. In order to fully utilize and maximize the benefits of green infrastructure systems, it is essential to consider the principles of multifunctionality, connectivity, integration and social communication during the planning phase (Boverket, 1992; Li, Wang, Paulussen & Liu, 2005; Gülçin, 2018).

In order to provide green infrastructure in sustainable campuses, it is necessary to utilize rainwater and wastewater, create rain gardens, include renewable energy-oriented designs that increase energy efficiency in campus planning, use plant species that are suitable for the climate and soil conditions of the campuses, create roof gardens, and create permeable floor coverings. This approach provides a sustainable, holistic solution (Alshuwakhat & Abubakar, 2008; Torres, 2010; Güllü, Köksal & Şengül, 2012; EPA, 2015; Büyükkurt, 2019; Kurt Konakoğlu & Çelik, 2023).

2. Sustainable Campus Concept

Universities are institutions that facilitate the convergence of scientific, artistic, and cultural pursuits, wherein academic and administrative personnel, as well as students, coexist within a structured framework. Consequently, universities also exemplify a socially responsible model that is visible within society. Consequently, the intellectual diversity and educational outlooks of universities provide insights into societal issues. In order to provide guidance to society in terms of the concept of sustainability, it is essential that universities maintain this concept as a core tenet of their corporate identity, campus life, scientific studies and structural practices (Thomashow, 2014; Özipek, 2018).

The sum of the places where universities carry out their activities or have functions related to the university is called a campus (Heijer & Magdaniel, 2018). University campuses are an important part of the city, contributing socially and culturally to cities and adding vitality to the region with the young population they host. The location of the campuses and their accessibility to the city, as well as the social and cultural spaces provided in the campuses, reveal the relationship between universities and the city (Saklı, 2019; Mohammed, Ukai & Hall, 2022). The concept of 'sustainability in higher education' first appeared in the Stockholm Declaration in 1972 (Dawodu, Dai, Zou, Zhou, Lian, Oladejo & Osebor, 2022).

The expansion of university campuses has been driven by the need for larger areas that can accommodate evolving requirements. The emergence of new social needs has led to the addition of diverse functions to university buildings, beyond the traditional domains of education and research. These include food and beverage, housing, social, sports, health, administration, recreation, and more. This has resulted in the transformation of university campuses into self-contained systems, situated at a distance from city centers, and capable of addressing a comprehensive range of needs (Bilgin, 2006).

The growing population and the diversification of educational institutions have given rise to two distinct approaches to managing university campuses. The first of these approaches regards university campuses as analogous to small cities, given the range of functions they perform, including accommodation, rest, work, and transportation. Additionally, the variety of activities conducted on campus to meet the needs of users is noteworthy. An alternative perspective is to conceptualise the university campus as a 'complex building'. In terms of waste management, transportation, water and material consumption, and energy consumption, it functions similarly to a large-scale building. Both approaches adopt an energy-efficient set of systems and a campus logic that is sensitive to the users of the campus. These approaches are regarded as the primary tenets of sustainability (Hasol, 1998; Alshuwaikhat & Abubakar, 2008; Ayvacı, 2009; Güllü, Köksal & Şengül, 2012).

Sustainable campus is also referred to as green campus, green campus, green university, environmentally friendly campus, eco-campus (Güler, 2001). A sustainable campus is a university that embodies the principles of environmental stewardship through institutional policies and practices that safeguard the integrity of natural systems. Additionally, it serves as a living laboratory, wherein the potential for action in numerous domains, including energy, transportation, education, food, water, and the production of innovative and environmentally friendly technologies, is demonstrated and applied (González-García, Aguado, Solascasa, Palomo, González, García-Llorente, … & Montes, 2022; YKT, 2024). The implementation of sustainable campus initiatives is of paramount importance in reducing energy consumption and emissions, improving waste management practices, fostering collaboration between academic and social units on campus, and the application of sustainable methods (Benliay & Gezer, 2019). It is incumbent upon the staff of a sustainable campus to provide environmental education at both the undergraduate and graduate levels. They must also adopt and utilize practices such as water retention structures, waste management through bio-gas and composting research, LED and solar lights, and an energy park. Additionally, they should strive for food self-sufficiency, adopt sustainable architectural approaches, and implement environmentally friendly heating and cooling systems (Shukla & Khimani, 2015; Öktem, 2020).

3. Planning and Design of Sustainable Campuses

Given that campuses possess all the defining characteristics of urban environments, they represent the most straightforward setting in which to implement the principles of sustainability (Güllü, Köksal & Şengül, 2012). For a university to be considered sustainable, it must engage in sustainable practices that are integrated across all campuses. In this regard, it is crucial to ensure that all elements that comprise universities, including the structural design of administrative and educational buildings, transportation within the campus, environmental layout of the campuses, waste management, plants used on the campuses, and the utilization of energy resources, are constructed in a manner that prioritizes sustainability (Kurt Konakoğlu, 2022). In this context, the recommended steps for universities to follow in order to become sustainable campuses are presented in Figure 1.

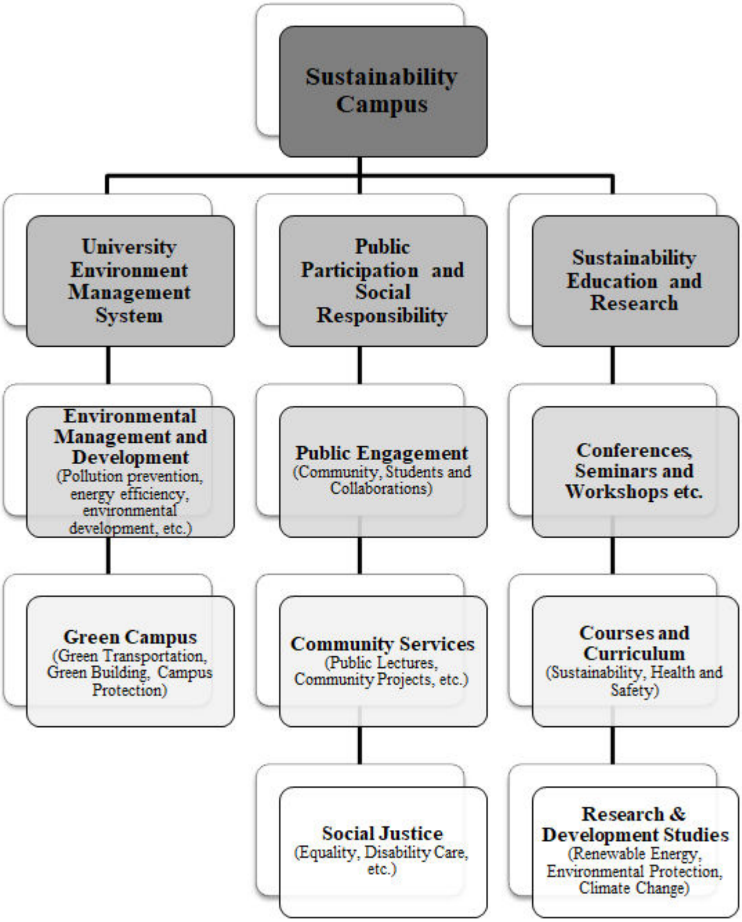

Figure 1. Steps that universities should follow to become sustainable campuses (Alshuwakhat & Abubakar, 2008)

The physical structuring of each university campus is different from each other depending on many factors such as the structure of the university, the location and size of the campus, the education system created in line with the mission and vision of the university, and the quality of its social and academic community. Accordingly, each campus should be designed in accordance with its specific requirements and ontological characteristics (Koca, 2020).

The primary objective of university administrations that have elected to pursue the designation of ‘sustainable university’ or ‘sustainable campus’ should be to ascertain their current position and to define a sustainability mission and vision in alignment with this assessment. Subsequently, a Sustainability Office should be constituted with the objective of coordinating initiatives, regulations, and developments, as well as reporting on the aforementioned processes. In the fourth stage, the establishment of a committee is recommended. It is the responsibility of the committee to ensure that the university's sustainability goals, objectives, budget, and functioning are all aligned with one another. The fifth and most crucial stage is the formulation of a strategic plan. The strategy setting process comprises four sub-stages: teaching, research, community outreach and collaborations, and campus sustainability (Figure 2) (Alshuwakhat & Abubakar, 2008).

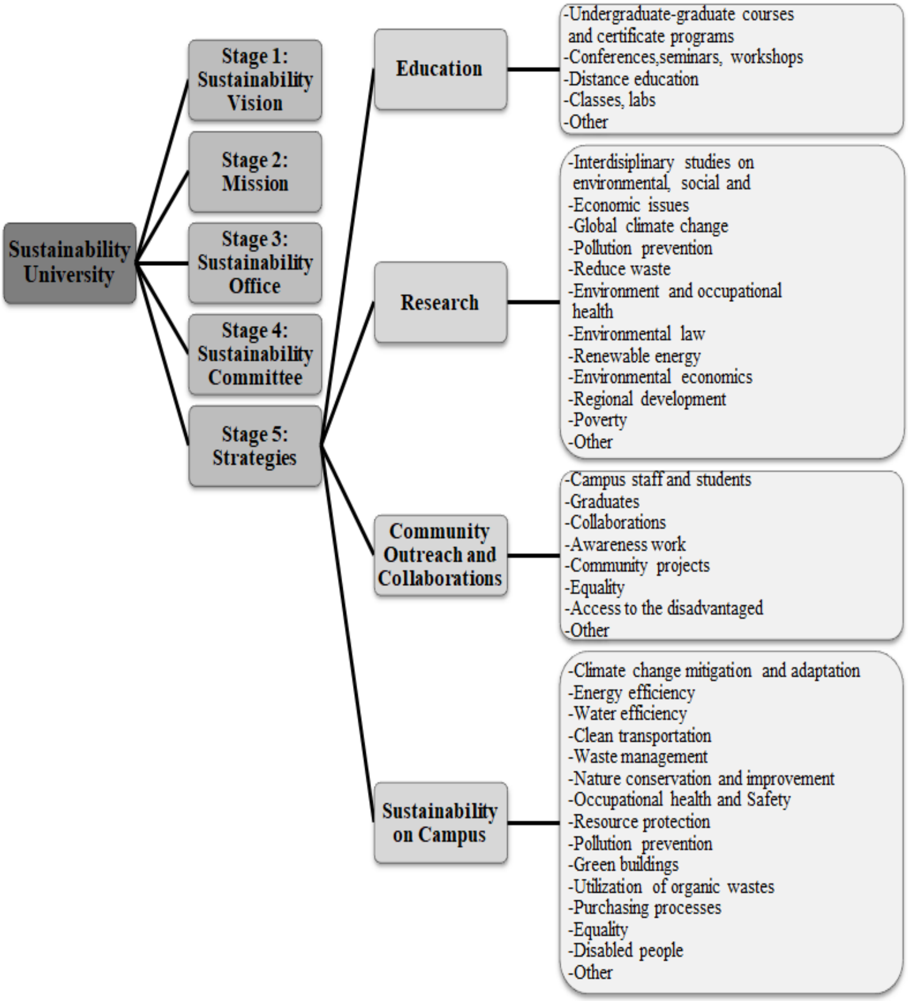

Figure 2. Sustainable university model proposal (Velaquez, Munguia, Platt & Taddei, 2006; Alshuwakhat & Abubakar, 2008)

The sustainability of ecological, social, and economic factors is ensured by the reuse of rainwater and wastewater on university campuses, the preference for renewable energy sources and water and energy efficient designs, and the implementation of practices such as green buildings and roofs (Güllü, Köksal & Şengül, 2012; Özdal Oktay & Özyılmaz

Küçükyağcı, 2015). According to Thomashow (2014), sustainability is not just about building green certified buildings or providing local food and clean energy sources to the community. It is necessary to make sustainability a philosophy of life and to have common sense for ecological principles. In this process, in order for universities to become successful sustainable campuses, these five stages indicated in Figure 2 and the main categories of 'Infrastructure (Energy, Materials, Food)', 'Community (Management, Investment, Health)' and 'Teaching (Curriculum, Interpretation, Aesthetics)' identified by Thomashow (2014) should be successfully created and implemented (Agı Günerhan & Günerhan, 2016).

4. Functions of Green Infrastructure in Sustainable Campuses

Green infrastructure is a concept used for all ecology-based approaches, from green roofs to eco-friendly rainwater management systems, both in cities and small-scale urban models (EPA, 2010). Green infrastructure consists of elements such as green roofs, green roads, wetlands, green walls, rain gardens, rain gardens, rain ditches, rainwater harvesting, road trees, flower plots, green plots, plant ditches (bioswales design), pavements with permeable surfaces, etc. that provide services such as carbon absorption, recreation, rainwater drainage, groundwater recharge, climate regulation, air quality, etc. within the city (Benedict & McMahon, 2006; EPA, 2015; Green Building Council, 2016; BfN, 2017; Belfast City Council, 2020). Green infrastructure practices are preferred because they offer cost-effective solutions, reduce energy costs, reduce damage and material losses caused by floods, and protect public health and environmental health (Özdemir, 2009; Büyükbayraktar, Özyavuz & Çelik Aslan, 2022).

The functions of green infrastructure both in cities and in campuses, which are considered as small-scale urban models, are as follows (European Commission, 2013a; European Commission, 2013b; EPA, 2015; Gülgün Aslan & Yazici, 2016):

The role of green infrastructure in reducing the urban heat island effect;

- Trees provide shade,
- Vegetation balances the ambient temperature through transpiration and evaporation,
- Green roofs reduce heat reflection,
- It facilitates urban heat transfer by creating air corridors.

The role of green infrastructure in cleaning the air;

- Trees precipitate, store and manage the dispersion of pollutants,
- Improving air quality by reducing air pollution,
- Green walls trap air pollutants while at the same time supporting wind flow, allowing polluted air to be removed.

The role of green infrastructure in carbon sequestration;

- Trees sequester CO2 (carbon captured from the atmosphere by photosynthesis) and store it (carbon stored in below- and above-ground biomass during development).

The role of green infrastructure in flood prevention;

- Permeable pavement and green spaces facilitate the absorption of water, ensuring the continuity of the water cycle,

- With green roof applications, the amount of runoff caused by heavy rainfall can be reduced,
- It provides the opportunity to save installation and maintenance costs compared to gray infrastructure.

The role of green infrastructure in providing habitat;

- Green roofs and walls provide habitat for insect and bird species,
- Botanical gardens, arboretums and green spaces designed for special species are a major attraction for tourists,
- Green infrastructure in cities is an important source of bee species.

The role of green infrastructure in recreation services;

- Increases social interaction,
- It contributes mentally and psychologically by enabling urban people to spend time in nature,
- It contributes to individuals' feeling of belonging to a society and to an increase in the level of welfare,
- People living in areas with high biodiversity are less likely to suffer from allergic diseases,
- Gardening activities are effective in treating stress and panic attacks.

Green infrastructure implementations are frequently preferred today as they provide cost-effective solutions, reduce energy costs, reduce flood damage and material losses, and protect public health and environmental health, both because they establish physical and functional connections between the built environment and green areas and because of the functions mentioned above. The successful implementation of green infrastructure on campus requires the collaboration of campus staff, faculty, students, and community members.

5. Conclusion

The concept of sustainability, which emerged with the objective of reducing the impact of climate change and environmental degradation, is a key consideration in the design of university campuses around the world (Saygın & Ulusoy, 2011). Universities are populated by a considerable number of individuals, including students, academic and administrative personnel, and those engaged in maintenance and upkeep of the grounds and infrastructure. Universities have both direct and indirect negative impacts on the environment, including the production of pollutants, in addition to the benefits they provide to the cities in which they are located. It is therefore of the utmost importance for universities to pursue sustainability in two key areas: firstly, in reducing their own pollutant output, and secondly, in leading the way and setting an example for society (Agı Günerhan & Günerhan, 2016). The concept of a sustainable campus is used to describe those campuses that are sensitive to the ecological environment and aim to minimize their impact on the environment (Alshuwakhat & Abubakar, 2008).

Campuses organize a wide variety of structural spaces and their interrelationships within a context of their own, while organizing the different types of users who will use this environment. This small urban space can create an active and equitable social environment by reducing carbon footprint, conserving water resources and supporting biodiversity. At the same time, it is crucial that the entire natural and built environment is accessible to all types of users and that students are directly or indirectly involved in sustainable practices while on campus. A design approach that is both physically and semantically inclusive will have a sustainable impact in educating and empowering the community within the campus, and in serving the world with the people who are educated. As a learning environment, green campuses actively promote sustainability by involving faculties, administrative and academic staff and students in the design and implementation process (Koca, 2020).

In order for a university to be called sustainable, it must carry out sustainable activities and these activities must be adopted by all campuses of the university. In this regard, it is important that all elements that make up universities, such as the structure of administrative and educational buildings, transportation within the campus, environmental layout of the campuses, waste management, plants used in the campuses, and the use of energy resources, are built in a way that ensures sustainability (Kurt Konakoğlu, 2022).

Universities play an active role in solving environmental problems and raising public awareness by utilizing the power of interdisciplinary cooperation and knowledge. Since universities are seen as a pressure factor on the environment, they directly or indirectly harm the urban ecosystem. With this understanding, sustainable campus designs that are environmentally sensitive and can use energy efficient methods have become widespread (Koca, 2020; Kurt Konakoğlu, 2022). In order to provide green infrastructure in sustainable campuses, it is necessary to adopt practices such as utilizing rainwater and wastewater, creating rain gardens, incorporating renewable energy-oriented designs that increase energy efficiency into campus planning, using plant species suitable for climate and soil conditions in the campuses, creating roof gardens, and creating permeable floor coverings. In this way, a sustainable integrated approach is ensured (Alshuwakhat & Abubakar, 2008; Torres, 2010; Güllü, Köksal & Şengül, 2012; EPA, 2015; Büyükkurt, 2019; Kurt Konakoğlu & Çelik, 2023).

The implementation of sustainability criteria in university campuses provides economic gains through water and energy efficient designs that reuse rainwater and wastewater and increase energy efficiency; physical gains through green buildings and renewable energy-oriented designs that increase air quality and comfort features in and around the buildings and campus; and social gains through healthy community-oriented designs that prevent environmental pollution and reduce the negative effects of climate change (Güllü, Köksal & Şengül, 2012; Özdal Oktay & Özyılmaz Küçükyağcı, 2015).

As a result, in sustainable campuses, green infrastructure practices, waste management, water recycling and transportation with environmentally friendly models contribute to the reduction of environmental impacts and the creation of a sustainable living space. In this way, university campuses not only serve education and research activities, but also become pioneering institutions in the field of sustainability. If universities assume a leading role in achieving global sustainability, this change, which starts at the campus scale, can affect the region in time and a global change and transformation can be achieved.

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The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

1st author contributed %60, 2nd author %10, 3rd author %10, 4th author %10 and 5th author %10 to the article. There is no conflict of interest.

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Planning and Design Strategies for Campus Resilience

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1. Introduction

Today, cities face growing environmental, social, and economic problems, such as the increasing frequency and severity of natural and man-made disasters, the widening effects of climate change, the spread of epidemics, terrorism and cyber-attacks, and the increase in financial bankruptcies. This situation challenges the resilience of cities' infrastructures, creates severe pressure on economic and social structures, and necessitates governments, companies, institutions, and individuals to prepare emergency action plans and develop risk management strategies. As one of these stakeholders, universities need to understand and recognize such risks and determine planning and design strategies that will increase resilience as a fundamental element of sustainability initiatives (Brian Fisher, 2017). In addition, universities, as microcosms containing different population structures and complex infrastructures, lead research and problem-solving efforts on resilience and sustainability. They are exemplary structures in combating similar vulnerabilities to those of the city exposed to natural and man-made disasters (Storms et al., 2019). In particular, sustainability studies on university campuses are carried out with a broad scope and various environmental, economic, and social strategies.

On the other hand, resilience is evaluated within the sustainability framework and is often not considered separately. However, since sustainability and resilience are complementary concepts, seeing the distinction in working practice can be challenging (Ercoskun, 2012). For an organization, resilience, as part and parcel of sustainability, must become an organizational goal linked to various support systems (Brian Fisher, 2017).

Resilience can be generally defined as the ability of societies, infrastructures, environments, and cities to cope with disasters (Akbaş, 2023). Although the concept is based on the construction and defense of cities in different civilizations throughout history, the issue of resilience was defined in the literature as "the ability to withstand deterioration and change without losing the relationship between the elements that formed it before deterioration" in a study conducted by Holling in 1973 (Akbaş, 2023; Holling, 1973). With this definition, Holling tried to define resilience within the socio-ecological systems framework by establishing a link between society and ecological systems (Akbaş, 2023; Holling, 1973).

Resilience is conceptualized not only in ecology but also in fields such as engineering, sociology, economics, and environmental sciences, and it has environmental, social, and economic components such as sustainability (Coaffee, 2013). When resilience is examined with a broader literature review, it is also associated with concepts such as robustness, speed, diversity, redundancy, integration, coping, sensitivity, coordination, effectiveness, adaptation capacity, durability, environmental sensitivity, equality, and repetitive processes (Dincer & Yalçıner Ercoşkun, 2021). When this multivariate multidisciplinary concept is associated with universities, “university resilience” emerges. The ability of an institution of higher education to continue its core missions of education, research, and service despite potentially disruptive events, as defined by the University of Texas System (The University of

Texas System, 2024). It also means the institution’s increased ability to cope with environmental stressors and shocks (Brian Fisher, 2017).

Despite their active role in solving environmental problems and raising social awareness, universities, like many other institutions, directly or indirectly create pressure on the environment (Güllü et al., 2012; Özdal Oktay & Özyılmaz Küçükyağcı, 2015). These effects increase the importance of sustainable and resilient university campuses. With this understanding, *“sustainable and resilient university campus”* designs and applications that use environmentally sensitive and energy efficient methods and aim to develop environmental, social, and economic dimensions in the city with the university’s staff and students, as well as all internal and external stakeholders, in, are becoming widespread all over the World (Güllü et al., 2012; Özdal Oktay & Özyılmaz Küçükyağcı, 2015).

Sustainable campuses play an essential role in reducing energy consumption and emissions, improving waste management, enabling different units to work together on and off campus, and using sustainable methods in technology production(Özdal Oktay & Özyılmaz Küçükyağcı, 2015). Regarding resilience within the sustainability framework, issues such as using their current potential, knowing and measuring their vulnerabilities, strengthening their weak aspects, and managing the crisis are at the forefront for universities. University resilience helps to protect the lives and property of the institution's students, staff, and faculty in the face of potentially catastrophic events and disasters, as well as to ensure the continuity of operations (teaching students, caring for patients, conducting research and services) despite disasters or to quickly restart operations after such events. (The University of Texas System, 2024). This concept encompasses not only the capacity of institutions to withstand and adapt to different types of disruptions but also their capacity to recover and thrive in their aftermath. In this context, this study explores the multifaceted dimensions of campus resilience by evaluating the policies, practices, and community dynamics that contribute to the resilience and well-being of academic environments. The study draws attention to the need for a holistic approach to this issue, emphasizing the importance of mental and physical health support, social cohesion, sustainable practices, and effective governance in promoting resilient campuses. It aims to provide insights and recommendations to enhance the preparedness and adaptive capacity of higher education institutions.

2. The Concept of Resilience and its Development

UNDRR (2024) defined resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management." Before this broad definition was made, the concept of resilience dates back to ancient times. Throughout history, humanity has tried to resist disasters and attacks and prepare society. For example, Ancient Greek cities built high walls to increase their defenses used acropolises for strategic advantage, implemented planned urbanization, and provided military training to their citizens. They also strengthened their defenses by taking advantage of natural obstacles, developed anti-siege technologies, and established economic and diplomatic alliances to ensure their security. In the Middle Ages, disaster-resistant structures such as churches and monasteries were built, and plans were made to reconstruct society after disasters (Akbaş, 2023; Desouza & Flanery, 2013; Mumford, 2007). From the 16th century onwards, the term resilience began to be used in many disciplines, such as physics, engineering, medicine, sociology, and psychology (İrdem & Mert, 2023; Meerow & Newell, 2019; Yaman Galantini, 2024). In the 18th century, with the Age of Enlightenment, as people became more aware of natural disasters, more scientific approaches began to be developed to be resilient to disasters and to prepare society (Akbaş, 2023; Yanez & Kernaghan, 2014). Environmental scientists used the concept of resilience in the 1970s. It was associated with urban issues from the perspective of "resilience of ecological systems" and became widespread in the 1980s with the concepts of environmental policies and sustainable development (Akbaş, 2023; D'Ascanio et al., 2016; Yaman Galantini, 2024). Holling, who established the concept in the literature, expressed the issue of resilience as "the ability to withstand deterioration and change without losing the relationship between the elements that formed it before deterioration" in his study published in 1973 (Holling, 1973). As Holling stated in his definition, change is always ongoing. It is essential to keep up with this, to take shape and maintain its existence, especially in the face of sudden changes. This situation shows resilience and endurance in the context of specific criteria. Resilience can differ depending on environmental, economic, ecological, and spatial criteria. (Yaman Galantini, 2024).

While resilience was used to understand ecological change and balance in the late 1970s, it was included in studies on disaster risk reduction in the mid-90s. After the 2000s, it was used with climate change adaptation processes (Dincer & Yalçıner Ercoşkun, 2021). The concept of resilience related to cities, especially recently, is striking in conjunction with natural disasters. Natural disasters pose severe dangers to people, and being resistant to disasters and minimizing their effects is gaining importance. For this reason, disaster management plans are being created, and the concept of resilience gives rise to the concept of a resilient city in this context. In addition to natural disasters, the concept has begun to be used differently to cope with man-made disasters such as terrorist attacks, accidents, and fires.

This term is also vital for sustainable development. These two concepts, which are in close dialogue, aim for environmental awareness, economic development, and social welfare (Akbaş, 2023). Resilient city indexes have been developed to include this goal. Tools that measure cities' resilience, such as the City Resilience Index (CRI) by ARUP and the Resilient Cities Index (RCI) by Economic Impact, have been developed. (ARUP, 2024; Economic Impact, 2023). These tools are designed to enable cities to measure and monitor multiple factors that contribute to their resilience, diagnosing strengths and weaknesses and measuring relative performance over time (ARUP, 2024).

Developed by ARUP and supported by the Rockefeller Foundation, CRI (Table 1) aims to reveal the strengths and weaknesses of the city as a tool with four pillars, 12 targets, and 52 indicators (Economic Impact, 2023).

Table 1. Resilient Cities Index (ARUP, 2024)

Dimension	Category	Indicators
Health & Wellbeing	MINIMAL HUMAN VULNERABILITY	1.1 Safe and affordable housing 1.2 Adequate affordable energy supply 1.3 Inclusive access to safe drinking water 1.4 Effective sanitation 1.5 Sufficient affordable food supply
	DIVERSE LIVELIHOODS & EMPLOYMENT	2.1 Inclusive labour policies 2.2 Relevant skills and training 2.3 Local business development and innovation 2.4 Supportive financing mechanisms 2.5 Diverse protection of livelihoods following a shock
	EFFECTIVE SAFEGUARDS TO HUMAN HEALTH & LIFE	3.1 Robust public health systems 3.2 Adequate access to quality healthcare 3.3 Emergency medical care 3.4 Effective emergency response services
Economy & Society	COLLECTIVE IDENTITY & MUTUAL SUPPORT	4.1 Local community support 4.2 Cohesive communities 4.3 Strong city-wide identity and culture 4.4 Actively engaged citizens
	COMPHERENSIVE SECURITY & RULES OF LAW	5.1 Effective systems to deter crime 5.2 Proactive corruption prevention 5.3 Competent policing 5.4 Accessible criminal and civil justice
	SUSTAINABLE ECONOMY	6.1 Well-managed public finances 6.2 Comprehensive business continuity planning 6.3 Diverse economic base 6.4 Attractive business environment 6.5 Strong integration with regional and global economies
Infrastructure & Environment	REDUCED EXPOSURE & FRAGILITY	7.1 Comprehensive hazard and exposure mapping 7.2 Appropriate codes, standards and enforcement 7.3 Effectively managed protective ecosystems 7.4 Robust protective infrastructure
	EFFECTIVE PROVISION OF CRITICAL SERVICES	8.1 Effective stewardship of ecosystems 8.2 Flexible infrastructure services 8.3. Retained spare capacity 8.4 Diligent maintenance and continuity 8.5 Adequate continuity for critical assets and services
	RELIABLE MOBILITY & COMMUNICATIONS	9.1 Diverse and affordable transport networks 9.2 Effective transport operation & maintenance 9.3 Reliable communications technology 9.4 Secure technology networks
Leadership & Strategy	EFFECTIVE LEADERSHIP & MANAGEMENT	10.1 Appropriate government decision-making 10.2 Effective co-ordination with other government bodies 10.3 Proactive multi-stakeholder collaboration 10.4 Comprehensive hazard monitoring and risk assessment 10.5 Comprehensive government emergency management
	EMPOWERED STAKEHOLDERS	11.1 Adequate education for all 11.2 Widespread community awareness and preparedness 11.3 Effective mechanisms for communities to engage with government
	INTEGRATED DEVELOPMENT PLANNING	12.1 Comprehensive city monitoring and data management 12.2 Consultative planning process 12.3 Appropriate land use and zoning 12.4 Robust planning approval process

The RCI, developed by Economic Impact, is a “comprehensive urban resilience assessment that examines cities’ preparedness to cope with shocks by examining their critical infrastructure, environment, socio-institutional dynamics, and economy” (Economic Impact, 2023).

Table 2. Resilient Cities Index (Economic Impact, 2023)

1.CRITICAL INFRASTRUCTURE	2.ENVIRONMENT	3. SOCIO-INSTITUTIONAL	4. ECONOMIC
1.1 Electricity	**2.1 Flooding**	**3.1 Digital government**	**4.1 Economic robustness**
1.1.1 Electricity price	2.1.1 Riverine flood risk	3.1.1 E-gov portal for residents	4.1.1 Business environment
1.1.2 Electricity quality	2.1.2 Coastal flood risk	3.1.2 Open data availability and accessibility	**4.2 Exposure and risk**
1.2 Water and sanitation	**2.2 Heat stress**	**3.2 Legal**	4.2.1 Economic volatility
1.2.1 Water provision quality	2.2.1 Heat stress	3.2.1 Crime and safety	4.2.2 Insurance penetration
1.2.2 Wastewater treatment	**2.3 Air pollution**	3.2.2) Justice and law enforcement	**4.3 Innovation & entrepreneurship**
1.2.3 Water management	2.3.1 Air quality	**3.3 Inclusivity, involvement and awareness**	4.3.1 AI readiness
1.3 Transportation	**2.4 Disaster management**	3.3.1 Income inequality	4.3.2 Innovation ecosystem
1.3.1 Congestion	2.4.1 Hazard monitoring	3.3.2 Social protection benefits	**4.4 Human capital**
1.3.2 Smart traffic management	2.4.2) Hazard management	3.3.3 Vulnerable group integration	4.4.1 High-skilled workforce
1.3.3 Public transport quality	**2.5 Decarbonisation**	3.3.4 Culture of readiness	
1.3.4 Transport electrification	2.5.1 Net zero progress	**3.4 Health and well-being**	
1.4 Built environment	2.5.2 Carbon removal	3.4.1 Health emergency response	
1.4.1 Energy efficiency	2.5.3 Renewable energy adoption	3.4.2 Longevity	
1.4.2 Future-proofing structures	**2.6 Waste management**	3.4.3 Work-life balance	
1.5 Digital infrastructure	2.6.1 Recycling and circular economy initiatives		
1.5.1 Internet quality	2.6.2 Single-use plastic		
1.5.2 Cybersecurity preparedness			

The RCI index defines “resilient cities” as cities that can effectively anticipate, weather, adapt to, and recover from environmental, economic, social, and climate changes. The index assesses the performance of 25 cities across four key criteria, 19 indicators, and 42 sub-indicators. According to the index, a resilient city should value learning and innovation to recover from a shock and thrive in changing conditions (Table 2).

The Cities Resilience Index (CRI) and the Resilience City Index (RCI) are both frameworks designed to assess and enhance the resilience of urban areas (ARUP, 2024; Economic Impact, 2023) . The CRI typically evaluates cities based on their ability to withstand and recover from various shocks and stresses, including natural disasters, economic downturns, and social challenges. It assesses factors such as infrastructure robustness, emergency preparedness, and community engagement to gauge how well a city can manage and bounce back from disruptive events. On the other hand, the RCI focuses on similar themes but may emphasize different aspects or use varied metrics to measure resilience. Both indices aim to comprehensively understand a city's strengths and vulnerabilities, empowering policymakers with the knowledge they need to improve urban resilience.

Despite their differences in focus and methodology, the CRI and RCI share common goals. Both indices strive to enhance urban resilience by identifying critical areas for improvement and encouraging cities to adopt better practices and strategies. They emphasize integrating risk management, sustainable development, and community involvement into urban planning. By providing a structured approach to evaluating resilience, these indices help cities prioritize investments and interventions that can reduce vulnerability and strengthen their capacity to cope with future challenges. Although these methods target cities, they also serve as a reference for the resilience of the universities that are a part of them.

3. Resilience on University Campuses

Numerous scientific studies in the literature relate individual, community, and urban resilience to planning and disaster preparedness (Desouza & Flanery, 2013; Godschalk, 2003; Pickett et al., 2014; Sharifi & Yamagata, 2016). As such, topics such as sea level rise, biological ecosystems, climate change, natural and man-made disasters, and the creation of resilient cities and communities have gained importance, but very little research has focused on university campus resilience (Storms et al., 2019). This is probably because most university campuses are less interested in resilience when investigating or addressing it within sustainability. While many universities have sustainability offices and/or directors, very few have resilience offices and/ or directors. At the same time, sustainability is considered together with the concepts of green campus, eco campus, and climate-friendly campus on campuses. In this context, since it is subject to rankings such as UI Greenmetrics, it increases prestige, and this issue is prioritized for universities.

Nevertheless, it can be said that universities are among the most proactive groups in the fight against resilience and actively combine sustainability measures with resilience (Storms et al., 2019). For example; Istanbul Technical University has set many targets with its 2021-2048 Climate Action Plan. Although such goals are important in terms of climate, such a step also makes the university more resilient to climate change in many ways (ITU, 2021). Resilience on campus is not only related to climate but also to many other factors such as infrastructure, emergency preparedness, community support, security, energy efficiency, sustainability, health services, psychological support, flexibility of educational programs, and effectiveness of communication systems.

Campus resilience refers to the ability of a university campus to prepare for, respond to, and recover from various types of disruptions. This includes not only the physical infrastructure but also organizational systems, human resources, and community networks. Resilience is about learning from the past and examining the present to prepare for the future. At the core of resilience is social connection and cohesion. Resilience also provides a perspective on how strengths and vulnerabilities interact (Second Nature, 2018)

Each university campus has unique characteristics due to its location, environmental, economic, and social resources and structure. Resilience fundamentally includes environmental, social, and economic dimensions. Some sub-criteria within these foundations may not apply to some campuses. In order to assess resilience, the actual skills, characteristics, and attributes of the campus are different in each community, and all specific indicators that need to be considered may differ.

3.1. Practices for University Campus Resilience

3.1.1. Practices of San Francisco State University

In collaboration with Second Nature and The Nature Conservancy, San Francisco State University conducted a community-based study to assess the impacts of extreme weather and climate change and generate and prioritize solutions to improve their communities' resilience, sustainability, and equity (Second Nature, 2022).

San Francisco State University has established a Campus Resilience Office that is responsible for coordinating and planning university emergency event management. The duties of this office include: developing and conducting pilot studies to test plans and procedures to facilitate the development, maintenance, and implementation of the university's emergency operations plan; facilitating emergency notification communication within the University of San Francisco community; educating students, faculty, and staff on emergency preparedness; and engaging external partners to enhance the university's overall preparedness. This is a significant effort to promote resilience.

3.1.2. Campus Resilience Dimensions developed by Community Resilience Organizations & Second Nature

Developed by Community Resilience Organizations through Second Nature with support from the Kresge Foundation and guidance from the Climate Leadership Network, including members of the Resilience Assessment Working Group and the CRUX program, the Campus Resilience Criteria provide an assessment of resilience along five dimensions (Second Nature, 2018). 1) Infrastructure, 2) Economics, 3) Ecosystem Services, 4) Social Equity & Governance ve 5) Health & Wellness

This assessment is intended to provide a broader perspective on how to design implementation plans that address strengths and weaknesses, knowledge gaps, and priorities and build resilience. This tool can help universities complete their initial Campus-Community Resilience Assessment, track progress over time, and determine their strengths, challenges, and priorities related to resilience..

Resilience is learning from the past, examining the present, and preparing for and improving future conditions. This assessment includes environmental, social, and economic factors to establish a healthy, resilient, and dynamic campus system at the university. The dimensions and criteria included provide a more comprehensive perspective on community resilience and how strengths and vulnerabilities interact. Some criteria may not apply to some campuses. The assessment is comprehensive enough to be used by all campuses but may not include all location-specific indicators that should be considered, as each campus has unique, different, and specific characteristics.

Table 3. Campus Resilience Tool by Second Nature (Second Nature, 2018)

CRITERIA	SUB-CRITERIA					
INFRASTRUCTURE	Housing & other buildings - structural risks	Housing & other buildings - structural risks	Transportation - resources	Energy - self-sufficiency & efficiency	Water supply & management - consumption	Emergency preparedness
ECONOMICS	Institutional finances	Investments in resilience				
ECOSYSTEM SERVICES	Natural areas - knowledge & management	Campus property - land use & public access	Waste management			
SOCIAL EQUITY & GOVERNANCE	Civic engagement & participation	Diversity	Resilience communication & awareness	Education & curriculum		

HEALTH & WELLNESS	Food systems - access	Food systems - equity	Health care & services - individual & collective wellbeing	Sense of place

This assessment tool, offered through Second Nature, is geared toward assessing resilience and is intended to help further inform and organize the college campus. Community Resilience Organizations developed this tool through Second Nature with support from the Kresge Foundation and guidance from the Climate Leadership Network, including the Resiliency Assessment Working Group and CRUX program stakeholders. The table includes criteria and sub-criteria (Table 3.). Each sub-criterion is rated on a 5-point scale from vulnerable=1 to strong=5 (Second Nature, 2018). As a result of the assessment, stronger and more vulnerable areas of resilience on campus can be identified, and resources and data can be created to build resilience.

3.1.3. Resilience Practices of Virginia Tech University

The Center for Sustainable & Resilient Infrastructure exists at Virginia Tech University to develop and implement innovative, secure, efficient, sustainable, and resilient solutions for rebuilding, renewing, and managing infrastructure facilities, networks, and systems (Virginia Tech University, 2024). The Center for Sustainable and Resilient Infrastructure (CSRI) is a partnership between the Virginia Tech Transportation Institute (VTTI) and the Transportation Infrastructure and Systems Engineering (TISE) Program of Virginia Tech's Department of Civil and Environmental Engineering (CEE). CSRI's mission is to design, develop, and implement innovative, safe, efficient, sustainable, and resilient solutions to redesign, renew, and manage infrastructure facilities, networks, and systems and to train the next generation of transportation professionals. Working primarily on sustainability and infrastructure of transportation infrastructure, the center has developed, tested, and implemented innovations, including new approaches to assessing the safety of pavements and bridges using innovative vehicle and tire technology and tools for life cycle cost and environmental assessment of transportation infrastructure.

Virginia Tech has a Community Resiliency Model (CRM) for social resilience. From May 2023 to December 2023, approximately 1,000 employees and students joined CRM to learn how to monitor and work with their nervous systems. This skills-based stabilization program's main focus is restoring the natural balance of the nervous system. CRM Workshops help adults and children learn to follow their nervous systems, bring body, mind, and spirit into better balance, and encourage people to pass these skills on to their families, friends, and communities.

This program is not just about individual learning but also about building a strong, resilient community. It aims to teach the university community about their nervous system and how to regulate it while also showing them how to connect with others more effectively and cope with their daily stressors. The program is a comprehensive social resilience initiative that aims to educate and unite campus stakeholders and students.

3.1.4. Campus Resilience Index (CRI) developed by Lost &Found Foundation

In 2010, the Lost & Found Foundation was founded as a student organization based at the University of South Dakota to reduce young adult suicide (Young et al., 2024). In 2020, the Campus Resilience Index (CRI) was developed to assess campus social resilience. The current situation of the campuses was analyzed, and the social support or lack of support provided by the campuses to students was investigated to determine whether it led to the students' good or poor mental health (Lost&Found, 2024; Young et al., 2024).

It comes out amid increasing reports of poor mental health and suicide risks affecting higher education institutions in South Dakota and the surrounding region (Lost&Found, 2024; Young et al., 2024). The CRI is a partnership-focused tool that assesses the capacity of college and technical school campuses and communities to prevent suicide, identifies areas of strength in prevention, and recommends programs, policies, or resources that can reduce suicide risk and enhance student mental health and well-being (Lost&Found, 2024; Young et al., 2024).

The index provides strategies to help communities and states prevent suicide(Lost&Found, 2024; Stone et al., 2017; Young et al., 2024). It includes methods to strengthen economic support, improve access to suicide care, create protective environments, promote connectedness, teach coping and problem-solving skills, identify and support at-risk individuals, and lessen harm from suicidal behavior. This comprehensive package aims to address both immediate and long-term needs in suicide prevention for students. Figure 1 shows the Campus Resilience Index in the form of 7 main criteria and 35 sub-criteria. The most striking aspect of this index is that it focuses on a particular and special issue for the university. It has highlighted the depth of the resilience issue, as it shows that many parameters must be considered and measured regarding this specific issue under the title of social resilience.

Figure 1. Campus Resilience Index by Lost and Found Foundation (Lost&Found, 2024; Young et al., 2024)

The issue of university resilience, which is not limited to the practices examined, is still evolving. As can be seen, campus resilience practices are vital strategies that universities employ to ensure their ability to withstand, adapt to, and recover from a variety of challenges, including natural disasters, economic downturns, and other disruptions. It can be said that the first steps have been taken in universities for the concept of resilience, which is a multi-criteria concept, but extensive and comprehensive studies are needed. It would be beneficial to develop resilience indexes, which have been developed comprehensively for cities, for universities as well.

These applications, which are still developing, are becoming increasingly critical in our age with climate change, rapid technological advances and changing social needs, and reveal the need for durable campuses as well as sustainable campuses.

As in examined practices, resilience, based on economic, social, and environmental parameters, aims to strengthen institutions' existing infrastructures, eliminate their vulnerabilities, and develop them in a more flexible, harmonious, and sustainable framework.

4. Planning and Design Strategies for Campus Resilience

Because universities are integral to urban environments, campus resilience and city resilience are deeply interconnected. A resilient campus contributes to social, economic, and environmental stability, increasing the overall resilience of both itself and the city in which it is located. Through disaster preparedness, sustainable practices, and robust healthcare initiatives, campuses can act as community hubs that provide resources and support in times of crisis and benefit the broader urban population. Universities often lead research and innovation in applicable resilience strategies. Using their research and technology, they promote resilience by developing projects, effective disaster plans, and sustainable urban planning strategies. Furthermore, the existing social and cultural dynamics of campuses affect urban resilience. University campuses that promote social equality, diversity, and inclusion can serve as models for broader social change. By developing strong community ties and networks, universities can increase the social cohesion and collective action vital to resilience in adversity. In essence, resilient campuses increase significantly to the resilience of the cities in which they are located.

First and foremost, every university needs a comprehensive campus resilience plan. A comprehensive campus resilience plan is a critical document to ensure that the campus is prepared for various threats and can respond effectively in crises. This plan begins with assessing threats, risks, and potential damages and should include preventive measures such as infrastructure strengthening, cybersecurity measures, and education and awareness. In addition, team or teams, communication strategies, and evacuation plans are created for emergencies. Critical functions for business continuity should be identified, and recovery methods such as data backup should be determined. The plan should also include post-event assessment and recovery processes. Internal and external communication strategies should be determined, ensuring the plan is tested and updated regularly. In addition, appendices such as emergency contact lists and campus maps should be part of the process.

Resilience absolutely requires determining risk factors. For this purpose, the threats that the institution may face should be determined, graded, and defined as a process for each risk. All kinds of preventive measures should be determined, and workflows such as emergency plans, business continuity plans, recovery plans, etc., should be created to ensure that service and communication are not interrupted and to subsidize the damage that occurs. The workflow in Table 4 can be created separately for each risk. Risks should be determined not only in terms of disasters and physical damage but also in economic and social terms. For example, determining emergency assembly areas for earthquakes is a physical precaution, while raising community awareness on how to act in an emergency is a social precaution. In particular, studies on community resilience, such as CRI at the University of South Dakota, should be conducted to identify and implement unique, special issues related to the campus (Lost&Found, 2024; Young et al., 2024).

Table 4. Campus Resilience Plan for Potential Risks

Risk Assesments	Threats, damage analysis and risk rating.
Preventive Measures	Infrastructure reinforcement, cybersecurity measures and education-awareness programs.
Emergency Planı	Emergency team, communication plan, evacuation plan and health-safety measures.
Business/Work Contuinity Plan	Plans
Recovery Plan	Post-event recovery processes and evaluation and improvement of the plan.
Communication Plan	Internal and external communication strategies and channels.
Updating and Testing the Plan	Testing the plan, drills and regular updates.
Appendices	Emergency contact lists, maps and campus disaster plans, etc.

After the risks are identified, the current situation and resources are determined, and a strategic plan for the future should be made. It is a multi-stakeholder process that involves campus administrators, students, academic and administrative staff, student communities, planners, architects, and other stakeholders. Keywords such as emergency management, sustainability, risk analysis, crisis planning, flexibility, community solidarity, communication strategies, infrastructure security, psychological support, and capacity management cover the essential elements of ensuring campus resilience.

5. Conclusion

The study shows that building resilient campuses, such as sustainable campuses, is critical to the safety and well-being of university communities. By implementing sound planning and design strategies, universities can reduce the impact of adverse events and create sustainable, harmonious, and thriving environments for learning and growth.

Related to adverse conditions experienced all over the world, resilience has gained significant importance in university campus design and planning. Resilience refers to the ability of a system or institution to withstand and adapt to various challenges, disruptions, and changes. Universities must incorporate resilience as a foundational element of their sustainability initiatives. Resilience in university campus design and planning involves considering the potential risks and uncertainties that may arise, such as natural disasters, technological failures, or social unrest, and developing strategies to minimize their impact and ensure the continuity of operations. For his purpose, planning and design strategies can be implemented, and the Comprehensive Campus Resilience Index (CCRI) can be developed Index to enhance university campuses' resilience. These planning strategies may include:

1. Incident response planning: Developing comprehensive plans and protocols to respond effectively to various incidents, such as natural disasters, cyber-attacks, or pandemics.

2. Implementing robust infrastructure: Ensuring university campuses have resilient infrastructure systems, including power supply, water management, and communication networks, to withstand disruptions and sustain operations during emergencies.
3. Integrating green and sustainable design principles: Incorporating green spaces, renewable energy sources, and sustainable building materials in campus design enhances environmental resilience and supports the well-being of students and faculty.
4. Community engagement and collaboration: Establishing partnerships with local communities, government agencies, and other stakeholders to share resources, expertise, and support in times of crisis and to foster a sense of community resilience.
5. Developing a diverse and flexible campus layout: Designing campuses with interconnected buildings and flexible spaces that can be adapted for various uses promotes resilience. This allows for quick reconfiguration and adaptation to changing needs or emergencies.
6. Creating redundancy and backup systems: Having redundant systems in place, such as backup power generators or duplicate data storage, ensures the continuity of critical operations, even in the face of disruptions or failures.
7. Incorporating technology and digital solutions: Utilizing advanced technologies, such as smart sensors, data analytics, and monitoring systems, can improve situational.

This study aims to create a framework for determining priorities in the resilient campus planning and design process. The criteria revealed by examining the practices carried out for resilience in universities have formed the basic backbone of a comprehensive campus resilience plan. It is thought that campuses need a comprehensive assessment tool and checklist in the context of resilience, and also the proposed CCRI should be developed in future studies.

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The article complies with national and international research and publication ethics.

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Sustainable University and Innovative Approaches: Pioneers of Türkiye

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1. Introduction

Sustainability is a form of development that addresses the needs of both the present and future generations (Adams et al., 2018). Although concerns about the world's natural resources are a significant aspect of sustainability, other critical issues include poverty, consumption, gender equality, population growth, human rights, education, peace, social cohesion, security and climate change. All of these factors influence how we live in the future. Sustainability requires a holistic approach that must be integrated into the decision-making processes and investments (Bokolo et al., 2020). It serves not only as a model for society but also fosters inclusive and critical thinking. Moreover, it plays a crucial role in addressing sustainability challenges by minimizing the negative environmental, social, economic, and health impacts (Adenle & Alshuwaikhat, 2017).

In recent years, sustainability studies have significantly impacted the systems and stakeholder relationships of businesses (Hernandez et al., 2021). Sustainability, now recognized as a crucial criterion in universities, emphasizes the importance of considering the environmental, economic, and social dimensions in policy and strategy development. While everyone plays a role in promoting sustainability, educational institutions have significant responsibilities (Davis, 2010). Sustainability policies, strategies, and projects implemented by universities—institutions that can set an example for society in education, research, and societal contributions—will serve as models for other higher education institutions.

1.1.Summits on Sustainability of Educational Institutions

Since 1972, universities have voluntarily signed numerous declarations to demonstrate their commitment to sustainability (Wright, 2002). The initial step in promoting sustainability in higher education institutions began with the Stockholm Declaration and continued with the development of other significant declarations and summits (Table 1).

Table 1. Summits for educational institutions to achieve sustainability (adapted from Anthony, 2021; UN, 1987; UNESCO, 2015)

Year	Country	Declaration	Coverage
1972	Sweden	Stockholm Declaration (United Nations Conference on the Human Environment)	The declaration on human activities impacting the natural environment provided a perspective on how higher education institutions can address environmental protection.
1975	Serbia (Former Yugoslavia)	Belgrade Charter (International Workshop on Environmental Education)	It aimed to address environmental problems globally by establishing a comprehensive framework for ecological education.
1977	Georgia (Former USSR)	Tbilisi Declaration (Intergovernmental Conference on Environmental Education)	It established a framework that provides guidelines for environmental education at the national, regional, and global levels.
1990	France	Tallories Declaration	It aimed to reduce pollution and degradation of natural resources by establishing an educational research policy for information exchange. It is the first declaration specifically addressing the sustainability of universities.
1991	Canada	Halifax Statement (Declaration)	It aimed to guide current and future growth in relation to sustainable development by proposing eco-friendly practices to address the causes of environmental degradation.
1992	Rio De Janeiro, Brazil	Agenda 21 (Promoting Education, Public Awareness and	It provided guidelines to reduce consumption patterns by promoting sustainable development, bringing the concepts of

		Education, United Nations Conference on Environment and Development)	sustainable universities and green campuses to the forefront.
1993	Japan	Kyoto Declaration on Sustainable Development	The declaration outlined the principles of sustainable development in research and teaching activities, aiming to reflect best practices across universities.
1993	United Kingdom	Swansa Declaration	Educational research policy changes and the enhancement of public roles were targeted at promoting sustainable development in society.
1994	Geneva, Switzerland	Copernicus University Charter for Sustainable Development	On university campuses, initiatives have been encouraged to strengthen institutional commitment and foster positive environmental attitudes.
1997	Greece	Thessaloniki Declaration International Conference on Environment and Society	A new vision for sustainable education and the role of social awareness was introduced. This vision aimed to provide a platform for mobilizing actions at both national and international levels.
1998	Paris, France	World Declaration on Higher Education for the Twenty-first Century: Vision and Action and Framework for Priority Action for Change and Development in Higher Education	The aim was to raise awareness about the importance of sociocultural and economic factors in achieving sustainable development for future generations.
2001	Luneburg, Germany	Declaration on Higher Education for Sustainable Development	It has created a facilitating role in advancing sustainable development within higher education institutions by generating new knowledge about the educational aspects of the sustainable development goals.
2002	Johannesburg, South Africa	Unbuntu Notification	It called for the establishment of a global learning platform to generate action-oriented initiatives for sustainable university campuses.
2004	Barcelona,Spain	Barcelona Declaration Education for Sustainable	Higher education institutions are crucial for addressing societal challenges. To achieve

		Development (EESD)	sustainable development, it is essential to include these institutions in relevant programs.
2005	Austria	Graz Declaration on Commitment to Sustainable Development	University campuses were called to prioritize sustainable development in their daily operations and to use universities as models for advancing the social aspects of sustainability.
2005	Brussels, Belgium	Bergen Declaration	University campuses around the world have been established to indoctrinate the principles of sustainable development.
2006	Strasbourg, France	Strasbourg Declaration on the Responsibility of Higher Education for a Democratic Culture Citizenship, Human Rights and Sustainability	Activities aimed at enhancing university campuses' commitment to sustainable societies and democratic culture were presented.
2006	Boston, USA	Climate Commitment of American College and University Rectors	University campuses have committed to becoming climate-neutral communities by integrating sustainable development into their curricula and educational experiences, supported by the implementation of a comprehensive action plan policy.
2007	Lucerne, Switzerland	Lucerne Declaration on Geographical Education for Sustainable Development	Education for sustainable development has been enhanced by linking geography in education.
2008	Sapporo, Hokkaido Japan	Sappora Sustainable Declaration	The need for university campuses to collaborate closely with policymakers was emphasized, as the governance role of universities becomes increasingly uncertain.
2009	France	World Conference on Higher Education United Nations Educational, Scientific and Cultural Organisation	A deeper understanding of the issues and a greater interdisciplinary focus on sustainable development within higher education institutions have contributed to citizen education, supported human rights, and promoted societal well-being.
2009	Italy	Turin Declaration on Education and Research	It called for a new approach to economic and social development that aligns with

		for Sustainable and Responsible Development	sustainable development principles. Additionally, it proposed an ethical path to achieving sustainable development by introducing an energy policy focused on ecosystems.
2009	Tokyo	Tokyo Declaration of HOPE	Action objectives have been established for trainers, lecturers, and facilitators to further promote education for sustainable development.
2012	Brazil	The Higher Education Sustainability Initiative (HESI) Rio+20	Access to quality education was identified as essential for achieving the International Development Goals.
2015	New York	United Nations Sustainable Development Summit -UN Sustainable Development Summit	Universal access to quality education and lifelong learning opportunities for everyone.
2018	New York	The United Nations Youth Strategy Youth 2030	The goal is to enhance activities at global, regional, and national levels to address the needs of young people and to advocate for their rights.
2021	Paris	UNESCO World Conference	It is a conference focused on discussing the contributions of education, science, culture, and communication sectors towards sustainable development and determining the agenda items.

1.2. Sustainable University Criteria

Sustainable and ecological campus practices are referred to as ‘small cities’ in the literature because of their population density and impact on the environment and society (Alshuwaikhat & Abubakar, 2008). Universities contribute to the Sustainable Development Goals through their education, research, social responsibility projects, and campus practices (Figure 1).

Improving Education and Raising Awareness (SDGs 4): Universities create awareness among students and the general public by arranging training courses on sustainable development. In this regard, sustainability classes, workshops, and seminars were integrated into the curriculum. These activities are meant to empower students with information that will help them achieve their goals of development (Sterling & Scott, 2008).

Figure 1. Sustainable Development Goals (SDGs) (United Nations, 2024)

Research and Innovation (SDGs 9): Universities lead research and innovation projects related to sustainable development. These projects have contributed to significant progress in areas such as environment-friendly technologies, renewable energy sources, and sustainable urban planning (Filho, 2011). For example:

Sustainable Campus Practices (SDGs 11): Universities contribute to environmental sustainability on their campuses through various initiatives. These practices encompass energy-efficient buildings, waste management programs, water conservation systems, and enhancement of green spaces (Disterheft et al., 2013).

Social Responsibility and Partnerships (SDGs 17): Universities develop social responsibility projects and collaborations to achieve sustainable development goals. These initiatives focus on creating solutions for sustainable development through partnerships with various stakeholders at both local and international levels (Lozano, 2006).

Sustainable Energy and Resource Management (SDGs 7): Universities contribute to sustainable energy goals by utilizing renewable energy sources and implementing energy efficiency projects. Campuses are equipped with solar panels, wind turbines, and energy-efficient systems to promote sustainable energy use (Alshuwaikhat and Abubakar 2008). A sustainable university aims to protect natural resources and the environment, foster a thriving campus economy and a high quality of life, and develop effective processes or management systems (Galioğlu, 2015). Within this framework, a sustainable campus impacts societal transformation by addressing the physical, social, and developmental aspects of a city (Koca, 2020; Atıcı et al., 2021). The implementation steps for establishing a sustainable campus are detailed in Figure 2 of the International Alliance of Research Universities (IARU) report (IARU, 2024).

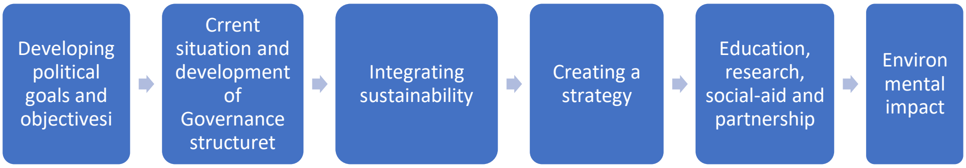

Figure 2. Sustainable Campus Implementation Steps

To transform into sustainable campuses, universities must adopt the concept of sustainable universities with a distinct sustainability perspective. They should be equipped with the necessary resources to ensure environmental, social, and economic sustainability (Figure 3) (Öktem & Mutdoğan, 2020; Anthony, 2021; United Nations Environment Programme UNEP, 2013).

As an environmental dimension, it is essential to foster a culture of sustainability through environmental improvements and eco-friendly initiatives.

- Conservation of energy and resources, efficient environmental management, and energy-saving measures such as green buildings, natural ventilation, air conditioning, and greenhouse gas emissions reduction (Atıcı et al., 2021; Filho, 2015; Alshuwaikhata and Abubakar, 2008). Additionally, it involves advanced building control systems that utilize applicable passive energy technologies and integrate them into the overall design for maximum impact, including more efficient HVAC systems; the use of renewable energy sources such as wind, solar, and geothermal for heat and power; campus-wide heating; and reducing energy costs by installing centralized control systems to manage cooling and lighting. This includes incorporating energy-saving lighting, such as compact fluorescent and metal halide luminaires, encouraging natural lighting, rainwater harvesting to conserve water, and landscaping practices that promote the use of drought-tolerant native plants on campuses.

- Ecosystem protection, minimizing biodiversity loss, preserving green areas within the university, supporting sustainable landscaping, and implementing pesticide control measures.
- CO_2 emissions management, establishing policies aimed at reducing the carbon footprint, and ensuring the reduction of greenhouse gas emissions.
- Waste recycling, reducing the impact of environmental emissions on local air pollution, minimizing hazardous waste, and managing food waste through methods such as converting food waste to compost, and reducing the amount sent to landfills. It also includes implementing recycling programs and reducing plastic and paper wastes.
- To create eco-friendly designs and prioritize the sustainability of materials.
- To prevent incompatible conditions.
- To ensure that urban mobility is integrated into planning.
- Prioritizing bicycles and pedestrians, improving transportation, encouraging bicycle use, providing a system that promotes public transport for staff, students, and visitors, and supporting green transportation initiatives through appropriate equipment.

As a social dimension, student groups are the most critical. One of the primary goals is to address students' problems and contribute to the long-term development of healthy individuals within a sustainable campus framework (Kalaycı, 2020).

- Stakeholder participation in planning, diversity on campus, prevention of discrimination, and increasing disabled access are necessary.
- To create an equitable learning environment that supports the well-being of both current and future university communities, ensuring equal rights for all in teaching and research, as well as campus development and sustainability.
- To provide social protection and security (public welfare).
- To implement programs and projects focused on research and education, as well as organizing conferences and seminars.
- To create programs for student engagement and social coexistence on campus, while introducing innovative and eco-friendly solutions.
- To develop sustainable policies integrated with academic programs.
- To ensure awareness and sensitivity to environmental sustainability principles and initiatives.

In terms of economic performance, universities act as employers, investors, and consumers within their immediate environment (McKenzie, 2004). There are potential risks associated with the utilization of resources, depletion of resources, and sustainability of production. At this point, the environmental dimensions and use of renewable energy sources also become crucial factors.

- To ensure financial sustainability in the short, medium, and long term,

- To provide organizational management, risk management,
- To establish investment and wage policies,
- To assess sustainability with its economic component in the generated waste,
- To enable graduates to contribute to the economic and ethical development of society and organizations.

Typically, the current structures and infrastructure of university campuses are designed in unsustainable ways, and it is expected that efforts to address this issue will occur over the long term. However, several key factors currently prevent the success of sustainability initiatives, including a lack of interest and participation, insufficient financial resources, inadequate support from university administrators, poor communication and information sharing, resistance to change, and lack of performance indicators (Güngör Tanç et al., 2022).

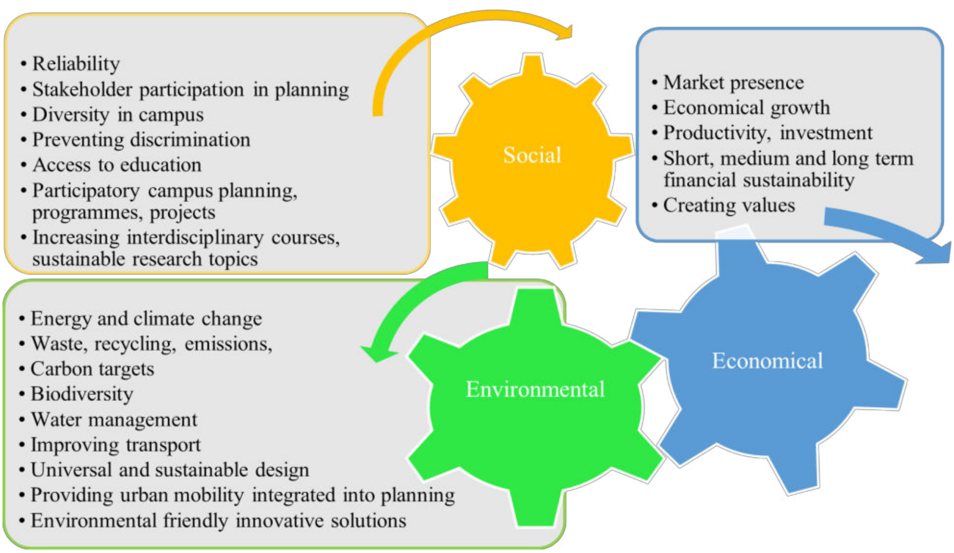

Figure 3. Environmental, social and economic dimensions of the sustainable campus

1.3. Organizations and Evaluation Systems Related to the Sustainability of Universities

Various assessment systems and organizations have been developed to evaluate and encourage universities'sustainability efforts. By utilizing these systems, universities can enhance their environmental, economic, and social sustainability initiatives to achieve their sustainability goals. As the interest in sustainable campuses has increased, the use of international sustainability assessment systems has become more widespread. Some important assessment systems and organizations in this area are described below.

The Global Reporting Initiative (GRI), established in 1997, is an international organization that sets principles for sustainable reporting. The GRI sets standards for economic, environmental, and social sustainability (GRI, 2024) and provides a reporting framework applicable to both small and medium-sized organizations, whether international or national in scope.

The Association for the Advancement of Sustainability in Higher Education (AASHE) was founded in 2005 with almost 1000 members from the USA, Canada, and 20 other countries. It supports higher education institutions, staff, and students in the advancement of sustainability practices. AASHE offers various training services, resource materials, and assistance to promote and implement sustainability practices (Uçar & Özdemir, 2022; Cole, 2003).

The International Sustainable Campus Network (ISCN) is a global organization that examines best practices for campus sustainability and integrates sustainability into research and teaching. The organization issued the 'Sustainable Campus Declaration' in 2010. The ISCN supports universities worldwide in their sustainability efforts and facilitates the sharing of best practices (ISCN, 2021).

The Sustainability Tracking, Assessment, and Rating System (STARS) is a framework developed by AASHE to assess universities'sustainability performance. STARS provides a comprehensive system for monitoring, evaluating, and benchmarking the sustainability achievements of universities. This enables universities to report on and improve their sustainability efforts. STARS assesses performance in categories such as education, research, operations, planning and management, and engagement and collaboration (AASHE, 2024).

The Times Higher Education Impact Rankings (THE) is an annual global ranking system that evaluates universities based on their contributions to the United Nations Sustainable Development Goals (SDGs). This ranking assesses university performance in various dimensions, including education, research, social impact, and cooperation, and encourages sustainability practices in these fields. Since 2019, universities have been assessed based on indicators related to 17 goals. The steps to be followed for this (Acuner et al., 2023; Sterling & Scott, 2008) are as follows: **Policy Development:** Defining the mission, aims, and objectives in alignment with the university's strategic plan. **Implementation:** Carrying out actions related to education, training, research, and application, encompassing the roles of dissemination and administrative management sectors within the university. **Evaluation:** Assessing performance with appropriate data and information collection methods to ensure the university's social, economic, ecological, and governance outcomes. **Optimization:** Preparing a sustainability report to support decision-making processes, alongside analysis and evaluation. These steps provide a strategic and comprehensive roadmap to help universities achieve their sustainability goals (Times Higher Education Impact Ranking, 2024). In 2022, 1410 universities participated in THE-Impact Rankings and 1906 universities from 108 countries and regions participated in 2024.

The ISO 14001 Standard is a framework for environmental management systems that focuses on identifying, implementing, and auditing environmental objectives, policies, and responsibilities. It includes various goals aimed at enhancing sustainability on campus (Simkins and Nolan, 2004; Karaman, 2006), such as minimizing waste, conserving resources, and reducing environmental pollution. Additionally, it seeks to raise environmental awareness within the community, create a foundation for campus environmental protection, support management in the ongoing improvement of environmental performance, highlight the importance of environmental management, promote voluntary participation in environmental initiatives, and demonstrate a dedication to exceeding regulatory requirements.

The Green League, launched in 2007 by the UK student campaigning network People and Planet, is recognized as the first league table to assess the environmental performance of universities (Grindsted, 2011). The criteria used included policy and strategy, environmental audits and management systems, carbon management, employee rights, sustainable food practices, staff and student engagement, education, energy resources, waste and recycling, and water conservation.

The Environmental and Social Responsibility (ESR) index, developed in 2009 by The Environmental Association for Universities and Colleges (EAUC), was designed to assess the sustainability performance of UK universities (Grindsted, 2011). The index is based on five key indicators: organizational strategy, integration of environmental concerns, environmental management, environmental performance, and the impact and assurance of the collected data (Suwartha and Sari, 2013).

The Green League and ESR Index contribute to the ranking of universities based on sustainability, but they are typically focused on specific countries or narrowly defined regions.

UI GreenMetric, developed by the University of Indonesia (UI) in 2010, enables universities to share information about their sustainability practices. Its primary criterion focuses on practices that promote sustainability and enhance the quality of life of stakeholders at Green Campus universities (GreenMetric, 2024a; Anthony, 2021). The UI GreenMetric World University Ranking System ranks universities based on six main indicators. According to the scoring system, the indicators are as follows: Environment and Infrastructure (SI) (15/1500% points), Energy and Climate Change (EC) (21/2100% points), Waste Management (WS) (18/1800% points), Water Use (WR) (10/1000% points), Transport (TR) (18/1800% points), and Education and Research (ED) (18/1800% points). The total score was based on 10.000 points (GreenMetric, 2024a). The evaluation tools for this ranking system are updated annually, encouraging universities to adopt sustainability practices for campus management (Atıcı et al. 2021). The ranking also offers each university the opportunity to identify its strengths and weaknesses in advancing sustainable development (Suwartha & Sari, 2013). The environmental aspect covers natural resource use, environmental management, and pollution prevention; the economic aspect addresses profit and cost reduction; and the social aspect involves education, community, and social participation (Kalaycı, 2020; Ardalı & Köksal, 2022). Figure 4 illustrates the connection between the 17 Sustainable Development Goals and the six main categories of GreenMetric's green measurement indicators.

Figure 4. Linking Sustainable Development Goals to GreenMetric's Green Measurement Indicators (Sari, 2023).

The GreenMetric Ranking System aims to enhance the livability of university campuses for both users and the environment (Mutdoğan, 2020). In 2023, GreenMetric rankings were based on categories, such as campus population and campus size. For instance, Figure 5 shows the campus sizes for 2023 according to campus area (GreenMetric, 2024a).

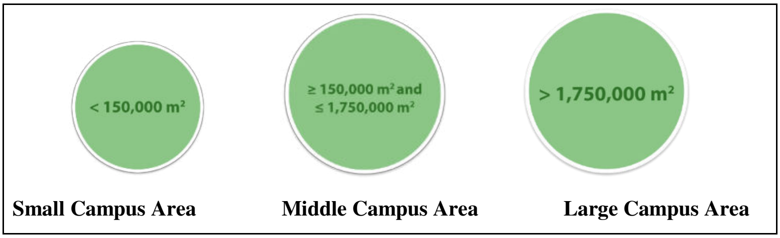

Figure 5. Campus area classification

While encouraging universities to adopt green policies, GreenMetric also explored the relationship between a country's environmental performance, universities'sustainability practices, and their academic performance (Atıcı et al., 2021; Ali & Anufriev, 2020). Table 2 presents the top ten universities in the GreenMetric ranking for 2023, along with their scores on various sustainability criteria.

Table 2. Top 10 Sustainable Universities

Sequencing	Universities	Infrastructure	Energy and Climate Change	Waste	Water	Transportation	Education& Resarch	Sum - Points
1	Wageningen University, Netherlands	1350	1825	1800	1000	1750	1775	9500
2	NottinghamTrent University, United Kingdom	1375	1850	1800	950	1700	1800	9475
3	UmweltCampus, Germany	1275	1925	1800	1000	1700	1750	9450
4	University of Groningen, Netherlands	1325	1775	1800	1000	1800	1750	9450
5	University of California, USA	1400	1900	1800	1000	1575	1750	9425

6	University College Cork, Ireland	1250	1875	1800	1000	1700	1800	9425
7	University of Nottingham, England	1375	1825	1800	1000	1750	1675	9425
8	Sao Paulo University, USA	1450	1775	1800	950	1700	1750	9425
9	University of Connecticut, USA	1375	1775	1725	1000	1750	1775	9400
10	University of Bremen, Germany	1325	1775	1725	1000	1750	1800	9375

2. Material and Method

This study examines the development of sustainable universities, along with the organizations and evaluation systems that assess university sustainability. It examines the state of sustainability among universities, both globally and in Türkiye Within this framework, the sustainability activities and reports of the top ten universities in Türkiye, ranked by GreenMetric, were analyzed.

3. Findings and Discussion

3.1.Green University and Türkiye

The UI GreenMetric ranking model, pioneering in sustainable campus practices, has established itself in the literature with terms such as “green campus,” “green university,” “green curriculum,” and “green university index platform,” particularly since 2010. In addition to education, training, and research activities, the campus has been transformed into an eco-friendly space, with curricula also being updated to incorporate sustainability (Atıcı et al., 2021; Koca, 2020). Annually, the index assesses and ranks universities based on infrastructure, energy and climate change, waste management, water resources, transportation, education, and research. The ranking, which was first conducted in 2010, included 95 universities from 35 countries. Bilkent University was the first Turkish university to be listed and was ranked 83rd. By 2012, Sabancı University was ranked 144th and Bilkent University was ranked 209th. In 2021, the ranking featured 80 countries and 956 universities, and by 2022, 1050 universities were involved (GreenMetric, 2024b). 83 universities from Türkiye were included in the ranking.

Green universities are distinguished by their performance in terms of energy conservation, waste prevention and management, water usage, biodiversity, and sustainable transportation within buildings, facilities, and operations. The benefits of a green university include (Filho, 2015):

- Green universities provide visibility through promotion at the local, regional, and international levels.
- Since it is inclusive, students who participate actively engage in the practice.
- It provides methods and projects as a part of an innovative approach.
- Campus offers various activities and has a permanent institutional certification system.
- Each initiative leads to waste reduction and savings.
- It can raise awareness.
- The measures taken will contribute positively to the long term and help reduce costs.

The 2023 UI GreenMetric World University Rankings indicate that universities worldwide are increasingly adopting environmentally responsible practices. The ranking system network currently includes 1183 participating universities worldwide, with over two million faculty members, 17 million students, and a total research budget of $68 billion. Data from the 2023 GreenMetric rankings reveal that six universities in Türkiye are among the top 100 greenest universities in the world, as detailed in Table 3 (GreenMetric, 2024b; YOK, 2024).

Table 3. Top 100 sustainable universities in Türkiye

Green University	Sequencing	Green University	Sequencing
Istanbul Technical University	46	Özyeğin University	89
Yıldız Technical University	63	Ege University	96
Erciyes University	85	Yeditepe University	98

In the ranking, 45 universities from Türkiye, 36 public universities, and 9 private foundation universities were ranked among the top 500 greenest universities globally. The top 500 universities with sustainable, energy-efficient, nature-friendly, and eco-friendly campuses are listed in Table 4.

Table 4. Sustainable universities in the top 500 in Türkiye

Green University	Sequencing	Green University	Sequencing
Middle East Technical University	123	Hacettepe University	312
Başkent University	152	Düzce University	314
Izmir High Tech Institute	153	Sabancı University	317
İnönü University	156	Mersin University	319
Dokuz Eylül University	159	Niğde Ömer Halisdemir University	357
Bartın University	187	Ondokuz Mayıs University	364
Sakarya University	189	Çukurova University	375

Aksaray University	208	Kapadokya University	388
Tokat Gaziosmanpaşa University	231	Mardin Artuklu University	391
Afyon Kocatepe University	247	Antalya Bilim University	403
Hitit University	248	Bursa Teknik University	438
Trakya University	255	Van Yüzüncü Yıl University	446
Kütahya University of Healty Science	257	İstanbul Aydın University	458
Atatürk University	258	Kocaeli University	460
Hasan Kalyoncu University	262	Gaziantep University	463
Bilecik Şeyh Edebali University	278	Bursa Uludağ University	479
Muğla Sıtkı Koçman University	280	Gazi University	483
Fırat University	291	Selçuk University	491
İstanbul Sabahattin Zaim University	311		

3.2. Pioneering Universities-Policies and Practices

Turkish universities are implementing their own initiatives and efforts to meet sustainability goals and reduce their environmental, social, and economic impact. Many institutions have signed sustainability declarations and participated in various networks. For instance, Boğaziçi University and Özyeğin University earned certifications in sustainable practices such as LEED and BREEAM, while Akdeniz University focused on the "Zero Emission Campus" initiative, and Middle East Technical University focused on "Sustainable Water Management" (Bozat, Topdemir, & Gazi, 2016). In addition, these universities engage in a range of projects and practices (Maçin et al., 2020). In this context, the green visions of pioneering universities conducting these initiatives were analyzed based on GreenMetric indicators.

3.2.1. Istanbul Technical University (ITU) has made notable strides in both Türkiye and globally with its sustainability policies and practices, achieving a rank of 46th in 2023. Recognized as the "Most Sustainable University in the Middle East," ITU's sustainability initiatives cover a wide range of areas such as accessibility, waste management, sustainable landscapes and communities, wildlife conservation, healthy living, reducing inequalities, renewable energy, and water management.

- **Energy Efficiency:** ITU contributes significantly to sustainable campus goals through innovative energy efficiency projects. The university employs practices such as energy-efficient lighting systems, insulation materials, and energy-saving devices to enhance the energy efficiency across the campus. These measures help reduce energy use and minimize environmental impacts (ITU Sustainability Report, 2021).
- **Waste Management:** The university minimizes waste and increases recycling rates by developing modern and effective waste management systems. Initiatives such as recycling programs, waste separation systems, and waste reduction strategies are integral to achieving the university's sustainability goals. Notably, the university obtained a zero-waste certificate in 2020, demonstrating its compliance with the Provincial Zero Waste Management System Plan and its commitment to waste management (ITU Waste Management Report, 2020).

- **Green Building Design:** Green building design principles are applied in new construction projects and renovation of existing buildings. This approach considers factors such as energy efficiency, water conservation, use of natural materials, and environmentally sensitive building technologies. These practices are extensively covered in academic literature on sustainable architecture and construction techniques (ITU Green Building Projects Report, 2023).
- **Sustainable Transport:** Car-free transportation is promoted on campus through the provision of bike lanes, pedestrian walkways, and public transport facilities. These practices help reduce air pollution and traffic congestion, and contribute to environmental sustainability. The UniBike application is a successful example of these efforts.
- **Strategic Plans and Sustainability Goals:** ITU's strategic plans prioritize energy efficiency, waste management, and green campus projects. The university's sustainability roadmap highlights activities from past to present, including: 2005-2012 Water Control, 2013 Green Campus Implementation, 2016 Cooperation with Stakeholders, 2017 UI GreenMetric Ranking Application, 2020 THE-Impact Ranking Application and Obtaining Zero Waste Certificate, 2021 Sustainability Report, 2020-2021 Plan to Combat Gender Discrimination, 2021-2026 Environment, Climate and Sustainability, 2021 Establishment of the Sustainability Office, two orange flags at the 2021 Barrier-Free University Awards Ceremony, 2020-2021 Climate Action

Plan, 2021-2026 2022 Sustainability Report, 2021-2023 Sustainability Report (ITU Sustainability Report, 2022). ITU will work collaboratively with the full range of other organizations and entities around the world committed to advancing the use of telecommunications/ICTs for a connected world by 2030. ITU Strategic Plan Report, 2024)

- **Social Responsibility and Collaborations:** ITU actively engages in industrial cooperation and entrepreneurship. The university develops social responsibility projects and collaborates with various stakeholders to achieve sustainable development goals (Lozano, 2006).

ITU has achieved significant national and international success with its sustainability initiatives, playing a crucial role in reaching its sustainable campus goals through various projects. These efforts bolster the university's contributions to environmental, social, and economic sustainability, as documented in academic literature and reports, and significantly enhance its leadership in this field. ITU participated in the THE-Impact Ranking, encompassing all Sustainable Development Goals (SDGs), for the first time in 2020. According to the 2023 ranking, ITU is in the top 10 globally for SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), and ranked 58th overall. According to the 2024 THE-Impact Ranking results, Istanbul Technical University ranks 34^{th} among 1963 universities worldwide, and holds the top position in Türkiye.

3.2.2. Yıldız Technical University (YTU) has taken significant steps within the framework of various sustainability components as part of the

"Smart Green Campus" initiative. In 2020, the university included the Sustainable Development Goals (SDGs) index and GRI content index in its integrated report (Yıldız Technical University, 2020). Campus practices focus on areas such as energy efficiency, waste reduction, water management, and sustainable transportation. YTU is 801–1000th in World University Rankings 2024

- **Energy and Climate Change:** YTU enhances energy efficiency on campus by implementing low-energy lighting solutions. These measures help reduce the university's overall energy use and minimize environmental impact. Additionally, smart lighting systems and energy-saving devices are endorsed by academic research in the field of energy efficiency (Yıldız Technical University, 2024).
- **Waste Minimization (Zero Waste):** To achieve its waste minimization goals, the university conducts all official correspondence through the "Electronic Document Management System," thereby reducing paper usage. This system significantly lowers paper consumption and decreases waste generation. This highlights the positive impact of waste management practices and electronic document systems on sustainability (Yıldız Technical University, 2024).
- **Water Management and Efficiency:** YTU promotes water efficiency on campus by utilizing treated water and incorporating rainwater into the groundwater systems. To prevent water wastage and facilitate irrigation, sensor-activated faucets and underground water tanks have been implemented. The expansion

of permeable surfaces, improvements in drainage, and increase in green space help sustain the natural water cycle. Additionally, the reduction in hard, impervious surfaces contributes to the maintenance of this cycle. By allowing rainwater to permeate these surfaces, the university saves energy that would otherwise be used to treat the water sent to dams via the sewer system. These efforts are supported by academic research on water management and efficiency (Yıldız Technical University, 2024).

- **Sustainable Transport:** The Davutpaşa Campus is particularly well-equipped with sustainable transportation options and infrastructure, including bike lanes and pedestrian walkways. These initiatives enhance environmental sustainability by decreasing air pollution and traffic congestion (Afacan Fındıklı et al., 2021).

Yıldız Technical University plays a vital role in achieving its sustainability goals through ongoing research and initiatives.

3.2.3. Erciyes University (ERU) has taken significant steps towards advancing sustainability and environmental protection through the development of various practices and policies.

- **Green Spaces and Botanical Garden**: The total area covered with vegetation on the Erciyes University campus was 883,019 m². Open spaces constituted 94.36% of the university's total area. Most of these spaces feature sustainable landscape practices and green spaces. Additionally, there are social areas within the forested gardens of faculties. The area surrounding the artificial pond on campus is designated as an "international botanical garden," which hosts both local and exotic plant species. The objectives of the botanical garden include science and research, plant collection, conservation, education and information sharing, and inventory (Erciyes University, 2024).

- **Smoke-Free Campus Policy**: This policy has been implemented to protect non-smokers from passive smoking and to limit access to tobacco products for users. These practices are regarded as crucial for promoting healthy living and environmental protection.
- **Renewable Energy and Water Management**: The campus prioritizes renewable energy production and includes smart buildings and water-absorbing areas covering 24% of the space. Groundwater is utilized within the campus for water management, with efficient pumps extracting water as needed, thereby conserving energy. These practices enhance the university's energy efficiency and minimize its environmental impact.
- **Zero Waste Strategy**: In 2019, a waste management regulation was introduced to support the zero-waste strategy, and related activities began that year. This strategy aims to minimize waste and increase recycling rates. The university's commitment to effective waste management is a key component of its sustainability.
- **Sustainability Education and Awareness Raising**: ERU offers various sustainability courses in its curriculum and organizes training sessions, seminars, and conferences. These programs were designed to raise awareness of sustainability among students

and staff. Additionally, the university's official website features a "Sustainability Report," fulfilling one of the GreenMetric requirements.

- **Transport**: Erciyes University, ranked 5th in Türkiye and 85th globally in the 2023 rankings, achieved the highest score of 1600 points in the transport category. This category accounts for 18% of the total score (Zeybek & Doğu Öztürk, 2023).

Erciyes University has made significant progress in sustainability by conducting various projects aimed at providing environmental, social, and economic sustainability.

3.2.4. Ege University has been actively involved in numerous sustainability initiatives under the "Green Campus Project" and has achieved notable advancements in this area. The university's sustainability efforts focus on energy use, waste management, eco-friendly building designs, bike lanes, and organic farming (Ege University Sustainability Report, 2021).

- **Energy Use and Efficiency:** Ege University meets some of its energy requirements through renewable sources by installing solar panels across its campus. Additionally, the university is enhancing its energy efficiency by implementing LED lighting systems and wind energy terminals. Improved building insulation also contributes significantly to energy savings. These projects have been documented in reports on universities' sustainable energy use.
- **Wastewater Management and Recycling**: The university reduces its environmental impact by enhancing facilities that

clean and recycle campus wastewater. These initiatives have led to significant advancements in wastewater management and water conservation. Wastewater treatment plants and recycling programs are crucial for achieving sustainable water usage goals.

- **Eco-Friendly Design Principles**: Ege University incorporates eco-friendly design principles in its new construction projects and renovation of existing buildings. These principles involve the utilization of energy-efficient materials, maximizing natural light, and employing sustainable construction methods. The university's academic research on eco-friendly building design and construction projects provides a detailed discussion on these practices.
- **Bike Lanes and Transport**: Bicycle use is promoted on campus with dedicated bike lanes and parking areas established. Additionally, students can access community bicycles by joining them. The UniBike app, part of the "Pedestrian Priority Green Campus" project, helps reduce vehicle traffic on campus and enhances green spaces.
- **Sustainability Education and Awareness Programs:** The university organizes training and awareness programs that focus on sustainability for both students and staff. These initiatives aim to raise awareness of sustainability and promote eco-friendly practices. Seminars, workshops, and training sessions conducted within universities also feature in academic publications related to sustainability education.

- **Organic Agriculture and Sustainable Use of Natural Resources:** The university promotes organic agriculture on campus by minimizing the use of chemical fertilizers and pesticides, while ensuring the sustainable management of natural resources. These organic farming projects not only support environmental sustainability but also provide students with valuable knowledge and experience on this topic.

Ege University's projects in areas such as energy efficiency, waste management, eco-friendly design, bike lanes, and organic agriculture reflect its commitment to environmental sustainability. In 2023, the university was ranked 96th out of 1183 global universities and 4th among state universities in Türkiye in the GreenMetric World Green Universities ranking. Focused on the Sustainable Development Goals for 2030, Ege University strives to protect the environment and promote social benefits under the motto "Peaceful University, High Quality Education, Bright Future."

3.2.5. Özyeğin University distinguishes itself through its contributions aligned with the United Nations Sustainable Development Goals (SDGs). According to the Times Higher Education (THE) Impact Ranking 2022, Özyeğin University was recognized as the top foundation university in Türkiye overall. It ranked 8th among 58 Turkish universities and was placed within the 301-400 range among the 1406 universities evaluated globally. Özyeğin University ranked among the top 200 universities worldwide in four specific SDGs: Affordable and Clean Energy (SDGs 7), Decent Work and Economic Growth (SDGs 8), Sustainable Cities and Communities (SDGs 11), and Peace and Justice (SDGs 16).

- **Affordable and Clean Energy (SDGs 7):** Özyeğin University has undertaken various projects focused on energy efficiency and the use of renewable energy resources. Energy use was optimized through the use of solar panels and energy-efficiency enhancement systems throughout the campus. These achievements are detailed in reports on the university's energy management and sustainable energy projects (Özyeğin University, 2024a).
- **Decent Work and Economic Growth (SDGs 8):** The university is making significant progress in creating decent job opportunities for its students and community while fostering economic growth. Through collaboration and innovative programs, students are better prepared for the business world. Notably, the OzU-X Building was recognized as the top facility in the Innovation and Collaboration Space category in the THE-Impact Ranking 2022.
- **Sustainable Cities and Communities (SDGs 11):** The university is also distinguished by its initiatives aimed at developing sustainable cities and communities. Sustainability practices and green building projects carried out on the Çekmeköy campus highlight their contributions in this area. Additionally, these practices have been examined in academic articles that focus on eco-friendly buildings and sustainable urban planning.
- **Peace and Justice (SDGs 16):** The University implements diverse educational programs and community projects focused on peace and justice. These initiatives seek to enhance the students' understanding of human rights, peace, and justice. Notably,

EÇEM's achievements in this domain are evidenced by the honorable mention it received in the 'Social Responsibility Initiative' category for its NextGEN Project (EÇEM NextGEN Project Report, 2022).

Özyeğin University, recognized as the first institution in Türkiye to earn the "Zero Waste Certificate," serves as a model for environmentally sustainable practices. The university earned this certification through its initiatives to use resources efficiently, manage waste at its source, and implement separate collection and recycling at its Çekmeköy campus and dormitories. These efforts have been thoroughly documented in reports detailing the university's waste management and sustainability policies (Özyeğin University, 2024b). Özyeğin University has achieved significant success, both nationally and internationally, through efforts aligned with the United Nations Sustainable Development Goals. The results of THE Impact Ranking 2022 and various sustainability projects highlight the university's progress towards becoming an eco-friendly institution that contributes to society. These accomplishments underscore Özyeğin University's leadership in sustainable development and social responsibility.

Middle East Technical University (METU) places a strong emphasis on preserving and expanding green spaces on campus by implementing significant measures in sustainability and environmental protection. Its various projects and strategies in this area concentrate on key aspects such as energy use, waste management, ecological conservation, and sustainable transportation (Middle East Technical University, 2018):

- **Energy Use:** METU implements projects to promote the utilization of solar and wind power to improve energy efficiency and develop renewable energy resources. The installation of solar panels and wind turbines ensures sustainable energy production across the campus. These initiatives meet a significant part of the campus's energy needs and reduce its carbon footprint.
- **Waste Management:** METU has made significant strides in waste management through its recycling and composting projects and has implemented a 'Zero Waste Management System.' This system addresses the entire waste management process, including waste prevention, reduction, separate collection at the source, temporary storage, separate collection, transportation, and processing. As a pioneering initiative in Türkiye, METU treats wastewater from METU KENT lodging houses and Teknokent at a membrane plant with a daily capacity of 200 m^3 located in the Teknokent area, using treated water for irrigation in Teknokent's open spaces.
- **Ecological Protection and Preservation of Natural Values:** Approved in 2015, the Reconstruction Plan for Protect and the Lake Eymir Management Plan were implemented during the Strategic Plan period to protect forested areas, natural and archaeological sites, and Lake Eymir. By ensuring continued access to Lake Eymir for Ankara residents, the university connects urban dwellers with nature and enhances their quality of life. In 2021, METU has preserved 85% of its land and planted 1000 tree saplings.

- **Sustainable Transport:** The campus transport system aims to be eco-friendly, energy-efficient, smart, barrier-free, accessible, and safe. It emphasizes public transportation to reduce private vehicle traffic and promote pedestrian and bicycle circulation. This approach encourages the use of eco-friendly transport methods within the campus.
- **Nanotechnology and Space Technologies:** METU drives innovation in science and technology through pioneering projects in fields such as nanotechnology, space technologies, and environmental engineering. These initiatives have led to significant advancements in both academic research and industrial applications.
- **Education and Awareness:** The University raises awareness and educates future sustainability leaders by offering sustainability education to students. Numerous innovation programs have been developed to improve students' innovative thinking skills. These programs provide opportunities for students to learn about sustainability and to actively engage in related initiatives.

Middle East Technical University (METU) integrates sustainability initiatives into all aspects of campus life, effectively minimizing environmental impacts and promoting a sustainable lifestyle. The projects undertaken in areas such as energy use, waste management, ecological conservation, sustainable transportation, and education highlight the university's leadership and commitment in this domain. These efforts align with METU's mission of developing sustainable solutions for the future as an environmentally conscious institution.

According to the 2020 GreenMetric ranking, METU secured the second position among 56 universities in Türkiye, and ranked 103rd among 911 universities globally. In the 2022 ranking, METU was placed in the 601-800 range, and in 2023, it improved to the 501-600 range. However, in the 2024 World Universities ranking by THE, METU achieved notable advancement, ranking within the 351-400 band.

Yeditepe University was ranked the top foundation university in Türkiye in the 2017 UI GreenMetric evaluation. The university's sustainable campus initiatives focus on key areas such as campus setting and infrastructure, energy and climate change, waste management, water resources management, transportation, and education. Yeditepe's practices within the scope of sustainable campus management demonstrate significant progress towards environmental sustainability. The university's performance in the UI GreenMetric ranking reflects its strong commitment to sustainability (GreenMetric, 2024a; Yeditepe University, 2024).

- **Energy and Climate Change**: The university invests in renewable energy sources to enhance energy efficiency and lower its carbon footprint. Solar panels installed on campus constitute 10% of the university's energy needs. This approach not only reduces energy costs but also minimizes the environmental impact.
- **Biodiversity and Green Space Management**: There are 183 plant species and 2332 trees on the Yeditepe University campus, which contribute greatly to the conservation of biodiversity.

Efficient management of greenspaces sustains the ecosystem on campus, thus offering a natural ground for student learning.

- **Waste Management and Water Resources:** The university has also implemented various projects focused on waste management and efficient water use. Recycling and waste minimization initiatives, along with water-saving measures and rainwater collection systems, contribute to the campus's environmental sustainability.
- **Education and Awareness**: To raise awareness about sustainability, the university organizes training programs and awareness campaigns for students. These initiatives were designed to educate students about sustainability and cultivate their environmental consciousness.

Yeditepe University's commitment to environmental sustainability is evident in every aspect of campus life, highlighting its dedication to sustainable environmental policy.

4. Conclusion and Suggestions

Universities leading the way in sustainability in Türkiye have implemented various projects and initiatives aligned with their sustainable campus goals. These institutions serve as models for other higher-education establishments by developing comprehensive sustainability policies, strategies, and projects. By adopting a holistic approach that considers environmental, economic, and social dimensions, sustainable universities provide an example for society to achieve their sustainability objectives. The pioneering approaches of Turkish universities in the field of sustainability have significantly contributed to sustainable development across the country. These examples demonstrate how universities in Türkiye have implemented sustainability practices in various domains. Each institution undertakes various projects and programs aimed at reducing environmental impacts, conserving natural resources, and improving societal welfare.

This study demonstrated that universities in Türkiye are at the forefront of sustainability efforts and employ various innovative strategies to meet their sustainability objectives. These institutions are engaged in projects and programs aimed at minimizing environmental impact, conserving natural resources, and enhancing societal welfare. These universities are implementing exemplary practices in various fields, such as sustainable campus projects, energy efficiency studies, waste management, renewable energy use, and eco-friendly transport solutions. Institutions such as Istanbul Technical University (ITU), Yıldız Technical University (YTU), Erciyes University (ERU), Ege University, Özyeğin University, Middle East Technical University (METU), Sabancı University, and Yeditepe University are notable for their dedication and innovative strategies towards sustainability. These universities have adopted a range of initiatives, including the implementation of energy-efficient technologies, recycling and waste reduction programs, water conservation efforts, and the use of renewable energy sources, to promote sustainability across all aspects of campus life.

The pioneering sustainability practices of Turkish universities serve as a model for other higher education institutions and contribute significantly to sustainable development nationwide. By developing and implementing sustainability policies, strategies, and projects, these universities enhance and spread awareness of sustainability, both on their campuses and within the broader community. Key factors include the use of workshops and laboratories, maintenance of buildings and ground, energy and material consumption, waste management, water and material procurement, electricity and hydrocarbon fuel use in machinery, heating and lighting, and transportation. Environmental degradation extends beyond lecture halls and research laboratories to include living and administrative spaces (Lozano & Valles, 2007). University campuses with extensive and varied land use and activities have significant potential impacts on the environment. Consequently, universities must adopt a comprehensive approach to environmental management, recognize their social responsibility to educate the public, and promote sustainability. In terms of sustainable education, nearly all universities offer equal value, with relevant courses, conferences, and meetings in this area. Across universities, social responsibility clubs have worked to acquire students with a sense of sustainable and ecological awareness. Additionally, universities have placed significant importance on conservation efforts for local plant and animal species supported by sufficient green spaces.

In conclusion, universities should prioritize sustainability activities and reporting, keeping pace with global and national development. The sustainability efforts of universities in Türkiye are crucial for creating a livable and sustainable future. Continuation and expansion of these efforts will enhance sustainability awareness and practices, both within the academic community and throughout society. This will enable the realization of innovative and economic ideas that integrate ecology, technology, and design. A sustainable university should be open to learning, change, and development; actively involve both management and academic staff in these processes; adhere to sustainability principles; support interdisciplinary research; and collaborate with all stakeholders. University leadership serves as an inspiration and guide for a sustainable future.

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The article complies with national and international research and publication ethics.

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Qualitative Comparison of Sustainable Campus Evaluation Criteria

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1. Introduction

According to the Brundtland Report, sustainability is defined as "taking into account the needs of future generations while meeting present human needs" (Brundtland Commission, 1987). Initially, sustainability was considered in social and economic terms and environmental sustainability was ignored (Brundtland Commission, 1987; Bina, 2013). However, as environmental sustainability was later recognized as an important concept (Goodland, 1995; World Resources Institute, 1995; OECD, 2001; Esty et al., 2005; Jordan and Lennschow, 2009; Dahl, 2012; Moldan et al., 2012), it became clear that sustainability should be considered in all its components.

In this context, the concept of sustainability consists of three dimensions: environmental, social and economic (Figure 1). According to the figure, in order to ensure sustainable development and progress, environmental, social (societal) and economic dimensions should be addressed holistically at the same time (Reddy and Thomson, 2015; Maas et al., 2016a, 2016b; Sierra et al., 2017).

Environmental sustainability is defined as the continuity of natural capital (Goodland, 1995; Sutton, 2004; Morelli, 2011). In other words, it is the conservation-utilization balance between inputs (natural resources) and outputs (the product obtained) (Mutdoğan, 2020).

Environmental sustainability is an approach that aims to keep the environment healthy and balanced through the protection and management of natural resources. This concept aims to ensure the continuity of ecosystems and biodiversity by minimizing the negative impacts of human activities on nature (Landrum & Ohsowski, 2017;

Wagner, 2008). Basically, it aims to strike a balance between resource use and environmental protection without exceeding nature's capacity to regenerate itself.

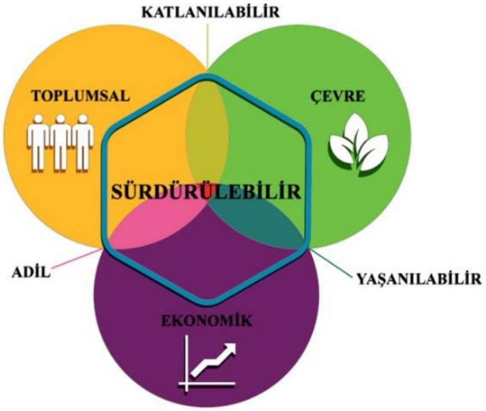

Figure 1. Concept and Dimensions of Sustainability

Social sustainability is the set of layers of a society consisting of traditions, customs and social relations from past to present (Palich & Edmonds, 2013; Goel & Sivam, 2015). It means the preservation and strengthening of social structures and relationships so that societies can live in health, prosperity and harmony in the long term (Gençoğlu & Aytaç, 2016). This concept aims to improve the quality of life of individuals and communities while promoting social equality, justice and human rights (Yeniçeri & Böcek, 2022).

Economic sustainability is the economic relationship between inputs and outputs (Goodland, 2002; Vivien, 2008). It is the efficient and responsible use of resources to ensure the long-term sustainability of economic activities (Rasouli and Kumarasuriyar, 2016). This concept aims to improve the welfare of present and future generations, taking into account the environmental and social impacts of economic growth

(Cheba et al., 2020). Economic sustainability encourages the adoption of innovative and sustainable business models while reducing the economy's dependence on natural resources and the environment (Macagno, 2013; Ushakov et al., 2023). This approach ensures that economic development is realized in line with the principles of environmental and social sustainability.

1.1. Sustainable University Campus Planning

The rapid depletion of natural resources on a global scale since the industrial revolution has increased the importance of sustainable planning. Today, the concept of sustainability, which should be considered as a necessity rather than a preference, is considered as a fundamental policy and principle for every sector. This concept, which initially aimed to observe the balance between development and the environment, later became a starting point for many fields such as technology, quality of life, economy, health, tourism and politics. In this context, sustainable spatial planning has come to the agenda as the use of outdoor spaces has started to change with increasing environmental and socio-economic problems. One of these is sustainable university campus planning (UNEP, 2013).

University campuses, which are small models of cities, are considered as important ecosystems that provide nature-human interaction with their housing, transportation, socio-cultural activities as well as education, academic studies, research and projects. In this respect, universities should actively promote sustainability for a sustainable world (Lukman & Glavic, 2007; Orr, 2010).

Sustainable university campus planning is an approach that aims to create an environmentally, economically and socially balanced campus (Liu and Wang, 2022; Krizek et al., 2012). This planning includes the efficient use of natural resources, preserving biodiversity and increasing green areas, reducing energy consumption and managing waste effectively (Alshuwaikhat and Abubakar, 2008; Krizek et al., 2012; White, 2014; Petratos and Damaskou, 2015; Orenstein et al., 2019; Liu and Wang, 2022; Perdana, 2024). In this way, universities reduce their ecological footprint while providing a healthier and more livable environment for students and staff.

A campus equipped with sustainable practices contributes to raising future leaders by instilling sustainability awareness in students (Yaşar & Ünlü, 2023). Therefore, such campuses function as a laboratory for the application of innovative and environmentally friendly technologies, allowing scientific research to be translated into practice.

The importance of sustainable university campuses has become even more evident in this era of increasing global environmental challenges. In order to tackle problems such as climate change, depletion of natural resources and environmental pollution, universities fulfill their responsibilities towards society and the environment. As part of this responsibility, sustainable campus planning encourages environmentally friendly and sustainable lifestyles (Günaydın & Yücekaya, 2020; Zhang, 2022). It also contributes to making universities more competitive and attractive in the international arena, making them among the preferred institutions for students and academics.

Activities carried out on campuses directly or indirectly have negative impacts on the campus ecosystem. Some of these impacts include waste, energy consumption, habitat degradation during construction, decrease in biodiversity, air pollution, carbon emissions, decrease in the quality of campus life, and increase in economic inputs as a result of environmentally unfriendly solutions. In this respect, the United Nations Environment Program (UNEP) sees universities as microcosms of environmental problems (Özdoğan & Civelekoğlu, 2018).

In order to eliminate or minimize these negative impacts, universities have adopted the concept of sustainability as their vision and are planned or revised under different names such as "sustainable university", "green university", "green campus" or "eco-campus" (Güllü et al. 2012). According to Oktay and Küçükyağcı (2015), UNEP has set some principles for a university campus to be sustainable. These are;

- Identify social, environmental, economic and managerial responsibilities,
- Planning and designing campus plans and creating management plans to achieve environmental goals such as zero carbon, water and waste management,
- Incorporate all components of sustainability into academic studies and course content,
- Develop sustainable policies and practices for the community, students and employees,
- To ensure student participation in activities related to sustainability,

- To develop cooperation between universities at national and international level.

Since 1990, universities have taken various initiatives related to sustainability, formed unions and societies, and signed conferences, summits and meeting declarations (Table 1) (Günerhan & Günerhan, 2016; Özdoğan & Civelekoğlu, 2018).

Table 1. Sustainability-Based Initiatives

Year	Conference, Summit, Meeting, Declaration
1970	Adoption of Earth Day
1972	United Nations Environment Conference, Sweden
1972	Stockholm Conference, Sweden
1976	Habitat Summit, Canada
1977	Tbilisi International Conference on Environmental Education, Georgia
1987	Brundtland (Our Common Future) Report, Norway
1990	Talloires Declaration, France
1991	Halifax Declaration, Canada
1992	Rio Conference, Brazil
1993	Kyoto Declaration, Japan
1993	Swansea Declaration, Wales
1993	COPERNICUS Charter, Poland
1997	Kyoto Protocol, Japan
1999	The definition of the Dow Jones sustainability index, the first global index, was established in the USA
2000	GHESP (Global Collaboration for Sustainability in Higher Education), Sweden
2001	Lüneburg Declaration, Germany
2001	Marrakesh Accords, Morocco
2004	Barcelona Declaration, Spain
2005	Graz Declaration, Austria
2009	Abuja Declaration, Nigeria
2009	Turin Declaration, Italy

The issues that the declarations and conditions signed by universities generally emphasize are listed as follows (Darendelioğlu, 2020).

- Environmental destruction
- Gaining a sustainable form of production and consumption habits
- Supporting research on sustainability issues

- Incorporating sustainability in all areas
- The importance of a participatory approach
- The importance of public, private sector and civil society organizations acting together

1.2. Sustainable Campus Assessment Systems

Measuring sustainability is a prerequisite for making qualified plans for sustainable campuses. For this, it is emphasized that expert opinions should be taken into consideration and each country should set its own standards by taking into account the existing indicators (Shriberg, 2002; Moldan et al., 2012).

Measuring sustainability is a complex process (Cook et al., 2017). Therefore, there is a need to use metrics and indicators that address all dimensions of sustainability. The most important reason for this is to monitor progress, predict the nature of future development trends and provide guidance for decision makers (Kates et al., 2001; Heink and Kowarik, 2010; Dobbie and Dail, 2013).

Indicators play an important role in achieving specific targets, evaluating policies implemented to measure progress, and identifying future risks through early warning information (DANTES, 2003; DEFRA, 2003; EPCEM, 2003). It also helps to raise public and political awareness (Gautam and Singh, 2010). Established in 2004, the International Ranking Expert Group and the studies conducted by Bossel (1999) and Comforth (1999) identified the characteristics that indicators should have (Shriberg, 2002; Lukman et al., 2010). These are;

- It should be in line with the aim and objective.

- The methodology for identifying indicators and weighting them for ranking should be transparent.
- The sequencing of indicators should be auditable and verifiable.
- It must be sensitive and adapt to possible changes.
- Good correlation with the ecosystem.
- It should be calculable and comparable.
- It should be in line with and support national legislation.
- The set of indicators should cover all dimensions of sustainability.
- It should encompass the values and conditions of the community or the region in which it is developed and be participatory.

In this context, since the Rio Summit, many sustainability assessment systems have been formulated internationally in order to reveal decision-making processes related to sustainability. Some of these and the most important ones are as follows;

- University League
- Green Metric
- International Sustainability Campus Network (ISCN)
- The S&P International Environmental & Socially Responsible Index
- The College Sustainability Report Card
- Global University Leaders Forum (GULF)
- The Sustainability Tracking, Assessment & Rating System (STARS)
- Environmental Management System (EMS)

- Graphical Assessment of Sustainability in Universities (GASU)
- Auditing Instrument for Sustainability in Higher Education (AISHE)
- Academic Ranking of World Universities (ARWU)
- Three Dimensional University Ranking (TUR)

Today, ISCN, Green Metric, STARS and GASU are among the assessment systems that evaluate Turkish universities.

1.2.1. University league

It was established by People & Planet in 2007. It is a system that evaluates and ranks the sustainability performance of universities. This evaluation system analyzes the practices and achievements of universities in the areas of environmental, social and economic sustainability. It also aims to motivate universities on sustainability and encourage good practices (University League, 2024a).

Since the university league comparatively evaluates the sustainability performance of universities, it encourages competition among institutions and creates a source of motivation for continuous improvement. This system enables universities to be more transparent on sustainability issues and showcase their achievements (Özdoğan & Civelekoğlu, 2018). It also contributes to creating a more sustainable and livable campus environment for students and staff. The main evaluation parameters of the University League are given in Table 2 (University League, 2024b).

Table 2. Main Parameters of the University League

No	Main Parameter	No	Main Parameter
1	Carbon Management	**6**	Energy Sources
2	Sustainable Food	**7**	Waste and Recycling
3	Ethical Investment	**8**	Carbon Reduction
4	Ethical Career	**9**	Water Reduction
5	Education		

However, each of the main parameters has sub-parameters. All sub-parameters are used in the same way in each main parameter. The percentages of sub-parameters are given in Table 3 (University League, 2024b).

Table 3. Sub-Parameters and Percentages

No	Sub Parameter	%	No	Sub Parameter	%
1	Environmental Policy	4	**8**	Participation	5
2	Audit and Environmental Management System	10	**9**	Education	10
3	Carbon Management	7	**10**	Energy Sources	8
4	Sustainable Food	4,5	**11**	Waste and Recycling	8
5	Ethical Investment	7	**12**	Carbon Reduction	15
6	Sustainable Staff	8	**13**	Water Reduction	8
7	Employee Rights				
Total					**100**

1.2.2. IU Green metric

Green Metric is an international system for assessing and ranking the sustainability performance of universities. Launched in 2010 by the University of Indonesia, this initiative is designed to compare and improve the environmental sensitivity and sustainability efforts of universities around the world. The green metric evaluates the performance of universities in sustainability through six main categories (Table 4) (UI Green Metric, 2024).

Table 4. Green Metric Parameters and Percentages

No	Main Parameter	%	No	Main Parameter	%
1	Infrastructure	15	**4**	Su	10
2	Energy and Climate Change	21	**5**	Transportation	18
3	Waste	18	**6**	Education and Research	18
TOTAL					**100**

The green metric assessment system provides a reference point for universities to improve and encourages the dissemination of good practices in sustainability. The annual rankings help universities compare their sustainability performance with other institutions and identify areas for improvement.

1.2.3. International sustainability campus network (ISCN)

The International Sustainability Campus Network (ISCN) is a global network established to develop and share sustainability practices of higher education institutions. Founded in 2007, it supports its members by providing guidance in areas such as sustainable campus management, sustainable education and research (Sesana et al., 2016; Saaida, 2023).

One of the main goals of ISCN is to make the sustainability efforts of higher education institutions more effective and visible. To this end, it helps its members to prepare and share sustainability reports on a regular basis (Poza et al., 2021). In addition, annual ISCN conferences enable members to come together to share their experiences, develop new projects and collaborate on sustainability (ISCN, 2024).

1.2.4. The S&P international environmental & socially responsible index

The S&P International Environmental and Social Responsibility Index is an index of international corporations with high performance on environmental and social responsibility criteria. This index provides a reference point for investors seeking to make sustainable investments. This index, which evaluates companies according to criteria such as environmental management practices, social responsibility policies and corporate governance standards, offers investors the opportunity to make more informed and responsible investments. These criteria include elements such as carbon emissions, energy efficiency, labor rights, social contributions and transparent governance practices (Table 5) (S&P, 2024).

Table 5. S&P Parameters and Percentages

No	Parameter	No	Parameter
1	Energy Use and Greenhouse Ga Emissions	**7**	Product Safety and Ethics Source
2	Water Use and Waste Management	**8**	Community Engagement Philanthropy
3	Pollution and Chemicals	**9**	Structure and Independence of the Bo of Directors
4	Biodiversity and Natural Resource Management	**10**	Management Transparency Accountability
5	Employee Rights and Working Conditions	**11**	Enterprise Risk Management and Ethi Behavior
6	Occupational Safety and Health	**12**	Employment Diversity and Inclusion

The S&P International Environmental & Socially Responsible Index encourages organizations to consider environmental and social impacts rather than focusing solely on financial returns (Tanjung, 2021). In this way, it not only generates profits, but also contributes to a more sustainable and just world.

1.2.5. The college sustainability report card

The University Sustainability Report Card is a tool that assesses and publicly reports on the sustainability performance of higher education institutions. Launched in 2007 by the Sustainable Endowments Institute, the report card aims to measure universities' environmental, economic and social sustainability efforts. It serves as a guide for institutions to assess their sustainability achievements and identify areas for improvement.

The University Sustainability Report Card grades universities based on various sustainability criteria. These criteria include climate change and energy, stakeholder engagement, transportation, investment priorities, food and recycling, green building, governance and endowment (Table 6). Each criterion is used to objectively assess the performance of institutions in this area and the results are expressed in letter grades from A to F (College Sustainability Report Card, 2024a).

Table 6. Main and Sub Parameters of the College Sustainability Report Card (College Sustainability Report Card, 2024b)

No	Parameter	Sub Parameter
1	**Climate Change and Energy**	Carbon Emission Inventory Emission Reduction Commitment Energy Efficiency Energy Conservation Renewable Energy Procurement Renewable Energy Investment
2	**Climate Change and Energy**	Proxy Voting Decisions Stakeholder Engagement School Community Contribution Sustainability Voting Record
3	**Transportation**	Alternative Vehicle Fleet Public Transportation Incentives for Car Sharing or Public Transportation

		Use Cycling Program Planning
4	**Investment Priorities**	Renewable Energy and Sustainable Investment Social Investment Optimizing Return on Investment
5	**Green Building**	Composting Landscape Waste Green Building Policy LEED Certificate New Construction Renovation and Retrofitting
6	**Food and Recycling**	Local Food Organic and Sustainable Food Production Reusable Dinnerware and Eco-Friendly Disposable Utensils Food Composting Recycling Program for Dining Halls Recycling Program for Office Waste
7	**Governance**	Sustainability Policies Sustainability Staff Green Procurement Policies Advisory Board Student Engagement Center Web Page
8	**Donation**	Investment Holdings Proxy Voting Registration Accessibility

1.2.6. Global university leaders forum (GULF)

GULF is a platform of the World Economic Forum that brings together leaders from the world's leading universities. It was established to promote collaboration on global education and research issues, develop innovative solutions and shape the future of higher education. Through this forum, rectors and presidents of member universities address common challenges and share best practices.

GULF members focus on key issues affecting education and research policies on a global scale. These include digital transformation, sustainability, social responsibility and innovation (GULF, 2024). The

Forum draws on the experience and expertise of its members to develop strategic directions and policies in these areas (Wiseman et al., 2016; Al-ahdal et al., 2021; Raettig and Muth, 2021). In addition, GULF members share their visions for the future of higher education, aiming to make education and research ecosystems more flexible, inclusive and innovative.

1.2.7. The sustainability tracking and assessment rating system (STARS)

It is a tool developed to help higher education institutions assess and report on their sustainability performance. STARS is managed by the Association for the Advancement of Sustainability in Higher Education (AASHE) and used by universities and colleges worldwide.

It has 3 main categories: environmental, social and economic performance. These 3 main categories consist of 17 sub-categories and 67 parameters (Table 7) (STARS, 2024).

Table 7. STARS Assessment Parameters

No	Parameter	Sub Parameter	Score
1	**Academic**	Curriculum	45
		Research	23
2	**Participation**	Campus Engagement	25
		Public Participation	25
3	**Operations**	Buildings and Ground	20
		Energy and Climate	26
		Food & Beverage	10
		Procurement and Waste	20
		Transportation	10
4	**Planning and Administration**	Coordination and Planning	11
		Investment	10
		Social Equality	14
		Prosperity and Work	11
5	**Innovation and Leadership**	Innovation and Leadership	10

STARS offers different rating levels to organizations: Bronze, Silver, Gold, Platinum. These levels aim to objectively reflect the sustainability performance and progress of organizations. The STARS scoring system is given in Table 8.

Table 8. STARS Scoring System

No	Degree	Score
1	Platinum	85 and above
2	Gold	65-84,99
3	Silver	45-64,99
4	Bronze	25-44,99
5	Rapporteur	24,99

1.2.8. Environmental management system (EMS)

EMS is a systematic approach used to manage and improve the environmental performance of organizations. It involves establishing policies, procedures and practices to identify, manage and mitigate environmental impacts (Green Element, 2024). This system enables organizations to control their environmental impacts, comply with legal requirements and achieve environmental goals (Arimura et al., 2007; Iraldo et al., 2009; Disterheft et al., 2012; Fuzi et al., 2019). It is usually implemented within the framework of the ISO 14001 standard, which provides a guideline for the establishment and continuous improvement of environmental management systems.

By identifying environmental risks and opportunities through EMS, organizations have the opportunity to continuously improve their environmental performance and achieve their sustainability goals (Nancy & Francis, 2018; Voinea et al., 2020).

1.2.9. Graphical assessment of sustainability in universities (GASU)

GASU is a tool that graphically assesses the sustainability performance of universities. It was developed to help higher education institutions monitor their sustainability strategies, goals and performance. The tool presents sustainability data visually, making complex information moreunderstandable and accessible. Using graphs, tables and other visual tools, institutions can easily monitor their progress in sustainability.

It analyzes the performance of universities in a broad perspective with data from different sustainability areas such as education, research, operations, governance and community engagement. This comprehensive assessment helps institutions identify their strengths and weaknesses in achieving their sustainability goals. It also allows universities to compare and benchmark their sustainability performance against other institutions. It automatically generates nine graphs by rating each indicator on a scale from 0 to 4 (GASU, 2024). Three approaches are used to assess and report on sustainability to graphically present sustainability efforts at universities and facilitate their analysis, longitudinal comparisons and benchmarking with other universities. These are accounts, narrative assessments and indicators. An example graphical assessment is given in Figure 2.

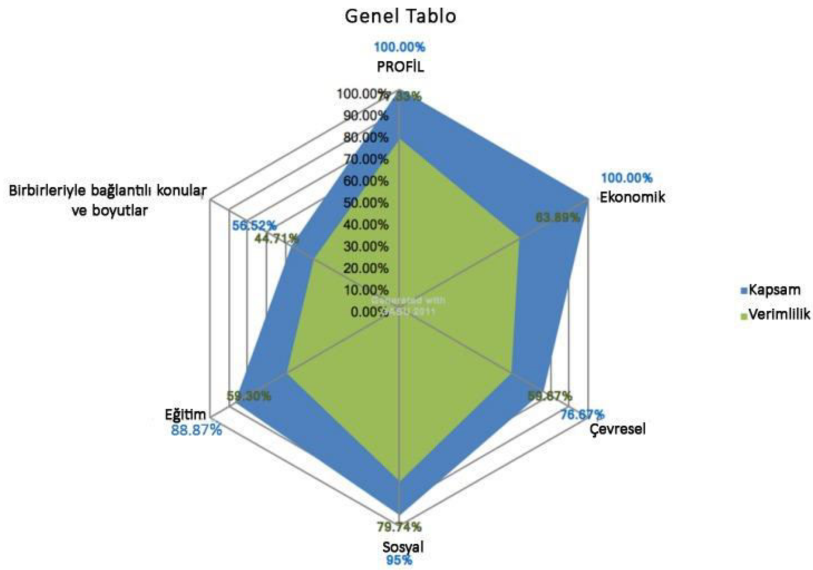

Figure 2. Example GASU Graph (Lozano, 2006)

1.2.10. Auditing ınstrument for sustainability in higher education (AISHE)

AISHE is a tool developed by DHO, the Dutch Foundation for Sustainable Higher Education in the Netherlands between 2000-2001 to assess the sustainability performance of higher education institutions. In the evaluation process, various areas such as education, research, management and contribution to society are taken into consideration. It uses five main criteria to measure the sustainability performance of institutions. These are policy and strategy, education and training, research, operations and external relations. Each criterion is examined in detail to determine how well it aligns with sustainability principles. These criteria help to identify strengths and weaknesses in the field of sustainability and form the basis for improvement efforts in these areas (Table 9) (AISHE, 2024).

One of the most important features of AISHE is that it offers a participatory and transparent process. It also aims to raise sustainability awareness and encourage institutional change. It can be used free of charge by any university. However, certified AISHE assessors are available to assist universities in their implementation.

Table 9. AISHE Parameters (URL-12)

No	Main Parameter	Sub Parameter
1	Vision and Policy	Vision Politics Contact Environmental Management
2	Specialization	Network Expert Group Staff Development Plan Research and External Services
3	Training Objectives and Methods	Graduate Profile Education Method Role of the Trainer
No	**Main Parameter**	**Sub Parameter**
		Student Examination
4	Education Content	Curriculum Integrated Problem Management Internship, Graduation Specialization
5	Outcome Evaluation	Staff Student Area of Specialization Community

1.2.11. Academic ranking of world universities (ARWU)

ARWU is a benchmark that evaluates and ranks the academic performance of universities worldwide. It was first developed by Shanghai Jiao Tong University in China in 2003. For this reason, it is often referred to as the "Shanghai Ranking" (Carnegie, 2022).

The main criteria used in the ARWU rankings include research output, highly qualified academic staff and alumni, individuals who have won the Nobel Prize and other prestigious awards, highly cited researchers, articles published in leading journals such as Nature and Science, and articles indexed by the Science Citation Index-Expanded (SCIE) and Social Sciences Citation Index (SSCI). These criteria are used to measure universities' academic activity, research capacity and overall academic reputation (Table 1.10). This objective and data-driven approach of ARWU enhances the wide acceptance and reliability of the rankings (ARWU, 2024a).

Table 10. ARWU Main and Subparameters (ARWU, 2024b)

No	Main Parameter	Sub Parameter	Score (%)
1	Quality of Education	Alumni of the institution who have won Nobel Prizes and Medals in their field	10
2	Faculty Quality	Nobel Prizes and Medal winners in their field	20
		Most Cited Researchers	20
3	Research Output	Articles published in Nature and Science journals	20
		Articles indexed in Science Citation Index-Expanded and Social Science Citation Inde	20
4	Per Capita Performance	Academic performance of the institution per capita	20

The ARWU ranking is a prestige indicator for universities around the world and guides students and academics in their university choices. It is also an important tool for governments and educational institutions in developing higher education policies and allocating resources. The position of universities in the ARWU ranking also has a decisive impact on international collaborations, capacity to attract students and faculty, and overall academic reputation (Olcay & Bulu, 2017).

1.2.12. Three dimensional university ranking (TUR)

TUR is an innovative ranking system that evaluates the performance of universities in three main dimensions. These dimensions are the quality of education and training, research capacity and the ability to serve society. Unlike traditional ranking systems, it focuses not only on the academic achievements of universities but also on their social impact. This provides a holistic assessment of universities and provides more comprehensive information for students, academics and other stakeholders.

2. Findings and Discussion

Although these assessment systems have been applied to universities around the world, measuring sustainability remains a complex and challenging process for universities. This is because these assessment systems are not able to achieve the desired goal or are inadequate in university campuses that have different characteristics both nationally and regionally. This is mainly because the relevant assessment system has not been developed according to the legal, socio-cultural and economic infrastructure of the region or country. In addition, each assessment system developed has positive and/or negative aspects compared to the others (Table 11).

Table 11. Positive and Negative Aspects of Evaluation Systems According to Turkish Universities

University League
Positive Aspects • Transparent as indicators are calculated from publicly available information.

Negative Aspects

- If the relevant indicator cannot be obtained by the university, it is evaluated with zero points. Therefore, this indicator is considered null and void.

Negative Aspects

- The indicators under the economic sustainability category measure the financial and investment activities related to scientific and administrative activities carried out by universities through banks. However, these indicators and their assessments are not harmonised for the majority of Turkish universities. In addition, managerial sustainability is not included.
- The system assesses universities around England and Scotland.

Green Metric

Positive Aspects

- Each category and indicator is numerically scored and statistically evaluated. It can update itself in line with possible developments

Negative Aspects

- Since all indicators are ecologically based, they do not take into account other components of sustainability. Therefore, social and economic sustainability is measured on the basis of ecological interests. However, since managerial sustainability is not included, there are no indicators related to it.
- Since the assessment is carried out by the authorised/authorised person(s) of the institution, it is important that they are familiar with the subject. Otherwise, a lot of effort and time is spent for the assessments.

The College Sustainability Report Card

Positive Aspects

- It creates effective sustainability policies with the results obtained. It does not contain only ecological-based indicators.

Negative Aspects

- Instead of numerical expressions, it grades universities by giving letters between A and F. This situation does not allow universities to be compared numerically for themselves.
- As in the university league, the indicators under the economic sustainability category measure the financial and investment activities of universities related to scientific and administrative activities carried out through banks. However, these indicators and assessments are not harmonised for the majority of Turkish universities.

The Sustainability Tracking, Assessment &Rating System (STARS)

Positive Aspects

- It can group universities with a rating system such as bronze, silver, gold and platinum.

Negative Aspects

- The rating system such as bronze, silver, gold and platinum alone makes it difficult to compare universities numerically.
- While determining the weight coefficients of the evaluation criteria, only EU regulation standards are taken into account. Therefore, this evaluation

system may not be valid for non-EU countries.
- In addition, managerial sustainability is not included.

Graphical Assessment od Sustainability in Universities (GASU)

Positive Aspects
- The system is based on the assessment of environmental, social and economic aspects.
- It allows universities to compare their achievements in different years. For this purpose, it creates performance visuals by utilising 'Amoeba' graphics.

Negative Aspects
- A large number of indicators require a large amount of data, making implementation and comparison between universities difficult.
- Since it evaluates in line with the Global Report Initiative (GRI), it is difficult to apply in universities that do not have a GRI report.
- In addition, managerial sustainability is not included.

Auditing Instrument for Sustainability in Higher Education (AISHE)

Positive Aspects
- It compares universities by giving 1-4 stars to universities or their departments.
- It is a strategy and policy-making tool rather than a system evaluation tool.

Auditing Instrument for Sustainability in Higher Education (AISHE)

Negative Aspects
- The system remains conceptually abstract. This makes it difficult to understand the parameters. Since the evaluation is carried out by a group of 15 experts in 1 day, the results become questionable in terms of quality. The evaluation system does not include managerial sustainability.

Three Dimensional University Ranking (TUR)

Positive Aspects
- It uses 'Triangle Graphic' to facilitate understanding

Negative Aspects
- The outputs may be insufficient as it simplifies the indicators related to sustainability too much. In addition, managerial sustainability is not included.

Sustainability assessment systems offer different approaches to measure the environmental and sustainability performance of universities. The university league provides transparency with publicly available information, but creates disadvantages by assessing the data that universities cannot obtain with zero points. Green Measurement focuses on ecological-based indicators and scores categories and indicators numerically, but does not sufficiently consider social and economic sustainability. While the University Sustainability Report Card provides results for creating effective sustainability policies, it creates comparative difficulties by using letter grades instead of numerical data. STARS groups universities into bronze, silver, gold and platinum grades, but may not be sufficient for quantitative comparisons and is only based on EU standards. GASU uses Amoeba charts to assess environmental, social and economic dimensions. However, there are difficulties in implementation due to the large data requirements. AISHE compares universities with a star system and functions as a strategising tool. However, it may cause difficulties in understanding abstract concepts. TUR simplifies sustainability indicators and explains them with triangular graphs, but this simplicity is insufficient in some cases.

These evaluation systems fail to achieve the desired purpose or are inadequate in university campuses which have different characteristics both nationally and regionally. This is mainly because the relevant evaluation system is not developed according to the legal, socio-cultural and economic infrastructure of that region or country. In this context, there is a need for the effective integration of sustainability into the activities and management of university campuses in Turkey and the existence of a new evaluation system suitable for Turkey's legal, socio-cultural and economic conditions.

Since most of the international indexes do not include clear, measurable and verifiable criteria and indicators or set very high standards for universities, it is difficult for universities in Turkey to meet these expectations. Apart from the positive and negative aspects expressed in

Table 11, some of the evaluation systems take into account the standards either in EU regulations or in their own legislation when determining the weighting coefficients of criteria and indicators. For this reason, non-EU countries cannot be assessed under the same conditions as other universities due to the non-binding nature of the relevant regulations to which they are not a party. However, only a few international sustainability assessment systems adopt a holistic approach that covers the three dimensions of sustainability. The others deal with individual aspects (Singh et al., 2012). At the same time, there is no system that assesses managerial sustainability in a separate category. In addition, there are 204 universities in Turkey, 129 of which are public and 75 foundation universities. In terms of economic sustainability, existing evaluation systems do not make any distinction between state and foundation universities, and evaluate them collectively. In Turkey, foundation universities are not subject to the Public Procurement Law and only the rules and procurement methods to be followed when making any procurement are determined by the Foundation Higher Education Institutions Tender Regulation. Therefore, state and foundation universities do not have the same conditions in terms of economic sustainability.

When the indicators used by the existing assessment systems for ranking are evaluated as a whole, it is seen that they emphasise the economic, environmental and social dimensions of sustainability. However, when the current literature on sustainability is analysed, it is found that new dimensions are tried to be added to sustainability. For example, Greenland et al. (2022) examined the dimensions of sustainability under five groups as economic, environmental, social, institutional and political (governance). Taghvaee et al. (2023), in their study in which they proposed an integrated sustainability model instead of weak and strong sustainability, examined sustainability in terms of economic, environmental, social and peace and cooperation dimensions. Wang et al. (2022), in their research on consumer behaviour, divided the dimensions of sustainability into five dimensions: economic, environmental, social, cultural and governance. Therefore, it is possible to state that among the dimensions that are tried to be added to sustainability, variables with a predominant governance aspect are important. However, it has been observed that the aforementioned evaluation systems either do not include managerial sustainability at all or evaluate it under one of the three dimensions of sustainability. Therefore, within the scope of the GASC, taking into account the current literature, the dimensions of sustainability have been designed in a four-dimensional structure as economic, environmental, social and managerial.

In conclusion, it should be emphasised that the KASK created within the scope of the project is functional and, in case of data sharing, enables the evaluation and rating of university campuses in Turkey not only in terms of economic, social and environmental aspects, but also in terms of managerial sustainability. Unlike existing assessment systems, with the KASK assessment system, university campuses can be assessed not only in terms of environmental, social, economic or managerial aspects, but also holistically. This will provide significant advantages for the university administration in identifying problems and formulating strategies for the future. The system includes environmental, economic and social sustainability as well as managerial sustainability. In addition, it will serve as a catalyst for reports on sustainability performances that each campus has difficulty in adapting to its own needs. Since the parameters and categories will be presented both individually and collectively in numerical expressions, relativity will be eliminated. Since the definition, content and scoring system of the parameters are clear, the evaluator will not need specific knowledge.

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The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

1st Author % 50 2nd Author %40, 3rd Author %10 contributed. There is no conflict of interest.

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Evaluation of the Relationship between University Campuses and the City in the Context of Sustainability

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1. Introduction

The university is a phenomenon that includes many different concepts, such as education, teaching, research and scientific production, as well as society, culture, social life, status and economy. Today, getting a university education is directly associated with the level of development in the most basic perception in societies. The relationship that universities, which have such a strong perceptual aspect in societies, establish with the city, based on their physical location, is also gaining importance. The relationship between the city and the university is established through the relationships of university students, faculty members and other employees with the city. Dialogues are formed between the spaces of university campuses and the users and city residents. In cases where these dialogues can be established healthily, universities strengthen their continuity and contributions to society, the knowledge based on science produced spreads to the city, and mutual communication can be established. The interaction between the public and university spaces revitalizes social life and marks the initial public/university engagement stage. Numerous studies emphasize the significance of the relationship between universities, the city, and citizens from various perspectives. Ali and Kim (2020), Kos et al. (2020), Gumprecht (2007) and Hosseininasab (2021) examined the multifaceted role of the campus, questioning the possibilities of university campuses to provide public spaces for cities, how university campuses can contribute to improving urban public services, and how university spaces can interact with their urban contexts to increase the sense of belonging among users through various field studies. Yaylalı Yıldız (2020), who questions the city-campus relationship, the situation of campuses as living spaces, and the impact of spaces on social life, emphasizes that the university can produce and share knowledge for the urban people while at the same time turning into a “place” where a student-centred social life can be made. Mohammed et al. (2022) systematically reviewed the literature on university-city and city-campus relationships to evaluate recent research trends to reveal the aspects that connect universities with their cities and address various perspectives and lessons for a sustainable campus-city relationship. Yamu et al. (2020) examine campuses in terms of their location relative to the city, master plan typologies, and the arrangement of buildings, focusing on the impact of the spaces offered by universities on creativity.

For this reason, universities' locations contribute to society, spread knowledge and science, and have sustainable spatial qualities. This research investigates the impact of the relationships universities build with their surrounding cities on the sustainability of university campuses. The study has raised concerns about the sustainability of universities outside urban areas and the lack of physical connection between these campuses and the city centers.

1.1. The Concept and Definition of University

The definition of university has been expanded and enriched in different periods. The origin of word university, also called an institution of higher education, is derived from the Anglo-French word “université” meaning “universe”, meaning “universality; academic community”. In Medieval Latin, it is based on the word “universitatem” (simple form universitas), meaning “whole, collective”, and in Late Latin, it is derived from the word “universus”, meaning “unity, society”, and “universe”, meaning “whole, complete” (URL1, 2024). According to the TDK, the word “university” (darülfünun) is defined as “an educational organizations consisting of faculties, institutes, colleges, etc., organizations and units that have scientific autonomy and public legal personality and conduct high-level education, training, scientific research and publication” (URL2, 2024).

According to Gökbel (2021), the four essential functions of a university are to produce, teach, present, and spread knowledge. The university fulfils these functions through research and development, education and training, consulting with society, and publishing activities (Figure 1). The university should be able to sustain all these functions together; performing some and not sustaining others does not coincide with the concept of a university as an institution.

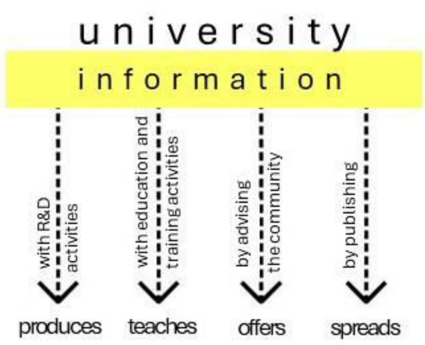

Figure 1: Reasons for the university's existence (Gökbel, 2021).

Based on the different definitions, universities are independent institutions organized within the social structure that address and examine societal problems, research, and present and teach the findings they obtain to humanity from an impartial and universal perspective. Since they have been in mutual interaction with and developing social life from the first universities to the present, they are also crucial for societies. Today's universities are no longer just educational centers, but also centers that ensure the economic, social, cultural and technological development of the city they are in or depending on. Universities are structures that simultaneously teach and produce for society (Demir, 2018).

There are many views on the first emergence of the university concept. In some parts of the world, religious sciences were given priority in addition to the development of law and professional sciences (Gençer Külahlı, 2017). Karasu (2022) emphasized that the foundations of higher education date back to Plato's Academy, Aristotle's Lyceum, and the Library of Alexandria.

1.2. Historical Development of Universities in the World

The historical development of today's universities has gone through similar paths, with temporal differences depending on the country. In Western and Eastern civilizations, educational institutions shaped in homes and around religious institutions come to the forefront under three main headings. According to Gürüz (2003), in the West, the church-centred university that started in the late 11th century, the nation-state university (von Humboldt University) in the 19th and 20th centuries, and the multi-university university model covering the last quarter of the 20th century (Karasu, 2022).

In Western Europe, between the late 11th and early 12th centuries, especially in the urbanized regions of Italy, France and England, the institutional infrastructure of universities began to form under the influence of different religious, social and economic factors. In this context, Bologna, Paris, Montpellier and Oxford Universities are considered the four oldest universities in the world, the first structures of which were established during this period (Gürüz, 2003).

Humanism emerged with the Renaissance and the Age of Enlightenment, and its reflections on society took place outside universities. It was only over time that universities ceased to be introverted scholastic institutions of thought and became institutions that adopted scientific thought as a principle. The first universities based on scientific thought were not under the control of the church but were founded by city governments (Tekeli, 2003).

The first example of modern universities based on scientific knowledge and thought dates back to the establishment of Humboldt University in Germany at the beginning of the 19th century. During his studies, Humboldt laid down the basic principles of a system that would later be named after him and considered the source of the modern university.

A university is an institution where education and training in all fields of science are carried out together with research activities and in an integrated manner; unlike vocational and technical colleges, its primary function is to conduct education and research without being oriented towards any profession, where faculty members and students can freely conduct research and education without being subject to any religious or political influence, and whose owner is the nation, not the state (Kavili Arap, 2010).

According to Muller (1985), Humboldt's works have also indirectly influenced the modern university structure in the USA. Until the 20th century, new departments, institutes and large research libraries were established in American universities within the scope of the education and training function. The law enacted in 1962 established American state universities, and higher education became widespread. (Turcan 1996). Thus, the boundaries of universities have reached beyond science in scope. Kerr (1991) calls the new university concept as 'Multiversity'. With multiversity, new interdisciplinary fields have been produced along with scientific disciplines.

In the 20th century, university campuses needed help finding a place within the city due to population growth (Kortan, 1981). As a result, with new campus plans, American model university cities located outside the city, unlike college-type universities such as Oxford and Cambridge, have begun to spread worldwide (Karasu, 2022).

1.3. Development of Universities in Türkiye

It is widely acknowledged that the first structures for higher education in Türkiye were the madrasahs in Anatolia. However, they differed significantly from Western models in scope during the Ottoman period before the Republic. The establishment of madrasahs began in the 11th century, while Western-style university models emerged in the 1700s and 1800s. (Güneş and Gökçe, 2022). The construction of the first madrasahs in Anatolia can be traced back to the mid-12th century. These madrasahs and the social complexes known as *külliye* were educational hubs where various disciplines were taught.

Educational institutions that provided Western-style education and were different from madrasahs began to be opened from the 18th century onwards. In this context, Mühendishane-i Bahri-i Hümayun was first established in 1773. Many universities based in the late 19th and early 20th centuries formed the basis of some universities such as Boğaziçi, İTÜ and Mimar Sinan University today (Gençer Külahlı, 2018). According to Gökbel (2021), the first emergence of the history of universities in Türkiye dates back to Darülfünun, not to the first madrasahs established in Anatolia. After the declaration of the Republic (1923), Darülfünun was closed with the University Reform carried out under the leadership of Atatürk in 1933, and Istanbul University was established. It is stated that the first traces of today's universities in the history of Turkish higher education date back to the late 19th and early 20th centuries, with the movement taking place after World War II. Universities were considered a tool for modernization during this period, and the aim was to establish universities in every region of the country. Over time, universities with different political and educational policies increased nationwide. According to the Council of Higher Education data, as of 2023, there are 129 State Universities, 75 Foundation Universities and 4 Foundation Vocational Schools in Türkiye (URL3, 2024).

2. Material and Method

2.1. Relationship between University Campuses and Cities

Within the scope of this study, it is argued that the site selection of university campuses affects the sustainability of universities. It is thought that the situations where university campuses are in the city center, on the periphery of the city, outside the city or in the countryside affect the sustainability of the campuses. Contrary to the concepts of being in the countryside and ecology that the idea of sustainability first evokes, campuses in the city center are easily accessible. They can be more sustainable in terms of social and economic aspects. Within the scope of this study, based on this argument, a literature review was conducted on campus, campus development, and university campus-city relationships in urban and outside the urban university campuses. Afterwards, a review was performed on the concepts of sustainability and sustainable campus, and the evaluation scales in the literature were explained. Among these scales, the significant relationship between the location of university campuses in the city and their sustainability levels was questioned through the UI Green Metric (Guidelines of UI Greenmetric World University Ranking) data, which has a place in the literature and evaluates some universities in our country, was chosen and analyzed in detail. Findings are presented and discussed.

2.2. The Concept of Campus

The word "campus" of French origin means "settlement" (URL4, 2024). The word campus generally means "a certain land on which the university and other related institution structures are located". It is derived from the word "camp", which means a large area in Classical Latin, and campus means garrison, a military camp based on a field. In Italian, it emerged as a derivative of the word "campo" (site, area) (Ilgaz, 2014). The definition of the campus concept of the university dates back to the 18th-19th century. The word campus was first used in the USA at the College of New Jersey (now Princeton University) to describe the open areas between university buildings (Gumprecht, 2007).

The first campuses that emerged were located in the city as individual college buildings. Still, over time, the possibility of expansion in cities decreased with the increase in population density in cities. With the rise in transportation opportunities due to the development of technology, campuses began to move outside the city in Europe and Türkiye (Gökbel, 2021). Outside the city centers where the urban texture is dense, universities are settled in large, open areas that will provide them with the opportunity for growth, development and expansion as "campuses". This type of campus settlement was inspired by the "castrum" (campus) of the Roman period (Begeç, 2002).

A campus can also be defined as an academic village established on a green area inside or outside the city or as the reflection of educational goals in physical planning (Gumprecht, 2007). As universities turned to more significant regions outside the city over time and needed various types of spaces for the needs of students, instructors, and employees in these areas, the quality of campuses developed and became more comprehensive. In this context, the essential functions of campuses can be summarized as Education-Training, Accommodation, Rest-Recreation, and Transportation. On-campus circulation networks connect these functions and form a holistic structure (Öz Döşer, 2023). According to Linde (1972), six different university layout models are based on the location of spaces and buildings. These are widespread, central, molecular, network type, cross-type and linear layout (Figure 2).

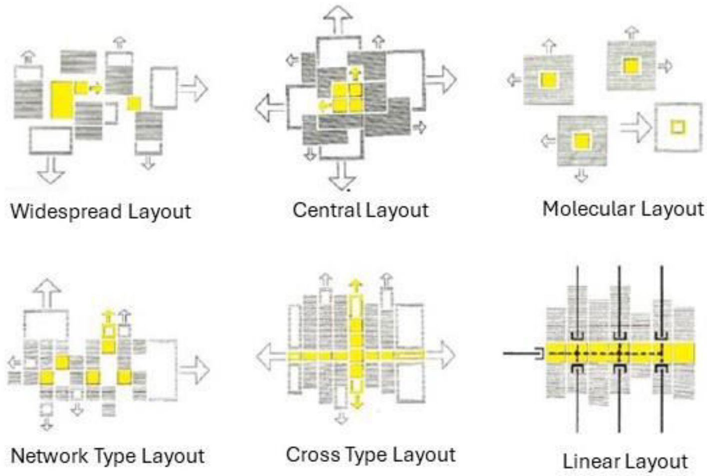

Figure 2. Campus Layout Models (Gökbel, 2021)

2.3. Development of Campuses

While the first university-like education in Europe was carried out in houses and churches, new structures added over time were scattered in various places within the city, taking the name of the city they were in. Although located in the town, universities avoided being affiliated with the city in the 1200s-1800s. Except for large cities, the majority of students coming from places outside the city needed help finding jobs in the cities after completing their education. However, this situation changed after the 1800s, and the university-city relationship strengthened (Brockliss, 2000). The first university campuses in medieval Europe were similar to monasteries, which were religious institutions. Campus structures were shaped as buildings with no university-city relationship, detached from the city, turned inward and faced the inner courtyard, and contained chapels, dining and meeting halls, libraries and accommodation units. Planning on university campuses dates back to the 15th century (Gökbel, 2021). As of the second half of the 19th century, with the influence of the Industrial Revolution, universities were also considered an element of urban planning (Sönmezler, 2003). Although the first structures in the USA started five hundred and fifty years after Europe in terms of university history, they progressed rapidly, and institutions considered the most comprehensive and well-equipped universities in the world were established. Although it takes its source from European university structures, the USA reinterpreted the concepts of university and campus and created a modernist campus planning system unique to itself. Unlike Europe, campuses in America appear to be isolated islands open to the outside world in nature. At the same time, they form an ideal, self-sufficient academic village model that can meet all the city's opportunities. Harvard University, founded in 1636, pioneered the establishment of similar college structures in the USA. The definition of the campus was made by emphasising the idea of creating large green areas around Princeton University and its university buildings. Another example is the University of Virginia, where Thomas Jefferson, who typologically took Roman architecture as an example, proposed building an academic village that would exemplify the ideal American society. The pioneer of campus models is still valid today. The American model offers various planning and campus-city relations (Gökbel, 2021).

2.4. Site Selection of University Campuses in the City

While the first universities were single-function, isolated institutions aiming to train qualified people, they evolved into an outward-looking and community-related structure. University campuses' educational, social, cultural, and economic effects on the academic and local community are significant in this context. While campuses benefit the city they are affiliated with, they also pave the way for developing a new urbanism approach depending on the town. In addition to their continuous relationship with the town, campuses can be considered small city models. The holistic structure of built structures serving different functions, open/semi-open areas, green areas and circulation networks is similar to the primary city structure. In addition, the user diversity on campuses can be considered as a reduced model of demographic diversity with different identities in cities (Öz Döşer, 2023)

When its historical development is examined, it is observed that the first universities were structured within the city. Especially after the Second World War, the increase in the pace of urbanization brought by technological developments and urban growth, the rise in the number of students together with the rapid population growth, and the increase in university faculties and various requirements made it difficult for universities to find a place for themselves within the city. Universities, which took shape in specific spaces within the city, began to be structured in areas outside the city to meet their spatial needs (Gökbel, 2021). In this context, within the scope of the university-city relationship, university campuses can be considered as “in-city" if they are located within the city and "out-of-city" if they are located outside the city. Although many out-of-city university campuses were initially established within the city and moved outside the city over time, this may not be true for all universities with a more extended history. While some campuses were established as non-urban campuses away from the city center during the period they were established, it is observed that they were located within the city over time with the city's growth. ITU Ayazağa and Ege University are such campuses. In this respect, universities have the potential to develop their surroundings (Özdemir, 2019).

2.5. University Campuses in Urban and Out-of-Urban

University campuses, whether urban or out-of-urban, are more than just educational institutions. They serve as vital social hubs, fostering relationships between the university and the city. A university's location plays a crucial role in facilitating interactions, as citizens benefit from the university's social, cultural, and research opportunities, and the university leverages the urban environment and its resources.

Urban university campuses exist as a single structure within the city according to its capacity or as a single structure at the beginning. They multiply their structures within a particular area or in the gaps within the city over time depending on increasing needs (Güner, 2023). The physical formation forms of urban campuses formed by the construction of new buildings within the city, re-functioning or transforming existing structures can be classified as universities developing in organic urban fabric, universities developing in urban blocks, and urban campus universities.

The structures within university campuses within the city are generally similar to other institutional structures. Different university buildings located at short distances where pedestrian access is possible contribute positively to the city. The fact that university facilities (gyms, library and auditorium) are also used by other non-university residents living in the city and that the university can also benefit from the city's opportunities establishes a strong bond between the university campus and the city (Kuyrukçu, 2019). On the other hand, although they are located within the city, introverted, isolated campus structures that cannot establish a relationship with the city can also be observed. On the other hand, some campuses scattered at various points within the urban fabric maintain their integrity and establish an intricate relationship with the city (Oktay, 2021). When evaluated from the university's perspective, one of the essential advantages of urban campuses due to their location is that students and other users can access many social, cultural, artistic, and sporting activities available in the city. Another vital advantage of urban campuses is that they are easily accessible and approachable (Gökbel, 2021). Especially after the Second World War, the increase in demand for education, the importance of interdisciplinary education, and the rise in the number of students with the establishment of new faculties and higher education institutions contributed to the establishment of new universities and the growth of urban university campuses (Tetik, 2013).

Due to factors such as the inability of urban campuses to have sufficient space for their needs in the city over time and the fact that using high technologies to build faculties and units affiliated with the university in a large area became a sign of prestige, universities began to turn to lands outside the city (Gökbel, 2021). According to Türeyen (1999), universities outside the city are called self-sufficient university cities that try to provide the necessary living conditions (housing, entertainment, shopping, sports, health and recreation) for their users to continue their primary functions of education, training, research and application.

Compared to urban universities, university campuses outside of the urban have advantages in terms of providing the spaces needed by scientific disciplines with technological infrastructure, being suitable for growth due to having space for the addition of new spaces, saving time for users with the structures located together and providing easy access to university buildings. However, when the urban campus-city relationship is considered, the isolation of non-urban university campuses from the environment causes them to be deprived of the cultural, social and economic opportunities the city will provide and the necessity to create them independently. In addition, the social opportunities and common areas offered by the city should also be provided on the campuses. In this case, just as is needed in a city, a strong spatial organization and a regular transportation network should be provided on the non-urban university campus. The location of the campuses is a critical factor; issues such as access to the city, infrastructure facilities, size and location in terms of institutions and resources that need to be cooperated in education and research gain importance (Keskin, 2024).

Although campuses are generally categorized as in-urban or out-of-urban according to the location of universities, it is a matter of debate that this classification has sharp boundaries. Although cities have specific boundaries, they are not closed spaces; these boundaries are flexible, variable and in a state of transformation. The city should be characterized as a fluid structure that spreads over various areas, differentiates morphologically, and with all its layers (Keskin, 2024). In this context, reducing all university campuses to only urban or non-urban ones is unnecessary. Campuses can be located in the city center and rural areas far from the city, on the periphery of the city or directly in the city center. However, a campus within the city can act as an external campus with an isolated structure that does not establish a relationship with the city. Depending on the city-campus reciprocal relationship, an internal university campus can become an external campus with the deterioration or disappearance of the urban structure over time. Similarly, a university campus initially established outside the city can integrate with the city or pioneer in forming a new city with its development over time, the opportunities it provides, and the construction formed in its surroundings.

3. Sustainability and Sustainable Campus Concepts

The sustainability of something is associated with its ability to maintain its current state or renew itself. In this context, sustainability means leaving a world that can sustain ecological, economic and social conditions for future generations (Utku, 2020). Today's sustainability concerns began to emerge in North America in the early seventies after the emergence of the environmental crisis. After realizing the danger of environmental degradation's impact on economic development and social justice, sustainability emerged as a slogan for overcoming these environmental challenges (Clougston & Calder, 1999).

There are different definitions of sustainability. The most commonly used standard definition is found in the Brundtland Report in 1987. According to this definition, "sustainable development is meeting the needs of today's generation without compromising the ability of future generations to meet their own needs". The concept of sustainability includes a holistic approach consisting of different components. In this context, sustainability has three primary dimensions: ecological (environmental), economic and social. The ecological (environmental) dimension of sustainability is related to the efficient use of resources in our environment and nature against the risk of depletion, the dissemination of renewable resources and reprocessing, raising public awareness of environmental problems and ensuring the continuity of ecosystems (Kalawi, 2021).

Among the sustainable development and sustainable environmental management studies carried out on a global scale, the Tbilisi Conference organized in 1977 with the cooperation of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Programme (UNEP) is considered the first attempt to bring a holistic approach to the environment in the field of higher education at an international level (Wright, 2002). The principles of the Tbilisi Conference revealed the necessity of including the issue of a sustainable environment in educational processes. They constituted a turning point in conducting research and studies in this direction. In the years following the Tbilisi Conference, the decisions of the Talloires Declaration and the Kyoto Declaration, which were convened in 1990, were crucial in developing sustainable campuses. In these declarations, decisions were made that included the design, management and operation of sustainable campuses within the scope of social, environmental and economic sustainability principles (Wright, 2002).

As a result of the increasing number of unprecedented environmental problems experienced in the world in the 2000s, such as population growth, global warming, excessive use of natural resources, oil-dependent energy, water and food shortages, sustainability-themed environmental approaches initiated by environmental committees, governments, non-governmental organizations and local governments have gained a priority place on the agenda of universities (Barlett & Chase, 2004; Velaquez et al., 2006; Bokhari, 2017). Universities, which play an essential role in the development and dissemination of sustainability awareness with their sensitive, investigative, innovative and open-to-development structures, carry out interdisciplinary studies and projects related to sustainability in many branches of science, such as architecture, engineering, art, geography and politics (UNEP, 2013). In this context, sustainable universities are higher education institutions that minimize the social, economic, and environmental problems that arise while carrying out the necessary activities within their structure. They also set an example for society regarding sustainability (Bokhari, 2017). The primary purpose of universities undertaking this task is to create areas with conscious waste management, keep energy savings to a minimum, use natural recyclable materials, and contribute to sustainable development by developing an environmentally sensitive vision (Puertas & Marti, 2019). These institutions, which are the centers of sustainable planning and design, also create a sustainable lifestyle in society with their sustainable and ecological practices.

Today, the International Sustainable Campus Network (ISCN) and the United Nations Environment Program (UNEP) publish guidance reports on sustainability, planning and ecological design, and sustainable campus management on university campuses (URL5, 2024), (URL6, 2024).

Based on these reports, sustainable campuses aim to reduce their ecological footprint by effectively using natural resources, especially energy and water. In addition, recycling, waste management, and sustainable transportation policies support the reduction of waste and, thus, the reduction of carbon emissions.

Economically sustainable campuses contribute to financial sustainability with efficient business and resource management. Active use of sustainable technologies encourages students and other campus users to develop their knowledge and skills on sustainability and to prepare for the future job market. In terms of the social dimension, sustainable campuses provide services for the vital needs of students and other campus users (cultural and social needs such as food, shelter, security, equality, health, education, freedom, and employment) and create social awareness by serving the society (Uzunkaya, 2024).

The literature includes studies of various institutions and organizations to determine and classify the standards for sustainable university campuses.

The International Association of Research Universities (IARU) has created a toolkit consisting of six sustainable campus implementation steps based on the experiences of its members in creating and maintaining a sustainable campus (URL7, 2024):

1. Mapping the current situation and developing a governance structure
2. Determining goals and a strategy for the process
3. Developing an Environmental Management Plan
4. Integrating campus activities
5. Education and awareness
6. Best practice case studies

Mitchell S. Thomashow, an educator and environmentalist writer who focuses on innovations in the field of sustainability and environmental learning, has classified the essential elements required for a campus to be sustainable under nine headings in his book "Nine Elements of a Sustainable Campus": energy, food, materials, management, investment, health, curriculum, interpretation and aesthetics (Thomashow, 2014). To improve the design of sustainable campuses and to question the sustainability of campuses, developed classifications have formed the basis of various certification systems.

4. Findings and Discussion: Assessment and Certification Systems for Sustainable Planning and Design of University Campuses

In order to evaluate and measure the sustainability performance levels of university campuses, many assessment and certification systems such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment's Environmental Assessment Method), Green League, Environmental and Social Responsibility Index, Green Metric, and SITES have become widespread and implemented in the world, especially in the last ten years (USBGC, 2009; BRE Global, 2010; USBGC, 2011; Swartha & Sari, 2013; Sustainable Sites Initiative, 2014; Lauder et al., 2015; Puertas & Marti, 2019; UI Greenmetric, 2023). These certification systems, which aim to minimize the damage to the environment, design sustainable environments and determine the sustainable planning and ecological design criteria of university campuses, are becoming increasingly crucial in objectively and concretely evaluating negative environmental impacts. These evaluation systems, which generally define and measure variables on topics such as land use and biodiversity, campus master plan, building design, use of resources, research and information technologies, carbon targets, responsibilities for sustainability, waste, recycling and local emissions, users, transportation, local integration, social integration, also allow for comparisons between universities.

Initially, these assessment systems were designed to enhance the environmental performance of structural elements and their surroundings. However, over time, they have evolved into comprehensive tools that assess environmental sustainability and address economic and socio-cultural issues. This transformation has broadened the scope of these systems, positively influencing their application in various areas.

The Green Metric (UI Greenmetric) indicators, developed by the University of Indonesia (UI) in 2010 to evaluate sustainability studies on university campuses around the world, are created by superimposing the different research and scales explained above and cover environmental issues, including the use of natural resources, environmental management and pollution prevention, economic issues such as profit and cost reduction, and social issues including education, community and social participation. UI Green Metric data constitutes the source of this study, as it also questions universities in our country in the context of sustainability, and our universities use these rankings in their sustainability studies. The significant relationship between the location of university campuses in the city and their sustainability levels was questioned through UI Green Metric data. The objectives of the Green Metric (UI Greenmetric) ranking are stated as follows:

- To contribute to academic studies on sustainable education and greening of campuses,

- To lead social change in line with the sustainability goals of universities,
- To provide evaluation criteria on the sustainability of campuses to higher education institutions on a global scale,
- To encourage sustainability practices in universities on a global scale,
- To facilitate international partnerships on sustainability.

The UI Green Metric, a ranking system for green campuses and environmental sustainability, assesses universities based on their environmental structures and initiatives across thirty-nine indicators in six criteria. This initiative believes that as critical collaborators, universities can significantly impact the joint effort between stakeholders and communities to combat climate change. It aims to inspire and develop new ideas and innovations, directing them towards energy and water conservation, waste recycling, and green transportation.

The ranking method creates a uniform system for universities, where the results are based on a numerical score that will allow ranking. This allows comparisons between rankings that can be made according to the criteria of universities' commitments to address sustainability and environmental impact issues. Universities that want to participate in the ranking are asked to provide numerical data on several criteria related to their green campus commitments. The requirements also include basic information such as the spatial size of the university, its population size, campus location, and the amount of green space, as well as information on energy use, transportation, water use, recycling, and waste treatment. Initially, the numerical data collected from universities are converted into a single score that reflects the university's implementation and efforts towards environmentally friendly and sustainable approaches. Universities are ranked according to this score. However, the rankings are expected to benefit university leaders in implementing environmentally friendly policies and developing sustainable practices among the academic community in their respective institutions.

A set of criteria that are considered reliable, simple and understandable are used in the ranking. Each criterion is categorized into a general information class, the results are processed, and the raw scores are weighted to obtain a final calculation. The current performance assessment tool, which can be seen in Figure 3, has 39 indicators and six criteria, namely, Environment and Infrastructure (SI), Energy and Climate Change (EC), Waste (WS), Water (WR), Transportation (TR) and Education (ED).

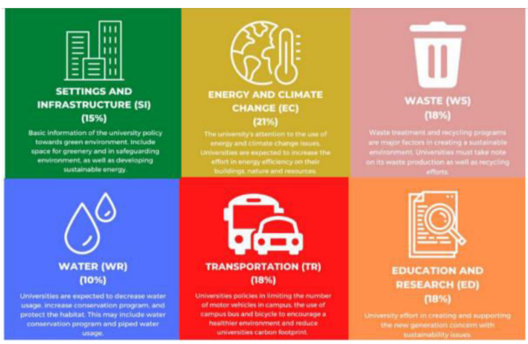

Figure 3. UI Greenmetric's recommended 'Main criteria for sustainable universities' (IU Green Metric, 2024)

The indicators and criteria in the model created are formed under Environmental, Social and Economic elements, emphasizing the essential components of sustainability. Criteria that are mostly considered necessary by universities interested in sustainability were selected. These are basic information about the size of the university and its zoning profile, whether urban, suburban or rural, green area degree, electricity consumption due to its connection with carbon footprint, transportation, water use, waste management, settlement and infrastructure, energy and climate change and information about education and research. In addition to indicators, the UI GreenMetric model aimed to obtain a picture of how universities respond to or cope with sustainability issues through policies, actions and communication.

The twelfth ranking was held in 2023, with the theme "Establishing the UI GreenMetric World University Rankings: The Way Forward." 1183 universities from 84 different countries participated. Participating universities are established in Asia, Africa, Europe, North America, Latin America, and Oceania. The distribution of numbers by continent can be seen in Figure 4 (UI Green Metric, 2024).

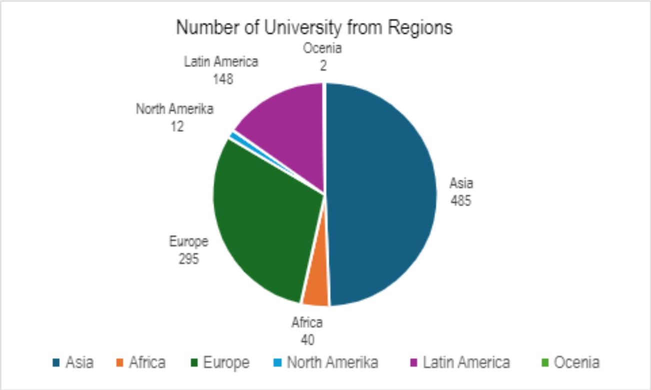

Figure 4. Distribution of participating universities by continent in UI Green Metric (2024) (Figure created by authors).

In addition, universities participating in the ranking are divided into two main groups according to the focus of their education and training programs: “comprehensive” (offering degrees in a variety of subjects) and “specialized” (offering programs focusing on a specific field or discipline) according to their campus type (Figure 5).

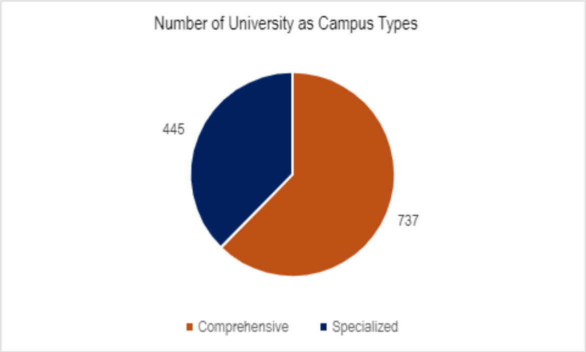

Figure 5. Distribution of participating universities in UI Green Metric (2024) according to their education-training program focuses (Figure created by authors).

In the ranking, universities were scored separately for each of the six criteria: Environment and Infrastructure (SI), Energy and Climate Change (EC), Waste (WS), Water (WR), Transportation (TR) and Education (ED). The total score received from the criteria was used for the final ranking. In addition, universities were categorized according to their location. Campuses were divided into five groups according to the environment and building type they were located in: “rural”, “urban”, “suburban”, “city center”, and “high-rise” (UI Green Metric, 2024). The ranking can be filtered according to campus location. The number and rates of universities according to campus location types can be seen in Figures 6 and 7 below.

Another ranking category is based on the size of the campus area of the university campuses ranked in terms of sustainability. The classification threshold is based on the UI GreenMetric 2021 ranking result (Quarter of Campus Area). Campuses with a campus area of < 150,000 m² are categorized as small campuses, those between ≥150,000 m² and ≤1,750,000 m² are categorized as medium campuses, and those > 1,750,000 m² are categorized as large campuses (Figure 8).

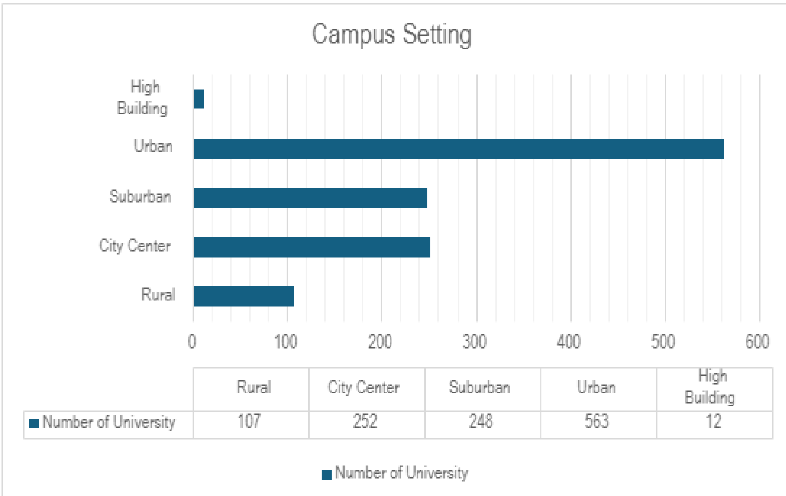

Figure 6. Distribution of participant universities' campus setting in UI Green Metric (2024) (Figure created by authors).

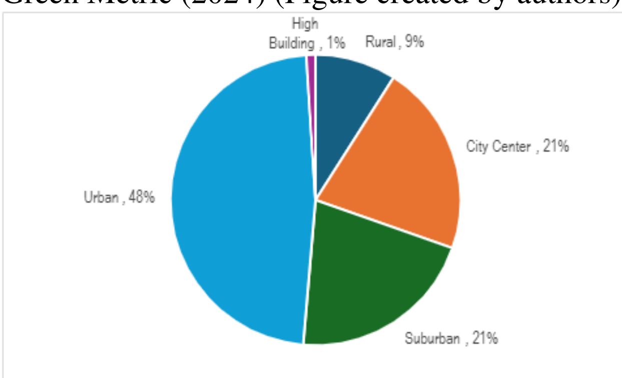

Figure 7. Rates of university campuses according to campus setting areas participated in UI Green Metric (2024) (Figure created by authors).

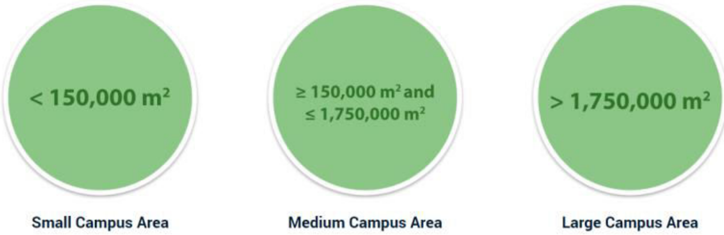

Figure 8. Classification of university campus areas participated in UI Green Metric (2024) according to the size of settlement areas.

When the top ten universities ranked according to the size of their residential areas are compared according to their campus settlement environment, the ratio of these universities is similarly ranked as urban, suburban and city center, respectively (Figure 9).

Ranking by Small Campus Area <150,000 m^2		
No	University	Campus Setting
1	Luiss University	City Center
2	Universidad Autónoma de Occidente	Urban
3	Siam University	Urban
4	Universidad El Bosque	Urban
5	Universitas Multimedia Nusantara	Suburban
6	Dhurakij Pundit University	City Center
7	Sunway University	Urban
8	Universidad EAFIT	Urban
9	Centro Universitário Facens	Urban
10	Universidad EIA	Suburban

Ranking by Medium Campus Area ≥150,000 m^2 and ≤1,750,000 m^2		
No	University	Campus Setting
1	Umwelt-Campus Birkenfeld (Trier University of Applied Sciences)	Rural
2	University of Groningen	Urban
3	University College Cork	Urban
4	Universitat Bremen	Urban
5	Dublin City University	Urban
6	University of Southern Denmark	Suburban
7	Leiden University	City Center
8	University of Turin	City Center
9	Politecnico di Torino	Urban
10	Leuphana Universitat Luneburg	Urban

Ranking by Large Campus Area > 1,750,000 m^2		
No	University	Campus Setting
1	Wageningen University & Research	Suburban
2	Nottingham Trent University	Urban
3	University of California, Davis	Suburban
4	Universidade de Sao Paulo USP	Urban
5	University of Connecticut	Rural
6	Universita di Bologna	City Center
7	Universidad Autónoma de Nuevo León	Urban
8	Université de Sherbrooke	Urban
9	Hame University of Applied Sciences	Suburban
10	Universitas Indonesia	Suburban

Figure 9. The distribution of the top ten universities participating in UI Green Metric (2024) by the size of their settlement areas (Figure created by authors).

When all the data is examined, it is concluded that the highest rate of sustainable university campuses is in universities located in cities. Then, universities located in suburban and city centres are almost equal. The universities with the lowest rate in the UI Greenmetric 2023 list as sustainable university campuses are in rural areas and high-rise buildings. The rate of being a sustainable campus decreases as moving from urban areas to rural areas. Another result of the categorizations is that university campuses are open to more than urban and non-urban areas. Still, most university campuses are located in “suburban” areas, which can be considered as intersection areas emerging from the city to the outside. In addition, universities located in the “city center”, although within the city, were also evaluated as sustainable campuses to a significant extent and were included in the ranking.

5. Conclusion and Suggestions

Universities are impartial and independent institutions that produce knowledge and science from different disciplines through education and training. They serve economic, social, cultural and technological values with different sub-units and structures. Throughout history, many universities have been established in different parts of the world at different times and contexts, and some of them continue to exist today with the newly established ones. Regardless of scope, universities are active living spaces with spatial characteristics where different users, especially students, carry out various activities. With these characteristics, universities can be considered as differentiated versions of cities. In this context, the study aims to evaluate universities and university campuses in the context of sustainability according to their physical locations and their relations with the city they are affiliated with. Many certification and ranking systems evaluate and measure the sustainability performance levels of university campuses. The Green Metric (UI Greenmetric) indicators developed by the University of

Indonesia (UI) in 2010 were used as the evaluation criterion within the scope of the study. In the ranking of 1183 universities, campuses are classified as “rural”, “urban”, “suburban”, “city center”, and “high-rise” according to the environment and type of structure they are located in. According to this classification, the rate of being a sustainable campus decreases as it moves from the city center and urban areas to rural areas outside of the city. Another ranking is according to the size of the campus settlement area, and in the ranking made as small, medium and large campuses, the rate of sustainable universities in the top ten is similarly ranked as urban, suburban and city center, respectively. When the literature research and Green Metric data are evaluated together, it has been observed that the proximity of universities to the city in their location selection is directly proportional to sustainability. Based on the definitions of sustainability as the ability of something to maintain its current state or to renew itself, universities' existence and development potential depend on their relationship with the city. The coexistence of the city and the university provides easy accessibility, benefiting from education training, cultural and social facilities, economic and technological development, public life, etc. It will positively affect them, as they can feed each other from different perspectives. As the university develops, the city will grow; as the city develops, the university will continue to evolve, and its sustainability will be ensured. However, as a result of the study, it is essential in terms of university-city relations that university campuses should not be divided only into inner-city and outer-city and that although cities have specific boundaries, these boundaries are flexible, variable and in a situation of transformation. Universities can also be located in the city center, periphery, and in different intersection areas. Depending on the city's variable characteristics, the city's physical location and sustainability can also change, and the university's development and change also affect the city's quality. In this context, the variable boundaries of the city and universities and reading this in terms of sustainability can also shed light on a new study. However, within the scope of the study, a sufficient number of studies were not found on the classification of university settlements in the Green Metric data as “suburban”, “high-rise building”, and “city center”, and examining these concepts in terms of literature and site studies will be a subject for future researches.

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All authors contributed equally to the article.

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Energy Efficient Approaches within the Scope of Sustainable Campus Design

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1. Introduction

The rapidly increasing population worldwide has brought about a rise in consumption. With this rise in consumption, the technology and industry sectors have expanded rapidly, making energy production and consumption phases -essential to both our daily lives and these sectors- significant contributors to environmental issues and global warming. Thus, energy is one of the most critical factors threatening the environment. In addition to the environmental damages associated with energy production and consumption, the potential inability to meet future demand has prompted a search for solutions.

At the United Nations Conference on the Human Environment held in Stockholm in 1972, the depletion of global resources and the seriousness of this situation were highlighted with quantitative data. The concept of "sustainability" was introduced in the "Our Common Future" report by the United Nations World Commission on Environment and Development in 1987 as a solution to these problems. With the definition of sustainable development in this report, governments and public institutions realized that environmental, economic, and social sustainability were crucial factors in their operations. The United Nations Conference on Environment and Development in Rio de Janeiro helped secure and strengthen international commitments to sustainable development, leading to the adoption of a comprehensive action plan known as "Agenda 21." The historical updates to this action plan culminated in the United Nations General Assembly's establishment of 17 sustainable development goals to be achieved by 2030, including goals addressing energy and climate change.

Energy plays a vital role in sustainability. From an environmental sustainability perspective, the use of renewable energy sources contributes to combating climate change by reducing greenhouse gas emissions and minimizing environmental pollution. Economically, utilizing domestic and renewable energy sources enhances energy security, creates new job opportunities, and supports economic growth. In terms of social sustainability, sustainable energy solutions improve the quality of life, reduce health problems, and broaden access to energy. Therefore, it is essential to shape energy policies in line with sustainability principles. The effectiveness of sustainability policies depends on the adoption and support of all stakeholders, including institutions, governments, society, educational institutions, individuals, industry and trade sectors, financial institutions, and investors. These stakeholders should support sustainability efforts, fulfill their environmental, economic, and social responsibilities, and collaborate for a sustainable future. Such efforts increase sustainability awareness, promote resource management and cost reduction, encourage social participation, and enhance sustainability consciousness. Universities, as significant and influential stakeholders, also play a substantial role in this regard.

Universities are important and effective stakeholders in the implementation and dissemination of the concept of sustainability. They provide education on sustainability topics to students and develop innovative solutions through research and innovation. Additionally, universities contribute to reducing environmental impact through practices such as the use of renewable energy, energy efficiency projects, resource management, and recycling. The campuses that universities establish as work, education, and living spaces serve as models for these processes. In this context, conscious consumption of energy resources on university campuses, reducing the use of fossil fuels, prioritizing the use of renewable energy sources, and promoting approaches to minimize energy consumption have made the concept of energy-efficient campuses a current issue.

This study first evaluates how energy, as one of the essential components of sustainable campus design, is addressed by reviewing the relevant literature on sustainability, sustainable development, the role and significance of campuses in sustainability, and the design and planning of sustainable and contemporary campuses. Secondly, it examines the energy-related policies of universities that stand out for their sustainability policies and achieve recognition in certification/ranking systems. The current practices and future policies of these universities provide exemplary models not only for universities in our country but also for our cities and other settlements.

In addition to examining the concepts in the relevant literature, this study aims to discuss and evaluate the prominent and necessary policies in energy management and the advantages these policies would provide, based on the examination of universities recognized for their energy policies.

2. Sustainability, Sustainable Campuses and Energy-Efficient Policies

Accessible and clean energy is not only one of the 17 fundamental sustainable development goals but also indirectly significant for other sustainable development goals. In this context, energy-efficient policies are seen as an important component of sustainable campuses. This study examines the concept of sustainability and sustainable development goals, the importance and impact of campuses within the scope of sustainability, the importance of energy efficiency in sustainability, relevant literature on sustainability, and energy policies of leading sustainable campuses.

2.1. The Concept of Sustainability and Sustainable Development Goals

According to the Turkish Language Association's dictionary, the term "sustainability" is defined as "ensuring the continuation of a state or any entity." However, sustainability is a concept that encompasses a wide range of different definitions and interpretations. Fundamentally, it involves the responsible use of the Earth's essential resources and their transfer to future generations. In summary, sustainability ensures the continuation of the functions, processes, and productivity of ecological systems for future generations (Chapin et al., 1996). With these characteristics, the concept integrates environmental and economic concerns, filling the gap between science and policy (Scoones, 2007).

At the 1972 Stockholm Conference, it was numerically demonstrated that the world's resources were depleting and that this could lead to serious problems. Although countries were aware of the seriousness of this issue, they initially hesitated on the steps to take. The concept of sustainability was first used in the 1987 report "Our Common Future" by the United Nations Commission on Environment and Development. This report is one of the first documents to address the concept of sustainability with concrete data. Since the Brundtland Report and the definition of sustainable development, governments and public institutions have recognized the responsibility to consider environmental, economic, and social sustainability in their activities (Amaral et al., 2019). Environmental factors have been among the basic principles since the post-1987 period (Koçhan, 2002; Uygun, 2012). Over time, the importance of the concept has increased, and it has become a constantly emphasized topic on the United Nations (UN) agenda (Heinberg & Lerch, 2010). Following international agreements signed after initiatives like the Rio Declaration and the Johannesburg Conference, it has become a global action plan.

Sustainability focuses on the interaction between the desire to improve people's quality of life and the limitations imposed by nature. Furthermore, the concept of sustainability is closely associated with the idea of preserving environmental quality. The primary goal of sustainability is to enhance and maintain quality of life without jeopardizing the future. Today, in a world facing issues such as rapid resource depletion, environmental degradation, and climate change, the importance of sustainable development is increasing (Çamayaz, 2023).

Over time, sustainability has become more significant with technological advancements, changing factors, and the increasing rate of resource depletion (Kurdoğlu et al., 2018). The main dimensions of sustainability, consisting of economic, social, and environmental factors, as well as the sub-dimensions defined by their intersections, are shown in the diagram below.

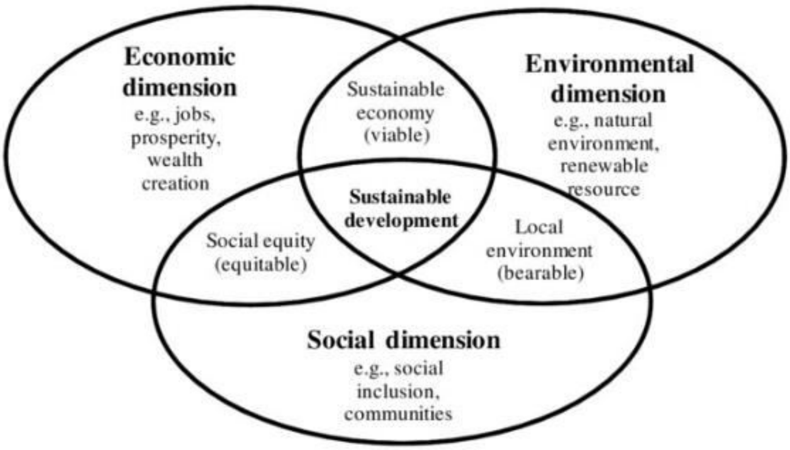

Figure 1. The Dimensions of Sustainability (Leat, Revoredo-Giha & Lamprinopoulou, 2011)

When examining sustainability through its three fundamental dimensions, which aim to balance economic development, social welfare, and environmental protection:

- Economic Dimension: This includes concepts such as income transparency, growth, savings, risk management, innovation, job creation, research and development (R&D), workers' rights, skill development and education, business ethics and compliance, and fair trade (Cato, 2009). A sustainable economic approach should consider the welfare and equity of the entire society, use resources and potentials consciously, and aim to ensure that future generations have access to the same opportunities (Yılmaz, 2018).

- Social Dimension: This addresses issues such as human rights, diversity and equal opportunity, labor standards, social justice, community participation, and cultural heritage. A socially sustainable society should provide equal opportunities to all individuals, promote social justice and inclusivity, respect human rights, and raise awareness of these principles (UN, 2023).
- Environmental Dimension: This includes the efficient and conscious use of resources, green energy, energy efficiency, recycling, recovery, waste management, wastewater treatment, emission sensitivity, climate change awareness, attention to harmful substance spills and leaks, natural resource consumption, water management, and access to clean water, and biodiversity. A sustainable environment aims to protect and use natural resources more efficiently, prevent pollution and environmental damage, and leave a healthier world for future generations (EEA, 2023).

These three dimensions are interconnected. Economic growth can have negative impacts on social and environmental dimensions, while improvements in social and environmental aspects can positively influence economic development. For example, investing in green energy not only reduces environmental pollution but also creates new job opportunities and enhances potential resource availability (IRENA & ILO, 2023).

Balancing these three fundamental dimensions of sustainability is crucial. Governments, businesses, and civil society organizations should work together and interactively to achieve this balance. Ensuring a balance between economic and social welfare and environmental sensitivity requires the awareness of all individuals in society to create a fairer and more livable world.

The Sustainable Development Goals (SDGs) were created to transform this general principle into concrete targets. These goals were initially presented with the Millennium Development Goals in 2000 and later updated and detailed with the "Transforming Our World: The 2030 Agenda for Sustainable Development" publication, accepted by 193 countries during the United Nations Sustainable Development Summit in 2015. These goals aim to ensure sustainability at a global level by targeting the environment, economy, and society (Yıldırım & Nuri, 2018; Gedik, 2020; Yüksel & Barut, 2023).

In this context, the 17 fundamental Sustainable Development Goals aim to enhance societal welfare in various areas such as the preservation of natural resources, reduction of inequalities, combating climate change, and improving healthcare services. These goals are summarized in the following table (Table 1);

Table 1. Sustainable Development Goals (BM, 2023; TCSBB, 2024; UNDP, 2024)

Sustainable Development Goals	**Goals/Indicators**
	**End poverty in all its forms everywhere** • Lower poverty, • Social protection systems, • Resilience of poor and vulnerable populations, • Equitable access to economic resources and basic services,

End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

• Access to sufficient, nutritious and safe food for all people,
• Sustainable food production systems,
• Genetic diversity in seeds, crops and animals,
• International cooperation for agricultural production.

Ensure healthy lives and promote well-being for all at all ages

• Lower maternal and child mortality rates,
• Combating infectious diseases and substance abuse,
• Reducing traffic accidents,
• Access to reproductive health services and health security,
• Improving environmental health.

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

• Free, equal, equitable, inclusive and quality education for all at all levels,
• Technical and vocational knowledge and skills necessary for sustainable development,
• Safe and inclusive learning environments,
• Increased scholarship opportunities,
• Number of qualified teachers.

Achieve gender equality and empower all women and girls

• Preventing all forms of discrimination and violence,
• Full participation of women in political, economic and social decision-making processes,
• Access to sexual and reproductive health services
• Policies and legislation for gender equality.

Ensure availability and sustainable management of water and sanitation for all

• Access to drinking water, adequate sanitation and sanitation for all
• Reducing water pollution and improving water quality
• Effective water use in all sectors,
• Integrated water resources management,
• Protection of aquatic ecosystems.

Ensure access to affordable, reliable, sustainable, and modern energy for all

- Access to affordable, reliable and modern energy services for all,
- Increasing the share of renewable energy production,
- International cooperation in clean energy research and Technologies,
- Research and investment in energy infrastructure and clean energy Technologies.

Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

- Sustainable economic growth, jobs for all,
- Economic efficiency and resource efficiency,
- Ending forced labour, slavery and human trafficking,
- Safe working environments,
- Sustainable tourism,
- Access to banking, insurance and financial services,
- Global strategy for youth employment.

Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

- Quality, reliable, sustainable and resilient infrastructure,
- Inclusive and sustainable industrialization,
- Support for small-scale industrial enterprises,
- Efficient use of resources and clean technologies,
- Technological competencies,
- Access to scientific research and information and communication technologies.

Reduce inequality within and among countries

- Support for low-income groups,
- Equal opportunities for all,
- Fiscal, wage and social protection policies that promote equality
- Supervision of global financial markets and institutions,
- Planned and well-managed migration policies.

Make cities and human settlements inclusive, safe, resilient, and sustainable

- Access to housing and basic services,
- Safe and affordable transport systems for vulnerable, population groups, inclusive and sustainable urbanization,
- Protection of World Heritage,
- Resilience to climate change and disasters,
- Good air quality and waste management,
- Safe and accessible green and public spaces for all,
- Economic, social and environmental linkages between settlements.

Ensure sustainable consumption and production patterns

- Sustainable management and efficient use of natural resources,
- Reduced food waste and food losses,
- Environmentally sound chemical and waste management,
- Reduced solid waste generation,
- Knowledge and awareness of sustainable development,
- Sustainable tourism,
- Restructuring incentives.

Take urgent action to combat climate change and its impacts

- Resilience to climate-related natural disasters and hazards,
- Climate change measures,
- Climate change mitigation, adaptation and capacity building,
- Climate change planning and management capacity.

Conserve and sustainably use the oceans, seas, and marine resources for sustainable development

- Prevent marine pollution,
- Sustainable management of marine and coastal ecosystems,
- Sustainable fish stocks and prevention of overfishing,
- Sustainable use of marine resources.

Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss

- Protect terrestrial and inland freshwater ecosystems, forests, mountain ecosystems and biodiversity, natural habitats and endangered species in accordance with international agreements;
- Rehabilitation of areas affected by desertification, drought and floods;
- Fair and equitable sharing of genetic resources.

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels

- Reduction of violence and child abuse
- Rule of law and equal access to justice
- Control of illegal acts and combating organised crime
- Effective, accountable and transparent institutions, responsive, inclusive and participatory decision-making mechanisms
- Fundamental freedoms
- Strong national institutions through international cooperation
- Non-discriminatory laws and policies.

Strengthen the means of implementation and revitalize the global partnership for sustainable development

- Development assistance
- Technology transfer
- Capacity building activities
- Rules-based and fair trade
- Policy harmonization
- Multi-stakeholder collaboration
- Data monitoring and accountability for sustainable development.

Sustainable Development Goals can be seen as a roadmap that enables today's generations to increase their well-being and fulfill their responsibilities while protecting and improving the quality of life for future generations.

2.2. The Importance and Impact of Campuses in the Context of Sustainability

Higher education institutions have a special social responsibility in societal development, particularly in educating future leaders, raising public awareness on sustainability, and promoting intergenerational behavioral change (Amaral et al., 2015). Universities have always had a significant impact on society, shaped by the needs and orientations of their communities. As institutions dedicated to generating, researching, and questioning knowledge, they bear a significant responsibility. Addressing solutions to the disruption of ecological balance, one of today's biggest problems, is also part of this responsibility. With their sensitive, research-oriented, and innovative structures, universities have become central to the issue of sustainability (Darendelioğlu, 2020).

The responsibilities and impacts of universities concerning sustainability can be generally categorized into three groups:

- Education and Research: By incorporating sustainability as a fundamental component of their mission and vision, higher education institutions contribute significantly to society beyond their educational activities. They adopt an educational approach that considers environmental, social, and economic dimensions, leading the way towards a sustainable lifestyle. The concept of sustainability is directly linked to universities' core duties, such as creating knowledge and awareness, promoting research and development activities, and setting examples for and contributing to society through social responsibility projects. A sustainable education approach helps students develop problem-solving skills, ethical values, and an awareness of being responsible global citizens, beyond merely transferring theoretical knowledge. Universities educate future leaders and professionals about environmental issues, sustainable practices, and green technologies by incorporating sustainability into their educational programs and courses. They conduct studies on renewable energy, waste management, sustainable agriculture, and climate change, contributing to the knowledge base needed to address environmental issues. Through scientific research and innovative work, universities can contribute to solutions in areas such as sustainable energy, agriculture, water management, and waste management.

- Campus Operations: Universities are large systems comprising various functions such as classrooms, dining areas, sports halls, dormitories, libraries, and laboratories. They consume large amounts of energy and resources and produce waste. One of the reasons universities are significant in the context of sustainability is that many university campuses, due to their size, the number of structures they contain, their layout, and population, resemble small urban settlements and thus provide a simulation of how larger contributions can be made to the economy, society, and environment. They can expand the efforts initiated on their campuses by experiencing these efforts firsthand. They can lead by example regarding environmental, economic, and social concerns that they must address in their activities, minimizing the negative environmental, economic, social, and health impacts of resource use. Universities can develop and implement effective policies on energy efficiency, waste management, and water conservation. These projects provide valuable data that can be applied to broader urban contexts.

- Community Engagement: Universities collaborate with local governments, businesses, and community organizations to promote sustainability beyond the campus. They help disseminate information and spur action in the local community through public events, workshops, and collaborations with local governments, businesses, and community organizations on issues such as conservation of energy and resources, waste reduction, promotion of social justice, and equality (Alshuwaikhat & Abubakar, 2008; Amaral et al., 2015; Amaral et al., 2020; Avila et al., 2017; Cole, 2003; Cortese, 2003; Güngör et al., 2022; Velazquez et al., 2006).

In recent years, increasing awareness and commitment to global sustainable development goals have encouraged many universities to adopt and integrate sustainability principles into their operations. Integrating sustainability principles and practices into the functioning of universities is crucial in building a sustainable future. To achieve this integration successfully, the following key elements should be considered (Lozano et al., 2013; Güngör et al., 2022):

- Inter-University Collaboration: Collaboration between universities should be encouraged to share knowledge and experiences in the field of sustainability, conduct joint research projects, and disseminate best practices. National and international networks and platforms can be established for this purpose.

- Development of Interdisciplinary Studies: Sustainability is a complex issue that transcends the boundaries of a single discipline. Therefore, collaboration between academics and researchers from different disciplines should be encouraged.
- Institutionalization: Sustainability should be integrated into the mission and vision of the university and supported with an institutional structure. Sustainability offices or committees can be established, sustainability policies and strategies can be defined, and resources can be allocated for research and education in this area.
- Campus Life Experiences: It is important for the principles of sustainability to be adopted and implemented in campus life. Practices such as energy and water conservation, waste management, protection of green areas, and promoting the use of bicycles can be implemented for this purpose.
- Training Educators: Sustainability education should be included in all disciplines and educational programs. Training on sustainability should be organized for academics and educators, and curriculum developments in this field should be supported.

In addition to these key elements, the integration of sustainability activities into universities involves the participation of stakeholders, monitoring and evaluating sustainability performance, and creating a culture of sustainability.

The first step towards becoming a sustainable university is to define a vision. A vision encompassing environmental, social, and economic dimensions should be created, considering the unique dynamics of each university. This vision should aim to minimize the negative impacts that may arise from any initiative and lead the community, as required by the definition of sustainability. It is important for each university to create and steadfastly implement its unique sustainability roadmap.

After defining the vision, the second stage of the sustainable university process is to define the mission. The university should analyze its current situation, identify the necessary stakeholders and strategies to achieve the vision's goals. A coordination office should be established to manage the defined strategies, involved stakeholders, and related sustainability activities. This office should coordinate initiatives and regulations, prepare reports, and enhance the visibility of activities through communication networks such as websites. A committee should be established to increase the activity of these efforts. The committee, comprising experts, should define goals, objectives, and policies and manage the integration into daily operations and the provision of funding.

The adoption of sustainability principles in universities has translated into tangible steps with the "green campus" approach. In this context, the term "green campus" refers to a framework where all elements operating within campus boundaries function in harmony, conserving resources and operating in an environmentally friendly manner (Filho et al., 2019; Acuner et al., 2023; Tan et al., 2014; Tiyarattanachai & Hollmann, 2016).

In this framework, green campuses, which are also part of the sustainability strategy, should lead the way in effective use of natural resources like energy and water, waste management, and recycling. Additionally, the protection and development of green areas, the provision of sustainable transportation options, and education and awareness activities to increase environmental consciousness are important components of this strategy.

Sustainable campus practices aim to improve the quality of life for all residents by providing environmental benefits such as nature conservation and enhancement, pollution prevention, and the utilization of organic waste. They also target the promotion of job safety and health, the concept of equality within the campus, and actions considering the disabled.

Sustainable campuses are essential tools for higher education institutions to fulfill their responsibilities to the environment and leave a more livable world for future generations. The widespread adoption and development of this approach are crucial for contributing to a sustainable future.

Campus planning for higher education institutions includes components such as building design guidelines, functionality, safety and protection, aesthetics and innovation, cultural/social aspects, and sustainability. This process provides significant guidance for campus development and highlights important elements to consider in the design process (Terro et al., 2021).

In the design, planning, and operational phases of campuses, principles that support learning, innovation, sustainability, and well-being are observed to enhance user welfare and ensure prolonged use. These principles can be summarized as follows:

- Sustainability and Green Design: Policies related to energy efficiency, waste management, and increasing the amount of green space on campuses are included. The integration of these features reduces environmental damage while creating a healthier living environment for students, staff, and visitors. Energy efficiency, coupled with improvements in ecological factors, lowers operating costs. Waste management reduces the amount of waste and promotes recycling, while green spaces not only offer aesthetic beauty but also support wildlife, provide opportunities for relaxation and stress reduction, and reduce carbon emissions. Additionally, creating mixed-use areas encourages the simultaneous conduct of various activities, while the principles of flexibility and adaptability ensure that spaces can meet different needs and facilitate socialization (Uzun, 2022; Kahveci, 2023).

- Technology Integration: This is a crucial element of contemporary campus design. Campuses enhance the learning experience, increase efficiency, and respond more effectively to user needs through the use of modern technologies. Technology integration also allows for a focus on improving the quality of life for campus users. Developing the benefits and comforts of technology in a sustainable environment is essential, which is possible through the continuous monitoring and analysis of data to detect any abnormalities in the system and improve energy consumption (Villegas et al., 2019).
- Active Learning Environments: These are another prominent feature in campus design. Active learning environments in universities have gained significant attention due to their positive impacts on student engagement and success. Research highlights the importance of active learning through individual and group participation in various effective activities such as research,

observation, writing, experimentation, discussion, problem-solving, and articulating concepts (Hadzibegovic and Slisko, 2013). Spaces that encourage interactive and participatory learning are created, while health and wellness initiatives are supported in these spaces. In this context, campuses offer facilities such as gyms, green spaces, and healthy eating options.

- Accessibility and Inclusivity: This principle ensures that everyone can equally benefit from campus facilities. University campuses function as small cities with their urban infrastructure, socio-cultural environments, and diverse user profiles. Inclusive design principles aim to create accessible and usable environments for everyone, considering this diversity. Therefore, inclusive campus design promotes the use of inclusive design principles and guidelines to educate and raise awareness among users (Özdemir & Nalbant, 2022).
- Community Engagement and Connectivity: These principles ensure that campuses function not only as centers for education and research but also as community hubs. They promote interaction among students, staff, local residents, and other stakeholders, fostering stronger community ties. Students' access to real-world experiences outside the campus enriches their learning and helps them build deeper connections with their communities (Saltmarsh & Wooding, 2016). Interaction with students from different disciplines enriches their learning experiences and allows them to expand their networks both on and off-campus. These collaborations provide students with a broader perspective and a

more diverse learning experience (Vidra et al., 2019). Universities are encouraged to actively develop community engagement initiatives for sustainable development as stated in the Copernicus Charter (Filho et al., 2019).

- Data-Driven Decision Making: This principle ensures the continuous improvement and development of campuses. Analyses based on user feedback and performance data aim to make campuses more effective and efficient. This approach ensures that decisions are made based on data analysis rather than solely on intuition or subjective evaluations (Provost & Fawcett, 2013).

In conclusion, through these principles and similar concepts, campuses become environments that promote learning, support innovation, ensure sustainability, and prioritize user welfare. They provide suitable environments for various activities such as education, research, social interaction, and personal development, focusing on important factors like sustainability, accessibility, and technology to meet user needs. Additionally, by addressing issues such as energy efficiency and effective use within sustainability, they have positive environmental and economic impacts on their surroundings and communities. Thus, campuses contribute to the welfare of society as fundamental elements of educational institutions, supporting the success and happiness of students, faculty, and staff.

2.3. The Importance of Energy Efficiency in Sustainability

The importance of energy in terms of sustainability is highlighted by various studies and research. Specifically, the reduction of greenhouse gas emissions by industries and the minimization of their environmental impacts contribute to sustainable development (Savaş, 2022). Increasing energy efficiency is crucial for providing clean energy and aligning with sustainable development goals (Yazgan & Soylu, 2022; Gültekin & Deste, 2021). Energy efficiency plays a critical role in reducing the adverse effects of energy production and distribution. Therefore, the effective use of energy is vital for sustainability (Naimoğlu & Akal, 2021). Lee (2014), Ilesanmi and Tewari (2022) emphasize the importance of energy efficiency in providing clean energy, reducing the environmental impacts of industries, and achieving sustainable development goals. Awan et al. (2014) explain in detail that the use of modern energy-efficient technologies is critical for ensuring economic, environmental, and social sustainability.

In this context, energy efficiency is crucial for sustainable development by reducing environmental impacts and enhancing economic and social welfare. Industries and societies must adopt energy-efficient practices and technologies to move towards a more sustainable future. Energy-efficient approaches to increasing energy efficiency encompass a wide range of applications and sectors, from wireless sensor networks to industrial processes and cloud computing. By promoting energy-efficient practices, technologies, and policies, societies can reduce energy consumption, lower carbon emissions, and progress towards a more sustainable and environmentally friendly future. Therefore, energy-efficient approaches are essential for social and economic welfare.

2.4. Sustainable Campuses and Energy Policies

As key actors in sustainability, universities compete with each other through their efforts in this area. Organizations that monitor, evaluate, and rank universities based on their sustainability practices and policies also exist. These organizations evaluate universities using various norms and create rankings accordingly. Below, the energy policies of university campuses that stand out in these rankings are examined.

2.4.1. Wageningen University and Research Center

Known for its expertise in sustainability and energy, Wageningen University has been a pioneer in research and initiatives aimed at reducing its carbon footprint through sustainable transportation programs (Paradowska, 2019). According to the GreenMetric rankings from 2016 to 2023, it holds the title of 'World's Most Sustainable University.'

Wageningen Campus has achieved 80% climate neutrality. This campus offers an innovative work environment for a sustainable future. It conducts various projects and activities in areas such as energy, water, construction, waste management, food, and transportation.

The energy policies of Wageningen Campus follow the principles of the 'Trias Energetica' concept:

- **Limiting energy demand**: Reducing energy consumption related to building technology and user behaviors. This involves both technological solutions and improvements in user behaviors to reduce energy consumption.
- **Using renewable energy sources**: Aiming to increase the amount of energy obtained from renewable sources like solar panels and wind turbines. These steps help maximize the use of renewable energy sources.
- **Efficient use of fossil energy sources**: Developing a vision for heat conversion through the use of geothermal energy and heat

pumps. This includes strategies to ensure sustainability and efficiency in heating systems and reduce fossil fuel consumption.

In the draft report on WUR Energy Transition 2050, published in December 2021, Wageningen University outlines its future goals for energy efficiency, summarized as follows (WUR, 2021):

- Reduction of CO2 emissions: Achieving a 72% reduction in CO2 emissions compared to 2005 levels by 2050.
- Energy efficiency: Increasing energy efficiency through methods such as LED lighting, energy audits, and energy monitoring.
- Development of energy demand: Avoiding new gas installations, widespread use of LED lighting, and conducting energy audits.
- Sustainable energy production: Installation of solar panels, development of solar parks, increased use of wind turbines and geothermal energy.
- Energy infrastructure: Implementation of the Aquifer Thermal Energy Storage (ATES) cycle, application of energy storage systems, and balancing the electricity grid.
- Energy savings: Significant energy savings by making off-campus locations more sustainable.
- Financial savings: Reducing energy costs by decreasing gas usage and using electricity more efficiently.
- Increase in sustainability: Eliminating or minimizing dependence on fossil fuels.

2.4.2. Nottingham Trent University

Nottingham Trent University (NTU) is one of the most sustainable universities in the world. It was ranked as the second most sustainable university globally in the 2022 and 2023 UI GreenMetric World University Rankings and the most sustainable university in the UK in the same list. NTU adopts a comprehensive and strategic approach to sustainability. Its campuses feature extensive green spaces, carbon-neutral/negative buildings, and superior transportation infrastructure, forming the foundation of NTU's sustainability policies and practices.

NTU has made significant strides in energy production and savings. The efforts in this area can be categorized into two main areas (NTU, 2021):

- **Meeting energy needs:** Producing 305,466 kWh of energy annually with solar panels on 14 buildings. Purchasing renewable electricity supported by Renewable Energy Guarantees of Origin (REGO) as part of its net zero carbon commitment.
- **Energy savings:** Contributing to energy savings through LED lighting, roof renovation work, and window replacements.

Policies guiding how energy is managed and monitored, minimizing waste, and optimizing low-carbon and renewable technologies at NTU are as follows (NTU, 2023):

- Complying with all relevant legal and regulatory requirements related to energy use, consumption, and efficiency.
- Monitoring and reporting energy consumption and carbon emissions when data is available.

- Identifying significant areas of energy consumption within the university and setting appropriate targets, objectives, and action plans to reduce energy waste.
- Supporting the purchase of energy-efficient products and services.
- Developing a preventive maintenance program to maintain and optimize the energy efficiency of installed building services.
- Optimizing the purchase and production of energy from low-carbon and renewable sources.
- Minimizing the energy used in conditioning indoor environments and maintaining reasonable working temperatures.
- Adhering to ISO:50001 principles.
- Considering low energy and passive design as much as possible in new construction and major renovation projects.

2.4.3. Trier University of Applied Sciences Environmental Campus Birkenfeld

Trier University of Applied Sciences' Environmental Campus has been ranked as 'Germany's Greenest University' in the UI GreenMetric rankings from 2017 to 2023. In 2023, it ranked third among 1,183 participating universities worldwide. At Birkenfeld, the newest campus, sustainability, internationalization, and applied research are of great importance. The Residential Campus model integrates the concepts of living, learning, and working, emphasizing the incorporation of ecological and sustainability-related content into education and research activities with an interdisciplinary approach (UCB, 2021). The university's sustainability approaches are shaped by a holistic understanding that encompasses environmental, economic, and social dimensions. The transformation of the campus from a military hospital to a modern university highlights the priority given to sustainability. The university's sustainability strategies are aligned with local and national sustainability goals and are implemented within a comprehensive system covering education, research, and campus management. These efforts ensure the university's international recognition and leadership position in sustainability (UCB, 2021).

Efforts to meet and save energy needs at the university include:

- Photovoltaic Systems: Producing electricity through solar panels installed on campus roofs and other suitable areas to meet part of the campus's energy needs.
- Biomass Facilities: Generating energy from organic waste through biomass facilities for heating and electricity production.
- Geothermal Energy Usage: Meeting campus heating needs by utilizing underground hot water sources.
- Wind Energy Projects: Generating electricity through wind turbines installed on or near the campus.
- Continuous projects to increase energy efficiency are being developed and implemented.

The university's energy policies, aligned with sustainability goals, include various strategies and practices, summarized as follows:

- Use of renewable energy: Meeting a significant portion of energy needs from renewable energy sources by implementing various renewable energy projects such as photovoltaic systems, biomass facilities, geothermal energy, and wind energy.

- Energy efficiency: Implementing measures to increase energy efficiency in all campus buildings and facilities, using modern and efficient technologies, and promoting energy-saving practices.
- CO_2 neutral target: Minimizing carbon emissions from energy consumption, adopting a zero-emission concept, and organizing all energy production and consumption processes to be CO_2 neutral.
- Use of electric vehicles: Replacing the university's vehicle fleet with electric vehicles and establishing the necessary charging infrastructure, thereby reducing fossil fuel consumption and minimizing environmental impacts.
- Sustainable energy education and research: Raising awareness among students and staff about sustainable energy, supporting research in this field, and including courses and projects on energy efficiency and renewable energy sources in academic programs.
- Energy monitoring and reporting: Regularly monitoring and reporting energy consumption. This helps evaluate the effectiveness of energy policies and take improvement measures when necessary.

2.4.4. University of Groningen

The University of Groningen, in the context of the energy crisis and rising energy prices, has emphasized the importance of sustainability and energy efficiency. In the 2023 UI GreenMetric rankings, it ranked fourth globally, showcasing its position in sustainability performance worldwide. To raise students' awareness of sustainability, various programs have been organized in education and research. A comprehensive communication network has been established across the university to increase awareness of energy conservation, and campaigns have been launched to promote energy savings (UG, 2021; UGGO, 2022).

Energy-focused initiatives have enabled the university to take significant steps towards its sustainability goals. Efforts to increase energy efficiency through both technical and behavioral measures are outlined below (UG, 2021; UGGO, 2022):

- Energy Production, Savings, and Policies: An energy task force consisting of energy experts, engineers, and behavioral scientists has been established.
- Building Systems: Identifying technical and operational savings in buildings by energy teams; optimizing heating and cooling hours by determining comfort times for buildings; constructing new buildings as energy-neutral; and renovating existing buildings.
- Renewable Energy Use and Energy Savings: Increasing renewable energy production to 25% by 2026 by using solar panels and ATES systems; implementing insulation works; converting lighting systems; and planning to become completely CO_2 neutral by 2035.

2.4.5. University of California, Davis

The sustainability approaches of universities are of great importance as part of their social responsibilities. The University of California, Davis, plays a global role in sustainability and climate change research on its campus, functioning as a living laboratory that develops, tests, and provides solutions to the world's problems through its botanical gardens, farms, and greenhouses.

The sustainability approaches at the University of California encompass a wide range. Sustainability policies and practices to achieve these goals are examined under twelve main headings: buildings, food and dining, zero waste, climate, laboratories, procurement, diversity, equity and inclusion, land management, transportation, energy, nitrogen footprint, and water. Under these headings, the university implements sustainability strategies. For energy, projects such as efficient lighting systems, thermal insulation, energy management systems, solar panels, and wind turbines are implemented, while water savings are achieved through water recycling and rainwater harvesting systems, and energy gains are achieved by replacing single-pass cooling systems with recirculating systems.

The University of California aims for a significant transformation in energy use. The focus in energy is to increase energy efficiency and move toward carbon neutrality, based on the core principles of the Sustainable Practices Policy. A significant portion of the university's energy consumption occurs in the central plants owned and operated by the campuses. With the determined steps, the university is working to reduce energy use and shift to cleaner energy sources while progressing toward its sustainability goals.

The university's energy-related policies encompass various strategies and practices in line with sustainability goals. These policies can be summarized as follows (UC, 2024):

- Adopting the Parksmart framework, a rating and certification program that aims to improve the design and operation of smart parking structures for more sustainable mobility within the campus, reducing operating costs, increasing energy efficiency, and improving lighting and ventilation.

- Designing or renovating campus buildings according to the LEED (Leadership in Energy and Environmental Design) standards, a green building rating system developed and managed by the U.S. Green Building Council.
- Achieving energy savings in air conditioning with Single-Pass Cooling, one of the best practices recommended by the International Institute for Sustainable Laboratories, the U.S. Office of Energy Efficiency and Renewable Energy, and the Environmental Protection Agency.
- Designing, constructing, and commissioning all new building projects to exceed energy efficiency standards by at least 20%, in line with Green Building Design.
- Reducing greenhouse gas emissions by reducing energy use and transitioning to Clean Energy sources.
- Implementing Energy Efficiency measures in all locations, buildings, and infrastructure systems.
- Installing Renewable Electricity Sources and Energy Storage Systems within the campus.

3. Conclusion and Suggestions

Universities play an important role in the adoption, implementation and dissemination of the concept of sustainability. In addition to the contributions they make by providing education and developing research and innovative solutions, in accordance with their job descriptions, they also serve as a model for sustainable applications for other settlements by using their campuses as a working, educational and living space as an application area.

In this context, energy-efficient approaches, as one of the important components of sustainability, are also important for universities and university campuses. Energy-efficient approaches cover a wide range of applications and sectors, from wireless sensor networks to industrial processes and cloud computing. These approaches offer important tools for reducing energy consumption, reducing carbon emissions and moving towards a sustainable future. Energy-efficient campus design requires conscious consumption of energy resources, reducing the use of fossil resources, giving importance to the use of renewable energy resources and highlighting approaches that will minimize energy consumption. In addition to their environmental and economic impacts, these approaches contribute to social welfare and the creation of efficient educational and living environments. Therefore, it will bring many benefits for university campuses to place the sustainability approach at the center of their operations.

Green metrics are essential tools for universities to measure their environmental impact and track their progress toward sustainability goals. Key topics and policies that universities can implement are summarized in the table below.

Table 2. Green metrics and its key topics and policies

Main Topics	Policies	Contents
Energy	Energy Consumption Tracking	• Accurately measuring energy consumption in various areas such as buildings, laboratories and dormitories • Identifying improvement areas by evaluating measurement results

		• Implementing energy saving initiatives such as LED lighting, efficient HVAC systems, etc.
	Energy Production	• Efficient use of renewable energy sources
Water	Water Quality Monitoring	• Monitoring water quality to ensure compliance with environmental regulations and identify pollution problems
	Water Usage Monitoring and Conservation Measures	• Water consumption monitoring • Rainwater harvesting • Drought-resistant landscaping etc.
Waste	Waste Stream Analysis	• Determination of types and amounts of waste produced
	Recycling	• Separation and transformation of recyclable waste • Composting
	Waste Reduction	• Reduction strategies such as reuse, sustainable purchasing, etc.
Transportation	Sustainable Transportation	• Promotion of sustainable transportation options such as walking, cycling, public transportation, and car sharing
	Sustainable Infrastructure	• Bike lanes, secure bike parking, and bike-sharing programs etc. • Charging stations for electric vehicles.

As a result of examining the energy policies of universities that stand out with their policies and practices regarding sustainability, it is observed that some approaches are common. These policies and practices are summarized in the table below.

Table 3. Sustainable universities and energy policies

Limiting Energy Demand/Reducing Fossil Fuel Use	• Building energy neutral buildings • Using electric vehicles and establishing charging infrastructure
Using Renewable Energy Sources	• Solar panels, • Wind turbines, • Biomass facilities, • Using geothermal energy.
Efficient Use of	• LED lighting,

Energy/Savings	• Changing roof and window materials/thermal insulation, • Energy auditing, monitoring, reporting, • Optimization of heating and cooling hours, • Use of modern technology, • Aquifer Thermal Energy Storage
Sustainable Energy Education and Research	• Educational programs, courses, projects, training/certification programs for different groups on sustainable energy

In general, the basic steps that universities that want to make progress in green metrics should follow at the beginning can be summarized as follows. By following these guidelines, universities can take important steps towards becoming more sustainable and environmentally responsible institutions.

- Conducting a detailed assessment of the current status in line with the headings given in Table 2 to assess the university's current environmental performance and identify areas for improvement.
- Establishing a sustainability committee to oversee environmental initiatives and coordinate interdepartmental efforts.
- Involving students in sustainability activities through courses, clubs, organizations, and volunteer programs.
- Collaborating with local governments, public institutions, NGOs, and other universities to share good practices and resources.
- Reporting on sustainability projects and progress to campus users, external stakeholders, and the public. Providing feedback through ongoing monitoring.

Universities should continuously invest in energy efficient technologies and support these technologies with effective energy management practices in order to increase energy efficiency and achieve sustainability goals. Regular reporting should be made in accordance with sustainability assessment criteria and strategic planning should be carried out in line with these reports. Sustainability and energy efficiency issues should be given more importance in education programs and students and staff should be made aware of these issues. These suggestions will help universities manage their sustainability efforts more effectively, create more environmentally friendly and energy efficient campuses in the future and will have direct positive effects for current and future generations.

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New Generation Campus Concept: A Reading-Mapping Experience Through Components and Spaces

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1. Introduction

"As a synergy environment, the campus is not only a center
where knowledge is produced, transferred and shared,
but also, a living, mobile, continuous, vibrant, identity-forming,
memory-producing and generation-transmitting
socialization and development mechanism.
While 21st century nations are struggling with
global crises and producing advanced technology,
the concept of CAMPUS is also evolving into a new era.
We will explore the new generation campus through spatial analysis."

From the introductory text of the workshop
"CAMPUS.OLOGY: Manifestations on a New Generation University"

In the context of the complex global issues and crises of the 21st century, the concept of the University, like every concept in which transformation is inevitable, has required a reorganization.

This book chapter, which focuses on the new generation university concept called 4.0 University and offers a conceptual framework, ends with the deciphering of a workshop setup and its final products that enable an original reading and mapping of the 4th Generation campus component; thus, reveals the current roles of the university concept from a theoretical and experimental framework.

In the most general terms, the university is an educational institution with an administrative and academic organization, and naturally; it has changed its shell and reorganized to undertake new roles in the face of economic, political, social, technological changes and developments and most importantly, scientific paradigm breaks in human history.

In this context, the text consists of two main parts:

1. a brief analysis of the missions, visions and roles undertaken by the university as an institutional organization from the first-generation university of the Middle Ages to the fourth-generation university of today's Information Age.

2. an evaluation of the findings of a thematic workshop titled *"CAMPUS.OLOGY: Manifestations on a New Generation University"* which allowed the participants to produce a manifesto through intellectual and spatial readings in the axis of a fiction where the components that constitute the new generation university are analyzed and examined in the background.

While the first quarter of the 21st century witnessed global crises, developments in information and communication technologies offered new opportunities for solving these crises. Digitalization, which describes the 21st century, provides opportunities for information sharing, collaborations, partnerships, and funds within a global network. At this point, the 21st century university -which interacts with different actors and sectors in a leadership position, produces creative, innovative ideas, inventions and products in the market through Research & Development, and assumes a motivating and society-transforming role as a value-creating institution- is in a new organization that increases the practical use of theoretical knowledge.

The Thematic Workshop, which is the subject of the text, was organized (1) to examine the concepts of university life experienced by students, who are the reason for the existence and backbone of the university, and the campus that creates a space for this multi-faceted life, (2) to read the campus through the basic components that a new generation university should have, (3) to express the obtained data visually and textually with a current analysis method, mapping, and to convey the ideas developed on the new generation campus organization in line with the obtained findings with a visual manifesto and thus (4) to create awareness in the students. In this context, the results envisaged by the organizers of the Workshop were achieved.

1.1. “University” as a Concept

Derived from the Latin term *"Universitas"* (the city where universal sciences are taught and produced) and corresponding to the concept of a guild - a guild of students or teachers, the word "university" carries the meanings of "a community of wise men who come together to share and pass on their wisdom" and "an institution that teaches knowledge to a whole".

Erdem (2000) begins his article titled *“Change in the Understanding of the University”* with the following words: “A university is not a glass palace; it is an institution that is accessible and shares the information it obtains with the society. Because science and knowledge are for everyone.” In his article titled *“The Changing Roles and Duties of the University in the Information Society”*, the author states that universities are cultural communication centers that play a leading and active role in the development, progress and prestige of societies, and in their economic and political life (Erdem, 2013).

The statements, which explain that the university as an institution is at the very center of social development, also describe the fact that the concept of the university is naturally and inevitably open to change and transformation. Today, we are talking about the concept of a new-generation university and its organization, which we can call the fourth generation, which has roles beyond its antecedent -three generations of universities.

At this point, the definition of university by UNESCO and the determinations regarding the new roles the university should undertake in the 21st Century can be analyzed. UNESCO (1995) defined “the important role of higher education” as follows:

- Social development,
- Economic growth,
- Supporting the production of competitive goods and services,
- Shaping and preserving cultural identity,
- Maintaining social ties,
- Fighting against poverty,
- Supporting a culture of peace.

The “new roles” that universities should undertake in parallel with social changes are framed by UNESCO (2000) as follows:

- To actively participate in the solution of major global, regional and local problems such as poverty, hunger, illiteracy, social exclusion, and increasing inequalities at international and national levels.
- To work tirelessly to advance sustainable human development, universal respect for human rights, equal rights for women and men, justice and the implementation of democratic principles in universities and society, and intellectual and moral solidarity through understanding, non-violence and peace-loving culture among nations, ethnic,

religious, cultural and other groups, especially by making alternative suggestions and recommendations.

- To work on protecting and supporting cultural diversity and developing intercultural understanding and harmony and mutual enrichment of cultures,
- To help students grasp the knowledge, skills, attitudes, values and abilities that will enable them to be guided as responsible and committed citizens.
- To change and transform themselves, to strengthen their ties with different levels and forms of education, and to increase the quality and effectiveness of education for all and the educational process in various aspects.

2. Paradigm Shifts in the Evolution of the University

2.1. First Generation University: Educational University

The first universities, along with their predecessors, emerged in Europe in the 12th century. The University of Bologna, founded in 1088, the University of Paris, founded in 1150, and the University of Oxford, founded in 1167, were church-centered institutions organized as guilds. The first university institutions, based on the Greek-Roman academic culture, have described a long historical period from the Middle Ages to the Age of Enlightenment as the "First Generation University Concept" (Erdem, 2016). According to this understanding, which focuses on education and training, the university aimed to "create critical professions" and "train people for the professions that society needs" through pre-service education.

2.2. Second Generation University: Research University

The concept of the modern university, which envisages the university to be open to all segments of society within the scope of equal opportunities, has defined the second-generation university by indicating a paradigm shift in the understanding of the university. In the modern university understanding, where the basic assumptions of the positivist/rationalist paradigm are valid, “scientific knowledge production” is essential and in this context, it is fundamentally organized on the mission of research. In order to create this research infrastructure, specialized chairs or institutes were established under the management of professors and emphasis was placed on postgraduate education. The modern university understanding, which is a nation-state institution, aimed for its students to develop as citizens of a nation-state that protects the cognitive structure of society with the worldview it imparts. The representative of the modern university, which focuses on the principle of free and universal education, was the Wilhelm von Humbold University, founded in Berlin in 1810 (Erdem, 2016).

2.3. Third Generation University: Entrepreneurial University

The second half of the 20th century points to another paradigm shift regarding the critical missions of the university concept. Especially after World War II, the political, economic, social, scientific and technological developments experienced worldwide have been a critical threshold for the university concept, and universities have begun to see themselves as responsible for problems experienced worldwide, especially social problems, beyond the mere understanding of “doing science”. The mission of developing solutions to these problems has led universities to assume an institutional entrepreneurial function, to work interdisciplinary with public and private sector institutions, foundations, associations, companies and such. Thus, to become “multiversity” by assuming a multi-institutional structure (Erdem, 2013). In this context, the second half of the 20th century, when international competition brought about by globalization gained momentum, witnessed the development of "university-industry cooperation" activities and the formation of entrepreneurial universities.

The second half of the 20th century witnessed another revolution: the “information revolution.” The information age defined by this revolution necessitated a society that needed individuals with “lifelong learning” and the “information literacy” skills required to continuously improve and update itself. The centers of information production for this society, called the “information society,” are, naturally, universities as academic research institutions.

The rapid development of information technology, its becoming cheaper and thus widespread with the information revolution; since it has eliminated the concepts of distance and borders in communication, it has also led to the transfer of the concept of university from a local dimension to a global dimension, and this globalization has created new forms of mobility that do not depend on the displacement of students and academics. In this way, university students can join, register and receive degrees in the educational programs of other countries by using virtual education techniques without going to these countries. (Günay, 2007 and Rehber, 2007). This situation can be described as a groundbreaking transformation in the concept of university: conceptually, the university now has the potential to transform all areas of life in the 21st century.

This internationalization of higher education defines a new type of "institutional mobility" by allowing universities in developed countries to provide education in campuses they have opened in other countries (branch-campus model) and two or more countries to come together to establish a common higher education institution (Çetinsaya, 2014).

Universities that have adopted the entrepreneurial university mission within the knowledge economy required by the information age have begun to form their staff in a way that they can commercialize the results of their scientific research. New technologies, the expectations of new student profiles (diversified age groups with the ideal of lifelong learning, working students, globalizing students), profit-oriented corporate universities, virtual universities, market-oriented competitiveness and the ambition for success triggered by competition, etc. have been the factors that define the entrepreneurial university (Scott, 2002).

Gürüz (2001) stated that the concept of the modern university has evolved into the concept of the contemporary university and defined the role of the university today as follows:

> *Today's universities are institutions that determine the types and areas of their activities according to the needs and expectations of the society and the resources allocated to them. Therefore, the contemporary university is an institution with an extraordinarily complex structure that is integrated with all segments of the society, whose responsibilities to the society in terms of its activities are monitored and whose activities are directed by the society, which creates additional financial resources by evaluating all the facilities, equipment, knowledge and*

manpower it has with an entrepreneurial mindset, and which is managed with contemporary management techniques.

Neo-liberal policies and practices have been largely influential in the emergence and development of the entrepreneurial university concept. İbicioğlu et al. (2010) states that the entrepreneurial university undertakes a mission that aims to train students as "entrepreneurial" career candidates, encouraging them to participate in commercial activities in different fields of activity, thus ensuring that the theoretical knowledge taught is put into practice.

Yavuz (2012), who states that the third generation Entrepreneurial University should cooperate with the industry and that this cooperation aims to create income diversity in the pre- and post-production stages, compared to the second-generation Modern University model, emphasizes that the entrepreneurial university should increase its autonomy against the state by establishing a relationship with the state through indirect mechanisms.

Etzkowitz (1983) created the theoretical framework of the Entrepreneurial University concept with the definition of "a university that provides new sources of financing through activities such as cooperation with a private enterprise, contract research, and patents".

Slaughter and Lselie (1999) argue that in the Entrepreneurial University approach, where universities began to be managed like large companies, higher education institutions began to approach scientific knowledge as a commodity that was offered and sold to the market, and that in this context, this market was the criterion that determined issues such as which courses would be given, which research would be supported, which student profile would be served, and which registration policy would be adopted.

Odabaşı (2006) stated that in order for a university to be considered entrepreneurial, in addition to the basic condition of being "innovative", it must also meet criteria such as creativity, adaptation to change, risk taking, pioneering and competitive thinking.

Schulte listed the objectives required for a higher education institution to be considered an Entrepreneurial University as follows (2004:188):

- To train graduates who are not job seekers but job creators,
- To make entrepreneurship an interdisciplinary research topic,
- To ensure that the research conducted is not only for scientific publications but also to be the source of innovations in society and economy and the starting point for developing business ideas for new businesses.

Robertson (2008) enlists the "keywords" of the entrepreneurial university as follows:

- Strong leadership that develops the entrepreneurial capacities of all university actors
- Strong connections with external stakeholders that create added value, university-industry collaboration
- Entrepreneurial outcomes that will have widespread impact on individuals and institutions
- Innovative learning techniques that enable entrepreneurial actions
- Support for effective information flow between institutions
- Multidisciplinary educational approaches that focus on solutions to complex global problems and reflect real-world experience

Wissema (2009), who emphasizes that a university can become an entrepreneurial university if it expands its goals based on education, training, research and social responsibility and transforms itself into a new institution that "creates value" and "contributes" to the development of the region in which it is located, lists the qualities that third-generation universities should have as follows (Table 1):

- Scientific research is the basic principle.
- For institutes with transdisciplinary knowledge units focused on special areas of interest, interdisciplinary consensus and creativity issues should be the driving force.
- Thanks to its technical knowledge, it should create a network that can cooperate with industry, research and development organizations, financiers, professional service providers and other universities.
- It should compete to recruit well-equipped academics and students, as it will be in an internationally competitive market.
- It should produce groundbreaking and applicable scientific studies.
- It should also give importance to artistic fields that are not considered scientific.
- It should be multicultural and cosmopolitan, operating in an international environment, hosting a large number and variety of staff and student profiles, and where the common language is the universal language, English.

- In addition to traditional basic purposes such as research and education and research, it should adopt the principle of transferring the value of the knowledge it produces to the society.
- In order to have an autonomous structure that is not under state control, education funds must be transferred through independent intermediaries.

Table 1. Three generations of universities and their comparative characteristics (Wissema, 2009).

Aspect	First generation universities	Second generation universities	Third generation universities
Goal	Education	Education and research	Education, research and utilization of knowledge
Role	Protection of truth	The cognition of nature	Creation of added value
Output	Professionals	Professionals and scientists	Professionals, scientists and entrepreneurs
Language	Latin	National	English
Management	Chancellor	Part-time scientists	Professional management

The most important component of the entrepreneurial university approach is the Technopark formations where university-industry cooperation is concretely experienced. Third generation entrepreneurial universities; in line with the targets such as converting the knowledge and Research & Development accumulation of entrepreneurial university faculty members into economic value, i.e. production, increasing employment opportunities and creating new business areas; have established university-industry cooperation through Technopark formations by cooperating with local governments (Kiper, 2010).

2.4. Fourth Generation University: Transformative University

The first quarter of the 21st century describes a process in which information and communication technologies have penetrated into every aspect of life, and this process is called Digital Transformation. Digitalization and the Industry 4.0 project put forward by the German Government have led to the emergence of the concept of University 4.0. University 4.0 has become a concept that represents the need for a new university organization by making radical changes in higher education, as in many other areas, and has indicated a paradigm shift for the new generation of universities.

The digitalization that we have experienced in the globalizing world in the 21st century has also triggered rapid technological developments, and in this context, it has inevitably required the re-questioning of the functions and roles of universities and their transformation into institutions that go beyond keeping up with the times and shaping the modern era (Pawłowski, 2009; Zuti and Lukovics, 2015; Lapteva and Efimov, 2016).

The fourth-generation university is expected to have the following features, in addition to the components of the third-generation university, and to have a transformative feature beyond entrepreneurship:

- Providing uninterrupted learning opportunities through different channels, such as traditional, blended/multi-channel or online,

- Opening short-term training and certification programs that include diversity in order to gain professional qualifications,
- Providing opportunities for students' career management and skill development,
- Transforming universities into innovation areas,
- Providing part-time positions within the university to professionals and artists with different profiles working in a wide range of different sectors
- Similarly, providing part-time work opportunities for scientists in academia,
- Creating uninterrupted connections and support programs between industry, researchers and students,
- Encouraging undergraduate and graduate students to take an active role in social activities,
- Making interdisciplinary study models mandatory,
- Becoming locomotives in local dynamics in line with global and local goals of universities,
- Producing motivation and driving force for society to create value beyond creating a value,
- Raising not only professionals but also politicians, managers, entrepreneurs and intellectuals who can guide society.

Yıldız Aybek (2017); presents a diagram expressing the Components of University 4.0 in her article titled "Transition Process to University 4.0: A Conceptual Approach", (see Figure 1). The components that the author gathered under three groups:

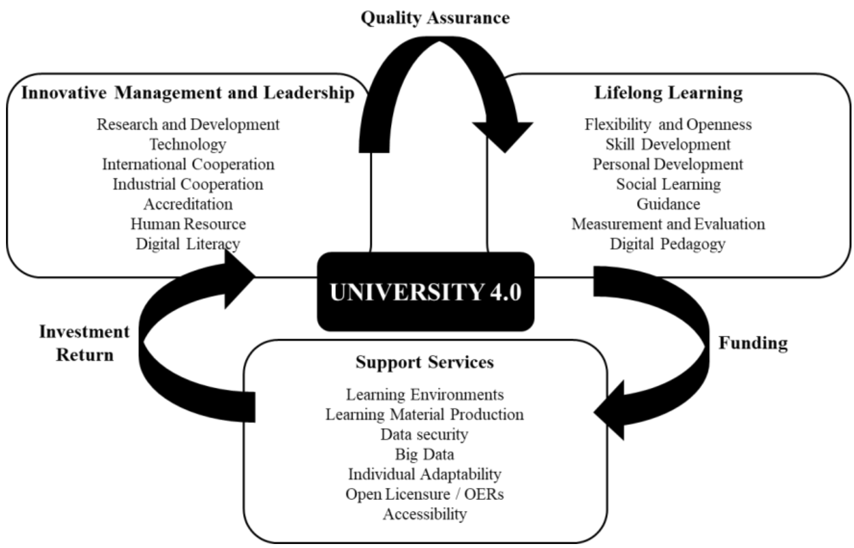


Figure 1. Components of University 4.0 (Aybek, 2017). (The scheme developed by Aybek was translated from Turkish to English by the authors).

Innovative Management and Leadership

This component emphasizes that university education should be managed with innovative and visionary strategies. Since the number of professions requiring expertise is increasing in the 21st century, goals such as training professionals who are qualified for the age, prone to an interdisciplinary work culture, and able to adapt to change, organizing joint programs and events with other sectors and especially industrial branches, providing an infrastructure suitable for a digital university, and adopting a management and leadership approach that produces sustainable approaches should be developed.

Lifelong Learning

Since digital technologies provide individuals with flexibility in terms of time and space and enable the use of different tools for learning, a university that is a candidate to be the fourth generation needs to determine strategies on how to manage these tools with which learning approaches and methods; and how to make them more effective and efficient. In this context, it should provide guidance and assessment services that increase access, monitor, direct and even offer individualized environments by effectively implementing digital technologies throughout the lifelong learning process.

Support Services

Digital strategies need to be developed and updated in order to manage digital processes. In this process, it should not be enough to analyze big data and present the results; processes and applications should be developed in the context of these results and systems that can be adapted to the individual should be offered. The learning environments offered to students should be checked in terms of course material, accessibility, data security, user satisfaction, etc., and materials that include video, audio, animation and interactive applications in addition to written resources should be developed by "expert teams". Common course material pools should be open to contributions and use with common licensing standards. Providing this infrastructure and opportunities can also provide significant support for universities that do not have financial means.

3. Material and Method

The overarching aim of the *"CAMPUS.OLOGY: Manifestations on a New Generation University"* workshop was to ignite the consciousness of young adults (of the Faculty of Architecture) for the new paradigm of higher education concepts and spaces. Thus, they would enable 'the design critique' persona within themselves. Workshops offer vibrant, fast-moving, fast-thinking, thought-provoking tools that are tailored to create a shift in a designer's mindset in a fast-effecting way. In this regard, this tool was chosen as the primary methodology for this mission.

The subjects of this study were chosen from fourth-year Urban Design and Landscape Architecture students from Amasya University Faculty of Architecture and second-year Urban Design and Landscape Architecture, Architecture, and Interior Design students from Istanbul Medipol University Faculty of Fine Arts, Design and Architecture. The rationale was to exchange and cooperate with students and professors from different backgrounds.

The framework of the workshop was structured as pre-site (pre-Istanbul) and on-site (at Istanbul) Works. **Pre-Istanbul Works: Module 0** was an introduction to fourth-generation university to fourth year Urban Design and Landscape Architecture students of Amasya University. Besides, worldwide universities are revisited in terms of their philosophy and assets in higher education. The discussion was moderated by the mentors.

Pre-Istanbul Works: Module 1 was a process to call out Istanbul Medipol University Faculty of Fine Arts, Design and Architecture students to question the issue in a fast-paced and diverse workshop environment. Next, pre-decided fourth-generation university dimensions (below) were introduced to the participants.

- interdisciplinary collaboration
- digital development & artificial intelligence
- participation
- entrepreneurship
- innovation

Following, the participants were asked to participate in a dimension-themed group of their choice. **Pre-Istanbul Works: Module 2** unfolded the workshop's aim and served as a meet and greet platform for two universities' students online. Also, the pilot study results (on-site interview) for Amasya University campus were shared.

Istanbul Works: Module 3 started with Prof. Dr. Emel Birer 'Campus and the Invisible Codes', Assoc. Prof. Dr. Deniz Aslan 'Campus and the Landscape', and Assist. Prof. Dr. Pınar Çalışır Adem 'Mindmap for Designers' seminars. The seminars followed by field trips in the quest for the fourth-generation campus idea and space. **Istanbul Works: Module 4** was a desk-based group work with conducting conceptual research of the selected dimension. The following task was to create a conceptual mind map that would form the basis of a set of interview questions. In **Istanbul Works: Module 5,** the participants were asked to create a set of semi-structured face-to-face interview questions, conduct interview sessions with Istanbul Medipol University students, and visually record (took snapshots of the places mentioned in the interview) the places where the interviewee mentioned. For **Istanbul Works: Module 6** task, the workshop participants were asked to create a digital collage -that accentuates the vertical spine of the spatial organization of the campus environment- based on the responses from the interviewees. Eventually, **Istanbul Works: Module 7: Manifestations** were produced as a digital collage which resolved the essence of each dimension and bring out the future opportunities to enhance the campus environment based on the dimension.

4. Findings and Discussion

The findings of five themed group the findings are as follows.

4.1. Interdisciplinary Collaboration

The concept of interdisciplinary collaborations includes (Repko et al., 2020);

- Part-time positions for industry 'residents', artists and employees of government, community or other knowledge institutions,
- Part-time employment of scientists in positions outside the university,
- Interdisciplinary teams with hackathon sessions,

In this context, the mind map of **Interdisciplinary Collaboration** reveals that (Figure 2) user groups, activities, spaces, shared / common areas are interconnected, and these concepts are inevitable for the ideal collaboration in a campus environment. As much as spatial and activity-based concepts come forward in the mind map, the time and frequency factors also affect the quality of interaction for the collaboration. Based on the conceptual research '**Interdisciplinary Collaboration Team'** created a set of semi-structured interview questions that search for 'when, where, and how' the user experience is affected by (Table 2).

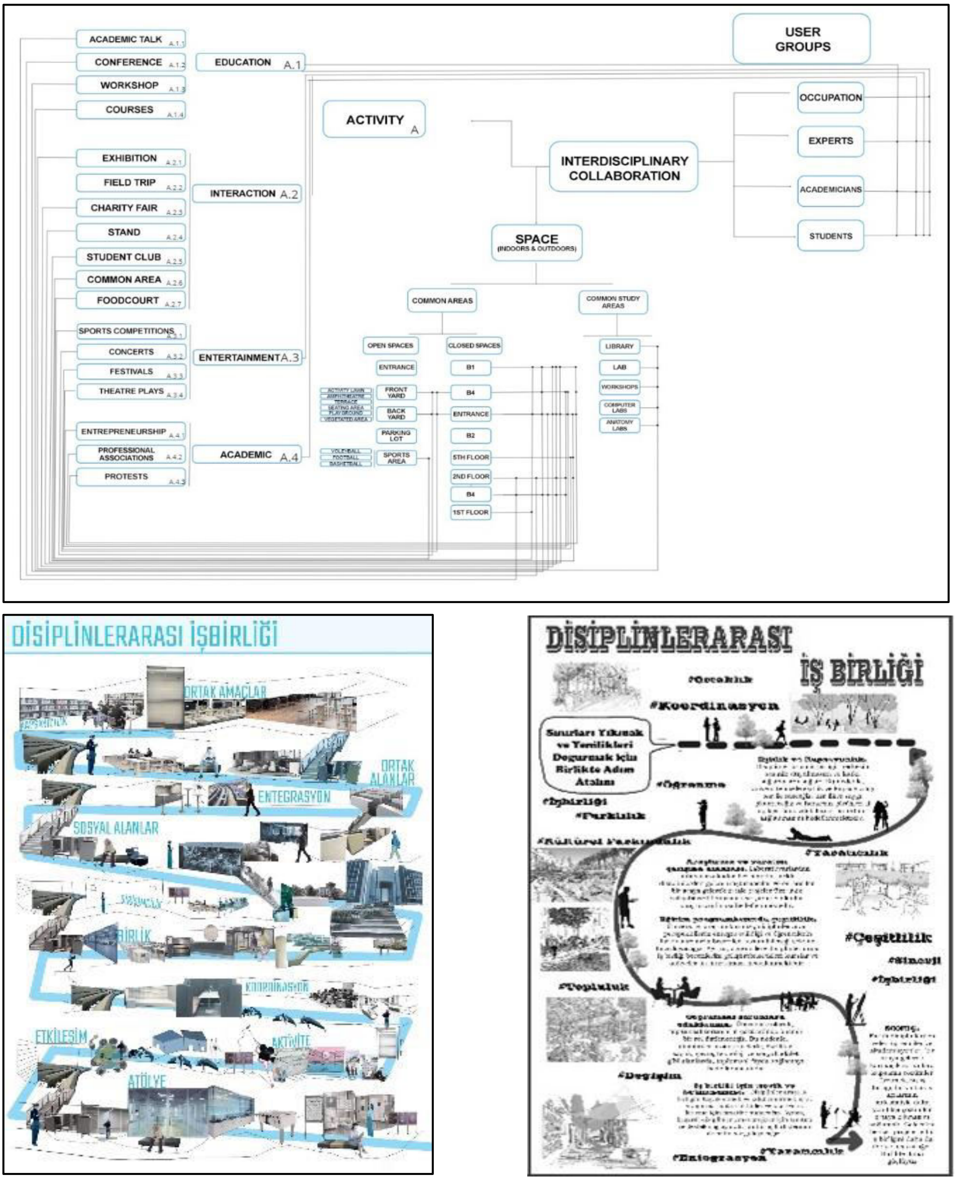


Figure 2. Interdisciplinary Collaboration Conceptual Mind Map (top), Interdisciplinary Collaboration at Existing Places (bottom left) and Manifestations for Enhancing Interdisciplinary Collaboration (bottom right) at Istanbul Medipol University, South Kavacik Campus (Zehra Peker, Emir Furkan Doğan, Ece Güleç, Azra Baytar, Esra Toprak, Zeynep Topal, Esmanur Kılıç)

Table 2. Semi structured Face to Face Interview Questions for Interdisciplinary Collaboration (Zehra Peker, Emir Furkan Doğan, Ece Güleç, Azra Baytar, Esra Toprak, Zeynep Topal, Esmanur Kılıç) (Table created by the authors

Information to be Addressed		**Semi structured Face to Face Interview Questions (Table created by the authors)**
Conceptual definition / Activity / User Groups	**A**	We are working at a fourth-generation university. What do you understand by "interdisciplinary collaboration"?
Space	**B**	What are the venues that encourage students from different departments to come together and work on joint projects? What are they?
Space	**B.1**	What kind of venue would you suggest for such an event? (for example, a courtyard like this)
Time frame	**B.2**	How often do you find yourself in these spaces? (e.g. impromptu, once a week, after class)
Space	**C**	Where do you think are the places on campus where people from different departments can interact? Can an open-minded/non-prejudiced collaboration be established? In what kind of a place? Why this place?
Space & Equipment	**D**	What kind of space should there be to develop our skills and abilities while collaborating across disciplines? And what kind of equipment is required?
Activity	**E**	Do you collaborate with students or institutions from other departments in your department? What disciplines on your campus could support your department when you come together?
Space	**E.1**	Where? Why this location? Are there any potential locations?
Time frame	**E.2**	When? How often?
Activity & Space	**E.3**	Do you think these spaces are adequate for a meaningful collab? What are the problems encountered in the use of common spaces?
Space	**E.4**	So where should it be? (Future-oriented)
Activity & Space & Time frame	**E.5**	Do you do joint projects with students from other departments or institutions? Where and when?
Activity & Space & Time frame	**E.6**	Do you take joint courses with students from other departments or institutions? Where and when?
Activity	**F**	What kind of events bring different disciplines together on campus? (e.g. sports activities, social, charity bazaar)
Activity & Space	**F.1**	Where do these events take place? Why should they be in this location? (E.g. easy access, opportunities to socialize and meet students)
Space	**F.2**	Where should it be?
Time frame	**F.3**	When should it be?
Space	**G**	In which of the public areas on campus (library, laboratory, garden, ground floor, etc.) do you find yourself most productive?
Space	**G.1**	Which of these places do you have place attachment to?
Activity & Space & Time frame	**H**	Are there any factors that prevent people from coming together in common areas (foyer, garden, library, studios, conference hall)? Where do you encounter these problems the most?
Space	**I**	Are there areas open to periodic (changing, transforming) use for carrying out joint work?
Space	**J**	What are the contributions of coworking spaces to interdisciplinary collaboration?

The interview questions were directed to students studying in Architectural Restoration, Management Information Technologies, Interior Architecture, Pharmacy, English Language Teaching, Psychological Support & Rehabilitation, Architecture, Psychology, Interior Architecture, Medicine. In the semi-structured face-to-face interviews, it was observed that the most emphasized keywords/terms were 'interdepartmental, collaboration, teamwork' regarding the functioning of the concept, 'communication, togetherness, helping' regarding the action of the concept, and 'university environment' regarding the spatial dimension of the concept. The participants stated that the available spaces for interdisciplinary collaboration are concentrated in the open public spaces, classrooms, workshops, laboratories, and workshops located in the Garden, Ground Floor, Library, and B5 Floor (Figure 2). The manifestation for Interdisciplinary Collaboration is presented in Table 3.

Table 3. Manifestations on Interdisciplinary Collaboration based on Figure 2 (Zehra Peker, Emir Furkan Doğan, Ece Güleç, Azra Baytar, Esra Toprak, Zeynep Topal, Esmanur Kılıç)

	Interdisciplinary Collaboration (Table created by the authors)
Manifestation #1	Equality and inclusiveness: Interdisciplinary collaboration ensures that everyone's voice is heard and contributes. Therefore, we will promote equality and inclusiveness in our university, respect every opinion, and aim to provide an environment where everyone can express their views openly.
Manifestation #2	Research and creative workspaces: From laboratories to studios, it is aimed to create flexible and creative spaces where researchers and students from different disciplines can come together and work on joint projects.
Manifestation #3	Diversity in educational programs: We will design our university programs in a way that integrates interdisciplinary perspectives and allows students to gain skills in different areas. In addition, it is aimed to create courses and workshops where students can develop interdisciplinary collaboration skills.
Manifestation #4	Focus on social problems: As a university, we will play an important role in solving social problems. Therefore, interdisciplinary projects aim to provide social benefit, especially in areas such as health, environment, technology, and social justice.
Manifestation #5	Incentivize and Reward Collaboration: We will provide research funding, awards, and opportunities for academic advancement to encourage and reward interdisciplinary collaboration. We will also emphasize the importance of such collaborations by providing promotion and support for successful interdisciplinary projects.

Manifestation #6	It is aimed to bring together students and academics from different disciplines to produce comprehensive solutions to complex problems. This collaboration aims to provide more innovative solutions by combining different perspectives. We will take this collaboration even further with similar projects

4.2. Participation

The concept of participation is elaborated as (Barr & McNamara, 2022);

- The role is not just to create value, but to allow the local network to create value, so the university becomes a facilitator and motivator.
- Undergraduate and graduate student teams and PhD participation in comparative or global games on societal challenges,
- The university has a partly global focus but has a strong local network and is a helpful driver of its local ecosystem,

In this context, the mind map of **Participation** reveals that (Figure 3) democratic mechanisms, societal, administrative, social and academic bodies as well as technologic infrastructure are interconnected, and these concepts are inevitable for the ideal participation in a campus environment. The interview questions were directed to students studying in Aviation Management, Media and Visual Arts, Nursing, Pharmacy, Architecture, Interior Architecture, Landscape Architecture. In the semi-structured face-to-face interviews (Table 4), it was observed that the most emphasized keywords/terms were ‘initiative, participating, interaction’ regarding the concept; ‘social media’ regarding the functioning mechanism of the concept, and ‘open public spaces’ regarding the spatial dimension of the concept. The participants stated that the available spaces for participation are concentrated in the Garden, Ground Floor, Food court and B1 Floor. The manifestation for ‘Participation’ is presented in Table 5.

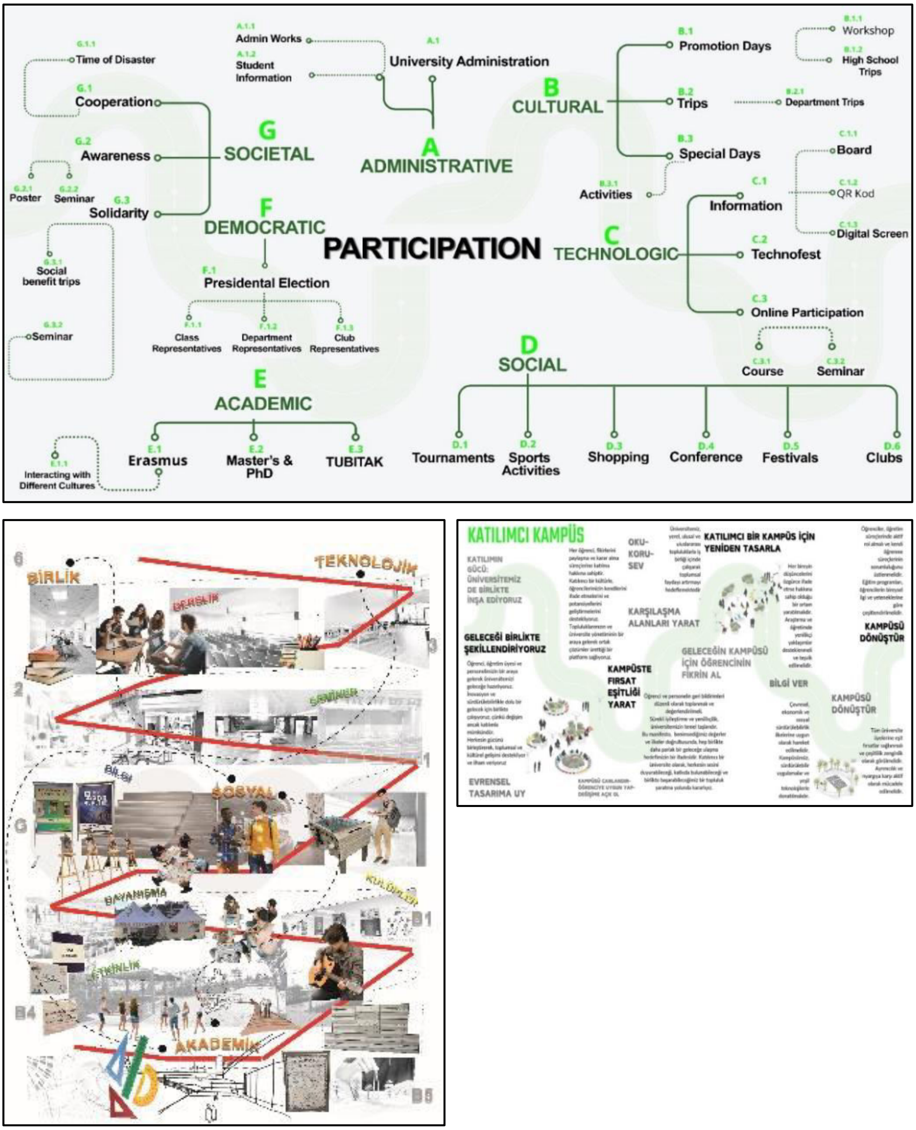


Figure 3. Participation Conceptual Mind Map (top), Participation at Existing Places (bottom left), Manifestations for Enhancing Participation (bottom right) at Istanbul Medipol University, South Kavacik Campus (Beyza Öztürk, Esra Kavaklıoğlu, Ata Ketken, Beyza Nur Turunç, Zeynep Sude Ayık, Eda Yazıcı, Burak Arvasi)

Table 4. Semi structured Face to Face Interview Questions For 'Participation' (Beyza Öztürk, Esra Kavaklıoğlu, Ata Ketken, Beyza Nur Turunç, Zeynep Sude Ayık, Eda Yazıcı, Burak Arvasi) (Table translated and created by the authors)

Information to be Addressed		**Semi structured Face to Face Interview Questions (Table created by the authors)**
Concept	**A**	What is participation? What does participation mean to you?
Concept, Space	**B**	When participation is mentioned, which places come to mind?
Space	**C**	Where do you get the news from at the university?
Space	**D**	Which places contribute to the creation of a participatory environment at our university?
Time	**D.1**	How often do you use these places?
Activity	**E**	How do you find the communication and cooperation between students on your campus?
Space & Activity	**E.1**	Where do you provide communication and cooperation the most?
Concept	**E.2**	How can we strengthen communication and cooperation?
Concept & Space	**F**	What is your biggest challenge in campus life?
Space & Time	**F.1**	When and where do you experience the most difficulty?
Concept	**F.2**	Do you have any suggestions for a solution to this challenge?
Activity	**G**	What are the common points of club representatives in their activities?
Activity	**G.1**	What is your news source for these events?
Space	**H**	Where do you spend the most time on campus?
Space	**I**	What are the events and activities you enjoy the most in campus life?
Space & Activity	**I.1**	Where do you learn about these events and activities?
Concept	**J**	What can be done to increase social life on campus?
Space	**J.1**	Where can it be done?
Space	**K**	Which of the places or facilities on your campus do you use the most?
Time frame	**K.1**	When do you use them?
Activity	**L**	How do you communicate with Erasmus, masters, and doctoral students at the school?
Space	**L.1**	Where do you get information about these programs?
Activity & Concept	**M**	In what cases do you participate in the school administration?
Concept	**M.1**	Is school information sufficient for you?

Table 5. Manifestations on 'Participation' based on Figure 3 (Beyza Öztürk, Esra Kavaklıoğlu, Ata Ketken, Beyza Nur Turunç, Zeynep Sude Ayık, Eda Yazıcı, Burak Arvasi) (Table translated and created by the authors)

	Participation (Table translated by the authors)
Manifestation #1	We prepare our university for the future by bringing together our students, faculty and staff. We work together for a future full of innovation and sustainability, because change is only possible through participation. By combining the strengths of everyone, we support and inspire social and cultural development.
Manifestation #2	Every student has the right to share their ideas and participate in decision-making processes. We support our students to express themselves and develop their potential with a participatory culture. We provide a platform where our communities and university administration come together to produce common solutions.
Manifestation #3	Student and staff feedback should be regularly collected and evaluated. Continuous improvement and innovation are the cornerstones of our university. We are committed to creating a community where everyone can have a voice, contribute, and live together.
Manifestation #4	Our university aims to increase social benefit by working in collaboration with local, national and international communities.
Manifestation #5	An environment should be created where every individual has the right to express their thoughts freely. Innovative approaches in research and teaching should be supported and encouraged.
Manifestation #6	We must act in accordance with the principles of environmental, economic and social sustainability. Our campus must be equipped with sustainable practices and green technologies.
Manifestation #7	Students should take an active role in the teaching process and take responsibility for their own learning processes. Educational programs should be diversified according to the individual interests and abilities of the students.
Manifestation #8	Equal opportunities should be provided to all university stakeholders and diversity should be seen as an asset. Discrimination and prejudice should be actively fought against.
Slogans	we shape the future together; create equal opportunities on campus; comply with universal design; read-involve-protect; create encounter areas; get students' opinions on the campus of the future; redesign for an inclusive campus; give information; transform the campus
Hashtags	None

4.3. Entrepreneurship

The concept of entrepreneurship includes (Oztel, 2019; Leih & Teece, 2016);

- Strong leadership that develops the entrepreneurial capacities of all university actors on campus,
- Establishing strong ties with external stakeholders that create added value, increasing university-industry collaboration,

- Creating entrepreneurial outcomes that impact individuals and institutions,
- Implementing innovative learning techniques that lead to entrepreneurial action,
- Removing boundaries to support effective information flow between institutions,
- Multidisciplinary educational approaches that focus on solutions to complex world problems and reflect real-world experience,
- Encouraging entrepreneurial thinking and leadership practices.

In this context, the mind map of **Entrepreneurship** reveals that (Figure 4) technology, leadership, interaction and space are interconnected. These concepts are inevitable for the ideal entrepreneurship practices in a campus environment. The interview questions were directed to students studying in Landscape Architecture, Architecture, Law, Engineering, Radio and Television, Medicine, Interior Design. In the semi-structured face-to-face interviews (Table 6), it was observed that 'Technology Transfer Office, Labs, Studio and Workshop spaces' emerged as the common spaces for entrepreneurial activities.

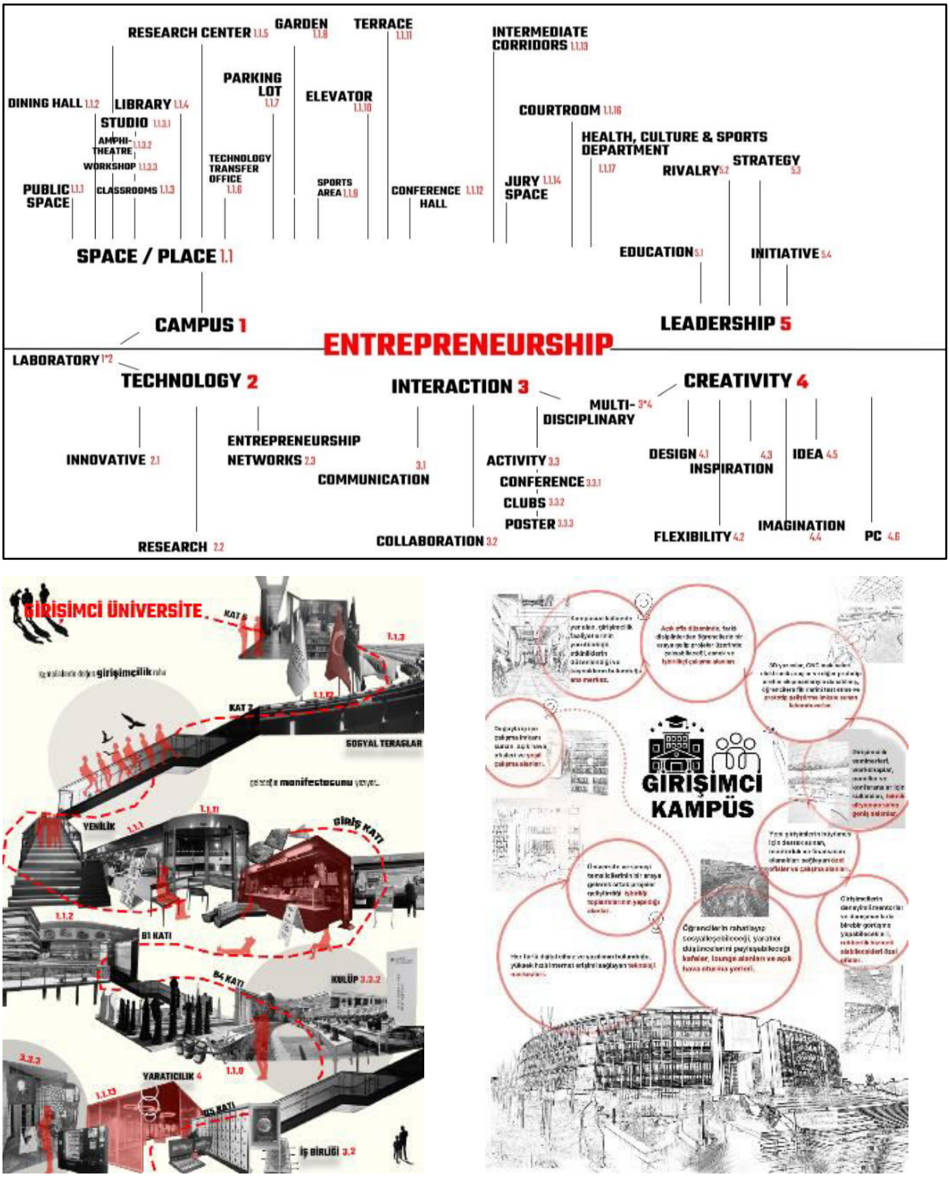


Figure 4. Entrepreneurship Conceptual Mind Map (top), Entrepreneurship Concept at Existing Places (bottom left), Manifestations for Enhancing Entrepreneurship (bottom right) at Istanbul Medipol University, South Kavacik Campus (Öykü Şen, Melike Çabuk, Sudenur Karabacak, Seda Yıldız, Dilara Yaşar, Pınar Arslan, Durukan Altun)

Table 6. Semi structured Face to Face Interview Questions for Entrepreneurship (Öykü Şen, Melike Çabuk, Sudenur Karabacak, Seda Yıldız, Dilara Yaşar, Pınar Arslan, Durukan Altun) (Table created by the authors)

Information to be Addressed		**Semi structured Face to Face Interview Questions (Table created by the authors)**
Concept	**A**	Is there an entrepreneurship-related club or student union at our university?
Concept, Stakeholder	**A.1**	Which departments come together in student clubs?
Place, Space	**A.2**	Which venue do you prefer?
Place, Space, Activity	**B**	Which types of events held in entrepreneurial venues provide you with the opportunity to interact with the most participants?
Activity	**B.1**	Which entrepreneurship-related events are organized in the university's public spaces?
Activity, Space	**B.2**	How do different disciplines work together in the shared work areas on campus?
Place, Space	**B.3**	Where are the shared work areas of different disciplines?
Place, Space	**B.4**	Which space do you think is the least productive on campus?
Concept, Activity, Spatial organization	**B.5**	What do you suggest making this unproductive space productive?
Place	**C**	In which venues do you find the most productive networking opportunities?
Place	**C.1**	Where are the places where students interact the most?
Place	**D**	In which venues on campus do you find the opportunity to communicate with students or faculty members?
Place	**D.1**	Where are the jury meetings held?
Concept, People	**D.2**	Is it possible for other departments to participate in the jury and watch?
Place	**D.3**	If the venue is not suitable, do you have a suggestion for a venue?
Activity	**E**	Does the university provide you with opportunities regarding entrepreneurship and innovation?
Place	**E.1**	Where does it provide opportunities?
Place	**E.2**	Can you suggest a venue?
Activity	**F**	You want to conduct an entrepreneurship activity at school. Which department's academics would you contact for this?
Activity, Place	**F.1**	How would you announce this entrepreneurship activity?
Space	**G**	Where are the areas that you can apply the knowledge, you have acquired in theory in practice?

Table 7. Manifestations on ‘Entrepreneurship’ based on Figure 4 (Öykü Şen, Melike Çabuk, Sudenur Karabacak, Seda Yıldız, Dilara Yaşar, Pınar Arslan, Durukan Altun) (Table created by the authors)

	Entrepreneurship
Manifestation #1	A main hub located in the heart of campus, where entrepreneurial activities are carried out, events are organized, and resources are located.
Manifestation #2	Flexible and collaborative workspaces in an open office layout where students from different disciplines can come together and work on projects.
Manifestation #3	Laboratories equipped with 3D printers, CNC machines, electronic tools and other prototype production equipment, providing students with the opportunity to test their ideas and develop prototypes.
Manifestation #4	Open-air offices and green workspaces that offer the opportunity to work in touch with nature.
Manifestation #5	Large halls with technical infrastructure used for entrepreneurship seminars, workshops, panels and conferences.
Manifestation #6	Private offices and workspaces that provide support, mentoring and financing opportunities for new ventures to grow.
Manifestation #7	Private offices where entrepreneurs can meet one-on-one with experienced mentors and advisors and receive guidance services.
Manifestation #8	Cafes, lounge areas and outdoor seating areas where students can relax, socialise and share their creative thoughts.
Manifestation #9	Technology centers that provide high-speed internet access and all kinds of digital devices and software.
Slogans	None
Hashtags	None

The participants stated that the available spaces for entrepreneurship are concentrated at the Terraces, Ground Floor, B1 and B4 Floor, Student Club Areas. The manifestation for ‘Entrepreneurship’ is presented in Table 7.

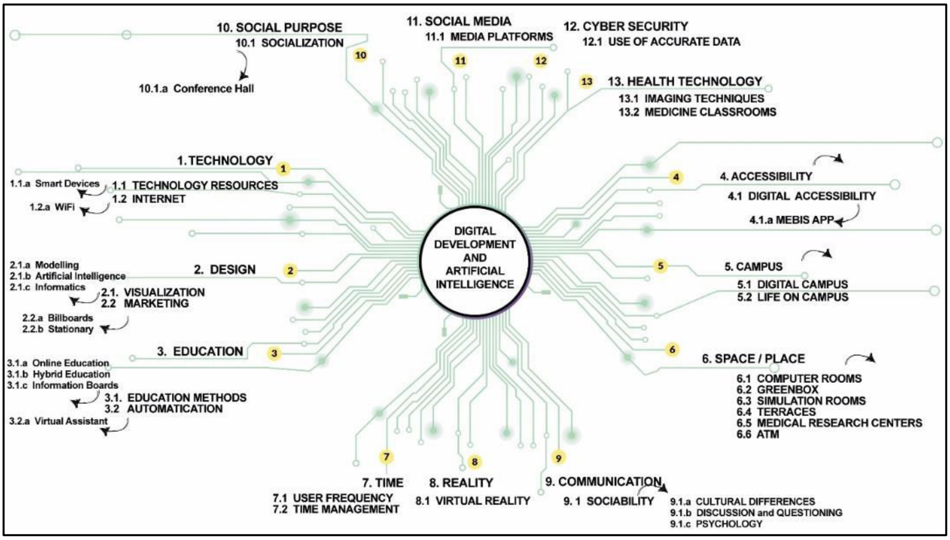
4.4. Digital Development and Artificial Intelligence

The concept of digital development and artificial intelligence includes (Yavuz, Kayalı, & Karaman, 2023; Cantú-Ortiz et.al., 2020);

- Digital Campus is the emergence of new opportunities through innovative technologies to enhance the on-campus teaching and learning experience in universities.

- Digital Students are young adult students who have grown up actively using technology as part of their lives.
- Digital Educators are individuals who have digital skills to educate students in a technology-supported and lifelong learning environment.
- Digital Education is an educational system that uses technology and offers a wide range of teaching opportunities, including face-to-face, blended and online learning efforts.
- Digital Research consists of the processes of research, the production, dissemination and presentation of knowledge to the service of society.
- Digital Culture is defined as a set of beliefs, values and assumptions shared by the employees of the institution regarding digital technologies.

In this context, the mind map of **Digital Development and Artificial Intelligence** reveals that (Figure 5) accessibility, space, cyber security, communication, sociality, design, education are interconnected. These concepts are inevitable for the ideal digital development and artificial intelligence practices in a campus environment.



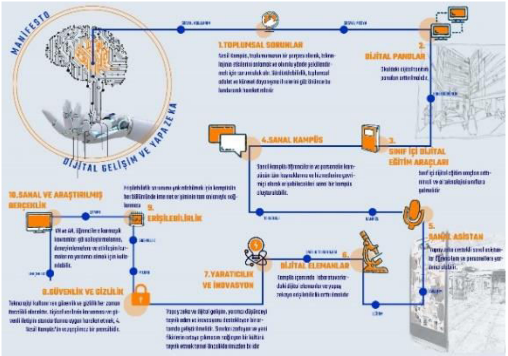


Figure 5. Digital Development and Artificial Intelligence Conceptual Mind Map (top), Digital Development and Artificial Intelligence at Existing Places (bottom left), Manifestations for Enhancing Digital Development and Artificial Intelligence (bottom right) at Istanbul Medipol University, South Kavacik Campus (Su Gürler, Taha Eren Karataş, Esmanur Güç, Ebru Durduran, İsmail Emir Altunbaş, Göktuğ Kayabaş, Zeynep Uyumaz, Şevval Yıldız)

Table 8. Semi structured Face to Face Interview Questions for 'Digital Technology and Artificial Intelligence' (Su Gürler, Taha Eren Karataş, Esmanur Güç, Ebru Durduran, İsmail Emir Altunbaş, Göktuğ Kayabaş, Zeynep Uyumaz, Şevval Yıldız) (Table created by the authors)

Information to be Addressed		Semi structured Face to Face Interview Questions (Table created by the authors)
Concept, Materials, Infrastructure	**A**	What are the technology opportunities in your department?
Concept, Materials, Infrastructure	**A.1**	What are the technology opportunities in your school?
Space	**A.2**	Where are they used?
Space	**B**	How often do you use media for presentations?
Time frame	**B.1**	At what points do you use these media content?
Space	**B.2**	When do you use these media content?
Space & Equipment	**C**	Where are the internet access points at your school?
Activity	**C.1**	How often do you use these access points?
Space	**D**	In which of your courses do you use online education methods?
Time frame	**D.1**	Where do you use these education methods?
Activity & Space	**D.2**	When do you use these education methods? (D2)
Space	**E**	Do you use social media opportunities in your department?
Time, Time frame	**E.1**	How often do you use them?
Place, Space, Activity	**E.2**	Where do you use them?
Concept, Activity	**F**	Do you produce social media content on campus?
Time, Time frame	**F.1**	How often?
Place, Space	**F.2**	At what points do you produce them?
Place, Space	**G**	Where do you get announcements about your university campus?
Time, Time frame	**G.1**	How often do you receive announcements?
Concept, Materials, Infrastructure	**H**	What channels does your university administration use for communication?
Time, Time frame	**H1**	How often do you use them?
Concept, Materials, Infrastructure	**I**	Do you have a digital application at your university?
Time, Time frame	**I1**	How often do you use these applications?

The interview questions were directed to students studying Medicine, English Literature, Law, Architecture, Management Informatics, Psychology, Marketing. In the semi-structured face-to-face interviews (Table 8), it was observed that 'Green Box, spaces around Billboards, Computer Labs' emerged as the common spaces for the use of digital technology and artificial intelligence activities.

Table 9. Manifestations on 'Digital Technology and Artificial Intelligence' based on Figure 5 (Su Gürler, Taha Eren Karataş, Esmanur Güç, Ebru Durduran, İsmail Emir Altunbaş, Göktuğ Kayabaş, Zeynep Uyumaz, Şevval Yıldız) (Table created by the authors)

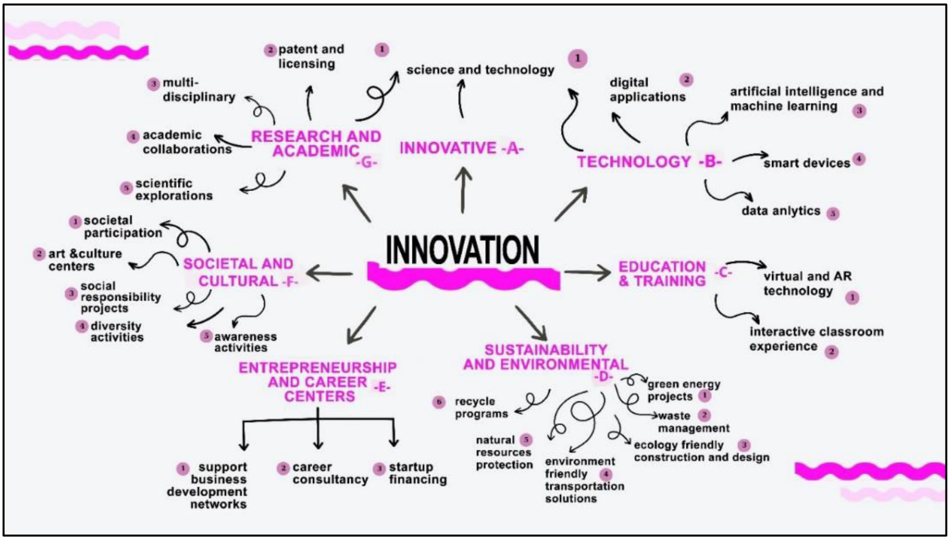
	Digital Technology and Artificial Intelligence
Manifestation #1	Social issues: As part of our society, 4th Generation Campus takes responsibility for understanding and positively shaping the impacts of technology. We act with the principles of sustainability, social justice and global solidarity in mind.
Manifestation #2	Digital boards: Digital billboards in schools should be increased.
Manifestation #3	In-class digital education tools: In-class digital education tools should be increased, and AI technology should come to classrooms.
Manifestation #4	Virtual campus: A virtual campus can be created where students and staff can access all the resources and services of the campus online.
Manifestation #5	Virtual assistant: AI-powered virtual assistants can assist students and staff.
Manifestation #6	Digital elements: Accessibility to digital elements and artificial intelligence in laboratories on campus should be increased.
Manifestation #7	Creativity and innovation: AI and digital development must be developed in an environment that encourages creative thinking and supports innovation. Fostering a culture that pushes boundaries and enables new ideas is one of our key priorities.
Manifestation #8	Accessibility: Providing full internet access in every part of the campus to eliminate accessibility problems.
Manifestation #9	Security and privacy: Security and privacy will always be a priority when using technology. Acting in accordance with personal data protection and secure communication standards is an indispensable principle of the 4th generation campus.
Manifestation #10	Virtual and augmented reality: VR and AR can be used to help students visualize, experience, and interact with complex concepts.
Slogans	None
Hashtags	social use, social media, cyber security, technology, campus, design, education, health technology, space, sociality, time, reality

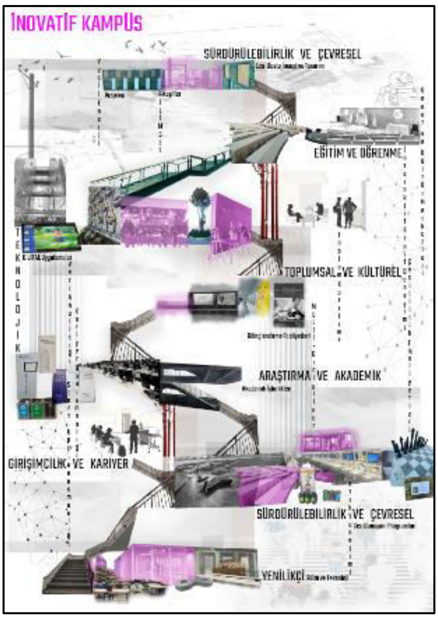
4.5. Innovation

The concept of innovation addresses that (Kaloudis, 2022);

- The university becoming a dynamic, open innovation space,
- Academic start-ups, academic patenting, student-based entrepreneurship, training programs for innovation and entrepreneurship
- Numerous policy measures that finance collaboration between universities and the private and public sectors can be considered channels/activities that are assumed to have a direct impact.

In this context, the mind map of Innovation reveals that (Figure 6) research and academic bodies, science and technology, education and training, sustainability, society and culture, entrepreneurial activities are interconnected. These concepts are inevitable for the ideal innovative practices in a campus environment. The interview questions (Table 10) were directed to students studying Banking and Insurance, Architecture, Landscape Architecture, Management and Information Systems, Dentistry, Law, International Relations, Psychological Support and Rehabilitation, Medicine, and Visual Communication Design. The participants stated the spaces for innovation activities are concentrated at Ground Floor, B4, Terraces, and the Garden. The manifestation for 'Innovation' is presented in Table 11.





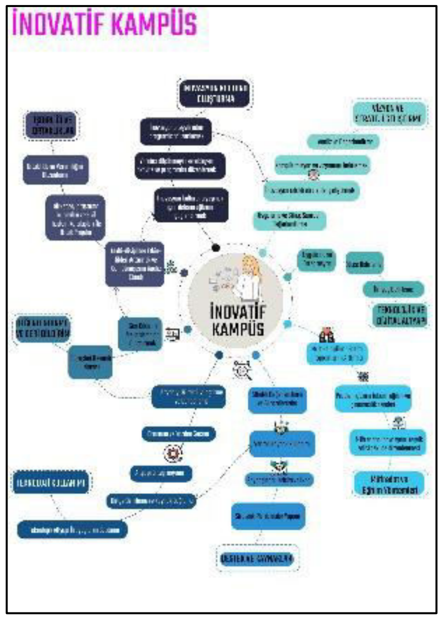


Figure 6. Innovation Conceptual Mind Map (top), Innovation at Existing Places (bottom left), Manifestations for Enhancing Innovation (bottom right) at Istanbul Medipol University, South Kavacik Campus (Buse Sağlam, Miray Zeynep Uçar, Nilay Bilecen, İrem Kakşi, Betül Dilara Topalcı, Ceyda Aksoylu, Berkay Sarı)

Table 10. Semi structured Face to Face Interview Questions for 'Innovation' (Buse Sağlam, Miray Zeynep Uçar, Nilay Bilecen, İrem Kakşi, Betül Dilara Topalcı, Ceyda Aksoylu, Berkay Sarı)

Information to be Addressed		**Semi structured Face to Face Interview Questions (Table created by the authors)**
Space	A	In which environments are innovative ideas produced? Why and when
Space	B	In which spaces on campus are constant changes or interactions observed? Why?
Space	C	Can you put the information you have learned into practice on campus? If yes, in which environments? Why?
Space	D	Where are the flexible spaces open to exploration located on campus? Why and when?
Space	E	Where on campus are they supported in terms of ecological sustainability and with which infrastructure elements?
Space	F	In which environments and why and with which tools is innovation supported on campus in line with the mission of the university?
Activity	G	Are user opinions received on campus? In which spaces is the impact of feedback seen?
Space	H	Where are flexible and collaborative spaces located on campus? Why and when?
Space & Concept	I	Do students use digital resources for research or study? Where are they used?
Equipment	J	What digital tools do they use to enhance the student experience on campus? (Student portal, mobile applications, etc.)
Activity	K	Is there training on campus to help students gain digital skills? Where is it done?
Equipment	L	What is the technological infrastructure of the campus? Is there fast and reliable internet access? Can every student easily connect to the internet from anywhere on campus?

Table 11. Manifestations on 'Innovation' based on Figure 5 (Buse Sağlam, Miray Zeynep Uçar, Nilay Bilecen, İrem Kakşi, Betül Dilara Topalcı, Ceyda Aksoylu, Berkay Sarı) (Table created by the authors)

	Innovation (Table created by the authors)
Manifestation #1	Organizing programs that encourage innovation. Organizing activities and programs that support creative thinking. Strengthening communication networks to spread the culture of innovation.
Manifestation #2	Analysis and Evaluation. Determining the campus mission and vision. Developing innovation-focused strategies. Implementation and Post-Process Evaluation.
Manifestation #3	Needs Assessment. Budget Determination. Implementation and Integration.
Manifestation #4	Organizing the curriculum in a way that encourages innovation. Organizing problem-solving-based education and entrepreneurship courses. Increasing multidisciplinary education programs.
Manifestation #5	Making Strategic Plans. Communicating and Convincing Stakeholders. Using Resources Efficiently. Providing Continuous Evaluations and Updates.

Manifestation #6	Determining Technological Infrastructure Needs. Determining Budget and Providing Resources. Ensuring Infrastructure Integration. Selecting Hardware and Software. Continuously Improving and Updating the Infrastructure.
Manifestation #7	Organizing the Efficiency of Partnerships. Joint Projects with Companies, Research Institutions and NGOs. Increasing Multidisciplinary Activities and Analyzing Their Returns.
Slogans	Creating a culture of innovation; Vision and Strategy Development; Setup Cooperation and Partnerships; Provide Technological and Digital Infrastructure

4.6. Coding the Invisible: Superimpose of Fourth-Generation University Dimensions for a Spatial Reading

In the scope of this workshop, the concept of fourth-generation university had been conceptually **resolved** into five dimensions, **represented** via mind maps, **decoded** its spatial marks through face-to-face interviews, **generated** spatial and operational manifestations for future opportunities. While these last-mentioned manifesto productions were being developed; the spatial representation of the five components as a digital collage in between floor layouts (vertical spine) was transferred into concentrated cross-relational spatial clouds as they represent unique fragments in the campus universe. The superimpose of dimensions-based floor layouts was subjected to cumulative assessment (Figure 7). The spatial cloud has shown that as the floors proceeded, each dimension per se was found to be dispersed equally. This might be in relation to the spatial organization that activates cross-sectional interior and exterior relations, the design of vertical circulation systems on campus, as well as open and re-programmable architectural features of the interior space.

Figure 7. Spatial representation of 'the superimpose of interdisciplinary collaboration, participatory, innovation, entrepreneurship, digital development and AI concepts' Istanbul Medipol University South Kavacik Campus floor layout (Diagram by the authors)

5. Conclusion and Suggestions

"As a synergy environment, the campus is
not only a center where knowledge is produced, transferred and shared,
but also, a living, mobile, continuous, vibrant, identity-forming,
memory-producing and generation-transmitting
socialization and development mechanism.
The campus,
where individual, collective and institutional evolution is inevitable,
is the scene of a conceptual and spatial transformation in the 21st century.
In order to analyze, comprehend, brainstorm and create a manifesto
forthis transformation called the new generation,
LUDARCH and URBAN EXPLORERS CLUBS invite
Urban Design and Landscape Architecture,
Architecture and Interior Architecture undergraduate students
to a COLLECTIVE CAMPING ENVIRONMENT!"

From the "CAMPUS.OLOGY" workshop open call text

In this text, a theoretical and conceptual framework has been drawn on the new generation campus by revealing the new and critical roles, functioning and organization of the university and, above all, the new dynamics of campus life in the globalizing and digitalizing world of the first quarter of the 21st century. Based on this framework, the setup of an experimental workshop focusing on producing a manifesto on the new generation campus and the inferences made through the forms of representation that were the final products were presented.

Within the scope of the workshop, firstly, the new generation campus and its components were conveyed to the participating students by the mentors; then the participants were asked to choose a component they were interested in doing research, so that workshop teams were formed accordingly. Each team analyzed the component they chose and structured questions to direct to the students living on campus. In addition, they first created a conceptual system by brainstorming in the context of the component they were working on and prepared a mind map by mapping method. In the second stage, the participants were asked to read the new generation campus components on the example of the host university campus -Istanbul Medipol University South Campus. In this context, the participants made a spatial reading on the concepts that constitute the component on the basis of floor layout and function in the Istanbul Medipol University South Campus building, which is a vertical campus. The participants expressed this reading with a visual map using the mapping method, then developed and visualized a manifesto on the new generation campus based on all the data and analyses they obtained and presented all these textual and visual findings verbally.

These collective readings and mappings made during the workshop encouraged the participants, who are architecture faculty students with professional disciplines dealing with space organization, to think about concepts and enabled them to produce manifestos that could form the basis for the design knowledge production phase. All these ideational productions were visualized through posters produced during the workshop. Contemporary analysis methods such as reading and mapping motivated the participants to understand and interpret concepts, to acquire information/data through discovery and experience, to search for ways and means of thinking, and thus to gain awareness. This book chapter, which presents the components and keywords of the concept of university, that has evolved into a new generation university model in the 21st century and conveys the final products of the workshop structured on this axis, offers an up-to-date knowledge and word cloud regarding the 4th Generation or new generation campus which is called the transformative university.

The concept of the university, which evolved upon another paradigm shift in the 21st century, is a current research topic. The findings of the workshop, which was designed to raise awareness among the most important actors of the campus, the students, also provided a ground for future research and studies by the authors who were the workshop organizers and created a driving force for them to ask new questions on the organizational form and spatial organization of the new generation campus concept. The findings of the workshop inspired future studies such as increasing the questions structured during the workshop process and creating larger samples and creating checklists and developing models on the new generation campus design based on the answers to be received.

The fourth generation university is a concept that represents a significant evolution in the functioning and spatial organization of the campus; however, the reorganization of the new generation university is an "abstract" issue related to the synergy of the campus rather than its "concrete" physical spatial organization. In this context, it is necessary to look at the issue of campus design from a higher umbrella, in terms of the new roles undertaken by the new generation university concept, because it is this new form of organization that shapes the campus design principles.

The new functions undertaken by the university within the roles it has assigned to itself (leadership, collaboration, entrepreneurship, creative innovative inventions, funding, service to the community) actually trigger a mechanism that reorganizes the spatial design of the university campuses.

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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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Water Sensitive Campuses in Adapting Climate Change

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1. Introduction

Water, which is necessary for the continuity of a healthy ecosystem and all socio-economic development, is one of the most important assets of nature and is limited. However, increasing pressures due to natural and human factors negatively affect water resources. Increasing pressures due to population, agricultural and industrial water use create imbalances between supply and demand, creating a global problem called water scarcity (World Water Council, 2018). This situation makes it even more important to manage water use in a sustainable way.

Cities face many danger factors in the fight against climate change. Some of these threats are the formation of urban heat islands, the decrease in the amount of usable water, increasing urban floods due to changes in precipitation patterns, the frequency of natural disasters and the risk of floods. The "Water Sensitive Urban Design" approach, which increases urban infrastructure resistance against the possible risks of climate change and ensures the continuity of the water cycle with methods that adapt to nature, aims to minimize the impact of urbanization on water resources.

The study aims to evaluate how cities can be resilient on the way to becoming water-sensitive cities, how water can be integrated into urban design, and how water-sensitive design elements and alternative water resources can be used in campus areas.

2. Material and Method

The study created a conceptual framework by first evaluating the literature. The pressures of cities on water resources and the effects of water resources on cities were investigated, and the existing theories and methods for urban water planning were examined.

The Water-Sensitive Urban Design approach, which offers nature-based solutions to the problems that today's cities face in the fight against climate change and to which they expose the ecosystem, was evaluated through sample projects. As a result of the research and the examples examined, Water-Sensitive Urban Design strategies and management criteria were determined. Considering the possibilities and needs for the development of campuses with a water-sensitive urban design approach, design and management suggestions were developed.

3. Findings and Discussion

3.1.Water Source

Water is a natural and limited entity. The total amount of water in the world is approximately 1.4 billion km^3. 75% of the water on earth is salt water covered by oceans. Only 2.5% of the total water is fresh water and only 1.2% of the fresh water is on earth. Only 0.03% of the fresh water on earth constitutes the amount of usable water. This rate is gradually decreasing due to the negative effects of industrialization and urbanization (Unesco, 2020).

3.2.Water Consumption

According to the United Nations, global water consumption has increased approximately sixfold in the last 100 years (Aquastat, 2010).

In Türkiye, water consumption has increased approximately 3.5 times in the last 50 years. Water consumption is expected to continue to increase due to population growth, changing consumer structure, economic developments and other factors. According to World Bank data, 69% of water use in global is in the Food and Agriculture sector, 19% in the Energy, Trade and Industry sector and 12% in drinking water and domestic use. The Table 1 shows the change in water use rates in Türkiye over the years (TSKB, 2019).

Table 1. Changes in Türkiye's Water Usage Rates by Year (TSKB Economic Research, 2019)

YEAR	IRRIGATION (BILLION M^3)	HOUSEHOLD (BILLION M^3)	INDUSTRY (BILLION M^3)	TOTAL (BILLION M^3)
1990	22,0	5,1	3,4	30,5
2004	29,6	6,2	4,3	40,1
2008	33,8	5,8	6,0	45,6
2010	38,2	5,8	6,0	49,9
2012	41,6	6,0	8,4	56,0
2014	35,9	5,7	9,1	50,7
2016	43,1	6,2	11,1	60,4
2023	72,0	18,0	22,0	112,0

3.3. Water Scarcity

Increasing pressures on water resources are causing imbalances between supply and demand, creating a global problem called “water scarcity.”

The Falkenmark Indicator, one of the most common indicators used to measure water stress, is calculated by dividing a country’s/region’s available water resources by the number of people living in that country/region (Falkenmark et al., 1989).

Table 2 shows the classification of water scarcity levels according to the annual amount of water per capita.

Table 2. Falkenmark Index

Per Capita Consumption	
Falkenmark Index (m^3/capita/yr)	**Category**
> 1.700	No Stress
1.000 – 1.700	Stress
500 – 1.000	Scarcity
< 500	Absolute Scarcity

According to Table 3, compared to other countries in Europe and around the world, Türkiye is among the countries experiencing water stress in terms of the amount of usable water per capita.

Table 3. Global Water Stress Index (TSKB Economic Research, 2019)

Country	**Amount Of Renewable Fresh Water**	**Population**	**Falkenmark Index 2015**
Canada	2.902.000	35.832.513	80.988
Norway	289.927	5.166.493	56.117
Brazil	8.233.000	205.962.108	39.973
Russia	4.525.000	144.096.870	31.402
Croatia	114.550	4.225.316	27.110
Sweden	222.833	9.746.355	22.861
Serbia	159.185	7.114.393	22.375
Congo	1.283.000	76.796.619	16.838
Ireland	71.786	4.677.627	15.347
Bulgary	105.982	7.202.198	14.715
Slovakia	66.601	5.421.349	12.285
Albania	30.818	2.885.796	10.679
USA	3.069.000	321.039.839	9.560

Hungary	91.697	9.855.571	9.304
Bangladesh	1.227.000	161.200.886	7.612
Switzerland	51.173	8.237.666	6.212
Nigeria	950.000	181.181.744	5.243
Holland	81.802	16.900.726	4.840
Spain	162.392	46.449.565	3.496
France	196.846	66.456.279	2.962
China	2.840.000	1.371.000.000	2.071
Romania	34.827	19.870.647	1.753
Germany	132.000	81.197.537	1.626
Türkiye	**111.990**	**78.741.053**	**1.422**
Poland	40.797	38.005.614	1.073
Czech Republic	10.020	10.537.275	951
South Africa	51.350	55.297.225	929

Considering the effects of the current population and economic growth rates, the pressure on Türkiye's water resources is expected to increase. Therefore, Türkiye needs to protect its water resources and use them efficiently to provide usable and sufficient water to future generations.

3.4. Urban Water Management and Design Approaches

The areas where the effects of climate change are felt most intensely are cities. Increased temperature, changes in precipitation regime, increased air pollution, drought and water shortage, extreme weather events, rainwater causing floods or inundations are the obvious results of climate change. Increasing impermeable areas due to covered surfaces, roads, buildings and other city structures cause heat to be stored on the surface and temperatures in cities to be higher than in surrounding rural areas (Howard, 1818). This situation is defined as the "Urban Heat Island" (Figure 1).

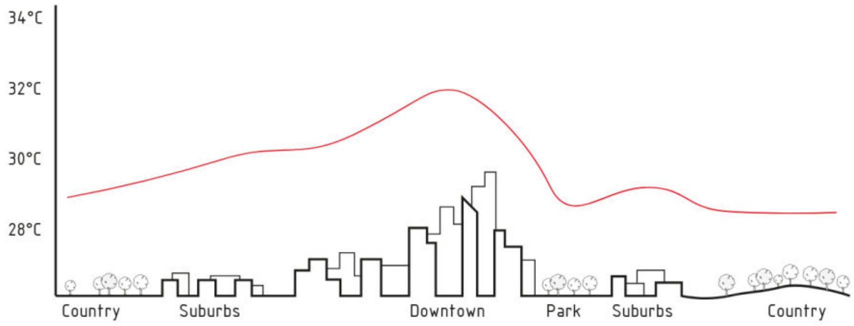

Figure 1: Urban Heat Island Effect (Slunecko ,2020)

Along with the effects of climate change, increasing water consumption due to population puts pressure on urban water use. Unlike other sectoral uses, urban water use is a vital need and has a supply-demand situation that requires continuity. The need for water management and planning emerges when all these situations are considered.

When we look at literature research, especially in the last 50 years, many approaches and terminologies have been developed regarding water management in cities and how it can be integrated into design.

While an approach based on water supply and access was used in the past, public health issues increased with city sewage needs and new approaches were developed. Then, a period began in which drainage issues became the main focus of how a city managed water.

However, over time, new searches began in cities worldwide that saw these approaches needed to be more sustainable. It began to be accepted that water was not only an element that needed to be eliminated from cities but also an element that needed to be managed at its source.

From the 1970s onwards, approaches that focused on design and supported every stage of the water cycle in the city with this design began to come to the fore (Figure 2).

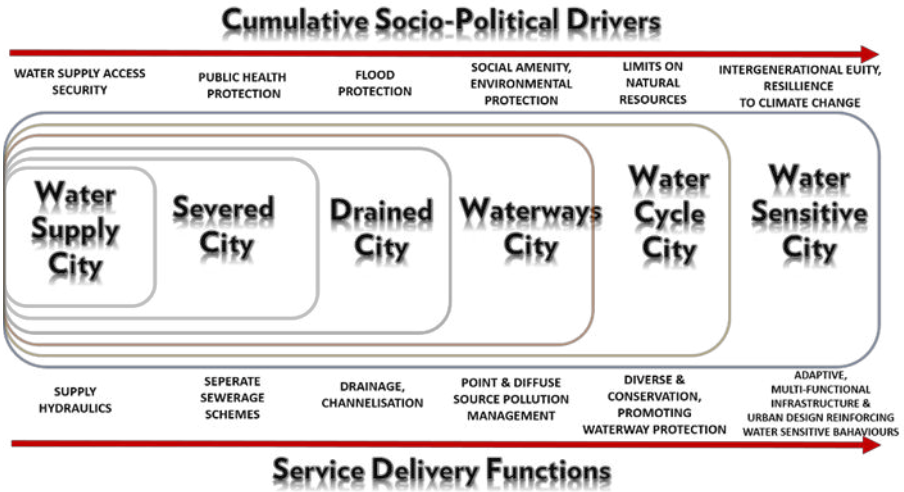

Figure 2: Urban Water Management Transitions Framework (Brown et al., 2009)

The reason why each of the approaches differs is that the local problems and focal points faced by each country differ.

Countries have developed new approaches that have largely common principles but include designs that can be adapted to their natural environments and social needs. This situation is consistent with Derrible's (2017) hypothesis that "Cities are shaped by the challenges they have to deal with."

Sustainable Drainage Systems are a prominent approach in the UK to improve water quality, water quantity and public recreation.

LID - Low Interaction Development is a prominent approach in the US based on rainwater and the hydrological cycle in urban areas.

Sponge Cities approaches are used in China to control urban flooding and minimize its effects. The aim is to hold water, slow its flow and adapt to water. In this way, increasing flood disasters can be dealt with, urban watersheds can be protected and water quality can be improved.

In Australia, the Water Sensitive Urban Design approach has begun to be developed and used.

3.5. Water Sensitive Urban Design

The Council of Australian Governments defined Water Sensitive Urban Design as integrating urban planning with managing and protecting the urban water cycle, ensuring that urban water management is sensitive to natural hydrological and ecological processes (Johnstone et al., 2012). In short, it is an approach that integrates urban planning with managing and protecting the urban water cycle and aims to integrate it into design.

The objectives of Water Sensitive Urban Design are as follows;

- Protecting the quality of surface and groundwater,
- Minimizing the amount of polluted water discharged into the natural environment,
- Minimizing wastewater, ensuring the reuse of wastewater,
- Developing methods to reduce peak flows in surface flows,
- Collecting and reusing rainwater flows from roofs and other areas,
- Saving water
- Designing the landscape by integrating it with water to develop cultural and ecological values

Sustainable rainwater management units, roof gardens, biological water retention areas, biological swales, rain gardens, increasing urban permeability and road tree and plant boxes can be used as water sensitive urban design elements.

3.6 Water Sensitive Urban Design and Management in Campus Planning

At the United Nations Conference on the Human Environment held in Stockholm in 1972, the necessity for universities to work on sustainable green campuses was first brought to the agenda. In 1975, the International Environmental Education Program, the first program emphasizing sustainability in education, was launched by UNESCO and UNEP. The 1977 Tbilisi Declaration established the structural and institutional basis for universities to work on sustainability. Concepts such as sustainability and green campus were adopted and discussed in universities, and research began to be published.

While studies on sustainability continue today, it is considered as a fundamental element in the design and management of all public areas, especially universities.

Although they appear under different names such as Sustainable Universities, Green Universities, Green Campus, Eco-Campus, Sponge Campuses and Water-Sensitive Campuses, the main purpose of all these approaches is to minimize the negative impacts that may arise in terms of environmental, social and economic.

Universities are graded regarding sustainability using indexes such as the Green League, Environmental and Social Responsibility Index, and Green Measurement. The Green Measurement Index is the first rating system in the international arena. According to this Index, campus sustainability is addressed under six main headings;

1- Structure and Infrastructure

2- Energy and Climate Change

3- Waste

4- Water

5- Transportation

6- Education

The Green Measurement Index aims to contribute to the academic field in terms of sustainability in education and greening of campuses, to ensure social changes and to inform the society, policymakers and relevant stakeholders to make campuses sustainable.

3.7 Water Sensitive Campuses

3.7.1 China Cases – Sponge Campuses

The Sponge Cities approach, proposed and discussed in China in 2012, aims to regulate rainfall and to have the city act as a sponge that retains water and allows it to recycle.

In the Sponge Cities construction process that began in 2013, university campuses with large land use scales also play an active role.

In 2015, 16 pilot areas were constructed with the Sponge Cities concept, and in 2016, a second pilot area was determined and 14 more cities were listed.

The widespread Sponge Cities concept has also brought Sponge Campuses to the agenda. Many universities in China have started to revise their campus designs and create Sponge Campuses. Each university has started to put forward its own campus plan, considering the changing land structure and climatic characteristics, as well as the current potentials and threats.

- **Hunan City University Sponge Campus**

Hunan City University is located in Yiyang City, Hunan Province, China. The campus terrain, which includes Qinshang Lake, Cuiping Mountain and Yugu Mountain, has a rugged structure. The city where the university is located has a subtropical humid monsoon climate with heavy rainfall. When the current situation of the campus area was analyzed, many problems were identified, such as the deterioration of the water quality of Qinshan Lake within the land, the abundance of impermeable coatings on the campus, and the inadequacy of traditional drainage models used in flood situations. Since none of the buildings on the campus have roof greening or rainwater collection units, it is far from the "green building" standard. Rainwater is only stored in an area within the lake and discharged again. There is no purification system and the stored rainwater is not recycled and used. Considering all these problems, the deficiencies and targets in campus planning in terms of the use of water resources were analyzed and a sustainable campus design and management strategies were implemented.

Permeable pavements, rainwater retention tanks, wetlands and biological water retention areas are designed to control surface runoff.

There is no treatment of stored water, and the treated rainwater is not used for different uses such as landscape irrigation or gray water use.

The water retention pond built at the eastern entrance of Qinshan Lake has reduced the pressure on drainage systems even during the most intense rainfall periods. Drainage systems designed in two basins, north and south, are shown in the figures below. Figures 3 and 4 show the south drainage systems, and Figure 4 shows the north drainage system.

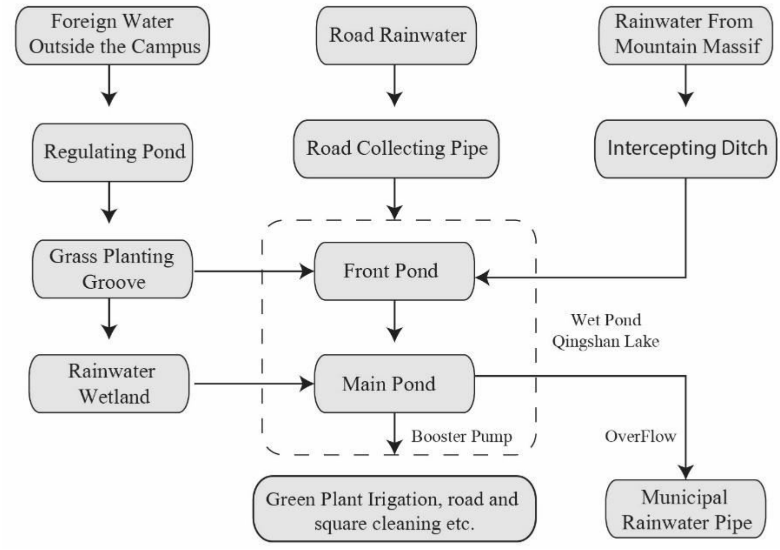

Figure 3. South II Drainage Area (Wen T. et al., 2019)

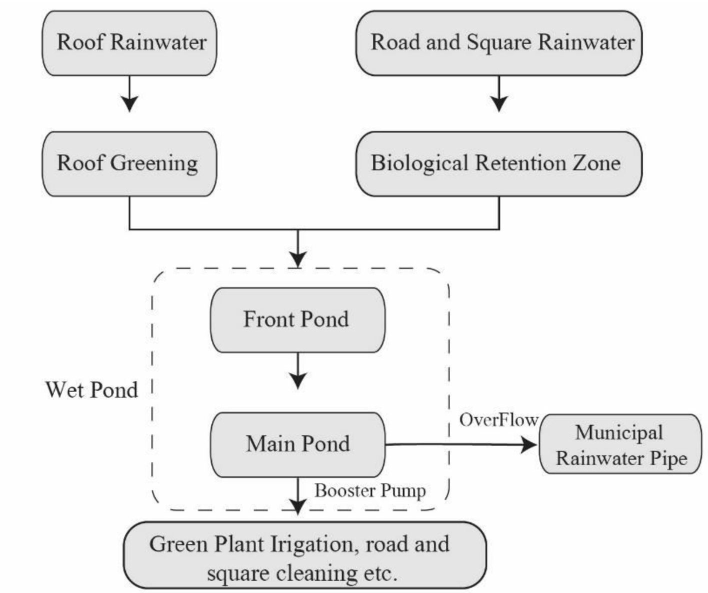

Figure 4. South I Drainage Area (Wen T. et al., 2019)

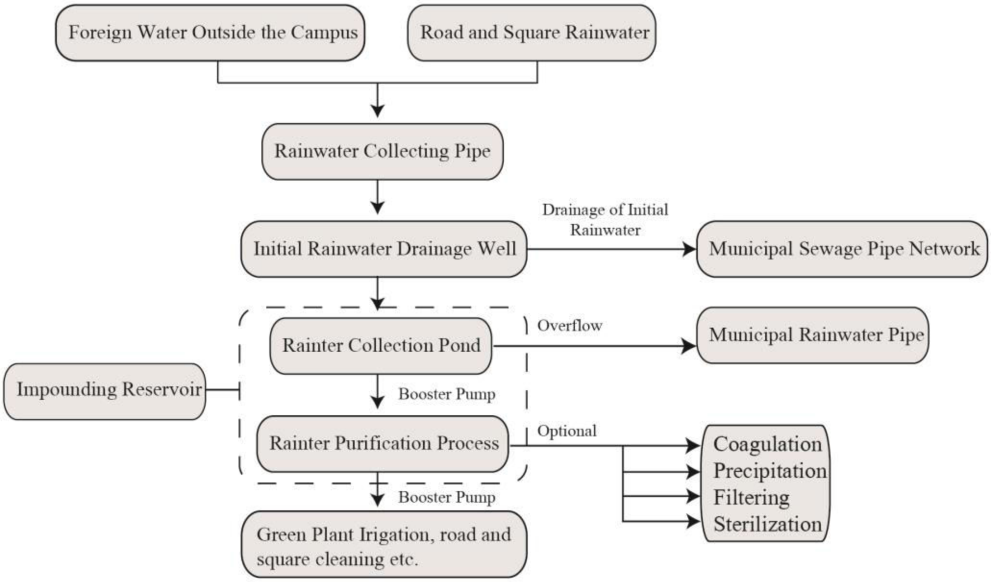

Figure 5. Rainfall collecting and disposing of the flow chart of north drainage area (Wen T. et al., 2019)

A comprehensive rainwater management system has been developed. Using rainfall data, the rainwater that can be collected from each building on campus has been calculated, and how much water needs can be met on the campus within the scope of a sustainable campus has been determined.

A water resources usage system has been established. The roofs of the buildings have been greened. Rainfall holding tanks have been placed on the south and north sides of each dormitory to be built. The stored water has been purified and used in the landscape.

- **Kunshan Yufeng Technical School Sponge Campus**

The total area of the campus is 36,937 m^2, the building density is 24.81% and the green area ratio is 41.57%. The abundance of green areas offers design opportunities. In the sponge campus design, the campus is usually designed by dividing it into many basins and rainwater is collected and purified by the units designed in each basin (Wang et al., 2011). This method is followed in the sponge campus application and the campus area is divided into three basins (Figure 5).

Figure 6. Kunshan Yufeng Experimental School (South Campus) Catchment Divison, Campus Design Layout (Fei, Y. et al., 2022)

The first basin is the most intensively used area, where most buildings on the campus and green areas are located. Green areas were designed to collect surface runoff and roof rainwater as a sponge with green roof applications. The second basin is the basin where there are more impermeable surfaces and hard pavements such as parking lots. Permeable pavement and permeable parking lots were adopted to reduce the total amount of rainwater discharged to the municipal network. The third basin is where sports fields and other functional areas are located. Rainwater was first treated in gray facilities and then collected in the terminal storage module for treatment and reuse through pipe networks.

3.7.2. Turkish Cases

The Green University Index, which prioritizes sustainability and aims to raise awareness about environmental awareness, annually rates the sustainability performance of universities in areas such as climate change, energy, water resources, waste, infrastructure, transportation and education-research.

According to the 2023 International Green Campus Index published by the Green University Index Platform, 96 Turkish universities -27 foundation and 69 state- are in the 1183 university rankings evaluated. Table 4 lists the Turkish Universities included in the Green University Index and their rankings (UI GreenMetric, 2023).

Table 4. Turkish Universities Included in the Green University Index

Istanbul Technical University (46)	Yıldız Technical University (63)
Erciyes University (85)	Özyeğin Üniversitesi (89)
Ege University (96)	Yeditepe University (98)
Middle East Technical University(123)	Başkent University (152)
Izmir Institute of Technology (153)	İnönü University (156)
İzmir Dokuz Eylül University (159)	Bartın University (187)
Sakarya University (189)	Aksaray University (208)
Tokat Gaziosmanpaşa University (231)	Afyon Kocatepe University (247)
Hitit University (248)	Trakya University (255)
Kütahya Sağlık Bilimleri Uni. (257)	Atatürk University (258)
Hasan Kalyoncu University (262)	Bilecik Şeyh Edebali University (278)
Muğla Sıtkı Koçman University (280)	Kastamonu University (287)
Fırat University (291)	İstanbul Sabahattin Zaim Uni. (311)
Hacettepe University (312)	Düzce University (314)
Sabancı University (317)	Mersin University (319)
Niğde Ömer Halisdemir Uni. (357)	Ondokuz Mayıs University (364)
Çukurova University (375)	Kapadokya University (388)
Mardin Artuklu University (391)	Antalya Science University (403)
Bursa Technical University (438)	Van Yüzüncü Yıl University (446)
İstanbul Aydın University (458)	Kocaeli University (460)
Gaziantep University (463)	Osmaniye Korkut Ata Uni. (473)
Bursa Uludağ University (479)	Gazi University (483)
Selçuk University (491)	

In this context, we evaluated examples of higher education institutions that have already adopted green campus practices in our country and are examples of good practices.

- **ITU Green Campus Project**

Istanbul Technical University managed to enter the Green University Index in 2019 with the studies and successful applications it carried out within the scope of the Sustainable Green Campus project launched in 2013. It became the first Turkish university to enter the first 100th place by ranking 54th among 780 universities evaluated worldwide. In the last index published in 2023, it ranked 46th among the top 50 universities (UI GreenMetric, 2023).

Within the scope of the green campus, it has focused on pedestrian and bicycle-friendly campus, sports, health and barrier-free design, waste management and recycling, and biodiversity.

A rainwater management plan has been created. Within the scope of this plan, applications have been made to discharge surface water on transportation routes in a nature-friendly manner or to accumulate it in certain reserve areas. In addition, permeable asphalts used in parking lots have been supported with buffer planting. Plant species resistant to temperature increases and has high carbon absorption have been used in the campus landscape design.

Rainwater collected by rain gardens and other rainwater collection units has been filtered through plants and directed to the pond. The campus has been considered as a socio-ecological system, aiming to increase the sense of belonging and environmental awareness of the landscape. In addition, sports and healthy living areas have been created, improving the overall quality of life on the campus.

- **Yıldız Technical University**

Yıldız Technical University is ranked 63rd in the Green University Index list with the Smart Green Campus applications implemented for the Davutpaşa Campus (UI GreenMetric, 2023).

For the natural water cycle to continue, green areas on the campus have been increased and drainage systems have been improved. Permeable surface areas have been expanded and water flow on the surfaces has been prevented.

Savings are made in the purification process with the applications made for the rainwater to continue its natural cycle.

Building designs have been realized to minimize energy consumption within the scope of the studies carried out for energy and climate change. With the Davutpaşa Campus Solar Panel Project, the university aims to produce its own electricity to be used on the campus. Within the scope of the Zero Waste Policy, it will prevent the formation of all kinds of waste and ensure its recycling.

Water ecosystems are protected by considering the ponds located on the campus. Studies are being carried out to increase the recycling and reuse of water. It aims to reduce the campus's irrigation water consumption by using smart irrigation systems. In addition, the irrigation water needs are met by using the water stored in underground water tanks as irrigation water.

4. Conclusion and Suggestions

Cities that are not designed and made resilient to water, cause ecosystem damage and reduce the quality of urban life. The pressure of urban development on water resources should be reduced, natural areas and permeable surfaces should be increased as much as possible, and rainwater should be considered as a resource and recycled. Water management should be addressed by including green infrastructure design principles, and ecosystem-focused solutions should be produced for the encountered problems. In this way, environmental, ecological and social problems can be prevented and cities can be made resilient.

The most obvious examples of Water-Sensitive Campus Areas studies carried out with the Water-Sensitive Urban Design approach are in Australia. Similarly, China, which has adopted the Sponge Cities approach, similar in terms of rainwater management and design principles, offers guiding examples with the Sponge Campuses it has built by placing the water element at the center of design and management.

Universities have the potential to lead the society in sustainable development by working on reducing the effects of climate change and developing technologies, and they are implementing green campus applications within this scope.

However, when looking at goals such as reducing the effects of climate change, building a more sustainable world, and better protecting the environment, it has been seen that the number of universities that include these goals in their strategic plans is low.

Similarly, water saving, water recycling, efficient water consumption devices and purified water have also been defined as goals by very few universities.

A study examining the strategic plans of universities in Türkiye with GreenMetric indicators and showing the green vision levels of universities, showed that only a quarter of the 150 universities included in the study developed strategies in the field of water and waste.

The studies carried out within the scope of Sustainable Campuses and Green Campuses in Türkiye need to be revised to address the water element. The concept of the Water Sensitive Campus offers nature-based solutions and strategies by placing water at the center of design and management.

For the design and management of the Water Sensitive Campus, protecting existing underground and surface water resources throughout the campus should be considered as the first principle.

Strategies should be determined for the control and effective use of rainwater. Ecological drainage should be prioritized to relieve drainage systems.

Water obtained from green roofs and rainwater retention areas through rainwater harvesting can be used for irrigation in campus landscapes, as well as for drinking water or toilets, etc.

Permeable surfaces should be increased on hard surfaces to help reduce rainwater's amount and flow rate. In this way, the polluting effect of rainwater is reduced and surface flow control is achieved.

The development of programs on how grey water can be recycled on campuses should be supported. Water distributed through the water network system should also be saved.

The use of water-saving devices throughout the campus and the use of purified water within the campus should be considered important.

It is expected that the study will contribute to the increase in practices aimed at reducing the effects of climate change on campuses and to the inclusion of more examples in our cities that prioritize water-sensitive approaches in the design and management of sustainable campuses.

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Accessibility in Sustainable Campuses with Small City Models

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1. Introduction

University campuses represent one of the important function groups in cities and contain a multifaceted structure. These campuses, which can be of different sizes, plans and designs, include various effects in terms of spatial, social, ecological and functional aspects. The design features of the campuses directly affect spatial sustainability, social and functional continuity, and the protection of the ecological structure (Ardıçoğlu et al., 2024). Campuses are settlements with certain requirements where university students spend most of their educational lives. Making some arrangements on the campus and encouraging the use of outdoor spaces in order for students, educators or staff to spend quality time is important for both learning and productive work (Düzenli et al.,2019).

Campuses, due to their innovative and pioneering roles in society, are the most important educational and training institutions that contribute to the spread of a sustainable lifestyle in society through sustainable and ecological practices. They are important stakeholders in the establishment of the values and culture of society and in the raising of young generations with an innovative perspective within the framework of these values. Therefore, sustainable university, sustainable and ecological campus practices have become a rapidly increasing trend worldwide. As interest in sustainable campuses increases, sustainable international indexes have started to be used. These are Green League, Environmental and Social Responsibility Index, Green Metric evaluation methods (Suwartha & Sarı, 2013). Universities; In improving environmental, economic and social conditions, they both produce solutions to social problems and contribute to behavioral change and the creation of values (Mulder, 2010). Sustainable campus; A sustainable university can be defined as an institution of higher education that works to minimize the negative environmental, social and economic impacts of its activities and leads society in a sustainable way of life (Velaquez et al., 2006). A sustainable university is also known as a green university, a green campus, or an eco-campus.

Accessibility is important for increasing the quality of life of users in sustainable campuses determined as small city models. Transportation networks should be clearly defined in building and environmental uses in accessible campuses. Appropriate routes should be determined according to different types of transportation and uninterrupted use should be provided. In this study, universities were evaluated as small city models and all types of transportation networks (bicycle, pedestrian, vehicle, etc.) in sustainable campuses were examined in terms of accessibility.

1.1. Sustainable Campuses as Small City Models

In addition to the legal framework of the concept of sustainability, societies expect businesses to make positive contributions to the environment. Businesses make the “sustainability” paradigm a part of their corporate strategies in terms of economic, social and ecological environment (Blackburn, 2007). With the increase in environmental problems, the terms “sustainable” and “ecological” have begun to enter our daily lives. The concept of “sustainability”, which first emerged internationally in 1970, was defined as protecting the environment and ensuring ecological balance. The issue of “the impact of human activities on the environment” held at the Stockholm Conference in Switzerland was addressed and attention was drawn to the damages caused to the environment. In 1987, a protocol was signed regarding substances that deplete the ozone layer in the Montreal Protocol, and a decision was made to reduce the consumption of harmful gases (Kayapınar Kaya et al., 2019). Universities are suitable places for sustainable and ecological applications due to their innovative and pioneering roles in society. They are the most important educational institutions that contribute to the spread of a sustainable lifestyle in society.

Universities play an important role in terms of sustainable education. Universities contribute to the spread of the concept of sustainability in society with sustainable and ecological practices due to the education and awareness they provide to the society. Therefore, sustainable university, sustainable and ecological campus practices have become a rapidly increasing trend worldwide. It is seen as a necessity for universities to be pioneers in sustainability, to teach students the principles of sustainable development and to integrate sustainability into organizational management and routine actions (Beringer &Adomßent, 2008; Bozoğlu & Ciğerim, 2022).

“Sustainable and green campus” (Figure 1) practices; environmentally sensitive, energy saving, real waste management methods have gained importance all over the world, especially in universities in Europe. These campuses apply real waste management methods, use environmentally friendly products and materials, and contribute to sustainable development (Duran, 2018). A sustainable campus respects the need to maintain natural resources and protect the environment. It is a campus that develops processes or management systems that help create a vibrant campus economy and a high quality of life. Sustainable programs are programs that result from an institution's commitment to environmental, social, and economic health (Galioğlu, 2015).

Figure 1. Sustainable Campus (URL-1;URL-2)

Velazquez et al. (2006) presented the sustainable university model. It consists of four components: vision, mission, university sustainability committee and strategies to develop sustainability. In the vision stage, the strategy for sustainability is a formation compatible with the philosophy of sustainable development. The second stage of the model is the mission statement of the ideal future envisioned in the vision. The third stage is the formation of the committee, which is the main decision maker on sustainability. The sustainability strategy, which is the last stage, includes a fourth component - sustainability on campus - in addition to the existing education, training, research and collaboration of universities and their access to society (Velazquez et al., 2006). In this part of the study, sustainable campus models were examined from the literature. Approaches in campuses that have the characteristics of a sustainable campus and present this model were examined and evaluated.

Harvard University (Figure 2) is among the good examples of sustainable campuses. It has developed Green Revolving Fund, Commuter Choice, Harvard Recycling projects for sustainable transition, and has set Ambitious Greenhouse Gas Reduction Target and Green Building Standards. The criteria taken into consideration for Sustainable Campus studies are climate change and energy, community participation, food, green buildings, health and well-being, nature and ecosystems, waste management and water management (Kalawi, 2021). While emphasizing sustainability, the campus also aims to inspire learning and scientific discoveries. Harvard University has planned to support and provide grounds for climate and sustainability research in all its faculties. It also aims to advance inter-university studies on climate and the environment. He announced the establishment of the Salata Instiute for Climate and Sustainability, which is a major and positive development in the world. It develops projects that will support sustainability and the transition to low and zero-carbon energy and accessibility in transportation.

Figure 2. Harvard University (URL-3;URL-4)

Melbourne University (Figure 3); The University of Melbourne aims to ensure its sustainability in institutional, financial and social terms. Its sustainability studies focus on issues such as education, energy, water, waste, research and development, materials, recycling and reuse. For this purpose, awareness meetings and seminars are organized for students and staff in the field of education. These educational seminars also support daily activities. In terms of energy, there are solar panels on the campus and the buildings have GreenStar certificates. It is also quite advanced in terms of recycling and waste management (Darendelioğlu, 2021).

Figure 3. Melbourne University (URL-5;URL-6)

Harvard University has a design based on ecological features such as climate change and energy, community participation, food, green buildings, health and well-being, nature and ecosystems, and water. While the sustainable campus concept has environmental uses that aim to inspire learning and scientific discovery, Melbourne University has targeted sustainability in education, energy, water, waste, research and development, materials, recycling and reuse. In this context, they have actually determined certain criteria and provided different processes.

The concept of a sustainable campus is based on certain principles and different criteria. Each rating system is based on different criteria and goes through different processes when evaluating universities. Sustainability transforms the performance (or expected performance) of a higher education institution into a general evaluation table by allowing comparisons between similar institutions with this evaluation (Bayhantopçu & Özuyar, 2021). Although it focuses on measuring the equipment and capacities of universities, there are rating systems based on the UN Sustainable Development Goals such as STARS, UI GreenMetric and Times Higher Education Impact Rankings (Gedikkaya Bal et al., 2022). When we look at the IU rating system, as of 2021, the evaluation criteria under the headings of structure and infrastructure, energy and climate change, waste, water, transportation, education and research have started to be applied. When transportation is evaluated under these headings; Zero-emission vehicle policy on campus, ratio of zero-emission vehicles to total campus population, ratio of parking areas on campus to total campus area, efforts to reduce parking areas for private vehicles in the last three years, initiatives aimed at reducing private vehicles on campus and improvement of pedestrian policy on campus have been at the forefront. Transportation system principles, also referred to as Environmentally Friendly Transportation Opportunities, play an important role in pollutant levels and carbon emissions at the university. Transportation policy encourages students and staff to walk around campus and avoid using private vehicles. Thus, it aims to reduce the carbon footprint on campus.

In Türkiye, sustainable ecological campus criteria are evaluated as 6 main criteria: Energy and climate change, waste evaluation, water management, sustainable transportation, sustainable education and on-campus greening. It is realized by using environmentally friendly, CO2 emission minimizing vehicles in on-campus transportation. Establishing bicycle houses on campus, popularizing electric and hybrid transportation vehicles and directing to public transportation are included in sustainable transportation (Kayapınar Kaya et al., 2019). When considered in this context, transportation and accessibility of individuals are important for the use of sustainable campuses (Günerhan & Günerhan, 2016).

1.2. Sustainable Accessibility on Campuses

Accessibility, defined as the ease with which people and commercial activities can reach desired facilities, products and activities, is also a performance criterion that combines the characteristics of the transportation system and land use (Bhat et al. 2001). Accessibility is defined as the possibility and ease of access to public services offered by a residential area. Planning accessibility aims to make distances easily accessible and to provide a wide range of transportation options, especially non-motorized transportation (Barter, 2000). It also means designing spaces that can be accessed and used comfortably by all individuals. An accessible environment is accepted as an environment where users can lead an active social and economic life (Papaioannou, 2008). In order to provide sustainable accessibility, it is necessary to consider transportation in a holistic manner within the framework of the principle. Sustainable accessibility requires mobility and the necessary infrastructure for social and economic development. While ensuring that people access these services safely and economically, it also reduces the negative effects on health and the environment. Sustainable transportation systems need to be supported, especially in large cities where mobility is high. Accessibility consists of the needs of individuals based on their characteristics such as age, income, and level of education, their physical capabilities and accessibility to transportation types, and their opportunities based on their characteristics such as income and transportation budget (Cervero et al. 1997; Shen, 1998). Therefore, accessibility needs to be addressed holistically within the framework of the principle of equality in ensuring sustainable transportation.

Sustainable access provides many benefits to the city and its users. Sustainable transportation systems help improves air pollution by reducing CO_2 and greenhouse gas emissions. The development of respiratory diseases decreases with the improvement of air quality. Active transportation types such as pedestrian and bicycle transportation make life easier among transportation types. The use of these types helps increase the level of physical activity. The increase in physical activity has a significant effect on the reduction of many health diseases. It reduces the level of vehicle use. Thus, it helps to reduce the number of traffic accidents and related injuries and deaths. This situation is shown as the increase in road safety (Eryiğit, 2012).

Figure 4. Sustainable Access(URL-7;URL-8)

Accessibility is the most fundamental element in the transportation effect of universal design. The main purpose of universal design is that everyone can access every object and every place. This situation is not only related to the physical disabilities of the users, but also to appeal to users of all ages and abilities. In this context, the human profile that meets the concept of "everyone" consists of a wide range. Ensuring the effectiveness of transportation in daily life is important in increasing the quality of urban life and in terms of the happiness of people. Establishing an adequate and economical transportation system increases the mobility of people in the city while also allowing for social integration, thus increasing the quality of urban life (Vuchic, 2000). In urban transportation, the necessity of ensuring the integrity of public transportation and integrated planning of land use and transportation plans is the most important element in increasing the livability in cities.

Bicycle transportation is a form of transportation that does not harm other people or the environment and contributes to the health of people.

1.3. Sustainable Access and Transportation on Campuses

On campuses, there should be spaces that meet the needs and desires of individuals outside of education and their use should support both social and physical values of individuals. The spaces and objects on campus should be in accordance with universal design principles in order to be able to create useful, comfortable, barrier-free designs. Building entrances, pedestrian paths and passages, ramps, stairs and sidewalks, environmental facilities (seating units, garbage bins, etc.), signs and information boards, stops and many structural elements and areas should be in accordance with sustainable design in public spaces (Erkovan, 2013; Düzenli et al.,2018).

The university includes targets for analyzing and reducing the impacts it creates on the environment inside or outside the campus. These targets can be grouped under the titles of reducing waste, recycling and recycling, energy use, reducing local emissions and air pollution, transportation and land use. Transportation and accessibility are among these targets. In this context, it is aimed to conduct traffic analysis, improve bicycle/e-bike and pedestrian transportation, reduce the average commute distance or the energy used by each user, and provide urban mobility integrated into planning. Zengel (1998) defined ideal accessibility as spending minimum time during circulation. He defined basic accessibility criteria as walking distance, time and connections between functions, land configuration and campus patterns (Zengel, 1998).

Accessible and safe transportation on campuses is provided by bicycle facilities and sustainable transportation opportunities. It is a set of features that must be possessed in order to be used comfortably, safely and equally by all individuals. It is aimed to increase transportation efficiency by encouraging users to use pedestrian transportation, to reduce environmental impacts caused by transportation, to encourage users to engage in physical activity and to protect the land. When evaluated within this scope;

- The distance between built environments and public transport stops must be accessible. It is very important for built environments; residential buildings, educational and public institutions, to be close to public transport stops.
- The distance between the places where users travel most frequently during the day should be suitable for walking distance and accessible by foot. For example, the distance of users to shopping malls and educational institutions is important in terms of being accessible by foot.

Figure 5. Accessible and Safe Transportation(URL-9;URL-10)

- In order to reduce vehicle dependency in transportation in cities, the transportation system should be planned with pedestrian priority. For this purpose, pedestrianization should be primarily an open green area arrangement supported by recreational activities.

- Planning transportation systems in cities is important. Appropriate pedestrian and bicycle path designs should be created, pedestrian and bicycle paths should be planned on safe routes. These transportation paths should be uninterrupted, controlled crossings should be provided at the intersections of the roads and should be supported with recreational activities.
- Uninterrupted and always accessible transportation should be provided by considering the city-campus connection.
- Motor vehicles belonging to the campus used for transportation purposes should be provided with sustainable fuel vehicles. Motor vehicles not belonging to the campus should be encouraged to switch to sustainable fuel vehicles.
- Self-generating vehicles should be included in order to reduce traffic within the campus, charging stations should be established and solar energy systems should be created.

2. Conclusion

Important decisions should be made in terms of planning to solve rapidly growing problems such as air pollution, global warming, energy and limited resources. In this respect, cities should be designed by analyzing and designing them correctly in terms of planning criteria. Especially campuses with the characteristics of a small city should meet the needs of all users without discrimination in the planning and design phase.

In campuses, access to structural environments and open space usage areas should be provided by all individuals. Accessible transportation plays an important role in determining the positions of individuals in society for the purpose of independent living. When considered for this purpose, universal access in Türkiye is not at the desired level. The usage connections between the spaces of the users should be evaluated. The corridors directed by the spaces should be provided with pedestrian mobility. In places where movement is intense, squares should be arranged and large formations should be designed. When the literature is examined, Harvard University and Melbourne University abroad, the campuses are designed as sustainable spaces in accordance with the outdoor usage of the users. Sustainable campus design principles have designs based on ecological features such as climate change and energy, green buildings, nature and ecosystems, water. Such approaches can create positive results when supported by sustainable access.

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The article complies with national and international research and publication ethics.

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Sustainability Unscripted: Smart Adaptations on University Campuses – Exploring the Impact of Adaptive Reuse of Historic Railway Campus on Students

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1. Introduction

The idea of sustainability, which is the most important concept used among academics and professionals to discuss the future, expresses that any social and financial development ought to enhance but not harm the environment (Newman & J., 1999). Indeed, even during pre-modern upheaval, mankind changed nature with stone apparatuses and fire. With the monetary and innovative changes, modern revolutions and spreading human populations brought about bunches of ecological problems, for example, the vast size of fossil fuels utilized, the demolition of normal assets, air and water contamination, nursery impacts, and so on (Sustainability Report, 2011).

As a result of the fine statement made by Brown et. al. (1987, p. 713) in their work titled Global Sustainability that '… Indefinite human survival on a global scale requires certain basic support systems, which can be maintained only with a healthy environment and stable human population', the first Earth Day was organized in the United States on April 22, 1970. After a year, Canada created a Department of Environment, followed by the Stockholm Conference on the Human Environment organized in 1972 (Kennet, 1972). In 1976, to center a consideration around the rapid worldwide urbanization, Canada hosted the first United Nations gathering on human settlements (Habitat) in Vancouver (Habitat, 1976). In 1984, the World Commission on Environment and Development was structured and headed by Dr. Gro Harlem Brundtland of Norway. Following 3 years, in the long run, the Brundtland report, 'our common future', discharged the term 'sustainable development' and made the definition, which is 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (United Nations , 1987).

Clearly, urban areas shape the world, and we will never start the sustainability transformation unless we can relate it to urban communities (Yanarella & Levine, 1992). Lefebvre expressed that thought as a "demand for a transformed and renewed access to urban life' and portrayed it as 'the right to the city, which is far more than the individual liberty to access urban resources: it is a right to change ourselves by changing the city' (Harvey, 2008).

As university campuses can be considered small cities because of their own very distinct communities, variety of daily activities such as working, studying, business, and even infrastructure facilities, and sharing the same environmental problems as an urban characteristic (Balsas, 2003; Norzalwi & Ismail, 2011; Saadatian et al., 2013; Asadi-Shekari et al., 2014), the responsibility of the campuses has a clear role in the above-mentioned transformation. Balsas states that they are the places where people of different backgrounds, incomes, lifestyles, and attitudes build societies that are at once transitory and lasting and have an ideal human scale (Balsas, 2003). Students are usually more environmentally conscious and open to new ideas (Tolley, 1996), and what they learn while in college is likely to influence their future choices (Toor, 2003)

However, with these unique, consciously small communities, the association of university leaders signed the Talloires Declaration for a Sustainable Future. It was signed by 31 university leaders and international environmental experts representing 15 nations worldwide, and as of February 2017, 502 college and university presidents had signed the declaration for sustainability principles (Balsas, 2003; The Heinz Family Foundation, 1995; Mainsfield, 1998; Sharp, 2009). So, the campus sustainability movement started with the Talloires Declaration in the early 1990s.

In recent years, international bodies like UNESCO have dedicated themselves to encouraging higher education institutions to commit to sustainable development and have created lots of policy documents to address the challenges they face in embedding sustainability into their operational structures. A notable guide titled "Education for Sustainable Development: Toward the Achievement of the SDGs (ESD by 2030)" was introduced at the 40th UNESCO World Conference in 2020. This guide outlines strategies for achieving the 17 Sustainable Development Goals by 2023 through education focused on sustainability (Mohammadi Y., et al., 2023; UNESCO, 2020; Dagiliūtė, Liobikienė, & Minelgaitė, 2018; Žalėnienė & Pereira, 2021). Hence, higher education institutions seem increasingly important to create change, and along the way, universities around the world are making projects aimed at advancing the United Nations Sustainable Development Goals (Sugiarto, Lee, & Huruta, 2022; Sharp, 2009).

1.1. Smart Adaptations on University Campuses

There are differences in universities' approaches to implementing sustainability criteria. According to the vast literature survey conducted in 2022, activities related to sustainable campus development are divided into three main categories: behavioral, learning and educational tools, and physical facilities (Sugiarto, Lee, & Huruta, 2022). Hence, some efforts carried out by the universities to implement sustainability criteria concentrate on how sustainability curriculums are implemented in universities, alongside campus practices and social welfare activities. Other researchers evaluated the contributions of universities to sustainability (Mohammadi Y. et al., 2023). However, sustainability on university campuses encompasses a comprehensive approach that includes sustainable policies and plans and environmentally friendly operations to manage CO2 emissions through improved transportation strategies.

1.1.1. **Sustainable Policies and Plans**

Universities that have demonstrated a commitment to both economic and environmental sustainability include Aalen University in Germany (1998) and Brown University (1996). These institutions have concentrated on reducing their environmental impact through resource conservation in the areas of paper use, heating, lighting, water, and procurement (Weenen, 2000). Broad sustainability strategies that incorporate environmental education and strive for operational efficiency within their infrastructure have been enacted by the Universities of Florida and Hertfordshire (M.Z. Abd-Razak et al., 2011). The University of Hertfordshire, United Kingdom, has developed a Sustainable Development Policy that considers environmental issues, equal opportunities, health, and safety. The University of Waterloo, Canada, on the other hand, claimed that the university can lead sustainability by internalizing a set of desired characteristics: awareness, efficiency, equality, cooperation, and natural systems. Indeed, the University of

Michigan (1999) assigned a full-time sustainable campus coordinator and signed the University of Michigan version of the Kyoto Protocol with the representatives of teaching, planning, financing, housing, construction, management, waste, and transportation. In addition, Appalachian State University in North Carolina set up local summer internships for students under the sustainable development program (Weenen, 2000). On the other hand, some campuses have developed planning policies. For instance, Cornell University (Ithaca) developed a bicycle committee plan in the early 1990's named 'Cornell Cycle'. The University of Oregon (Eugene) also developed a sustainability plan, which was approved in October 2000, while the University of Colorado (Boulder) developed a plan called 'Blueprint for a Green Campus." The University of Washington (Seattle) developed a campus master plan to encourage non-motorized transportation for the period 2002–2012 (Balsas, 2003). Yale has supported more than 1000 employees since 1994 to buy homes around campus areas, which are a short walk, bike ride, or shuttle ride away (Parker & Fields, 2012). The University of Wisconsin (Madison) has changed the workday/workplace and replaced 5-8 working hours with 4-10 hours with a part-time pilot shared parking program (Keniry, 1995). The University of Washington (Seattle) has also tried alternative work hours and telecommuting based on business needs (Balsas, 2003).

1.1.2. **Environmentally Friendly Operations**

Transportation strategies also play a significant role in campus sustainability, addressing the rising concern over CO2 emissions, which are predicted to increase significantly by 2030 (Woodcock et al., 2009). Universities are tackling this challenge by promoting public transportation and reducing reliance on private vehicles, which are major contributors to greenhouse gas emissions (B. Metz et al., 2007). The decentralization of cities and the increase in suburban areas have led to higher demands for personal vehicle use, exacerbating environmental and health issues (Tolley, 1996; Balsas, 2003)

To combat these challenges, many universities have implemented transportation demand management strategies, aiming to reduce congestion and enhance safety. This includes initiatives like increasing parking fees, promoting biking and walking, and improving public transit accessibility (Balsas, 2003). There are lots of solutions that university administrations have achieved.

For example, the University of California (Davis), which has 1.5 miles of roadway where all motor traffic is prohibited (Balsas, 2003), created an **auto-free zone**. Colorado State University, Fort Collins, Agnes Scott College, Georgia, and the University of Illinois closed their main campuses to all except emergency and service vehicles (Keniry, 1995). This idea restricts automobile traffic within campus, limits parking, and encourages users to shift to different transportation modes (Asadi-Shekari, Moeinaddini, & Shah, 2014).

The University of Washington (Seattle), for example, applied an extra **fee** to car users and used 40% of the income to subsidize public transit (Tolley, 1996). This program that they use has been a national model in transportation management. The other example is from Cornell University, where the TDM raised the price of parking in 1991, and the effect was a 26% reduction on single-occupant vehicle trips and lots of trip shifts to carpooling (Toor, 2003). On the other side, Arizona State

University (Tempe), for example, increased the parking fees in 1983 and applied a different park fee system to private automobile trips according to distance to the center of campus while working on different transit options (Farris & Radwan, 1989).

The University of Colorado (Boulder) uses small buses with **the Eco-Pass** program, which allows employers to buy passes for their employees. Pass holders ride the buses for free with a valid ID. As a result, there has been a 400% increase in total transit use in the last 5 years (Balsas, 2003; Toor, 1999).

Environmental-friendly fuels are another way that university campuses have tried over the years. For example, the University of Montana (Missoula) is using 100 percent biodiesel for its shuttle buses. Furthermore, they are also using refined fuel from the waste cooking oil from the campus dining halls in addition to commercially purchased fuel. The University of Vermont (Burlington) is also using a 20% biodiesel mix for campus buses (Toor, 2003; Campus Ecology Program, 2002). The University of California (Davis) has replaced 10 diesel buses with new low-emission buses (U.S. Department of Energy, 2002), while the University of Florida regional transit system has maintained a fleet of 92 diesel buses (Bond & Steiner, 2006). In order to encourage environmentally friendly fuels, the University of Colorado tries to lower permit fees for hybrid electric vehicles (Toor, 2003). On the other side, the partnership with Zipcar that Harvard made is among the first, and they have 25 shared cars and 9000 members. In addition, the pilot plug-in hybrid vehicle program was granted by the EPA to construct a 1200-

gallon roof rainwater recovery system to wash the university fleet (Parker & Fields, 2012).

Another solution is to–**encourage people not to drive alone or not to drive at all**. To achieve this goal, some campuses tried to pay the employees and provide free shuttle services, free parking for car sharing, and an emergency ride home. For example, Stanford University (California) has a Clean Air Cash program and pays 2500 employees who do not purchase a parking permit during the year. It started at 90 USD and has grown to 160 USD since then (Balsas, 2003; Toor, 2003; Parker & Fields, 2012).

Educational policies were also applied to achieve sustainability goals. Some universities use text and data mining programs for educational purposes to provide the university community with up-to-date information about transportation alternatives. The University of Cornell, the University of Wisconsin, the University of California (Davis), and the and the University of Washington (Seattle) have bicycle safety classes, readily available regulations, printed materials, and policies on bicycle programs.

Transit-university partnerships are a policy initiative aimed at reducing student automobile use (Delmelle & Delmelle, 2012), and several campuses have provided transit passes to students and employees, allowing free access to bus and rail transit (Toor, 2003; Brown et al., 2001). It has been practiced on university campuses since the late 1970s. In 1998, a survey found that 35 major universities offered some form of unlimited access to transit (Miller, 2001). Some of the campuses are developing high-frequency and late-night transit services (Poinsatte &

Toor, 1999) and providing a quarantined emergency ride home for employees who participate in transit passes or carpool programs (Toor, 2003).

The Yale Free **Shuttle System** provided 1.6 million day and night shuttle trips in 2010–2011 (Parker & Fields, 2012). The University of North Carolina (Chapel Hill) and the University of Wisconsin (Madison) have point-to-point shuttles, bicycle rentals or storage, and guaranteed rides home (Keniry, 1995). The University of Florida has *a regional* transit system in which bus transit to, from, and around the campus is provided by the regional transit system. The buses that operate 21 standard city routes, 9 campus-only routes, 4 late-night routes, and the RTS system have increased each year since 1995 (Bond & Steiner, 2006). Arizona State University (Tempe), in 1977, as a first attempt, operated a greyhound bus with a capacity of 50 people. However, because of a lack of round-trip frequency and mobility difficulties, in 1978 the university installed an open-air tram with a capacity of 60 passengers. It had an 18-minute' service frequency and took a 2-minute load and the same to unload. In 1984, the administration purchased three more trams. As a result, from 1984 to 1987, with properly working trams and increasing parking fees, there was a 45% increase in tram commutes (Farris & Radwan, 1989).

Decide to **walk** for short-distance travel, usually affected by safety concerns and comfort, weather and visual appearance, lifter containers or benches, etc. (Balsas, 2003). On the other hand, **cycling** is mostly affected by the topography and weather conditions. On some of the campuses, for example, with hilly sites, students tend to use cars or motorbikes. In addition, cycling can be affected by land use design policies (Akar & Kelly, 2009).–Although university campuses are considered compact within and around campus (Jalalkamali & Ghraei-N., 2012), one survey in the literature found that because the transportation infrastructure on and around campus is automobile-oriented, people drive their cars even for short distances (Akar & Kelly, 2009) and that vehicular traffic on campus has a negative impact on cycling (Balsas, 2003; Dober, 2000; Dill, 2004; Krizker & Jhonson, 2006; Stinson & Bhat, 2003). Luckily, bike lanes, bike racks, pedestrian crossings, and bike-friendly improvements also affect cycling as a travel mode (Jalalkamali & Ghraei-N., 2012; Balsas, 2003; Dober, 2000; Dill, 2004; Krizker & Jhonson, 2006; Stinson & Bhat, 2003). As a result, the University of Illinois built 7 miles of class bike lanes, custom-designed bike racks, and bicycle accommodation in the parking structures (Keniry, 1995). The University of Colorado (Boulder) has multiuse paths with separate lanes for bicyclists and pedestrians. They have about thirty bicycle paths, lanes, and routes that are a connection between the campus and the community (Balsas, 2003). The University of Washington (Seattle) has 362 lockers, more than any other college in the country. At the University of Oregon (Eugene), in addition to bicycle lockers, there are also locked bicycle cages to prevent vandalism and theft more effectively (Balsas, 2003).

Such measures not only aim to reduce the environmental impact of transportation but also enhance the overall quality of life on campus and in surrounding communities. The drive towards sustainability on campuses is a multifaceted endeavor involving significant changes in both operational practices and transportation logistics. These efforts are crucial but not adequate for reducing environmental impacts and promoting a sustainable future for the next generation.

1.2. Enhancing Sustainable Urban Development Through University-City Synergies

The strategic relationship between a university and its city is essential for achieving both academic goals and urban development, demonstrating the significance of physical ties that extend beyond campus accessibility and profoundly impact student social life and urban potential (Mohammed, Ukai, & Hall, 2022). Universities assist their cities reach their full potential, therefore this partnership also benefits the city. Maintaining a reciprocal relationship between the institution and the city is therefore considered essential to accomplishing strategic goals for both entities (Mohammed, Ukai, & Hall, 2022).

Urban planning and sustainability go hand in hand. Sustainability was essential to build habitable cities following World War II. Image of the City (1960) by Kevin Lynch depicts the grandeur and architectural beauty of cities, implying that real sustainability coexists peacefully with the urban landscape. Studies like those by Lund (2003), who emphasizes the advantages of mixed-use, pedestrian-friendly districts, and Jabareen (2006), who promotes compact, varied urban forms suitable for walking, cycling, and public transportation, lend credence to this idea. These environmentally friendly urban designs seek to shorten travel times, promote social contact, and enhance living standards.

As a result, a university campus should not be considered in isolation; rather, it should develop mutual advantages with the community and region it serves. As a result, while choosing a location for a new university, it is critical to evaluate the potential consequences on regional development and select a site that encourages positive growth (Thilagam, 2015).

As a result, the finest location for a university campus may be the city's historical area, which was once the heart of its foundation but is now relatively neglected and forgotten despite its enormous significance. The infusion of young and creative persons attending the new institution will revitalize this area, transforming the once-forgotten peninsula back into a bustling tourist destination. Furthermore, the adjacent social activity areas will be revitalized. As a result, this new location will contribute to the city's economic, environmental, and social sustainability. But how will the newly established university demonstrate its own sustainability?

1.3. Upcycling Heritage: Adaptive Reuse of historic State Railways (TCDD) Lodgings Campus

Upcycling is a sustainable practice that involves transforming waste materials into new, the perfect mix between ‘upgrading’ and ‘recycling', taking something that is disposable and transforming it into higher-value products (Sung, 2023; Singh, Sung, Cooper, West, & Mont, 2019; Wegener, 2016). Upcycling not only reduces waste but also extends the life cycle of products, encouraging sustainable consumer behavior and creating economic opportunities (Sung, 2023; Singh, Sung, Cooper, West, & Mont, 2019).

Upcycling improves the environment, the economy, and society in general. Upcycling has a substantial environmental impact since it reduces the volume of garbage headed for landfills and lowers the demand for virgin resources, conserving energy and lessening the effects of climate change. Economically, it generates work possibilities, particularly in waste-rich areas, and expands markets for creative, sustainable products. Upcycling fosters creativity and community participation, boosting local economies through workshops, markets, and collaborative initiatives (Sung, 2023; Singh, Sung, Cooper, West, & Mont, 2019).

Adaptive reuse of built heritage is another popular sustainable approach for preserving economic, environmental, and social values and passing them down to future generations. It also leads to a reduction in environmental effects and carbon footprint (Daneshmand, 2023) and extends a building's life, avoids demolition waste, encourages reuse of embodied energy, and also provides significant social and economic benefits to society (Tam, 2019; Yung and Chan, 2012).

Economically, adaptive reuse decreases the significant energy and material costs associated with new construction while also reducing greenhouse gas emissions from traditional building methods (Mohamed, Boyle, Yang, & Tangari, 2017; Tabak & Sirel, 2022). Building operations, which include energy from electricity and natural gas, account for about 28% of global greenhouse gas (GHG) emissions (Greer, Raftery, & Horvath, 2024). For every four commercial buildings built in the USA, one is demolished. Annually, the U.S. sees the demolition of roughly one billion square feet of buildings, which contributes to nearly half (48%) of the solid waste produced over a building's lifecycle. During construction, around 8% of lifecycle solid waste is generated, while maintenance and repairs contribute about 44%.

According to EPA estimates, the combined waste from construction, demolition, and renovation activities amounts to approximately 160 million tons per year, accounting for roughly one-third of total non-hazardous waste in the country (Greer, Raftery, & Horvath, 2024; Mohamed, Boyle, Yang, & Tangari, 2017). By converting existing structures for new uses, adaptive reuse can also generate significant long-term economic benefits for communities, particularly when integrated into economically diverse neighborhoods where such projects might enhance local job creation more significantly than in more affluent areas (Mohamed, Boyle, Yang, & Tangari, 2017; Tabak & Sirel, 2022; Owojori, Okoro, & Nicholas, 2021; Plevoets & Van Cleempoel, 2019).

Dikmen mentioned that the conservation of ecosystems and sources is the foundation of environmental sustainability. Economic sustainability is based on the long-term utilization of resources and their low cost. Human health and the preservation of cultural values are the foundations of sociocultural sustainability. (Dikmen, 2017).

Ecologically, adaptive reuse supports resource conservation by reducing waste and using recycled resources, lowering overall carbon emissions (Mohamed, Boyle, Yang, & Tangari, 2017; Tabak & Sirel, 2022).

Socioculturally, adaptive reuse has the potential to convert abandoned or dilapidated neighborhoods into thriving community hubs, attracting visitors and fostering social cohesion. Adaptive reuse promotes the continuance of social and cultural life by reviving ancient structures with new functions while preserving its cultural character, enhancing the community's fabric, and minimizing degradation and criminal activity that are frequently connected with vacant urban spaces (Mohamed, Boyle, Yang, & Tangari, 2017; Tabak & Sirel, 2022).

The importance of preserving ancient cities is widely acknowledged and unarguable in all economic, cultural, and ecological aspects. According to the International Council of Monuments and Sites (ICOMOS), historical cities and territories are renowned not only for their documented aspects, but also for the values associated with urban cultures. The buildings in an architectural setting reflect the lives of the civilizations they belong to. In this regard, it is critical to preserve them for their historic significance. The preservation of cultural assets for future generations without causing harm exemplifies the sociocultural continuity of conservation (Tabak & Sirel, 2022).

Application of the adaptive re-use strategy by educational institutions can contribute to acquiring available urban campus land, integrating the academic body into society, transforming deteriorated areas, preserving industrial heritage, and serving the university mission, which ultimately generates vitality and socio-spatial sustainability (Haniye Razavivand, 2020).

Moreover, the existence of a university invigorates metropolitan areas, augmenting the financial foundation, standard of living, and urban heterogeneity (Den Heijer, 2008). When urban colleges repurpose abandoned industrial areas, they become part of the city's fabric and contribute to its socio-cultural and spatial regeneration (Hoeger and Christiaanse, 2007; Haniye Razavivand, 2020). In addition to changing the sociocultural and economic landscape of their communities, these adaptive reuse projects also bring in new hybrid uses that revitalize local areas and promote community vitality (Haniye Razavivand, 2020).

As a microcosm of urban space, the university itself embodies qualities that make an environment responsive, like permeability, variety, and durability. According to theorists such as Appleyard, Bentley, Lynch, and others, these components are essential in creating livable and dynamic urban environments (Bentley et al., 1993; Lynch, 1981; Carmona et al., 2003). The application of urban design ideas on campus improves overall quality of life and promotes a sustainable urban environment, reflecting on the larger urban context.

So adaptive reuse of a historic heritage as a university campus is concentrated in the environment, economic, and social development corners of sustainability, which gives greater value to a forgotten and unused part of the city.

2. Material and Method

The study focuses on the adaptive reuse of the TCDD lodging campus used as a university campus, namely Ankara Medipol University. Initially, we conducted a comprehensive literature review to comprehend the connection between sustainability and adaptive reuse. We then carried out desktop research to explore the potential educational benefits of converting a historical campus into a university within a historical region. After spending over 10 years in the region and 4 years on the campus in question, we analyzed the richness and diversity of the region through field trips and photographs. After that, in the light of the restitution and restoration reports, statements were made on how the campus ensures the sustainability of the historical structures during reuse.

Finally, we conducted an online survey to investigate the perception of adaptive reuse of historical area among design students and its impact on education. We prepared the questions based on the criteria used to evaluate spatial behavior in urban public spaces.

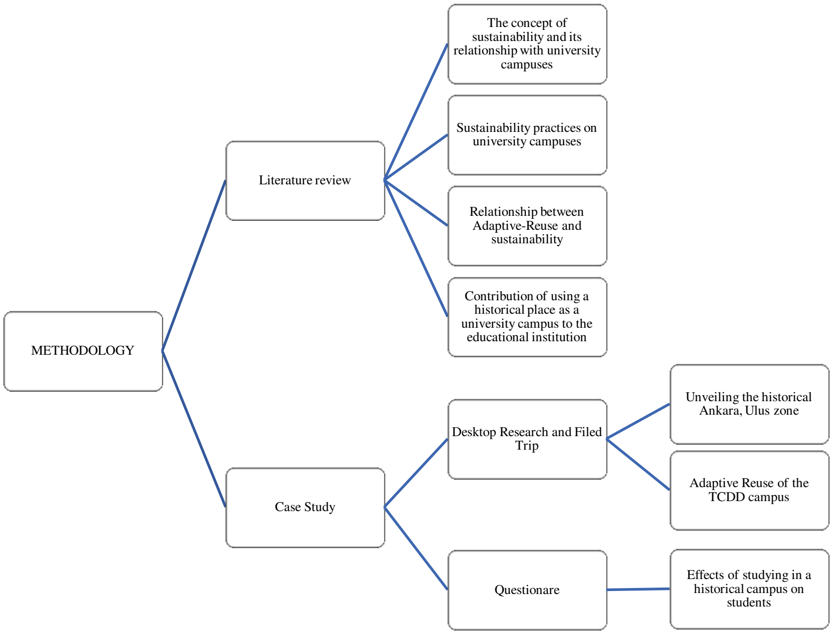

Figure 1. Methodological Approach

3. Findings and Discussion

The adaptive reuse of historical state railway structures on university campuses beautifully illustrates the convergence of heritage preservation and modern education, creating academic environments rich in cultural legacy. When we delve into the history of the Ulus district, we discover a rich historical existence. This historical area, which nourishes life in many ways, also supports an educational institution that strives to impart vision and mission to its students from all angles.

3.1. Echoes of the Past: Unveiling the Historical Layers of Ankara-Ulus Zone

Ankara's geomorphological location is the most important factor affecting the formation of the city's macroform. The citadel's summit is positioned on the hill's southern and western shores due to the rich topography. The original map (Figure 2), 1839, shows the interior and exterior walls of the citadel surrounding the two areas, which disappeared in subsequent periods (Mıhçıoğlu Bilgi, 2010).

Figure 2. 1839 Von Vincke Citadel Plan and 1924 Ankara Plan

We are seeing two master plans that have played a major role in Ankara's post-Republic urban development. Berlin architect Carl Christoph Lörcher drew up the Lörcher Plan between 1924-1929, while German architect Professor Hermann Jansen drew up the Jansen Plan between 1929-1939 (Figure 3).

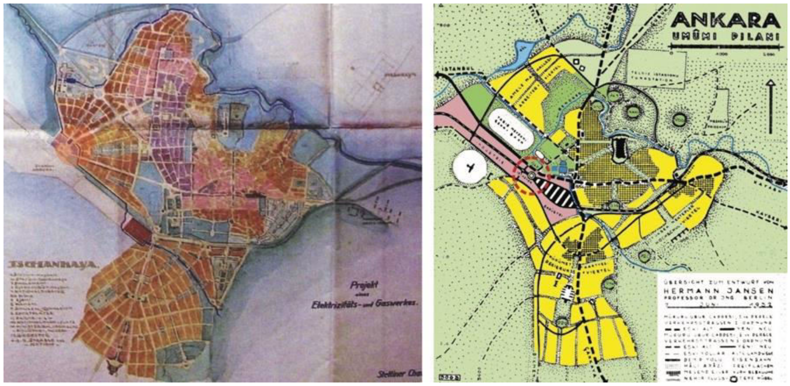

Figure 3. 1924 Lörcher Plan and 1929 Jansen Plan

Carl Christoph Lörcher drew the first Ankara plan, proposing a new center around the central station and a compact city that established the foundations of the New City. The plan's biggest contribution was the arrangement of land for the new public buildings requested by the government. The government also commissioned Turkish architects like Mimar Kemal and Vedat Tek, along with popular Western architects Giulio Mongeri, Clemens Holzmeister, and Ernst Egli, to design public buildings (Günay, 2012).

Within the newly established political boundaries, Ankara, of strategic importance, became the center of government and the test ground for the republican administration's attempts to develop a new society and city in line with the rules of modernism. The government chose to develop the city based master plan, organized a competition in 1928 and requested proposals from three European urbanists. The jury selected Jansen's urban design, aiming to transform an Eastern community into a Western metropolis. The goal was to construct an exemplary city that would foster a modern and contemporary living environment, establish new social norms applicable to other urban centers, and represent the Republic's achievements in establishing this new city (Günay, 2012).

Both plans clearly show that the administration of the capital Ankara, established itself in the new city around the citadel. This region, known as the Ulus, has become a center of intensive use by enlightened people, artists, and especially politicians during the early years of the Republic due to the presence of institutional, commercial, and social structures (Bayraktar, 2013).

In the fast-growing capital, the population had grown rapidly, and there was a need for housing and jobs. The old railway station, the main gateway to the city and the focal point of the transport network, was starting to become insufficient due to the increasing passenger capacity. It was therefore decided to build a new central railway station (Özgür, 2016).

The city's entrance gate, the state railway station, was located at the intersection of two important axes leading to the citadel, the İstasyon Caddesi (today Cumhuriyet Caddesi) and the Talatpaşa boulevard. Ataturk Boulevard, which is also one of the important axes of the city, intersects these two axes and continues throughout the city. In all of Ankara's plans to date, it is evident that these three axes have preserved themselves and grown with the city (Figure 4).

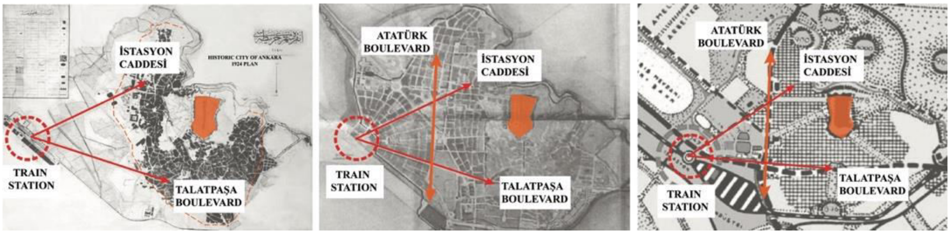

Figure 4. The two axes preserved; İstasyon Caddesi and Talatpaşa Bulvarı - 1924 Ankara plan, the Lörcher plan and the Jansen plan, respectively

İstasyon Caddesi, which leads directly to Ulus Square, and Atatürk Boulevard, which intersects the İstasyon Caddesi, host buildings that have secured a place in Ankara's early republican architectural history (Baloğlu, 2022). All of the buildings are themselves architectural subjects designed by famous Erupean and Turkish architects to reflect the style of the era. Apart from its architectural value, Anafartalar Çarşısı is also a living museum with its artworks, like ceramic wall panels and wall murals, produced by famous Turkish artists of the period. We can name the most important ones as the First Assembly Building (1920), the Second Assembly Building (1981), the Ankara Palace (1928), the İş Bankası (1929), the Sümerbank (1938), the Ottoman Bank (1926), Ziraat Bank, Ulus İşhanı, Anafartalar Çarşısı, Ulus Square, and so on (Figure 5).

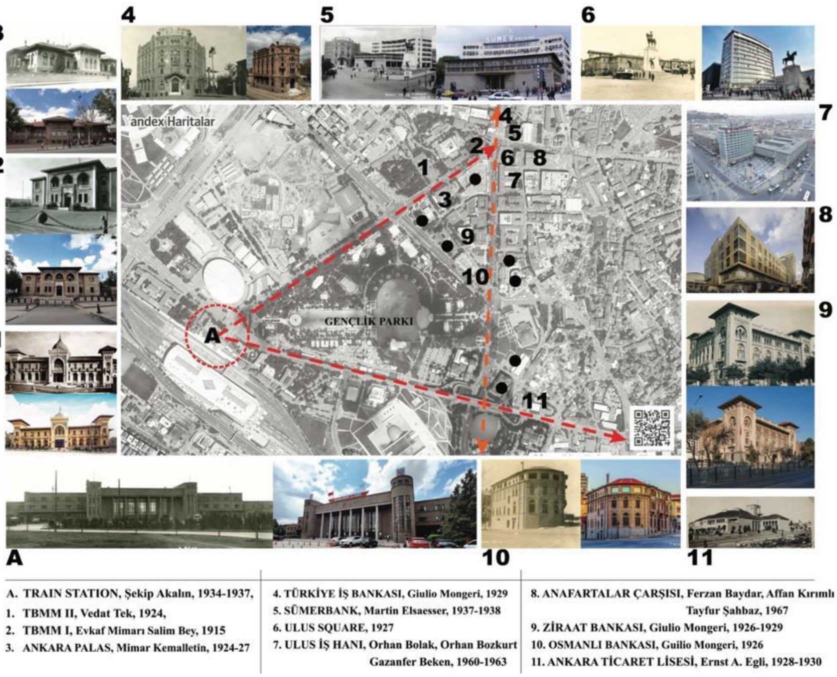

Figure 5. Historical buildings around the campus

The Ulus region is not only home to historical structures but also hosts variety of cultural facilities (Figure 6). Examples include the Painting and Sculpture Museum (1930), the Small Theater inside the Evkaf residential building (1930), the Opera Stage (1933), the Presidential Symphony Orchestra (CSO) (2020), and Cermodern (1927, adaptive-reuse 2010), which are venues for theater, exhibitions, concerts, and various other events.

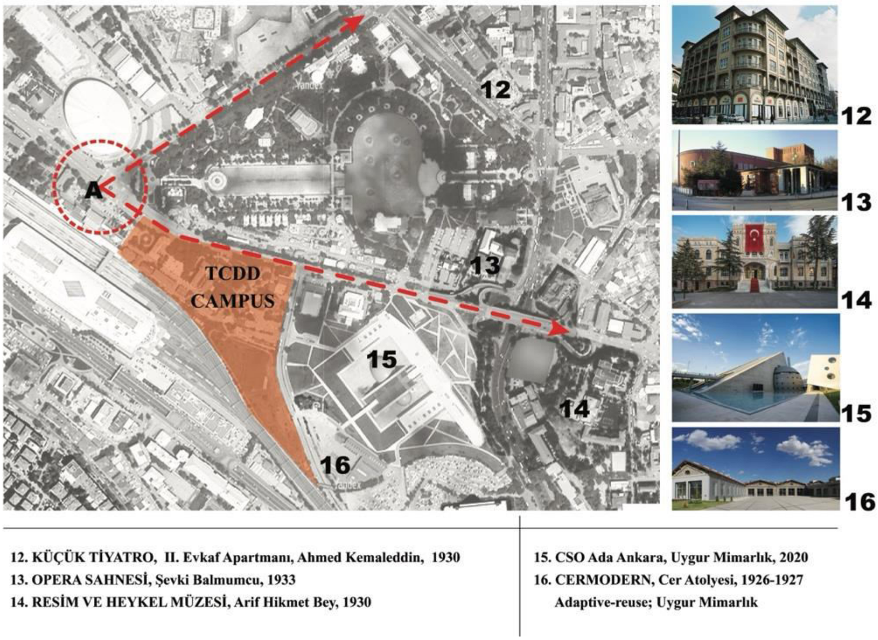

Figure 6. Social attractions around the campus

The Ankara Castle region has been an important center throughout history, not just after it became the capital. Ankara, which is geographically located between Marmara and Central Anatolia, was the first stop on the main route that connects Europe to the Middle East after leaving the central Marmara region of Istanbul. It hosted many nations throughout history, including the Hittites and Romans, and contains many historical relics from these periods. Between the 16th and 18th centuries, it continued to be an important center for the production and processing of mohair and angora in the Ottoman Empire (Günay, 2012).

Considering all of this, the significance of the train station and the surrounding area—which serves as a university campus—in terms of history, architecture, and politics becomes visible. Although wire mesh that surrounds the campus for security reasons, its transparency allows the campus to be connected with the city and its surrounding heritage.

3.2. Adaptive reuse of TCDD Campus: Before and After

The Anadolu Railway Construction Company prepared the 1889 Izmit-Ankara Line Convention to construct a station with buildings and annexes ranging from 0 kilometers to 49,750 kilometers. This source encompasses the technical specifications and the unit price list, outlining the detailed construction of the railway structures in the contract. The most important information obtained was the creation of a construction plan for the Anadolu Railway. As a result, the construction plan for the Anadolu Railway provides guidance on the placement of numerous additional structures, including dormitories, additional buildings, workers' houses, and security houses. This source clarifies that the railway heritage encompasses more than just passenger buildings and railways (Erkan & Ahunbat, 2008).The Ankara Station complex includes the Ankara Station Building, the Talatpaşa Residence, currently functioning as a museum, the Railways Museum and Art Gallery, the Ankara Open Air Steam Locomotive Museum, the Clock Tower Station Casino, the High-Speed Train Regional Directorate, known as the structure signed by architect Kemalettin, and, TCDD General Directorate Building, along with residential buildings and some other supplementary buildings that are unregistered (Yağcı, 2020).

Numerous structures within the university campus reflect the architectural and political trends of the era, contributing to our understanding of the past. The most significant among these is the State Railways 2nd Business General Directorate building and the TCDD

Museum and Art Gallery building. The other registered buildings include residential buildings known as double officer houses, TCDD staff housing, nursery and daycare facilities, and the Demirspor club building.

The historical campus transferred to Ankara Medipol University in 2018 is located at a gateway to the past. The university is supported and enriched by the old campus which is surrounded by numerous historical structures, cultural activities, and most importantly, its own historical value.

Some of the registered buildings included in the TCDD (Turkish State Railways) Station Complex are now part of the Ankara Medipol University Ulus Campus Housing Structures Survey-Restitution and Restoration Project. The locations of these registered buildings included in the project's work area are shown in Figure 7.

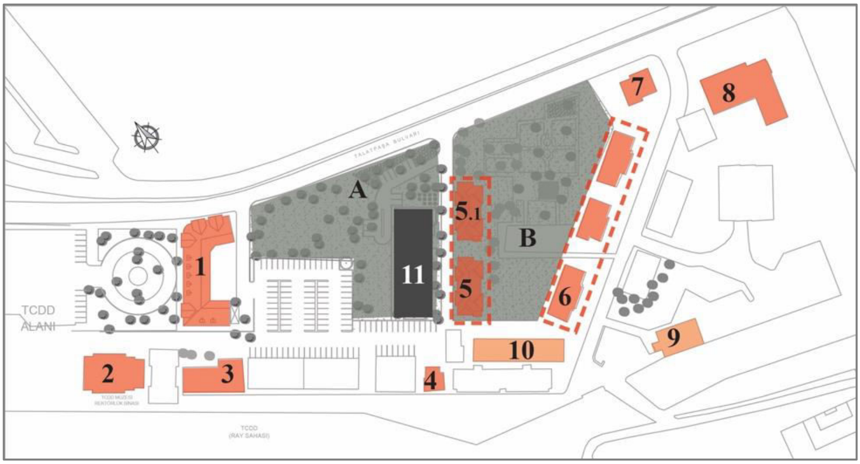

Figure 7. Campus map and registered buildings

3.2.1. TCDD 2nd Business General Directorate Building (No1)

It stands out as the most significant and monumental railway structure after the Republic. Architect Kemalettin Bey designed the building for the General Directorate of State Railways, and construction began a month after his death on August 11, 1927. They completed and opened the structure in 1928. The building was originally designed as housing for railway employees, but it has since been used for different purposes as a general directorate building, a vocational school, and a student dormitory (Yılmazyiğit, 1983).

The Railways magazine (issue: 31, vol. 3, p. 271) reports that the original design of the building, now known as the General Directorate of State Railways, was for a multi-story residential structure. These residences, intended for railway employees, temporarily occupied the General Directorate of State Railways until the completion of the new station and its annexes. However, they were unable to fulfill their original purpose, so they became known as the Directorate. The building was adaptive-reuse over and over again, served as a vocational school from 1941 to 1947, was handed over to the Ministry of National Education from 1947 to 1957, was used again as a vocational school from 1957 to 1961, then used as the State Railways Student Dormitory from 1961 to 1963, and afterwards, finally, it was given to the State Railways 2nd Operation Directorate (Yıldırım, 1981).

The original design called for the building to surround a large inner courtyard. However, only one-third of the building, which faces the station, underwent initial construction, with the remaining portions planned for later completion but never completed. In a design drawing showing the entire facade facing Talat Pasha Boulevard, a vertical line separates the one-third of the building from the rest; this separation is proving that it was originally planned to be constructed in two phases (Yağcı, 2020). The façade remained the same until today (Figure 8).

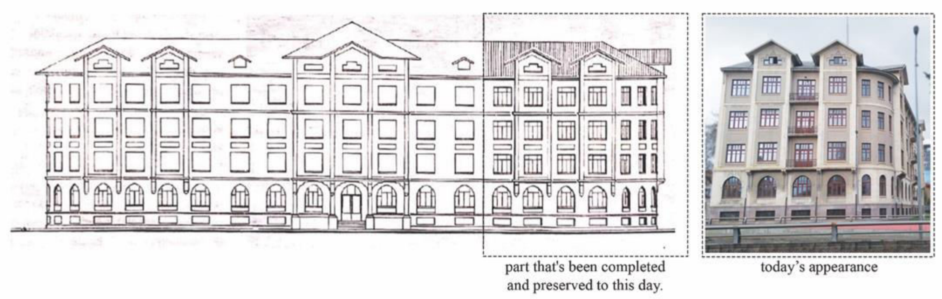

Figure 8. The schematic appearance of the 2nd Building of the Directorate-General of Operations and current view (2024)

As shown in Figure 9, the building designed as a residential structure was originally planned to have four apartments per floor. Between 1928 and 1941, it served as the general headquarters building, and from 1941 to 1961, it functioned as a student dormitory and later as the operations headquarters. During these periods, the walls dividing the apartments had been removed to ensure continuity from one end of the corridor to the other. Additionally, some rooms had been merged as needed to create larger spaces (Yağcı, 2020).

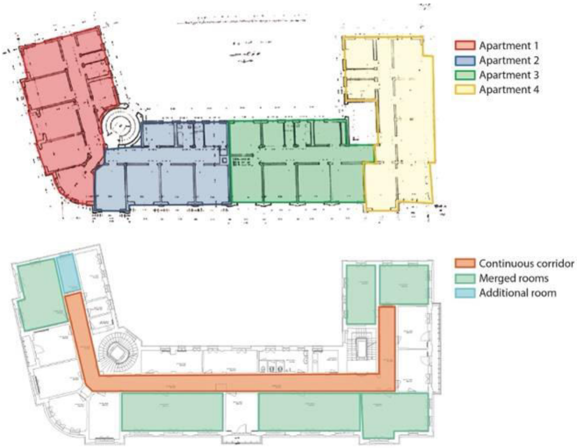

Figure 9. Original plan on top and changes made in the use of TCDD on the bottom

After inheriting the building, Ankara Medipol University followed the restoration studies, which suggested that rebuilding the original walls was not viable. As a result, the university kept the building's original layout, renovating the old and damaged internal rooms without changing the structure's architecture. As seen below, Figure 10, no alterations were made to the façade, keeping its original state.

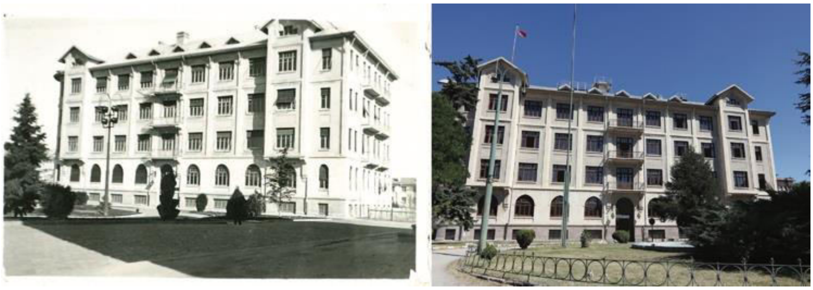

Figure 10. Rectorate building before and after Ankara Medipol University

3.2.2. TCDD Museum and Art Gallery Building (No2)

The building (Figure 11), designed by Kemal Süha Esen, one of the architects of the railways during the early Republic period, was commissioned in 1924 to meet the need for a hotel in Ankara at that time. Although it was named "Ankara Hotel," it was hardly used for this purpose. The stone structure was restored by the State Railways in 1990, and until 2018, its first floor served as an art gallery and the second as the Railways Museum. Despite some minor modifications, such as merged spaces and additions of wet areas to meet the needs of its former uses, the original character of the building has been largely preserved (Yağcı, 2020).

Figure 11. Museum and Art Gallery building, before and after Ankara Medipol University

The building, which was closed to use until it was incorporated into Ankara Medipol University, has since been restored by the university and continues to be used for several purposes such as presentations, meetings, and exhibitions.

3.2.3. TCDD Residential Unit (No3)

It is believed that the residential structures within the campus, intended for administrative staff, were built in the 1930s after the construction of the TCDD (Turkish State Railways) Station Complex. Restitution findings indicate that the facade of the building, both the southwest front and the northeast rear facades, particularly in terms of window arrangement, suggests that the section marked in Figure 12 was added later.

Figure 12. The original structure (left) and the additional structure (right)
According to restoration reports, additions to the building will be demolished and removed. Doorways that were previously sealed off inside the walls will be reopened. The building is currently in service as a university unit (Figure 13), although its restoration has not yet been completed.

Figure 13. From residential building to faculty service (above: TCDD use, 2020; below: Ankara Medipol Use, 2024)

3.2.4. TCDD Pink Villa (No4)

The building, which is currently very small and has unique architectural features, has lost its originality due to the changes made. As seen in **Figure 14**, additions had been made to the entrances on the basement and ground floors, and the terrace area on the first floor had been enclosed to convert it into a room (Yağcı, 2020).

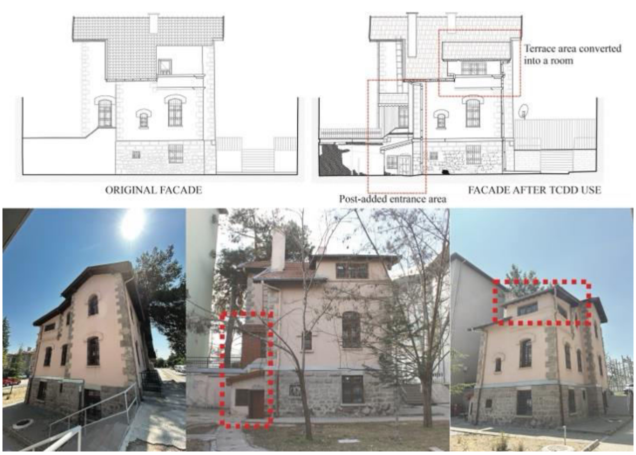

Figure 14. Pink house before and after TCDD use

According to the restoration report of Ankara Medipol University, the roof and the walls on the currently enclosed terrace on the first floor will be removed. Non-original elements that do not match the building's character, such as added partition walls and false ceilings, will be removed. The added entrance section on the basement level will be removed and rearranged according to the restitution project. A staircase with five stone steps, as originally planned, will be constructed at the basement entrance. The addition found at the ground floor entrance will also be removed and reorganized according to the restitution project. By 2024, the building, whose restoration will not yet be completed, will be used as a guesthouse.

3.2.5. TCDD Dual Officer Housing/Kindergarten (No5)

The residential buildings, thought to be constructed between 1930-1940, are known as “Dual Officer Houses.” The original design of the structure consists of two separate Houses with independent entrances, built side by side. Once a TCDD (Turkish State Railways) House building, it was later converted into a kindergarten for employees’ families. This rectangular building was transformed into a single structure by removing the common wall along the central axis. The building has undergone numerous modifications both inside and on the façade. A significant change was the alteration of the building’s main entrance façade.

Figure 15. Additional entrance hallway (left: TCDD use, 2020; right: Ankara Medipol Use, 2024)

A new entrance hall was added to the southeast façade to facilitate its use as a kindergarten (Figure 15), and the original entrance hall, where the main doors were located, was closed off to create rooms (Figure 16, no5). The original entrances had been preserved in the adjacent second building that continued to be used as residential housing (Figure 16, no5.1) (Yağcı, 2020).

Figure 16. Original entrances of the dual officer houses

Another obvious difference is the original balconies introduced in the plan schematics. The terraces and staircases leading to them had been enclosed with window (Yağcı, 2020). After receiving the property, Ankara Medipol University has substantially restored the structures to their former condition (Figure 17). The terraces has been returned to their former character, but the closed entrances could not be restored, and the new entry could not be re-constructed, therefore it has been left as it is. All non-original modifications to the interior have been removed, and with following maintenance and restorations, it has been re-opened as faculty offices (Figure 18).

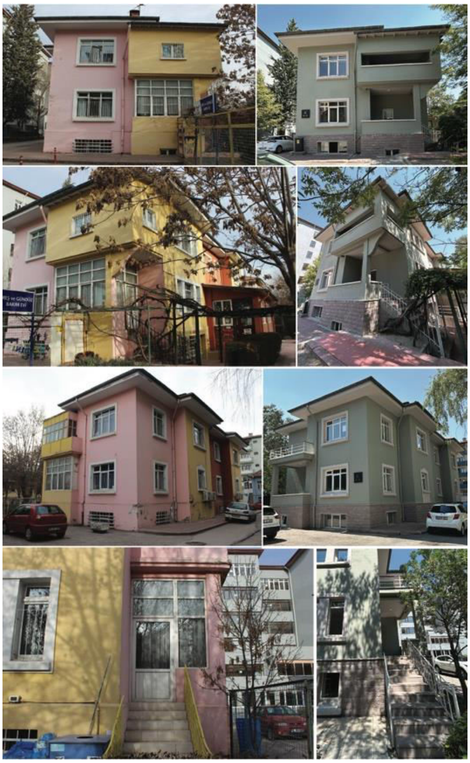

Figure 17. Deteriorated and preserved original façade (left: TCDD use, 2020; right: Ankara Medipol Use, 2024)

Figure 18. From kindergarten to faculty offices (above: TCDD use, 2020; below: Ankara Medipol Use, 2024)

3.2.6. TCDD Twin Houses (No6)

The TCDD was built as a housing unit for the staff of the Directorate-General and is among the structures that can retain the original scheme today. In the original plan of the building on the current plan, the two floors were constructed as two separate houses adjacent to each other. The entrances to the apartments on the floors are designed to be independent from the outside. Based on its current condition, no significant changes had been made on either floor of the structure. The biggest change is that the entrances to the apartment on the second floor are closed with a wooden window (Figure 19) (Yağcı, 2020).

Figure 19. Entrance landings covered with glazed windows

After being taken over by Ankara Medipol University, the poorly conditioned interiors (Figure 20) and the exterior façade (Figure 21) have been cleaned and renovated, and the landscape has been re-arranged. The building is also planned to be used as a housing unit for university staff.

Figure 20. Interior restorations (above: TCDD use, 2020; below: Ankara Medipol Use, 2024)

Figure 21. Exterior restorations (above: TCDD use, 2020; below: Ankara Medipol Use, 2024)

3.2.7. TCDD Single Residence (No7)

The building, originally constructed as a single residence for TCDD General Directorate employees, undergone significant changes and was divided into four separate residential units. Many interior walls had been built, some had been removed to create new spaces, and even some doors and windows had been sealed. According to the restoration report, walls that were previously removed will be rebuilt in line with the restitution project, and sealed doorways that are needed will be reopened. Non-original, mismatched constructions such as added partition walls and false ceilings will be removed. Non-original entryways will be closed off, and the space will be used for faculty offices (Yağcı, 2020).

Figure 22. Single Residence (above: TCDD use, 2020; below: Ankara Medipol Use, 2024)

3.2.8. TCDD Demirspor Club House/Wedding Hall (No8)

The historic structure was originally built within the railway station complex to serve as a venue for the social activities of Demirspor Club, a sports club for railway workers. Over time, significant alterations had been made to its floor plan to suit various uses, leading to a loss of its original architectural integrity. It is believed that the original layout of the building was a single rectangular mass extending in a north-south direction, as depicted in Figure 23. A rectangular structure aligned east-west was later added to the western façade of the building to serve as a wedding hall (Yağcı, 2020).

Figure 23. Additional structure, only the red structure is original

Ankara Medipol University chose not to destroy the existing addition because of the environmental challenges, instead, the university renovated the building as it was and repurposed it as a cafeteria.

Figure 24. From club house/wedding hall to cafeteria (left: TCDD use, 2020; right: Ankara Medipol Use, 2024)

3.2.9. TCDD Non-Registered Structures (No9-No10)

As described above, all structures within the campus have historically adapted to various functions over time with each use. The lack of education among users, the uncontrolled nature of changes and transfers, diminished the value of the buildings over time. Ankara Medipol University has restored the buildings as much as possible to bring their original values, renovated them, and repurposed them for educational use. Not only registered buildings within the campus but all usable structures have been transformed and put into service for educational purposes. Among the most important ones is the old childcare home (Figure 25) and the temporary structure, mamed hangar, used as a worker's cafeteria (Figure 26), which have been restored and is being used as design studios for the Department of Interior Architecture and Environmental Design.

Figure 25. From staff cafeteria to design studio, (3rd grade studio)

Figure 26. From Childcare home to design studios (1st and 2nd grade studios) (above: TCDD use, 2020; below: Ankara Medipol Use, 2024)

After being incorporated into the university, all structures within the campus have been renovated, landscaped, and transformed into educational facilities.

3.2. The Impact on Students of Using the Historic Railway Campus for University Purposes

As previously said, it is thought that adaptive reuse of historical environments for educational purposes strengthens students' connections to history and identity through their physical surroundings (Huang, Liu, Lyu, & Li, 2024; Bianchi, Medici, & Stefania, 2023). Adaptive reuse of such an environment is expected to have a significant impact on students' curricular and extracurricular activities, giving hands-on learning experiences that prepare them for the sustainability issues of the professional world (Rotchniak, 2015). As a result, the research conducted a survey among Ankara Medipol University, Interior Architecture and Environmental Design students to determine the influence of studying on such a historic campus and city center on students.

194 students out of 251 responded to the questionnaire. 30.9% of them are first grade students, 27.8% are second grade, 27.3% are third grade, and 13.9% of the respondents are graduated students. 38.7% of the respondents are not from Ankara, yet, 96.9% are living in Ankara during the semester. 57.2% of the respondents had no knowledge about history of the region before they started their studies on campus, but 65.9% had knowledge of the history of Ulus and the surrounding area. 69.5% of the students stated that the location of the campus significantly influenced their perception of the city.

The quality of urban space is a complex concept that is determined by various interrelated factors. Each community has its own unique set of characteristics that contribute to this concept, which can be viewed from two perspectives: the social dimension and the physical attributes and spatial layout of the environment. The physical characteristics and visual look of a place are crucial factors in understanding and experiencing it. According to the literature, in order to enhance the environmental quality, specific design principles should be implemented. These principles include permeability, variety, legibility, robustness, visual appropriateness, richness, and personalization (Fard, 2014).

Permeability describes how simple it is for individuals to enter a location, including the availability of multiple routes, mainly about the transportation (Fard, 2014). So we asked about the accessibility of the campus. Since the campus is located at the busiest point of the city and next to the intercity transportation point, the train station, there are many modes of transportation. These include metro, buses, and minibuses. Therefore, 90.2% of the students said that transportation to the campus is easy. 70% of the students are using public transportation, while 19.6% prefer to use private vehicles. The most used public transportation mode is subway (52.6%), and buses are the second most preferred mode of public transportation with 36.1%. Most importantly, 84.5% of the students stated that the fact that the campus is located in the city center positively affects the use of public transportation.

Variety refers to diversity of uses in a space, which gives people a variety of spatial experiences. In this case, we consider the whole historic area as a campus. We asked questions about students' interest in and reactions to various activities. First, it is asked how they assess the flexibility of the environment for various activities. Interestingly, although we mentioned above, there are many historical buildings, bazaars, museums, theaters, parks, concert halls, and many restaurants and cafes in the vicinity, 63.9% of the students stated that it is not flexible, and 68.5% claimed that it is insufficient. However, when we asked specifically whether they visit the social areas around the campus (CSO, CerModern, Ulus and its venues, Gençlik Park) for activities such as meeting with friends, eating, etc., 78.4% of them stated they do. When we asked whether they follow the art events taking place at the CSO, CerModern, Küçük Theater, and Büyük Theater around the campus, 80.4% stated that they do.

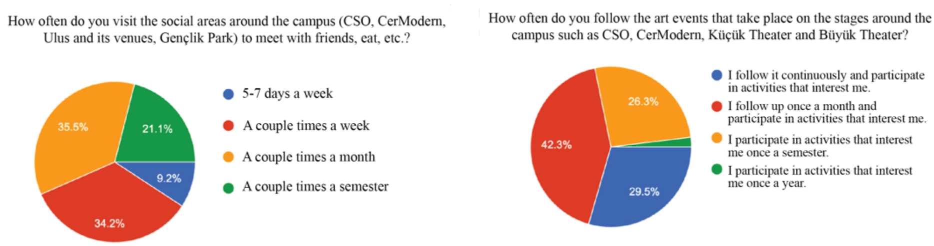

Figure 27. Frequency of following social activities around the campus

Robustness also refers to a location's capacity to accommodate a variety of uses. It is especially important in public areas where a range of activities and social interactions take place (Fard, 2014). Hence, when we asked how much time they spent at the campus, 70% of the students stated that they do not spend time on campus outside of class hours. 72% of the students do not enjoy spending time on campus. However, there is only one container café in the campus, and respectively 95.9% of the students stated that they find the social areas inside the campus highly insufficient (eating, drinking, meeting), and 88.8% stated that insufficient social areas negatively affect the decision to spend time on campus.

Legibility is the idea of how easily an environment can be understood based on its layout and physical components like landmarks and paths (Fard, 2014). As it is a very small campus and all the buildings have their own unique features, 69.6% of the students stated that it is easy to understand the spatial layout of the campus. Then we asked about how students perceive the campus environment and asked them to list the 3 most prominent structures inside the campus, and the results showed that the rectorate building (No. 1, 68%), the design studio (No. 10, 60.8%), and the building with classrooms (No. 11, 48.5%).

Visual Appropriation relates to how people interpret and attach meanings to a place (Fard, 2014). Having spent half the year on such a historically visually rich campus, we asked students how they would rate the visual attractiveness of the campus, and 75.2% of the students stated that it is not attractive. Yet 82.5% stated that they prefer to have a historical campus rather than a newly constructed building (the newly constructed building belongs to the Ankara Mediol University near the Ankara High Speed Train Station). This answer may have been influenced by the fact that the lecturers talked about the value of the campus during the studio classes so much. However, when we asked how they would evaluate the organization of the campus environment (location of buildings, location of common and green areas, etc.), 51% of the respondents claimed that it is chaotic.

Richness refers to the variety of sensory experiences a place offers, meeting a wide range of user expectations, particularly through visual cues (Fard, 2014). However, 75.2% of the students do not find the campus attractive, and 84% of them find the green areas on campus insufficient (for the green areas, see Figure 28). Also, only 26.2% stated that the campus environment positively affects their personal well-being and mental health.

Figure 28. Green area (B) and Green area (A)

Personalization is the process of involvement in modifying and personalizing a space to reflect their identity and preferences (Fard, 2014). When we asked students whether they feel a sense of belonging or attachment to the campus, 57.2% stated that no. Yet, 54.5% of the respondents claimed that living in a dormitory on campus positively affects their sense of belonging. On the other side, the design and historical context of the campus seem to have not much effect on the sense of belongings (49.5% stated that it does not affect).

Beside all, the survey also investigated how all these historical and architectural varieties affect architecture education. 58.2% think that studying on a campus with historical significance does not affect the learning experience; only 33.5% of the students stated that it does. Again, 54.1% stated that the campus environment does not influence their creativity and innovative thinking in architectural design. Only 29.9% stated that it affects positively. Respectively, 55.7% claimed that there are no examples where campus design directly influenced a project or idea that they developed. Only 39.2% stated that there are few examples.

4. Conclusion and Suggestions

For over half a century, humanity has discussed the sustainable use of resources, reduction in consumption, and energy production, crucial elements in the lifecycle of our environment. In the past decade, this effort has been intensified through the concept of smart cities, hoping to improve these initiatives even further. This is because there is a significant level of consumption taking place. People, reluctant to leave their comfort zones, pursue becoming 'elite' individuals without sacrificing their consumption habits, using terms like sustainability and ecological footprint. As widely discussed in literature, sustainability is a broad concept encompassing economic, environmental, and social dimensions, each containing a variety of different concepts. The best way to understand and implement these diverse concepts is undoubtedly through education. Hence, universities, whose primary goal is to provide vision and mission to students, play a crucial role in this context. Given that education is fundamentally based on a master-apprentice relationship where the apprentice must first learn from the master. Therefore, universities must first implement practices related to sustainability within their own institutions. As explained above and indeed in many examples not mentioned, universities are seen to be involved, but whether these practices are sufficient is a subject for another study. We can consider the concept of adaptive reuse as a successful application in this context of adequacy. The cost of constructing a new building in terms of all sustainability criteria is now an accepted fact. Similarly, the cost of demolishing an existing building is equivalent. Therefore, among the many concepts studied recently, such as recycle, reuse, upcycle, downcycle, the goal of transforming any expired item into something of higher value is an important step in maintaining sustainability. In this context, the sustainability of the historical TCDD train station complex as Ankara Medipol University is highly valuable.

As mentioned above, the TCDD train station complex located in the Ankara Ulus region is a site of high historical value. The Ulus area is the protagonist of Ankara's story as the first capital and hosts many valuable buildings and spaces. One of the most critical and important criteria of sustainability is sustainable transportation (Bayramoğlu Barman, 2013). Therefore, the Train Station, referred to as the city's gateway, and its surroundings are highly accessible by various public transportation means. Indeed, Ulus and its surroundings are a valuable part of the city with its entirely walkable and pedestrian-friendly feature.

Having an educational institution rise amidst all these features will undoubtedly make a significant contribution to the educational process of all the concepts we have discussed above. Because many historic buildings within Ulus continue to preserve their existence with the idea of adaptive reuse (Figure 5 & Figure 6). There are also advantages to being located in such a location in the university-city relationship. Prestigious other universities such as Gazi University and Ankara University are also located in Ulus and its vicinity. Therefore, the area in question can be said to be a common gathering area for students. Indeed, when we asked in the survey how often they had the opportunity to interact with students from other universities, 78.9% of the participants indicated that they had the opportunity to interact occasionally or rarely.

However, despite all affirmations, the survey conducted with students says that the actions taken to maintain a space's sustainability are not enough. Because, as mentioned above, students are not very satisfied with being on campus. The majority indicate that the lack of social spaces on campus is the reason for this dissatisfaction. When we asked students about the social spaces they need on campus, almost all mentioned the need for more seating areas and that a single type of dining area is insufficient (There is only a cafeteria and a small canteen-cafe on campus).

Ankara Medipol University has taken over aged, originality-compromised, out-of-use historical buildings, and even structures of no value, and has restored them as much as possible to bring their original state, maintaining and revitalizing the campus, and returning it to the city. However, even if all sustainability criteria are met, it does not seem possible to maintain the sustainability of the space we try to create if we do not give sufficient importance to the needs of its users.

Citizens can influence how their city is governed, developed, and maintained through participation (Held 2006; Cardullo and Kitchin 2019; Mora, Deakin, and Reid 2019). According to Lytras and Visvizi (2018), the awareness of end-users and their ability to use applications are considered 'smart' within the smart city context. Since the most important users on campus are students, the best way to maintain sustainability on campus is to involve students. In the survey, we see that the sense of belonging to the campus is not very developed among students, yet we know that this feeling is more common among those who stay in dormitories. Therefore, if the concept of sustainability is to have a connection on university campuses, it will be possible by involving students more in the development process of the campus.

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Author Contribution and Conflict of Interest Declaration Information

There is no conflict of interest.

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Examination of University Campus Buildings Through LEED Certification Systems

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1. Introduction

The concept of sustainability has emerged because of the profound impact of the Industrial Revolution on human life. The mechanization that emerged during this period changed people's lifestyles. People abandoned agriculture and migrated to work in factories as a result of mechanization. This migration was aimed at the rapid and economical construction of numerous worker housing units, and no attention was given to air conditioning systems. Fuels used in these climate control systems cause air pollution and create hazardous conditions for human health. This situation brings many states together, leading to joint decisions for the solution process. The most important decision is the creation of green building certification systems that are controlled by these certification systems (Uruk & Kulunkoglu Islamoglu, 2019).

Certification systems are widely used in different countries worldwide. The most common among these are Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), Green Star (Environmental Rating System for Buildings), DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen e.V.), CASBEE (Comprehensive Assessment System for Built Environment Efficiency), and IISBE (International Initiative for Sustainable Built Environment) (Anbarci, Giran & Demir, 2012).

The LEED and BREEAM certification systems, which stand out among the most widely used green building certification systems, influence the design and implementation techniques of buildings worldwide. The common goal of both certification systems is to ensure that while individuals create new living and working spaces for themselves, they avoid practices and products that would negatively impact the living standards of future generations. Therefore, the aim of these green building certification systems is an environmentally conscious change not only in the implementation and design of building projects, but also in all sub-sectors connected to the construction sector (Somali & Ilicali, 2009).

Educational buildings designed with sustainability awareness are important for maximizing students' working performance and comfort conditions. Raising sustainability awareness among students is possible by experiencing the living application of sustainability principles in the buildings where they study and integrate this awareness into all areas of their lives. Additionally, the building's interaction with its surrounding environment and its impact on the local community are among the goals of sustainability in education (Tavsan & Yanilmaz, 2019).

The demand for sustainable higher education buildings is increasing worldwide and in our country. Owing to their innovative structures, which are an example of society, higher education institutions that use sustainable technologies create a significant level of awareness around them. The UK and the USA, which are leading sustainable buildings, are gradually making sustainability in educational buildings compulsory with the laws they have prepared (Cakir Kiasif, 2019).

Many academic studies have been conducted on LEED and the BREEAM certification system, educational buildings, and sustainability in educational buildings. When the studies are examined, a significant number of works have been identified that address the LEED and BREEAM certification systems (Lee & Burnett, 2008; Utkutug, 2011;

Anbarci, Giran & Demir 2012; İsmail & Mihlayanlar, 2013; Erdede, Erdede & Bektas, 2014; Ravindu, Rameezdeen, Zuo, Zhou & Chandratilake, 2015; Orhan & Kaya, 2016; Dogan & Secme, 2018; Ugur & Leblebici, 2019; Uruk & Kulunkoglu İslamoglu, 2019; Scofield & Doane, 2018; Tavsan & Yanilmaz, 2019; Elkhapery, Kianmehr & Doczy, 2021; Celik & Gorgulu, 2021; Tavsan & Bektas, 2023). Educational buildings have been examined in terms of sensory characteristics (Turk & Midilli Sari, 2020), physical parameters (Kavaz Altun & Zorlu, 2021), periodic characteristics (Polat & Kilic, 2024; Karaibrahimoglu & Demirkan, 2019), lighting (Kayakus, 2018; Onak & Yildiran, 2020), accessibility for people (Ay, Baykus & Ekinci, 2017), outdoor design (Kaya & Ulusoy, 2018), and visual comfort (Yildiz, 2022). Sustainability in educational buildings has been considered from the perspective of lighting (Celik & Unver, 2019), comfort (Yanilmaz & Tavsan, 2021), and materials (Al Sensoy & Yetim, 2023). Sustainable educational buildings have been studied at the preschool level (Kizilkan & Canbay Türkyilmaz, 2021; Tonguc & Ozbayraktar, 2017), primary education level (Tavsan & Yanilmaz, 2019; Kayihan & Tonuk, 2011), primary and secondary education levels (Tavsan, Tavsan & Bahar, 2021), high school level (Canakkale, Yucedag & Bingol, 2022), and university level (Cakir Kiasif & Uygun Ugutmen, 2020; Cakir Kiasif, 2019; Celik & Ozturk, 2022). A comprehensive study on university campus buildings that have received LEED platinum certification in the USA has not been conducted, and the aim is to conduct a study on this subject.

Within the scope of this study, sustainable campus buildings were examined through the LEED BD+C New Construction v2009 certification system to identify the most effectively achieved sustainability criteria, with the aim of determining the systems applied in sustainable campus buildings by conducting content and visual analyses of university campus buildings in America that have received LEED platinum certification. Within the scope of the study, seven university campus buildings that had received LEED platinum certification in the BD + C New Construction v2009 certificate type in the USA were selected as the sample group. These buildings were analyzed and examined based on the sustainability criteria of sustainable land, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority credits. This study is important in terms of helping to determine the design criteria for sustainable campus buildings and providing data for future campus buildings with the criteria provided by the campus buildings that have received platinum certification.

1.1. Sustainable Architecture

Architecture is the creation of a physical environment that includes human needs. From past to present, humans have utilized and shaped the environment according to their own needs and the resources it offers them (Aykal, Gumus & Ozbudak Akca, 2009).

The concept of sustainability was defined in Our Common Future or Brutland Report published by the World Commission on Environment and Development in 1987. In the Brutland Report (1987), this concept, which is addressed as "sustainable development," is defined as " satisfying the needs of today without harming the ability of future generations to satisfy their own needs." Today, the concept of sustainability is used in sociological, ecological, economic, and other fields (Tavsan & Bal, 2021).

Sustainable architecture has been a concept in our lives for centuries, even though its meaning is not considered. According to Socrates, houses should have higher southern facades than northern facades to better capture winter sun, and the northern facade should be lower than the southern facade to protect against cold. According to Vitrivius, climatic conditions should be considered during housing construction (Yetkin, 2019).

According to Sev's (2009) definition, sustainable architecture is an activity that considers the life cycle of future generations in the current conditions and at every stage of its existence, ensures the use of renewable energy resources, considers the environment, protects people's health and comfort, and aims to use materials, water, and energy in buildings in the most effective way.

Sustainable architecture usually involves a range of strategies, components, and technologies that aim to reduce the environmental impact, while in many cases improving comfort and overall quality. The main objectives are listed in bullet points but are not limited to these.

- Use of daylight,
- Indoor air quality,
- Passive solar heating
- Natural ventilation,
- Tangible energy,

- Energy efficiency,
- Construction waste minimization
- Water saving,
- Solid waste management
- Renewable energy,
- Arid landscaping and natural landscaping
- Land conservation (Mclennan, 2004).

In general terms, sustainable architecture can be defined as a holistic construction process that adapts local data such as natural resources, materials, and climate to the structure, followed by a construction strategy integrated with the environment as guided by existing natural resources, can produce the energy it needs with the aim of reducing the consumption of resources, and provides water management and waste criteria (Tavsan & Yanilmaz, 2019).

1.2. LEED Certification System

The LEED certification system, established by the U.S. Green Building Council (USGBC) in 1998, has gained international acceptance. The aim of the certification system is to ensure that all persons and institutions involved in the building sector pay attention to the protection of the natural environment in their activities by drawing attention to the values of environmental resources. There is no obligation to work with any authorized person during the project or construction process. This is one of the main reasons why the LEED certification system is preferred to the BREEAM certification system. At the same time, one of the prominent reasons for preference is that it can be applied for certification both during the construction process and after the construction process is completed (Uruk & Kulunkoglu Islamoglu, 2019).

For the LEED BD+C New Construction v2009 certification type, buildings are evaluated on a scale of 110 points. After applying for the certificate, the buildings are obliged to obtain a total of 32 points with the criteria to be met in the pre-assessment process. Projects that pass the preliminary evaluation by obtaining the required score are evaluated based on other criteria and receive certification degrees according to the points they receive in total. There are four degrees of LEED certification (certified, silver, gold, and platinum) (USGBC, n.d.). The required points for each certification type are indicated in Figure-1.

Figure 1. LEED Certification Points System

The LEED certification criteria include two prerequisite criteria and seven main criteria. Buildings that scored 32 points in total from the prerequisite criteria were evaluated using seven main criteria. These criteria include sustainable land, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority. The scoring rates obtained from these criteria in the LEED BD+C New Construction v2009 certificate type are given in Figure-2.

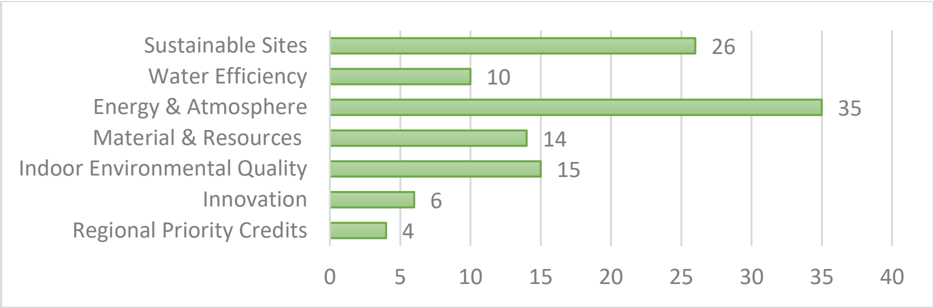


Figure 2. Score Ratios of LEED Certification Criteria

In the sustainable land criterion, one of the sustainability principles of the LEED certification system, alternative transportation methods that reduce the carbon footprint, such as bicycles and public transportation, have come to the fore. In the water efficiency criterion, the use of low-flow fixtures, rainwater recycling, and drought-resistant plants in landscaping is emphasized. In the energy and atmosphere criteria, energy savings are targeted using renewable energy sources, photovoltaic panels, and wind turbines. Recycling of materials is emphasized in the materials and resources category. Innovations in design stand out in the innovation criterion, whereas in the regional priority criterion, it is important to prioritize regional resources and benefit the people of the region.

Different LEED certification types have been developed for various project types. These certification types are Building Design and Construction (LEED BD+C), Interior Design and Construction (LEED ID+C), Existing Building Repair and Maintenance (LEED O+M), Neighborhood Development (LEED ND), housing (LEED Homes), Cities and Communities (LEED CC), recertification (LEED Recertification), and LEED Zero (LEED Zero).

Within the scope of this study, university campus buildings that have received LEED Platinum certification in the USA in the LEED BD+C v2009 certification type will be examined using sustainability criteria. Their practices regarding the points they received from the sustainability criteria were analyzed. The most effective LEED criteria for university campus buildings were identified.

1.3. Sustainable Campus Buildings

Universities, owing to their innovative and pioneering goals, are the most effective educational institutions in disseminating the principles of sustainability in society through ecological and sustainable practices. Accordingly, the concept of sustainable universities and ecological and sustainable campuses has rapidly spread worldwide. "Ecological and sustainable campus" practices aim to create campuses that minimize energy usage, promote environmental sensitivity, enhance waste management effectiveness, and utilize nature-friendly materials and products, all of which support sustainable development. Through sustainable and ecological campus practices, universities can economically establish their own resilience, resist environmental challenges and global climate change, and fulfill their social responsibility by raising awareness in society (Kayapinar Kaya, Dal & Askin, 2019).

The concept of a "Sustainable University" was first used alongside the concept of "Sustainable Development" at the United Nations Conference on the Human Environment held in Stockholm, Sweden. At this conference, a sustainable university was defined as a higher education institution that strives to minimize the negative social, economic, and environmental impacts while meeting its own needs and led the community to promote awareness of sustainability principles (Gunerhan & Gunerhan, 2016).

As awareness of sustainable campuses has increased, international sustainable indices have begun to be used. These indices include the Environmental and Social Responsibility Index, Green League, and GreenMetric assessment systems (Suwartha & Sari, 2013). The most widely used GreenMetric ranking model was launched in 2010 at the University of Indonesia, and its main objectives are to prevent the main problems in higher education institutions, such as a decrease in biodiversity, increasing environmental problems, consumption of non-renewable energy resources, seasonal and climate changes, droughts caused by global warming, and deterioration of ecological balance (Criteria & Indicators, n.d.).

Universities, by their working principles, aim to elevate the use of science and technology to higher levels. With their emphasis on innovation and modernity, higher education institutions are striving for continuous growth and development. In this case, the construction of higher education structures in line with sustainability principles is of high importance for social, environmental, and economic development (Cakır Kiasif, 2019).

2. Material and Method

This study, which examines university campus buildings through the LEED certification system, is quantitative in terms of creating a numerical analysis of university campus buildings and qualitative in terms of investigating the sustainability criteria of university campus buildings.

A qualitative case study research method was used in the study. A purposive sampling technique was used to select sample groups.

This study, which aims to reveal the sustainability criteria that are most effectively used in the design of sustainable campus buildings and how these criteria are met, consists of five stages: The study stages are provided in Figure-3.

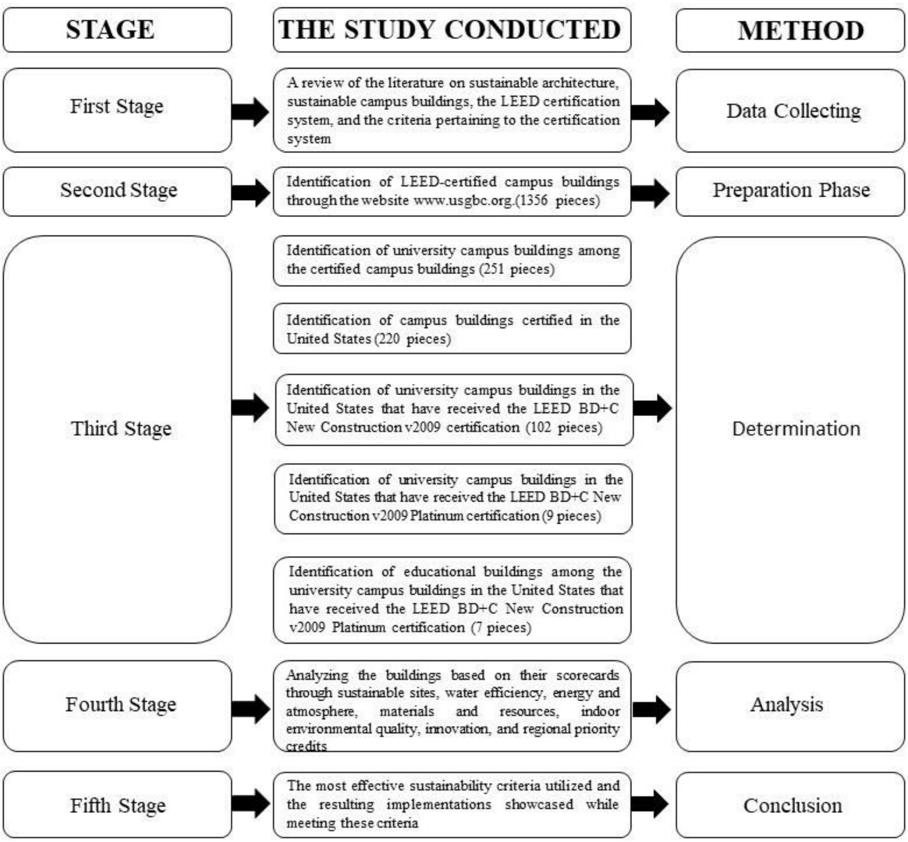


Figure 3. Working Structure

The first stage of the study consists of a literature review. Information on sustainable architecture, LEED certification system, and sustainable campus buildings are included in the literature review.

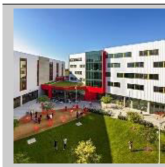
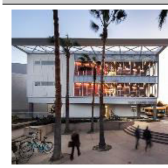
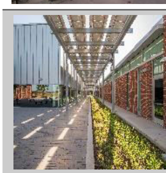
In the second stage of the study, to determine the sample group and preliminary preparation for the analysis, "campus" buildings that received LEED certification from www.usgbc.org were searched. A total of 1356 campus buildings that received LEED certification in different degrees and certificate types were identified by the scanning method.

In the third stage of the study, a sample group was formed from the identified structures using the purposive sampling method. Among the 1356 campus structures, 251 were identified as university campuses. Of these, 220 were located in the US. As the majority of university campus structures with LEED certification are in America, these structures were included in the sample group. Of these buildings, 102 were certified with the BD+C New Construction v2009 certificate type, and 9 received LEED platinum certification. As the structures certified with the highest LEED certification level, the platinum level, demonstrated a high level of compliance with the sustainability criteria, they were included in the sample group. Seven of the nine campus buildings were educational buildings within the campus, and these buildings constituted our sample group. The sample groups identified are listed in Table 1.

In the fourth stage, the scorecards of campus buildings in the sample group determined from www.usgbc.org were examined, and analysis tables were created. In the analysis table, the scores of the buildings based on the sustainability criteria are included (Table 2). The information in the literature about buildings was examined using a content analysis method and analyzed on the sustainability criteria of sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environment quality, innovation, and regional priority credits. The practices implemented to meet these criteria were examined. Visual analyses were performed on the visual images of the buildings.

In the last stage of the study, the most effectively used sustainability criteria and practices implemented while meeting these criteria were presented.

Table 1. Campus Buildings Comprising the Sample Group in the US

	Campus Building	Found in State	Project Area	Architecture Office	Certificate Score	Certificate Year
	**Kresge Centennial Hall Renovation**	Illionis	10628 m²	Lothan Van Hook DeStefano Architecture	86	2017
	**Las Positas College-Academic Building**	California	3814 m²	HMC Architects	85	2018
	**Otis Campus Expansion**	California	7619.3m²	Ehrlich Yanai Rhee Chaney Architects	84	2017
	**ETEC**	New York	21368m²	Cannon Design	83	2022
	**Center for Energy Education and Training**	Delaware	547.39m²	Tetra Tech	82	2013
	**SBCC West Campus Center**	California	2972.9m²	Kruger Bensen Ziemer Architects	81	2018
	**TCCD Energy Technology Center**	Texas	9247.5m²	BNIM Architects	80	2016

3. Finding and Discussion

When LEED-certified campus buildings were analyzed on the USGBC official site in April 2024, a total of 1356 campus buildings were identified. Of these, 220 are university campus buildings in the USA, and only 16 of them have LEED platinum certification. Within the scope of the study, seven university campus buildings that had received LEED platinum certificates in LEED BD+C New Construction v2009 Certificate type, which were determined by a purposeful sampling method, were analyzed. When looking at the scores achieved by the buildings in terms of sustainability criteria, the highest average score was obtained from the "Regional Priority" category, followed by the highest average score obtained from the "Energy and Atmosphere" category. The lowest score was obtained from the "Materials and Resources" category, which shows us that the applicability of this criterion is more difficult than the other criteria. There are buildings that have received full scores in Water Efficiency", "innovation", and "Regional Priority" criteria. This shows that these criteria are more applicable to university-campus buildings. There are no buildings with full points in the criteria of sustainable land, energy, atmosphere, materials and resources, and indoor environmental quality. Looking at the total points of the buildings, the Kresge Centennial Hall Renovation in Illinois, USA, is the building with the highest score in the LEED BD+C New Construction v2009 certificate type with 86 points. This building received full points in innovation and regional priority criteria.

3.1. LEED Platinum Certified Campus Buildings in the United States

In this section, the seven university campus buildings that comprise the sample group are examined based on the sustainability criteria they meet. The practices implemented to meet the sustainability criteria are identified. Thus, the information obtained will provide data on sustainability principles for future campus buildings.

- **Kresge Centennial Hall Renovation**

The building, initially constructed in 1954 in Illinois, underwent renovation in 2014 to create a modern, comfortable, healthy, and green working and learning environment for students, faculty, and staff (Kresge Centennial Hall n.d.). Starting in October 2014 and completed in January 2017, this building received LEED platinum certification in August 2017 with 86 points owing to its sustainability criteria. The building, which was awarded platinum certification, received full points in innovation and regional priority criteria. The building also received the Historic Preservation Award in 2018 (Northwestern Kresge Hall, 2018).

The building has sensors that automatically reduce the artificial lighting levels during bright times of the day. In addition, highly efficient and durable LED lights are used throughout the building. Occupancy sensors are located throughout the building to turn off lights in empty spaces (Kresge Centennial Hall n.d.). The 254 solar panel arrays on the roof have the capacity to generate 81 kW of electricity, which is sufficient to cover 5 percent of the building's electricity costs (Figure-4).

To reduce carbon emissions from automobiles, bicycle parking areas have been created in the building's garden to encourage employees and students to use bicycles (Figure-4). Additionally, shower facilities were provided within the building to promote bicycle usage as a preferred option. Low-flow fixtures were used in the building, and the urinals used only one-eighth of the water in the tank per flush. Thus, the water use in the building was reduced by 35%. The use of low-water landscaping plants also contributes to water conservation in buildings (Kresge Centennial Hall n.d.).

Figure 4. Roof panels and bicycle parking areas used in the building (Kresge Centennial Hall, n.d.).

Carbon dioxide sensors are used in classrooms; when these sensors detect carbon dioxide inside, they are activated, and ventilation systems are activated. In this way, unnecessary operation of the ventilation systems when the classrooms are empty is prevented, and energy is saved. The building envelope was also improved during restoration, and steps were taken to save energy. Both exterior wall insulation and window insulation of the building were optimized to the highest degree. Consequently, the total annual energy consumption was 34.2% lower than the baseline value set by the ASHRAE standards. Improved heating, ventilation, and air conditioning (HVAC) systems have been designed to achieve high-energy savings. Radiant ceiling panels or chilled sails in all offices and classrooms use cold water from a Central Plant to reduce the amount of energy required for air conditioning (Northwestern University, n.d.).

To reduce the environmental impact of the products used in this project, 30 percent of all purchased materials were produced within 500 miles of the site. Additionally, 22% of the materials used contained recycled content, with nearly 95% of the new wood sourced from Forest Stewardship Council (FSC) certified forests. Most importantly, more than 75 percent of existing building envelopes and structures have been reused. Furthermore, during construction, 93% of all waste generated is diverted from landfills through recycling or reuse (Northwestern University, n.d.).

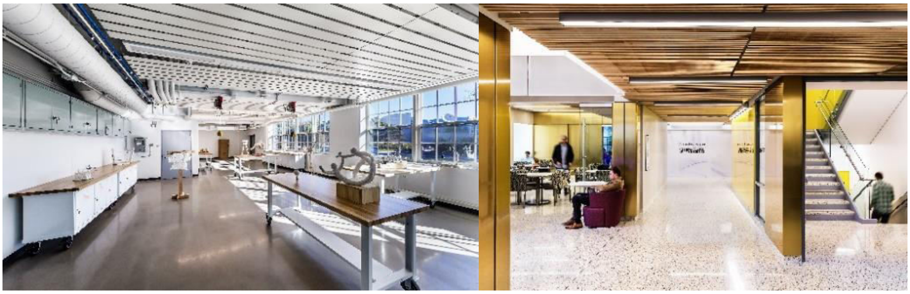


Figure 5. Interior visuals of Kresge Centennial Hall (Kresge Centennial Hall Renovation, n.d.)

The Kresge Centennial Hall project team used 100 percent low-emission materials, such as adhesives, sealants, paints, coatings, flooring, and composite wood. This ensured better indoor air quality by minimizing the emissions of volatile organic compounds (VOCs) and pollutants, such as formaldehyde (Northwestern University, n.d.).

- **Las Positas College-Academic Building**

Completed in California, this building received LEED platinum certification in November 2018 with 85 points thanks to its sustainability criteria (USGBC, n.d.).

It has sustainability criteria such as rainwater collection, renewable energy, thermal comfort design, and the use of recycled and low-emission materials.

With the sustainability systems implemented, the building has achieved 42% savings in water use and 57% energy savings (Figure-7) (Las Positas College Academic Building, n.d.). The building also aims to reduce the carbon footprint caused by transportation vehicles with access to public transportation and areas reserved for fuel-efficient electric vehicles. Low-flow WC fixtures and urinals were used in the building, and recycled grey water was reused in these areas. In addition, the drought-resistant vegetation used in the landscape enabled this building to score the full points in the water efficiency criterion (Figure-6).

The building aims to achieve high efficiency from natural lighting using skylights over large window openings and circulation areas. While indirect lighting is used throughout the building, energy savings is aimed at using LED lighting.

Figure 6. Drought tolerant landscape area designed in the building and skylights providing natural lighting (Client Testimonial, n.d.)

As with the other buildings examined throughout the study, this building received the lowest score in the materials and resources criterion. This is because of the low use of recycled materials and the lack of emphasis on the use of regional materials. User-controlled heating, cooling, and lighting systems are implemented in the building. This both saves energy in the building and creates a comfortable space for users. At the same time, the use of low-emission (VOC) materials in buildings has increased their indoor air quality. The natural view of a building provides visual comfort to users.

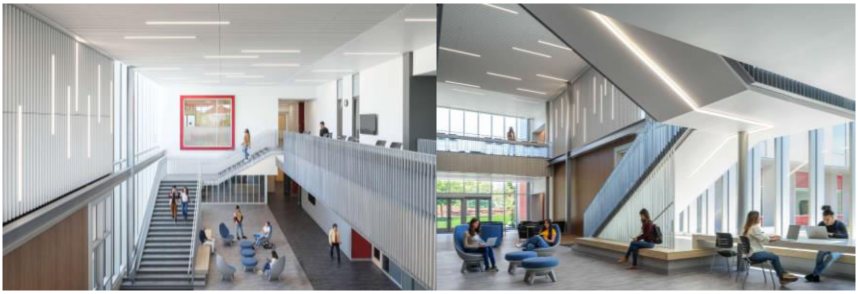


Figure 7. Interior visuals of Las Positas College-Academic Building (Client Testimonial, n.d.)

- **Otis Campus Expansion**

Completed in California, this building received LEED platinum certification in January 2017, with 84 points owing to its sustainability criteria (USGBC, n.d.).

Photovoltaic panels are installed on campus to provide the majority of solar energy. These panels also provide shading for the exposed upper level of the existing parking structures. The 545 kW solar system will result in an estimated 6,948 tons less CO_2 emissions over 30 years and will also save college energy (Otis College, n.d.).

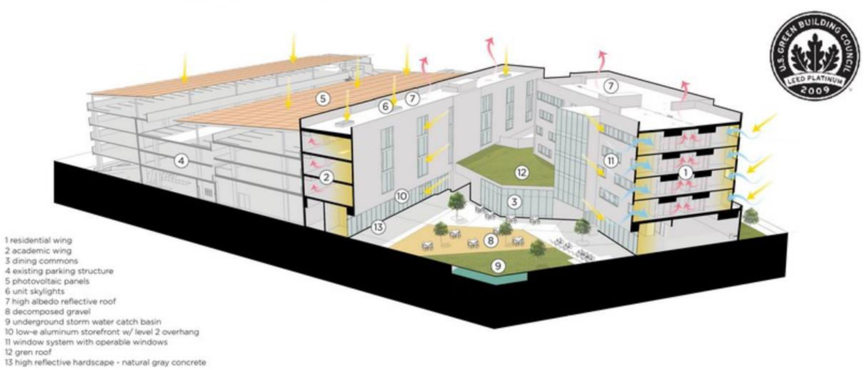


Figure 8. Sustainability diagram of the Otis Campus Expansion project (Sustainability, n.d.)

The completed indoor spaces, along with the protrusions on the first floor and green roof above the dining area, receive ample daylight. The green roof is both a relaxation area and keeps the dining area underneath cool. The highly reflective material (sarnafil) used on the roof surfaces reduced the heat effect in the interior.

The underground rainwater collection system used in buildings and drought-resistant plants in the landscape reduces water use and saves water (Otis College of Art, 2017).

Figure 9. Interior visuals of the Otis Campus Expansion (Frederick Fisher and Partners, n.d.)

Low/no volatile organic compound (VOC) paints, sealants, and adhesives were used throughout the interior. Dimmable daylight and space sensor lighting were installed to allow students to save energy and have more control. Other elements that helped the project achieve LEED Platinum include ample bicycle parking, dedicated spaces for low-emission and electric vehicles, and the use of local and recycled materials in construction (Otis College of Art, 2017).

- **ETEC**

Completed in New York, this building received LEED platinum certification in December 2022 with 83 points thanks to its sustainability criteria (USGBC, n.d.).

The building reduces its energy usage intensity by providing heating, cooling, and hot water usage through a geothermal heat pump system (Figure-10). This eliminates the use of fossil fuels, except during emergencies. Approximately 60% of the building's annual electricity is generated from on-campus solar panels located on podium roofs, with the remainder offset by purchasing renewable energy credits from off-site sources. The building has rainwater management infrastructure and saves

40% of the water with the fixtures it uses (Awards & Accolades, n.d.). The building also aims to increase water savings using low-flow faucets. The building is located within an area with easy access to public transportation with the aim of reducing its carbon footprint. In line with the same goal, space was allocated to low-emission vehicles within the land.

Figure 10. Energy-saving LED lighting systems and geothermal heat pump system used in the building (ETEC, n.d.)

In material selection, emphasis is placed on using local materials and materials with recycled content. The use of certified wood materials adds value to buildings in terms of sustainable material use. The use of large glass openings in buildings is aimed at saving energy by increasing the use of natural lighting. These large glass openings also contributed to energy savings by providing natural ventilation. Low-emission (VOC) paints, coatings, and flooring materials have been used to enhance the indoor air quality. In addition, an LEED consultant was engaged in the certification process of the building.

Figure 11. Interior visuals of ETEC (ETEC, n.d.)

- **Center for Energy Education and Training**

Completed in Delaware, this building received LEED platinum certification in June 2013, with 82 points for its sustainability criteria (USGBC, n.d.).

It has sustainable features, such as wind turbines, photovoltaic panels, native plantings, and a living wall (Delaware Technical Community College, n.d.). Designed for energy efficiency, this project incorporates many green design elements, including geothermal wells, green roofs for stormwater quality control, and biological retention basins for stormwater quantity control (Delaware Tech, n.d.).

Figure 12. Center For Energy Education and Training (Delaware Tech, n.d.)

While a building aims to save energy, it also aims to save water and receive full points in the water efficiency category. In this context, drought-resistant landscapes have been created. Low-flow products were preferred in faucets and toilet bowls used in the building. In addition, rainwater was treated and used as gray-water in the building. The building received the lowest score in the material and resources category. The reason for this is thought to be the lack of recycled materials and the lack of recycling of construction waste.

• **SBCC West Campus Center**

Completed in California, this building received LEED platinum certification in March 2018 with 81 points, owing to its sustainability criteria (USGBC, n.d.) (Figure-14).

Natural ventilation was provided through operable windows and blinds. External and internal permanent shading devices and high-performance glazing ensure maximum daylighting within the building (Figure-13).

The transparent eastern facade of the building allows for a full perception of the mountain and ocean views from inside the building. This building features a rooftop garden with drought-resistant plants. In addition, there were ditches that encouraged rainwater infiltration. Watersence-certified fixtures and fittings reduce water use (Santa Barbara City College n.d.). Owing to the efficient installation of plumbing, indoor potable water use was reduced by 33%, saving 83420 gallons of water. Unlike other buildings that use potable water in the restrooms, only purified water is used to flush toilets (SBCC showcases, n.d.). Thus, the building achieved the highest average score in the LEED certification criteria for water efficiency.

Figure 13. Wide glass facades used in the building and sunshades used as shading elements (Santa Barbara City College, n.d.)

The building also reduces the heat island effects. Heat islands are densely populated areas or cities that are warmer than the natural temperatures in the surrounding countryside. The light-colored concrete and rooftop garden keep the building cooler and use less energy for heating and cooling.

Roof gardens, which include plants native to California, also serve as habitats for animals. The roof is also intended to improve air quality and reuse and recycle rainwater (SBCC Showcases, n.d.).

Figure 14. Interior visuals of SBCC West Campus Center (Santa Barbara City College, n.d.)

Other sustainability principles provided by the building are as follows: energy efficiency exceeding the California energy code by 26%, total energy use of on-site solar panels that provide 13% of energy use, at least

20% of building materials are recycled, the use of large windows that allow natural daylight and require less energy use, and 92% of rooms have access to a view (SBCC showcases, n.d.).

The LEED certification process of the building was carried out with the support of a consultant, and the building received a LEED platinum certificate.

• **TCCD Energy Technology Center**

Completed in Texas, this building received LEED platinum certification in October 2016 with 80 points, owing to its sustainability criteria (USGBC, n.d.).

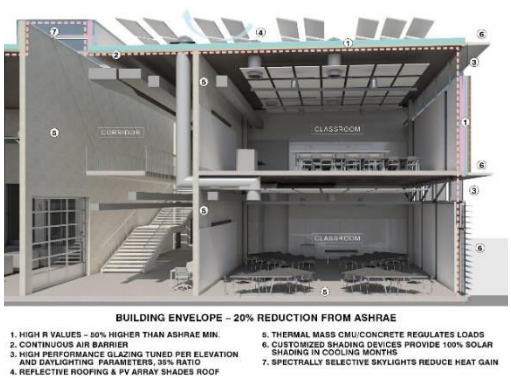


Figure 15. TCDD Energy Technology Center sustainability diagram (Tarrant County College District, n.d.)

Solar panels on buildings provide one-third of the building's energy. The panels were incorporated into the public courtyard design and provided shade to residents. Wind turbines are also used for energy production. Geothermal wells help regulate building temperature, and daylight harvesting reduces the use of artificial light (Figure-15). The wings of the building form an 'H' shape to allow more daylight into the interior. Sustainable water management purifies water by removing contaminants before it is used to irrigate landscaping or discharged into municipal stormwater systems (TCCD Energy Technology Center, n.d.). Purified water was used as greywater in the necessary areas of the structure. At the same time, drought-resistant plants were preferred in the landscape.

Figure 16. Solar panels providing shading effects on the building (Tarrant County College District, n.d.)

The most important applications in this building, which attach great importance to energy savings, are solar panels, wind turbines, and renewable energy sources. While receiving LEED certification, this building received 34 out of 35 points in the energy and atmosphere criteria, and received almost full points.

Figure 17. Interior visuals of the TCDD Energy Technology Center (Tarrant County College District, n.d.)

The systems implemented to meet the sustainable land, water efficiency, energy, atmosphere, materials and resources, indoor environmental quality, and innovation criteria of the examined structures are presented in Table 2.

Table 2. Analysis of the sustainability criteria of campus buildings awarded LEED platinum certification in America

	Kresge Centennial Hall Renovation	Las Positas College-Academic Building	Otis Campus Expansion	ETEC	Center for Energy Education and Training	SBCC West Campus Center	TCCD Energy Technology Center
Sustainable Sites	**21/26**	**21/26**	**22/26**	**19/26**	**20/26**	**20/26**	**16/26**
Alternative Transportation (Bicycle)	✓		✓				
Alternative Transportation (Public transportation access)	✓	✓	✓	✓	✓	✓	✓
Alternative Transportation (Fuel-efficient vehicles)		✓	✓	✓	✓	✓	
Water Efficiency	**5/10**	**10/10**	**6/10**	**7/10**	**10/10**	**9/10**	**4/10**
Low flow wc/armature	✓	✓	✓	✓	✓	✓	✓
Collection of rainwater		✓	✓	✓	✓	✓	✓
Recycling water		✓			✓	✓	✓
Use of drought tolerant plants in landscaping	✓	✓	✓	✓	✓	✓	✓
Energy and Atmosphere	**29/35**	**33/35**	**31/35**	**33/35**	**30/35**	**22/35**	**34/35**
Use of renewable energy	✓	✓	✓	✓	✓	✓	✓
Use of photovoltaic panels	✓		✓	✓	✓		✓
Use of wind turbines					✓		✓
Use of natural refrigerants	✓	✓	✓	✓	✓		✓
Use of HVAC intelligent control system	✓	✓	✓	✓		✓	✓
Materials and Resources	**9/14**	**3/14**	**6/14**	**6/14**	**3/14**	**6/14**	**7/14**
Recycling of construction waste	✓	✓	✓	✓		✓	✓
Use of recycled materials	✓	✓	✓	✓	✓	✓	✓
Use of regional materials	✓	✓	✓	✓	✓	✓	✓
Use of certified wood	✓			✓	✓		✓
Indoor Environment Quality	**12/15**	**10/15**	**9/15**	**9/15**	**9/15**	**14/15**	**11/15**
Natural ventilation	✓	✓	✓	✓	✓	✓	✓
Natural lighting	✓	✓	✓	✓	✓	✓	✓
VOC material	✓	✓	✓	✓	✓	✓	✓
Landscape		✓			✓	✓	
Innovation	**6/6**	**4/6**	**6/6**	**6/6**	**6/6**	**6/6**	**4/6**
Innovation in design	✓	✓	✓	✓	✓	✓	✓
Working with a LEED expert	✓	✓	✓	✓	✓	✓	✓

In the sustainable land criterion, alternative transportation routes are encouraged by creating bicycle parking areas in the university campus buildings. Simultaneously, access to public transportation and low-emission vehicles is provided. In this way, the aim is to prevent carbon emissions generated by vehicles.

For the water efficiency criterion, low-flow fixtures and urinals have been used in buildings. Rainwater harvesting has been implemented in several structures to facilitate reuse. In addition, the use of drought-resistant plants in landscaping aims to achieve water savings. The Las Positas College Academic Building and the Center for Energy Education and Training have achieved full points in the water efficiency category.

In terms of energy and atmospheric criteria, many buildings have used photovoltaic panels to generate electricity. Wind turbines have also been installed for electricity generation. Reflective materials were used on the roofs to provide natural indoor cooling. The use of transparent facades has increased to maximize the use of natural light. Unnecessary energy consumption was prevented by using HVAC smart control systems.

Recycled materials have been used in materials and resources criteria. In addition, the waste materials generated during construction were recycled. Materials have been sourced locally to reduce carbon emissions from transportation.

For the indoor environmental quality criterion, sunshades have been used to provide natural shading. Indoor air quality was enhanced by employing natural ventilation and natural lighting. Low-emission materials (VOC) are used to ensure indoor air quality. CO_2 sensors were installed in the buildings. Radiant heating and cooling systems have also been implemented. Incorporating external views has been utilized to achieve high indoor environmental quality. The SBCC West Campus Center received the highest score for the indoor environmental quality criterion.

For the innovation criterion, buildings that received points were guided by a consultant during the LEED certification process.

In the regional priority criterion, emphasis is placed on regional resource utilization and the features that benefit the region.

4. Conclusion and Suggestions

One of the most important criteria in university campus buildings with sustainable features is the energy and atmosphere. The reason for meeting this criterion is that the criteria are applicable, and the systems to meet this criterion are accessible. The applications that scored high in this criterion were the use of photovoltaic panels, insulation materials, wind turbines, natural coolers, natural ventilation, and HVAC smart control systems. In university campus buildings, a large amount of energy is consumed for activities such as ventilation, lighting, heating, and cooling. This situation highlights the importance of meeting this criterion. Sustainable university campus buildings minimize energy use and save energy. This situation ensures the protection of the resources needed by future generations.

According to the analyses conducted in this study, it was observed that sustainable university campus buildings received the highest sustainability scores from regional priority credits and the energy and atmosphere criterion (Figure-18).

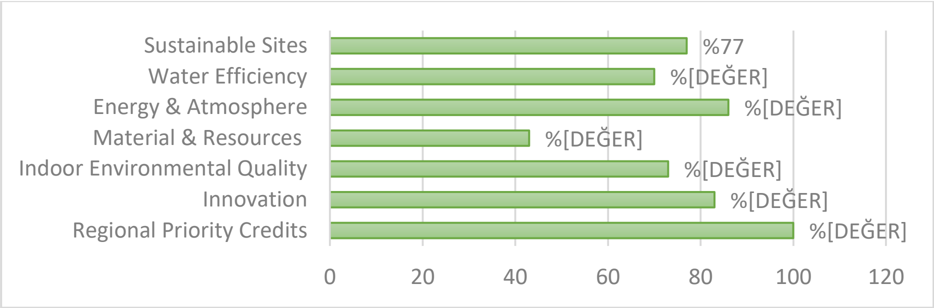


Figure 18. Analysis of Sustainability Criteria in University Campus Buildings (%)

The lowest score for university campus buildings was obtained from the materials and resources criteria. The reason for this is thought to be the awareness of materials with sustainable properties, the accessibility of materials, material costs, and design concerns. The reason for this score is the use of local materials and the recycling of material waste. In future educational buildings, more research can be conducted for this criterion, and sustainable materials can be accessed; therefore, the number of LEED-certified buildings can be increased.

Sustainable university campus structures provide a comfortable and healthy education space for those who teach and study it while also raising awareness of the concept of sustainability. Additionally, in university buildings that meet sustainability criteria, human productivity, and consequently, the quality of education, is enhanced. In this context, it is thought that determining the sustainability criteria in university campus structures and examining internationally recognized sustainable university campus projects will also guide projects to be implemented in our country.

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This article complies with the national and international research and publication ethics. Ethics Committee approval was not required for this study.

Author Contribution and Conflict of Interest Declaration Information

There is no conflict of interest.

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Evaluating the Spatial Quality of Streets and Avenues Associated with University Campuses: The Case of Adana ATU

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1. Introduction

Universities create multifaceted impacts in the regions where they are established (Arap, 2014). It can be stated that this impact exists in the dual relationship between the university and the city. Just as universities are expected to transform urban life, cities are also expected to enrich by the opportunities they offer to students (Arap, 2014). Parallel to the development they have shown since their establishment, they have also multifacetedly changed the socio-economic and cultural structure of the cities they are located in (Demir & Parin, 2021). Universities transform the cities they are located in socially, culturally, economically, and spatially. In cities where universities are established, various innovations occur based on the quality of life expectations of students and academics (Bostancı, 2017). From this perspective, university campuses contribute to the development not only within their boundaries but also in their surrounding areas. According to studies in the literature, there are works focusing on university campuses, university spaces, accessibility within and to the campus (Hilmoğlu & Kariptaş, 2022; Tutal, 2018; Körmeçli, 2022; Kuyrukçu & Berber, 2023; Özkaraca & İnceoğlu, 2021); user evaluation of campus landscape planning and landscape design (Vural et al., 2019; Yılmaz, 2015; Metin &Türker, 2022; Çorbacı et al., 2020; Pouya et al., 2019; Kahveci & Sandal, 2023); equipment elements within the campus and ergonomics (Kurt & Çelik, 2023; Sarıgül & Türkyılmaz, 2019); the location and impact of the university campus (Saklı, 2019); master plans of campuses (Salihoğlu et al., 2021); and barrier-free design in open spaces on campus (Kamer & Köşe, 2022). When looking at these studies, it is evident that most of the research has been conducted within the boundaries of the campus. With the aim of evaluating the placement and quality of universities not only within their boundaries but also in relation to their surrounding areas, this study examines the streets connected to the university. The study focuses on the axial analysis of the vicinity of a significant university campus in Adana, which is rapidly undergoing morphological development. The main objective of the study is to examine the spatial quality components of the street networks that influence the development of the campus. In this context, while conducting a case study on the newly established ATU campus in Adana, the spatial connections in its vicinity are evaluated in terms of quality. The concept of quality, which is a subject of many disciplines (İnceoğlu & Aytuğ, 2009), is a subjective concept that can vary from person to person and expresses the level of goodness of any character/condition (Uzgören & Erdönmez, 2017). The quality of an urban space is important for social life and a comfortable physical environment also affects the quality of life (Balçık & İnceoğlu, 2022). Despite being a subjective concept, there are objective indicators used to measure quality in urban spaces (Uzgören & Erdönmez, 2017). Although there are common aspects of various parameters in the literature on the quality of urban spaces, a holistic conclusion has not been reached (Balçık & İnceoğlu, 2022). Looking at the studies in the literature, many researchers such as Gehl (1997), Greene (1992), Jacobs (1993), and Project for Public Spaces have identified urban quality parameters. When examining the approaches to the concept of quality, which has various parameters, methodological differences are also observed. It has been determined that studies on urban quality use various methods such as surveys, situational analysis, on-site observation, mapping, and space syntax. This study, aiming to evaluate the quality of streets connected to the university campus, uses the "space syntax" technique proposed by Hillier and Hanson (1984) to conduct a situational analysis of spatial connections. In the context of space syntax, axial lines are an important tool for examining the movement and usage dynamics of areas on the campus access network. Based on this foundation, the spatial quality among different street and road layouts identified around the campus is analyzed using the quality parameters defined by Project for Public Spaces.

1.1. University-City Relationship

University campuses are highly significant as focal points of social, cultural, and academic life for both students and faculty members. Functional spaces that increase comfort and productivity are among the fundamental spatial goals of campus areas. Thus, the presence of functional spaces, especially open areas, that support comfortable, efficient, and active movement for everyone is increasingly enhancing the spatial value of campus areas. Additionally, because the computer-focused work of modern society is increasingly on the rise, this situation points out the importance of social open spaces. According to the study of Meng and et al. (2023), the functional spaces provided by campuses significantly impact the comfort and satisfaction of users; therefore, it is possible to evaluate the spatial quality of a campus in terms of usability, comfort, and aesthetics.

University campuses consist of fundamental physical components such as roads, buildings, and spaces (Darwish, 2021). While these components are integral parts of the campus's physical structure, they alone are not sufficient to define campus life. The definition of a campus is shaped by both the physical environment elements and user characteristics. This is because campuses are crucial environments for social activities that are integral to education. Therefore, organizing campus spatial areas according to student activities not only revitalizes campus life but also facilitates a healthy campus experience (Hanan, 2013). According to Dober (2000), the desired qualities of a well-ordered landscape include providing campus users with experiences that are functional, convenient, safe, pleasant, and stimulating as they navigate through different spaces. In this context, the most important aspect in evaluating the environmental quality of campus spaces is to take into account user experience and perception. Abu-Ghazzeh (1999) emphasized the importance of three main components, physical/ecological quality, behavioral/functional quality, and aesthetic/visual quality, in assessing the environmental quality of campus areas in his study. In a broader sense, the components of spatial quality can be defined as usability, functionality, safety, fluidity between spaces, suitability for activities, aesthetic appeal, diversity, and accessibility for everyone (Aydin & Ter, 2008).

Nowadays, university campuses and cities want to establish close relationships with each other. Cities and universities provide mutual benefits. The interaction that campuses establish with the city plays a significant role in contributing to the spatial, economic, and social development of the city (Alzouby & Talalqa, 2023). On the other hand, the level of publicness of campuses, depending on various factors such as the continuously increasing number of students and staff, the development of interdisciplinary studies, the diversity of social life, and cultural activities, focuses on the need to strengthen the interaction with the city. In Kim et al. (2016)'s study, it was found that only 56% of the spaces deemed suitable for student activities within a selected campus were chosen by students themselves. This indicated that students did not find adequate spaces for their social activities on campus. Thus, the users, in addition to the functional opportunities offered by the campuses, are leads to constantly search for new areas nearby of the campus for their social activities. In this context, the importance of the connections established by the university campus with its surrounding areas becomes apparent. Additionally, according to Way's (2016) study, students and faculty members do not prefer campus areas isolated from the city. As the days pass, demands on the campus integrating with the city and the networks supporting campus-neighborhood are increasing.

Campus-city relationship, which can be defined both physically and functionally, pertains to the campus's location and connections within the city (Mohammed et al., 2022). The physical relationship defining the campus's location within the city involves three main spatial configurations. As shown in Figure 1, these can be described as the campus being outside the city, within the city, or integrated with the city. On the other hand, functional relationship defines the mutual service potentials between campus and city in terms of various functions such as residential, entertainment, academic, infrastructure, and business (Den Heijer & Curvelo Magdaniel, 2018).

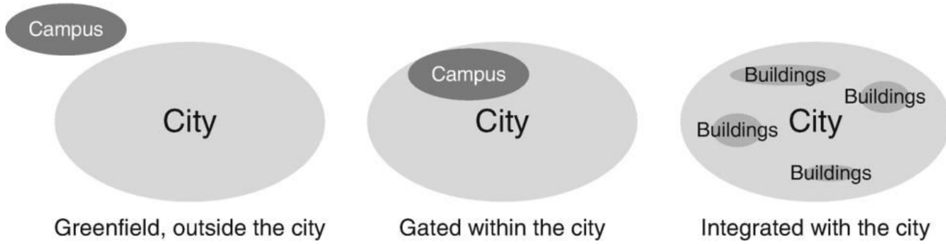

Figure 1. Physical campus–city relations (Den Heijer & Curvelo Magdaniel, 2018)

Depending on its location within the city, the campus environmental interactions have a significant impact on the identity of the university and its social life. Just as vibrant and active spaces within the campus are adopted by users, the lively streets that connect the campus to the city are equally important for the university's users. At this point, discussing the urban-campus connection axes is a fundamental necessity for a campus to interact with the urban environment both physically and functionally.

Streets, which are a significant representation of experiencing an urban environment, can offer strong connections to enhance pedestrian activity around a campus. Jacobs (1961) states that, streets and their connections, as the main public and vibrant places, are among the first things that come to mind in a city. Accordingly, if the streets are interesting, the city looks interesting; similarly, if the streets are dull, the city is dull as well (Jacobs, 1961). On the other hand, streets by themselves do not hold meaning; they find significance through with other uses, such as facilitating the engagement of a student community with its surroundings. Therefore, considering that streets play a vital role in the everyday lives of residents, they are expected to offer spaces for socializing, exercising, and participating in various daily activities. These areas create connections for all activities, including commuting to work, going to school, working, and leisure (Lee et al., 2021).

Additionally, spatial configuration in streets connections is concerned with how people use these spaces, how they behave, and how they feel in them (Hillier, 2014). When analyzing spatial configuration, as indicated in Figure 1, three distinct formations stand out: the ability for people to move linearly, interact within the area, and the variability of space viewed from any point (Darwish, 2021). These orientations are related to how users behave in that area, how they move, and what their needs are. Therefore, in the context of spatial configuration, analyzing user needs in addition to analyzing the physical environment will determine the spatial quality of street connections.

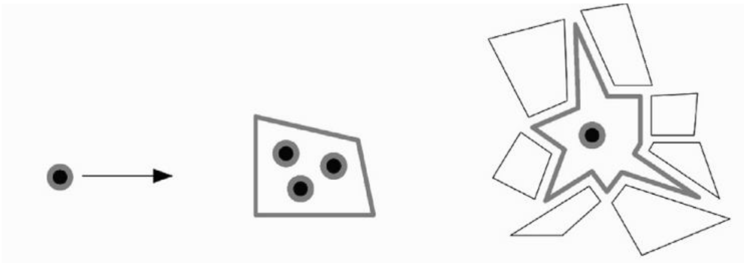

Figure 2. Three different forms of defining space (Darwish, 2021)

Streets and their connections that influence a campus's identity are significant public spaces influencing urban quality of life. For example, the spatial quality of streets frequently used by a student in their daily life and providing access to the campus directly affects the student's impression of the university. Streets that connect to a campus not only provide access to the campus area but also provide significant public spaces for campus users to interact outside the campus. Therefore, the quality of urban streets around the campus can have significant effects on the identity of a university. In this context, a street connection with high spatial quality can significantly enhance people's well-being (Wang et al., 2022). Quality typically signifies a level of excellence and can be applied to street spaces in terms of their environmental conditions and the service they provide (Tang & Long, 2019). In general, the combination of safety, security, usability, continuity, comfort, and attractivity is important for streets space quality (Fruin, 1971; Tang and Long, 2019). In fact, there are certain critical points for streets to have successful designs as public spaces: easy accessibility, usability, functionality, aesthetics, encouragement, safety, inclusiveness, compatibility with social diversity, and variety of options (Hanan, 2013).

Nowadays, evaluations of street quality are becoming increasingly important for the well-being of students (Du & Huang, 2022). A street environment that ensures spatial quality increases the frequency of social activities and influences the behavior of pedestrians. For example, streets, along with parks, squares, and other spaces they connect to, are important components of urban vitality (Tang & Long, 2019). Thus, one of the quality components is vitality, which includes the activity of street life and pedestrian flows. Vitality refers to the extent to which an urban space achieves social success. An active street encourages social and cultural interactions, contributes to crime prevention, and enhances the visual appeal of the street landscape (Jalaladdini & Oktay, 2012). Therefore, good and vital street connections that interact with the campus can increase the frequency of street activities, thereby influencing the behavior of campus users. Another quality factor is ensuring safety and security not only within campuses but also on the streets connecting to the campus. Therefore, ensuring the relationship between campus and city requires strengthening the security and safety aspects of social and functional activities in the physical street connections (Mohammed et al., 2022).

Additionally, creating a pedestrian-friendly environment is crucial. For example, ensuring that the streets surrounding the campus are accessible and designed to accommodate transportation modes like walking and biking can facilitate better interaction between students and these areas (Mohammed et al., 2022). This approach can foster the development of a stronger physical relationship between the city and the campus. Thus, city access networks shape and regulate pedestrian movement; their influence on accessibility comes from reducing distances and speeding up pedestrian flows (Dovey & Pafka, 2020).

In short, streets connecting university campuses are critical areas that significantly impact both the quality of life within the campus and its surrounding areas. These connections shape the integration between the campus and the city, making them essential arteries of daily life for all users such as students, academics, staff, and visitors. Therefore, evaluating the quality parameters of these street areas will ensure that these arteries contribute more effectively to daily life. In this regard, it is necessary to evaluate specific quality aspects. Firstly, physical connection pathways organized around a university campus to facilitate access and transportation enhance mobility in the campus vicinity. Another key point is that the presence of various service areas such as cafes, restaurants, and shops around the campus facilitates and enriches campus life. However, these functional areas must meet security and comfort conditions for availability at all times of the day. This enhances the well-being of users accessing the campus. Considering that streets are significant public spaces, connection areas should be able to bring together various user profiles by promoting social interaction. Cultural events organized in these areas make campus surroundings vibrant and dynamic. Streets should not only be accessible, comfortable, safe, and promote social interaction, but also have high aesthetic value to enhance visual perception. In this regard, green landscape areas provide environmental benefits by increasing the visual quality of streets. These elements demonstrate how critical streets connecting university campuses are in urban design and planning. Well-planned and managed streets hold significant value for both the campus interior and its surroundings.

1.2. The Concept of Urban Quality

The concept of quality, present in all fields from past to present, can be defined as user satisfaction, suitability for use, and alignment with user needs, depending on the level of development and the area of use (Orhan, 2015). The concept of quality is interpreted differently by various theorists across disciplines. In architecture, quality is linked to the satisfaction of users' needs. The quality of a space also impacts an individual's life (İnceoğlu & Aytuğ, 2009). According to William H. Whyte, a pioneer in analyzing the social use of urban open spaces (İnan, 2003), successful urban open spaces are lively, crowded areas frequently used by city dwellers. Whyte identified four key quality parameters: accessibility, diverse activities, comfort and a positive image, and spaces that support social activities, fostering interactions among people (Uzgören & Erdönmez, 2017). Jan Gehl (2013) considers urban quality in the context of activities occurring in urban spaces. He states that actions in public spaces can be influenced by various factors. Gehl categorizes urban activities into necessary, optional, and social actions, asserting that a quality space should be inviting for city users in terms of these activities (Gehl, 2011). Greene (1992) states that there is a relationship between space quality and design, emphasizing that the efficient organization and planning of a space for user settlement begins with the technical skills of physical planning. Many studies on urban quality use criteria obtained from Project for Public Places (PPS), a U.S.-based non-profit organization providing technical assistance, research, education, planning, and design recommendations (Zafer & Erdönmez, 2021; İnceoğlu & Aytuğ, 2009). Since 1975, PPS has contributed to the evaluation of space quality and the design of better public spaces, based on William H. Whyte’s research (URL: 2). The literature identifies various parameters and methods for assessing urban quality (Figure 3).

Various methods such as space syntax, surveys, and on-site observations have been used in quality assessments (Figure 3). Most studies have utilized surveys and situational analysis, often employing quality parameters from PPS and Nasar (1998-1992). Research has focused on squares and their surroundings (Zafer and Erdönmez, 2021; Doğan, 2024; Balçık and İnceoğlu, 2022; Rezaporian et al., 2023; Altınçekiç et al., 2014; Uşkan et al., 2021; Acarlı et al., 2018), parks (Kerem et al., 2022; Uzgören and Erdönmez, 2017; Erdoğan and Gür, 2024), university campuses (Bayrak & Sağlık, 2023), city centers (Femman et al., 2023; Hosseinikia et al., 2024), and neighborhoods (Saylan & Dinçer, 2017; Akten & Sunar, 2022). This indicates that urban quality concepts can be applied to improve important urban spaces. Therefore, addressing the spatial quality of university campuses and their surroundings, which are crucial for urban development, is vital.

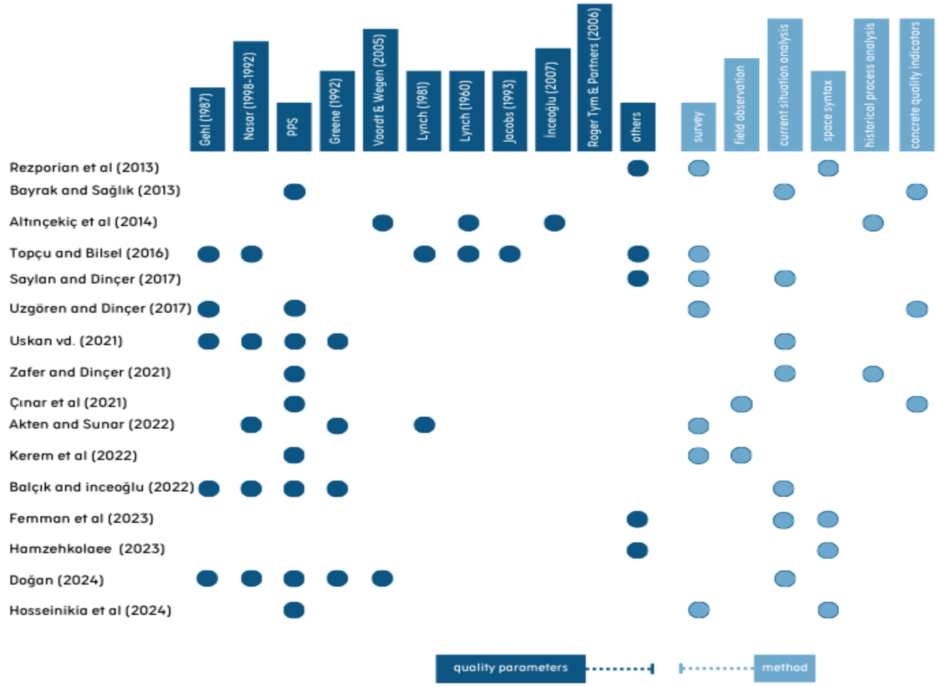

Figure 3. Parameters and methods used in the studies (prepared by the authors)

In the reviewed studies, surveys and situational analysis are commonly used methods. Survey questions are developed using study parameters and presented to users who experience the designated space (Kerem et al., 2022; Saylan & Dinçer, 2017; Akten & Sunar, 2022). Situational analysis involves using or creating parameters (in some studies, new quality parameters are derived from multiple existing ones) and techniques such as photographing, mapping, or on-site observation (Zafer & Erdönmez, 2021; Doğan, 2024; Balçık & İnceoğlu, 2022; Erdoğan &

Gür, 2024; Uskan et al., 2021; Acarlı et al., 2018). In studies using space syntax, results from space syntax are compared or evaluated alongside quality indicators. These studies assess the permeability and legibility of public spaces and how pedestrian movements, and user behaviors are influenced, aiming to improve urban areas through pedestrian path design (Femman et al., 2023; Hosseinikia et al., 2024; Rezaporian et al., 2023). Additionally, Concrete quality indicator methods are used to compare different spaces in terms of quality, often utilizing data from situational analysis (Uzgören & Erdönmez, 2017; Bayrak & Sağlık, 2023).

1.2.1. The Role of Project for Public Places (PPS) in the Literature

PPS aims to strengthen the connection between individuals and urban open spaces, transforming existing urban areas into vibrant public spaces that meet user needs (Aydınsoy, 2017). To achieve this, PPS defines quality spaces as being accessible, engaging individuals in activities, having a comfortable and positive image, and serving as social places where people meet and bring visitors. They have developed a space diagram (Figure 4) to illustrate these qualities (URL 1). PPS interprets this diagram as follows:

‘’...Imagine that the center circle on the diagram is a specific place that you know: a street corner, a playground, a plaza outside a building. You can evaluate that place according to four criteria in the red ring. In the ri ng outside these main criteria are a number of intuitive or qualitative asp ects by which to judge a place; the next outer ring shows the quantitative aspects that can be measured by statistics or research….’’ (URL 3).

Figure 4. Urban Quality Parameters According to PPS (URL, 1)

PPS categorizes urban quality parameters into four main areas: **sociability, uses and activities, access and linkages, and comfort and image** (Figure 4). **Sociability:** In spaces where this parameter is met, users see friends, meet new people, and comfortably interact with strangers. This encourages social activity, fosters a sense of place attachment, and helps build stronger community ties, thereby increasing users' sense of belonging (URL 1). Within the sociability parameter, various arrangements can be made, such as creating focal points that support diverse activities and gathering spots, and including elements that promote social interaction (İnan, 2003). **Uses and activities:** Activities, the cornerstone of a successful place, are the reasons users initially come to and repeatedly use a space. Activities make a place unique and special. When evaluating the use and activities of a space, it is important to consider activity diversity, gender balance, age diversity, all-day use, social use, and management principles (URL 1). For a place to possess the uses and activities parameter, periodic changes in activities, provision of elements that support activities, and creation of various events and programs to attract individuals can be made (İnan, 2003). **Access and linkages:** A place's accessibility can be evaluated by its visual and physical connections with the surroundings. A successful public space should be easily accessible and passable, visible from both near and far, and close to public transport. Additionally, the edges of a space are important. It is safer for a user to walk along a street lined with shops rather than around a blank wall or through an empty lot (URL 1). Measures such as adding signage at intersections, balancing roadside parking with other uses, widening sidewalks, and creating walkways can be implemented within this parameter (İnan, 2003). **Comfort and image:** The comfort and appearance of a place are crucial for its success. This parameter includes criteria such as comfort, safety, cleanliness, and the availability of seating (URL 1). To enhance the quality of a place within this parameter, regular cleaning and maintenance, ensuring safety, and placing functional landscape elements and amenities at selected points can be done (İnan, 2003). The development of the area surrounding a campus is crucial due to the significant impact universities have on the city's governance, spatial formation, economy, and cultural structure, and vice versa (Arap, 2014). Addressing spatial quality in this development will help the evolving street networks become healthier and more livable. By evaluating street networks using PPS quality parameters, focusing on sociability, uses and activities, access and linkages, and comfort and image, the city-university interaction can develop more healthily.

2. Material and Method

2.1. Material

The ATU campus, a rapidly developing university campus in the city, is located in the Sarıçam region, north of Adana (Figure 7). Approximately 15 km from the city center, the campus has high potential for physical connectivity with the city. However, being in a new residential area, the transportation lines at connection points are currently inadequate, weakening its physical link with the city. The university aims to adopt a student-centered quality policy to enhance campus life for students and other users. The campus includes educational and administrative buildings, research facilities, and sports areas. However, there is a lack of sufficient spaces for accommodation, entertainment, and relaxation. The linear design of the campus means social and cultural facilities are limited, pushing students to connect with the city for various needs. Therefore, it is crucial to strengthen the interaction between the campus and its surroundings. To meet the needs of the growing student population, it is necessary to enhance on-campus quality of life with functional, comfortable, accessible, and visually cohesive street layouts that promote social interaction and support activities.

2.2. Method

The study aims to evaluate the spatial quality of streets connected to the university campus. To this end, the study employs space syntax, Project for Public Places quality parameters, and Concrete quality indicators (Figure 5). Since the Project for Public Places quality parameters have been detailed in the previous section, this section will provide information on space syntax and Concrete quality indicators.

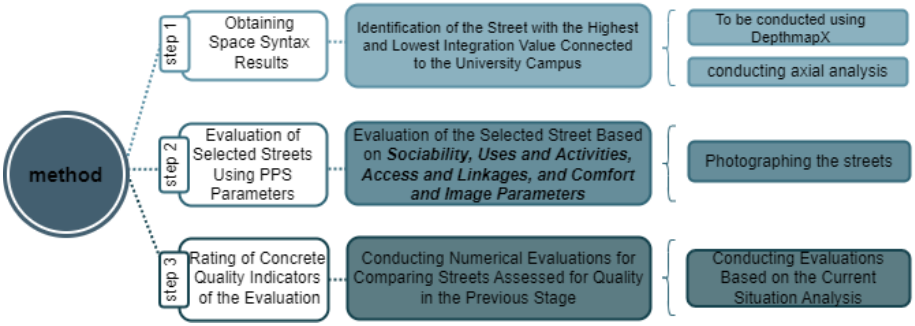

Figure 5. Methodology of the Study

According to space syntax theory, movement and experiences derived from user behavior affect spatial quality (Özbek, 2015). It combines the social meaning of space with its geometric properties (Yunistsyna & Shtepani, 2023). Space syntax parameters like integration value and connectivity represent the level of social interaction on streets (Dharmasthala et al., 2021). This method helps simulate pedestrian movement and determine the most suitable locations for social activities and services based on the physical form of spaces (Yunistsyna & Shtepani, 2023).

In summary, the use of space syntax in this study was decided due to its ability to analyze space usage patterns, define relationships between activities in the area, and correlate these values with social structures, leading to new spatial formations (Özyılmaz, 2009). The results will assist in analyzing the quality of streets connected to the university campus.

In space syntax, the axial analysis method is used. Axial lines can be described as lines of sight through all public spaces. Axial maps are used to obtain integration analyses. A higher number of axial lines indicates a higher integration level (Özbek, 2015). When a space represented by axial maps is analyzed, it calculates various values for each axis on the map, such as local and global choice, connectivity, control, entropy, depth, and integration (Hayta, 2011).

In space syntax, the integration value is calculated, providing information on a city's movement and density potential (Öztürk et al., 2018). Well-integrated streets are associated with higher usage frequency and more activities, while segregated streets are less used and potentially abandoned areas (Yunistsyna & Shtepani, 2023). Open spaces with the highest potential for user interaction, such as streets and squares, have the highest integration values, whereas isolated spaces have lower human presence (Hayta, 2011). Baran et al. (2008) found that high global integration increases street livability, while low integration correlates with reduced pedestrian activity. In space syntax diagrams, red lines represent the highest integration values, and dark blue lines represent the lowest. Integration value is a significant spatial variable that correlates well with social activities like movement and interaction (Xiao, 2017). In this study, the integration value (Rn) is set with n as 3, indicating local integration within a radius of three lines from each axis (Gündoğdu, 2014). This local integration measures an axis's relationship with other axes within the specified radius (Yeşil et al., 2024).

Concrete quality indicators using values of '+2, +1, -1, -2' aim to differentiate between positive and negative factors in the spaces determined by space syntax. The intervals that indicate a space's quality level as very poor, poor, average, good, or very good are established numerically. These levels are divided into five equal parts to create value ranges for very poor, poor, average, good, and very good (Figure 6).

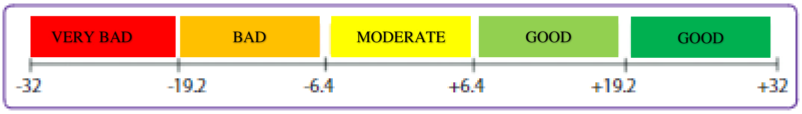

Figure 6. Concrete Quality Level Ranges (Uzgören and Erdönmez, 2017)

A value of +2 indicates that the desired quality features are met, while -2 indicates that they are not. Thus, a space evaluated in this way can have a maximum value of +32 and a minimum of -32. The streets analyzed using concrete quality indicators were based on studies by Uzgören and Erdönmez (2017) and Bayrak and Sağlık (2023) for the creation of the Table 2.

3. Findings and Discussion

3.1. Space Syntax Results

As mentioned in the previous section, the study first conducted an integration analysis using the R3 value for local integration. The depthmapX program was used for this analysis, resulting in the integration map shown in Figure 7. In this map, red lines indicate the highest integration values, while blue lines represent the lowest. The integration values calculated from the map in Figure 7 are listed in Table 1.

Table 1. Streets with the Highest and Lowest Integration Values

Ref no	Connectivity	Line Lenght	Integration (HH)
141	0	4969.55	-1
0 (elif su uludağ cad.)	14	163404	2.79911

Figure 7. Map Resulting from the Integration Analysis and the Overlay of the Campus Area

According to the values shown in Table 1 and the integration graph in Figure 7, Elif Su Uludağ Street has high integration and connectivity. This indicates that Elif Su Uludağ Street is heavily used by both pedestrians and vehicles. In contrast, Reference Street No. 141 has low pedestrian and vehicle traffic.

3.2. Evaluation of the Selected Streets in Terms of Quality Sociability

Inclusivity: On Elif Su Uludağ Street, due to the lack of urban focal points, it was observed that different users do not come together. The area's level of sociability is based on movement by students and local residents during the day. Reference Street No. 141 lacks spatial features that would bring users together (resting, entertainment, walking, sports, conversation, interaction, etc.).

Suitability for Recreational Activities: The presence of open green spaces along Elif Su Uludağ Street is positive. However, these spaces are not usable, and the high proportion of hard surfaces makes recreational areas insufficient. Reference Street No. 141 does not allow for individual and group activities due to the lack of landscaping.

Spatial Diversity: Elif Su Uludağ Street offers partial commercial variety. However, there is a lack of cultural spaces that would bring people together. Reference Street No. 141 lacks commercial, cultural, and social amenities.

Uses and Acitivities

Activity: Elif Su Uludağ Street is actively used in the morning and noon hours, with a decrease in use during the evening. Reference Street No. 141 is used only in the morning and noon hours as a connection area.

Activity Diversity: Both Elif Su Uludağ Street and Reference Street No. 141 serve as transition areas for access to the university campus and surrounding commercial areas, fulfilling only optional and mandatory activities. Social activities are not observed.

Originality: Both Elif Su Uludağ Street and Reference Street No. 141 form connections in a new residential area. Therefore, their originality values are low as they do not provide connections to historical or cultural areas.

Confor and Image

Safety: Both Elif Su Uludağ Street and Reference Street No. 141 are considered unsafe in the evening due to decreased use, insufficient lighting, and the lack of surveillance cameras on Reference Street No. 141.

Attractiveness: The attractiveness of Reference Street No. 141 is limited due to the presence of only residential buildings and undefined spaces. Elif Su Uludağ Street's connection to a garbage site and the resulting odor negatively impact its attractiveness despite the opening of new venues.

Cleanliness: While the cleanliness and maintenance of both Reference Street No. 141 and Elif Su Uludağ Street are handled by the municipality, Elif Su Uludağ Street is negatively affected by its connection to a garbage collection center.

Access & Linkages:

Connected: Elif Su Uludağ Street has many connections due to being a main axis, whereas Reference Street No. 141 has weak connections.

Accessible: Elif Su Uludağ Street has bus stops, intermittent bike paths, and pedestrian sidewalks, making it accessible. In contrast, Reference Street No. 141 has only an asphalt road, which is insufficient for accessibility.

Transportability: Elif Su Uludağ Street can be accessed by foot, private vehicle, and public transportation. Reference Street No. 141 can be accessed by foot and private vehicle.

The evaluation based on concrete quality indicators is presented in Table 2 below.

Table 2. Comparison of Concrete Quality Indicator Evaluations of Streets

Parameters & Criteria		Score	Elif Su Uludağ Street	Reference Street No. 141
Sociability	**Inclusivity (All Users)**			
	All	(+2)		
	Presence of Only Two	(+1)		
	Presence of Only One	(-1)		
	None	(-2)		
	Suitability for Recreational Activities			
	Very Suitable	(+2)		
	Suitable	(+1)		
	Very Little Suitable	(-1)		
	Not Suitable	(-2)		
	Spatial Diversity			
	Very Suitable	(+2)		
	Suitable	(+1)		
	Very Little Suitable	(-1)		
	Not Suitable	(-2)		
Uses and Acitivities	**Activity**			
	Usage at all times of the day	(+2)		
	Usage in the morning and evening	(+1)		
	Usage in the morning and noon	(-1)		
	Usage only at noon	(-2)		
	Activity Diversity			
	Optional, social, and mandatory activities together	(+2)		
	Optional and social activities	(+1)		
	Optional and mandatory activities	(-1)		
	Only mandatory activities	(-2)		
	Originality			
	Very Successful	(+2)		
	Successful	(+1)		
	Moderate	(-1)		
	Unsuccessful	(-2)		
Co nf	**Safe**			
	Very Safe	(+2)		

	Safe	(+1)		
	Unsafe	(-1)		
	Very Unsafe	(-2)		
	Attractiveness			
	Very Attractive	(+2)		
	Attractive	(+1)		
	Not Attractive	(-1)		
	Not at All Attractive	(-2)		
	Clean			
	Very Clean	(+2)		
	Clean	(+1)		
	Not Clean	(-1)		
	Not at All Clean	(-2)		
Access and linkages	**Connected**			
	Connected to more than 2 streets	(+2)		
	Connected to more than 1 street	(+1)		
	Connected to 1 street	(-1)		
	No connection	(-2)		
	Accessible			
	Very High	(+2)		
	High	(+1)		
	Low	(-1)		
	Very Low	(-2)		
	Transportability			
	Pedestrian-private vehicle-public transport	(+2)		
	Pedestrian-public transport	(+1)		
	Pedestrian-private vehicle	(-1)		
	Pedestrian only	(-2)		
TOTAL PUAN			**0**	**-15**

As seen in Table 2, in terms of concrete quality indicators, Elif Su Uludağ Street has a value of 0, while Reference Street No. 141 has a value of -15. According to the concrete quality indicator value, Elif Su Uludağ Street is of moderate quality, whereas Reference Street No. 141 is of poor quality.

4. Conclusion

University campuses interact reciprocally with the regions they are established in, supporting each other's development. Therefore, it is crucial to consider not only the campus boundaries but also the surrounding area's development. Evaluating the university and its surroundings in terms of spatial quality and fostering their development based on the findings is essential. This study, by examining the campus's surrounding area, aims to contribute to the literature on the university-city interaction. As spatial quality improves, the diversity, duration, and quality of urban space activities also enhance (Uzgören & Dinçer, 2017).

Considering the interaction between the studied streets and the developing university campus, it is vital to consider the study's findings for their development. To enhance the quality of these streets, parameters such as activity, activity diversity, safety, attractiveness, and cleanliness need to be improved. The design and quality of open public spaces both within the campus and its surroundings directly affect all users, including students, staff, and city residents. Improving these parameters will increase spatial quality, leading to greater activity diversity, longer usage durations, and higher social interaction levels.

Improving the streets will enable students to use nearby spaces more effectively. However, the proximity of the garbage collection site negatively impacts cleanliness. The waste brought to the site affects many aspects like odor, aesthetics, and maintenance, negatively influencing students' use of the campus surroundings. Therefore, it is crucial to take necessary measures to minimize the negative impacts of the garbage site. This will positively affect both the students' university life and other users' campus experience.

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article.

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An Assessment of Recreational Opportunities in the KTU Kanuni Campus

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1. Introduction

In developing and expanding urban areas, observable and measurable changes and pressures on land availability have significantly degraded the natural environment (Houghton, 1994; Doygun & Erdem, 2012). Rapid urbanization also brings with it various urbanization problems such as infrastructure and social deficiencies, haphazard development, parking and traffic issues, lack of business centers and pedestrian paths, deficiencies in recreational areas, and a lack of urban awareness (Çatalbaş, 2016). This situation paves the way for environmental problems in cities where natural resources are rapidly consumed, thus threatening the sustainability of these resources (Martens & Raza, 2010). In unplanned developments, adequate and suitable land is not allocated for different use areas, leading to the intermingling of areas with different characteristics. This results in the reduction of green areas that serve as buffers between them, causing numerous environmental problems (Keleş, 1984; Atanur & Ersöz, 2020). Open green spaces, as primary elements of urban use, provide ecological, aesthetic, economic, and psychological benefits to cities and their users (Çorbacı et al., 2020a). Furthermore, under increasing urbanization pressure, these spaces facilitate the reconnection between humans and nature, promoting natural interactions in increasingly gray urban areas (Işıldar, 2015; Çorbacı et al., 2022).

Universities, which hold a significant place and intense use within cities, highlight the socio-economic structure, cultural and political features of the communities they are part of, and possess significant potential to create alternative green spaces in urban areas (Korkut, 2011; Yıldız, 2020; Oğuztürk & Pulatkan, 2022; Ercan Oğuztürk & Pulatkan, 2023b).

These areas enhance the contributions of universities to the urban fabric, providing various social and environmental benefits to the city and its users. University campuses located in or near city centers offer numerous advantages to both the city and its residents (Kahveci, 2021; Ercan Oğuztürk & Pulatkan, 2023c). While city residents can benefit from the campus's library, educational and intellectual environment, auditorium, recreational areas, indoor and outdoor sports facilities, etc., students also integrate with the city and its users, contributing to their development through widespread education. Urban universities develop within building blocks, which are open to urban use and thus function as parts of the city (Sönmezler, 1995).

The location selection of university campuses, the region they are established in, and their economic, social, and cultural characteristics are crucial for the development of the campus and its surroundings, as well as for shaping their spatial arrangements. Therefore, establishing a university in a region aimed at development serves as a tool to achieve the set objectives. The contribution of higher education institutions to social, economic, and cultural development has been increasingly significant (OECD, 1982; Florax, 1987; Görkemli, 1999; Gültekin et al., 2008; Ercan Oğuztürk & Pulatkan, 2023c). These institutions offer various facilities to meet the social, cultural, and recreational needs of students and staff, in addition to academic and administrative activities (Karakaş, 1999; Ertekin & Çorbacı, 2010; Çorbacı et. al., 2020b; Ercan Oğuztürk & Pulatkan, 2023a).

To address the environmental, social, and economic issues faced by university campuses, ecological design and planning elements, as well as sustainable practices, are necessary. A sustainable university campus encourages minimizing adverse environmental impacts on a regional or global scale while fulfilling the economic, social, and health impacts arising from the use of resources (Hordijk, 2014). The concept of a sustainable campus aims to meet today's needs without compromising the needs of future generations, balancing protection and use while considering environmental rights. Key topics include green infrastructure, carbon sequestration, proper waste management, using eco-friendly materials, efficient water use, and energy-efficient and environmentally friendly practices (Ciravoğlu, 2006; Artar et al., 2019; Derbentoğlu, 2021; Altun, 2022). The rising trend of “ecological and sustainable campuses” worldwide aims to establish campuses that prefer eco-friendly products, are sensitive to the environment, save energy, have waste management, and support sustainable development. With ecological and sustainable campus practices, universities contribute economically to themselves, help combat global climate change and environmental problems, and fulfill their social responsibility by raising awareness in society (Kayapınar Kaya et. al., 2019).

The recreational potential and environmental impacts of university campuses have become significant areas of research and evaluation. This potential is associated with recreational facilities such as green spaces, sports areas, cultural activity areas, etc. However, it should be noted that these facilities have various impacts on the natural and built environment. University campuses are typically established in or near city centers, which has several advantages and disadvantages (Sönmezler, 1995). For students, this proximity offers easier adaptation to city life and social interaction opportunities, while city users benefit from the various facilities offered by the university (Çınar, 1998).

This study aims to reveal the recreational potential of KTU Kanuni Campus. In line with this aim, the recreational facilities of the campus and their environmental impacts will be addressed, highlighting important aspects for balanced sustainability. This study aims to contribute to the efforts of university campuses to provide a healthy and balanced environment for both their users and environmental conditions.

2. Material and Method

This study was conducted at the Karadeniz Technical University (KTU) Kanuni campus, located in the Ortahisar district of Trabzon (Figure 1). The research employed the literature review methodology (Forster, 1995). During the literature review process, existing literature, academic articles, the official websites of KTU Kanuni Campus, institutional documents, and other written sources were examined. Additionally, field studies and on-site observations at the KTU Kanuni Campus formed the basis of the research. During these studies, the physical features and environmental impacts of existing green spaces, sports areas, and dining facilities on the campus were examined in detail. The findings obtained were used to reveal the current recreational potential of the KTU Kanuni Campus, understand the impacts and issues, and develop solutions. Throughout this process, principles of sustainable urban planning and campus management strategies were considered in formulating the recommendations. These recommendations aim to contribute to efforts to provide a healthy and balanced environment for both the users of the KTU Kanuni Campus and the surrounding environment.

Figure 1. Location Map (World Map, Map of Turkey**,** Map of Trabzon Province, KTU Campus Map**)**

3. Findings

3.1. Population

Examining the population growth rate in the central district of Ortahisar, Trabzon, is crucial to identifying the problems and needs arising within and around the campus due to the increasing population over time. As shown in Figure 2, the population, which was 117,768 in 1955, increased to 156,027 in 1975 and reached 320,225 in 2015 (URL-1, 2024). In 2023, the population was determined to be 322,702. According to these data, the population has increased by 173.89% over the last 68 years.

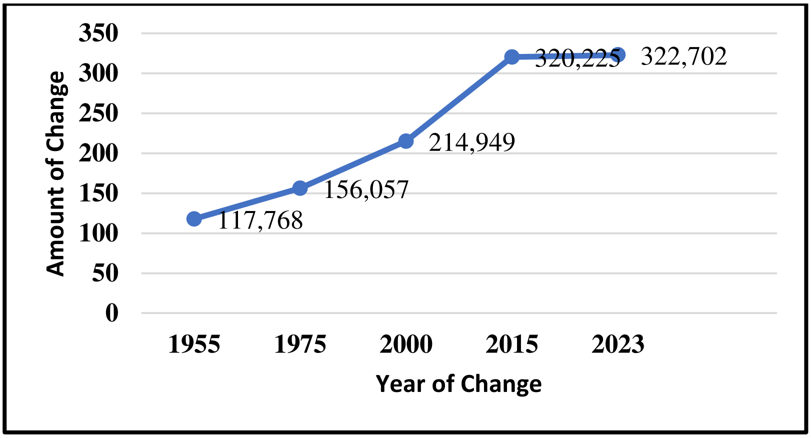

Figure 2. Population Growth Chart of Ortahisar District (URL-2, 2024)

Since its establishment, the KTU campus has shown continuous population growth and development from 1955 to 2023. Using data from the KYSMP (2016) study, the student population, which was 2,588 in 1975, increased to 14,128 in 2000 and reached 30,380 in 2023. Over the past 48 years, the student population has increased by 1073.48%, a change that is also reflected in the corresponding graph. Parallel to the increase in student numbers, there has also been a rise in the number of academic and administrative staff. The number of academic staff, which was 475 in 1985, increased to 1,045 in 2000 and reached 2,116 in 2023. This indicates a 345.47% increase in the number of academic staff over the years. The number of administrative staff, which was 834 in 1985, increased to 1,350 in 2000 and reached 3,544 in 2023. This shows a 325.72% increase in the number of administrative staff over the years. The 68-year change graph depicting the changes in the student, academic, and administrative staff numbers within the campus over the years is presented in Figure 3.

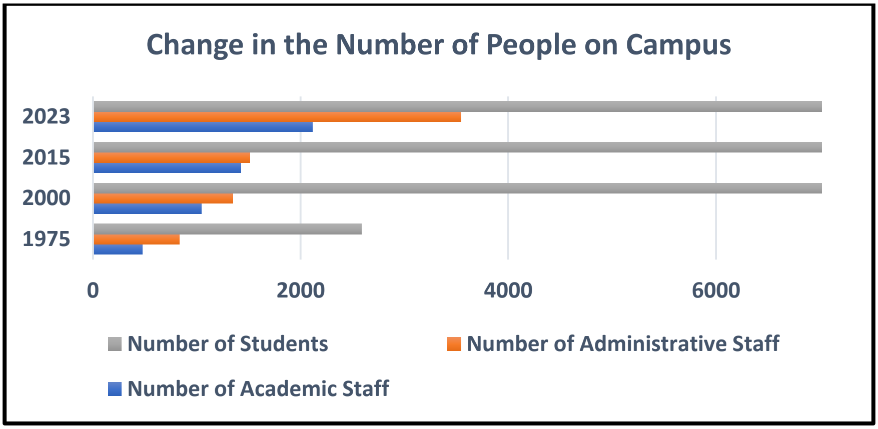

Figure 3. Change Graph of Population on Campus (Academic Staff, Administrative Staff, and Student Numbers)

The increase in population within the campus, particularly due to the rise in the number of students, academic, and administrative staff, holds critical importance in terms of the adequacy of the campus's existing facilities, needs, and problems. With the impact of the growing population, issues such as the inadequacy of the transportation network, increased demand for housing and administrative buildings, and the reduction of green spaces are anticipated from economic, ecological, social, and cultural perspectives. This situation is of great importance for identifying and preventing potential future problems. Campuses not only meet the educational and living needs of students but also provide working environments for academic and administrative staff. Therefore, carefully addressing the needs and problems brought about by population growth is vital for managing campuses in a sustainable and efficient manner. In this way, the needs of current communities can be met, and the quality of life for future generations and the protection of the environment can be ensured.

3.2. Recreational Areas

At KTU Kanuni Campus, there are various facilities aimed at meeting the individual and social needs of students during their free time and contributing to their sports and cultural development (Figure 4).

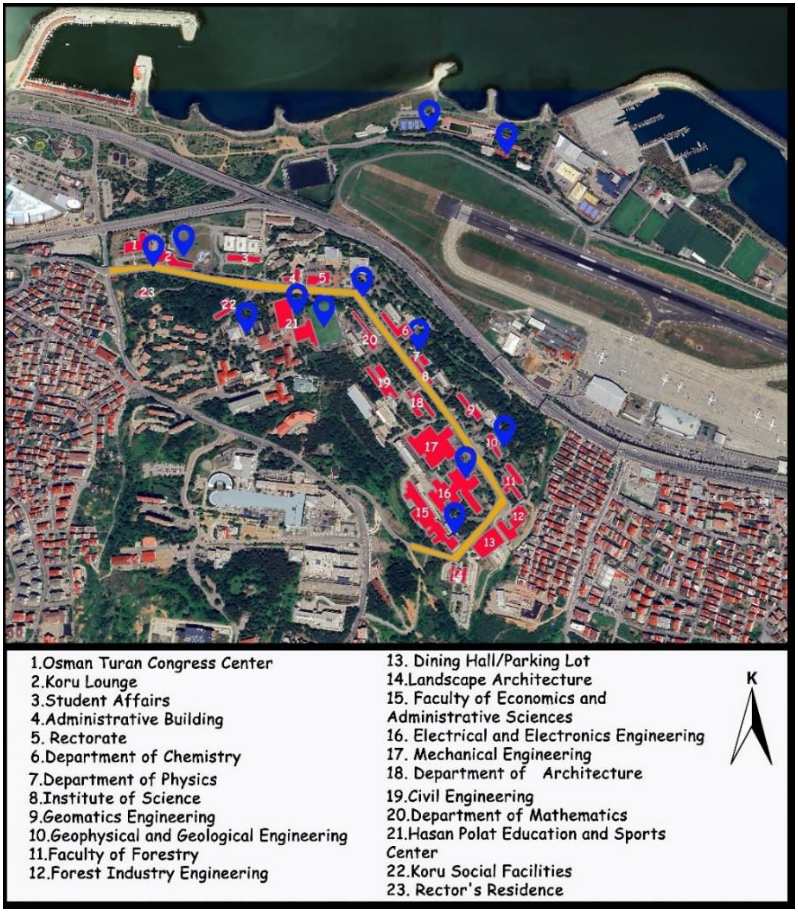

Figure 4. Map of Recreational Areas at KTU Kanuni Campus

Within the central campus, the social and cultural facilities include the Atatürk Cultural Center (with halls for 1000 and 250 people), the Koru Facilities, The Coastal Facilities, the Prof. Dr. Osman Turan Cultural and Congress Center (800 m², and halls for 600 and 250 people), the Tourism and Hospitality Vocational School facilities, and the Student House (Figure 5).

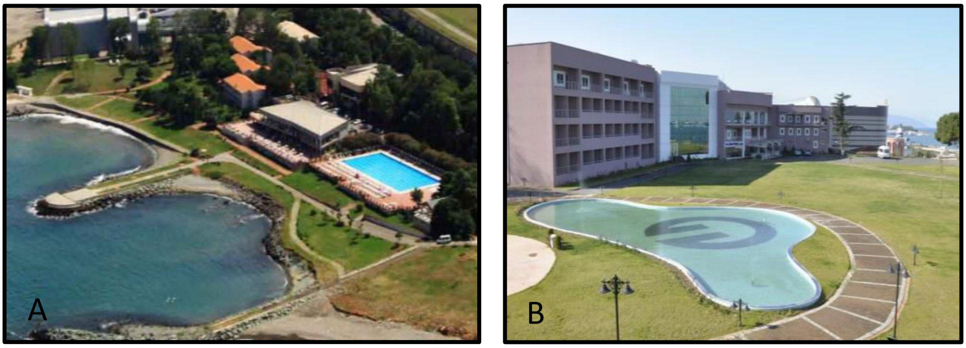

Figure 5. KTU The Coastal Facilities (A) ve KTU Koru Facilities (B) (URL 2, 2024)

Additionally, various sports facilities such as the Hasan Polat Indoor Sports Hall, a football stadium, and courts for basketball, volleyball, tennis, badminton, and mini football are available (URL-3, 2024) (Figure 6). The sports facilities within the campus are divided into two sections: indoor and outdoor. Among the sports halls in the Central Kanuni Campus are the Grass Field Sports Center (including chess, fitness, folk dance, dance halls, and a sauna sports complex), the Hasan Polat Sports Hall (a multi-purpose sports hall with a seating capacity of 800), and the Indoor Tennis Court. Furthermore, there are outdoor sports facilities in the Central Kanuni Campus. These include a grass football field and mini football field (URL-3, 2024). Furthermore, outside the boundaries of the campus but affiliated with the university, there are coastal facilities, mini basketball courts, tennis courts, volleyball courts, and a semi-Olympic swimming pool, as well as social and cultural structures such as the student house. These areas are among the indoor and outdoor facilities where students engage in both active and passive recreation (Günaydın, 2011) (Figure 6).

Figure 6. Images of Sports Areas at KTU Kanuni Campus (URL 2, URL 4, URL 5)

In addition to indoor and outdoor sports and recreational facilities, the campus has various areas where students can engage in recreational activities such as games, entertainment, socializing, and relaxation during their free time. Within the area, there are parks, seating areas under trees, and walking paths designed for sitting and walking activities, as well as other recreational areas in open green spaces. The passive recreation areas preferred by students in their free time include places along the coastline chosen for viewing purposes, amphitheater-style structures that meet sitting, resting, and entertainment needs, and other available areas (Figure 7).

Figure 7. Images of Cafes, Wooded Areas and Viewing Terraces within the Campus

4. Conclusion and Suggestions

The research and evaluations conducted within this study have revealed that KTU Kanuni Campus possesses a rich recreational potential. Green areas, sports facilities, and other recreational opportunities are significant resources for students and staff. However, it has been observed that the increase in recreational opportunities leads to increased environmental impact on campuses. These areas and facilities are also opened to the use of the city's people and visitors with different activities. With the increasing number of visitors, there is also an increase in environmental impacts such as waste production, water and energy consumption.

The assessment made in line with the hypothesis of the research, "The increase in recreational facilities leads to an increase in environmental impact on university campuses," shows that recreational facilities have a positive and significant relationship with environmental impact. In this context, the study not only confirms the hypothesis but also highlights the relationship between environmental impact and recreational facilities on university campuses.

In this regard, it is important for university administrations and planners to manage recreational facilities with environmental sustainability in mind. Important steps for environmental sustainability include activating waste management systems and promoting recycling programs, encouraging the use of technologies that ensure water and energy efficiency, preserving green areas and supporting projects that encompass extensive green spaces, ensuring community participation and awareness, and developing planning and management strategies in line with sustainability principles.

Additionally, the implementation of these projects, organizing education and awareness activities to increase environmental consciousness among students and staff, promoting alternative transportation methods and improving public transport options, preserving existing green areas and creating new green spaces, and protecting natural life and biodiversity can contribute to reducing environmental impacts. By implementing these recommendations, KTU Kanuni Campus can provide a more sustainable environment for both its users and the surrounding environment.

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University Campuses in the Scope of Ecological Landscape Design: The Case of Kayseri Nuh Naci Yazgan University

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1. Introduction

University campuses are places where many activities can be carried out with their educational buildings, accommodation areas, transportation axes, recreational areas. With the diversity of usage spaces, campuses are defined as a small-scale city as a part of the urban ecosystem. On campuses areas outside the building are generally arranged as recreational areas. In these recreational areas, there are active sports areas, seating areas, water elements, urban facilities and natural assets such as wooded areas and wetlands. Open and green areas on campus should provide integrity between buildings and the campus area. Open and green areas on campuses have two important functions: they should meet the recreational needs of users and protect the campus ecosystem. In order to preserve the ecological character of the campus landscape, natural and environmental features (topography, geology, vegetation, etc.) should be evaluated in a balance of protection and use during the landscape planning and design stages. Solution proposals should be developed in line with ecological landscape planning and design criteria in the decision-making processes.

The concept of sustainability is thought to have first emerged in the early 1900s in the form of conservation of existing resources. The concept of sustainable development was first mentioned in the Brundtland Report prepared by the World Environment Commission in 1987. After the concept of sustainability the concepts of ecological planning and sustainability have become important in university campuses, as in living spaces of all sizes.

For the purpose of ecological landscape design on university campuses, design studies should be carried out in which the natural landscape character is preserved, climate and topographic data are evaluated in the most effective way, local and renewable building materials and renewable energy sources are used, alternative green areas are designed for active and passive recreational needs, and natural vegetation is used in open-green areas (Yıldız, 2017).

After a period when technology rapidly spread to every aspect of life with the concern of modernization and ecological approaches were ignored, the concepts of sustainability and ecological design have come to the fore again today with the decrease in the quality of life in living spaces of all sizes. University campuses should also be carefully considered within the scope of ecological planning and design parameters. The NNYU campus area covered by the research is located on the border of the Kayseri Northern Ring Road (Kayseri Kuzey Çevre Yolu) The area where settlement was limited when the campus was established in 2009 is now an area where different urban uses such as a city hospital, shopping mall and Furniture City (Mobilya Kent) are located and construction continues rapidly with the development of the city in this direction. Climate, one of the important ecological parameters due to dense construction, changes in conditions such as air quality. In this context, NNYU campus is an area where ecological sensitivity can be increased compared to the densely used areas such as industry, shopping and hospitals around it. For this reason, NNYU campus area was evaluated in line with ecological landscape planning and design parameters and suggestions were developed for ecological campus design.

2. Ecological Landscape Design on University Campuses

University campuses are turning into ecosystems with many social and cultural activities such as education, work, accommodation and transportation. They also have an important place in the urban landscape matrix, especially because they have large landscape areas. University campuses should have environmentally friendly ecological features in order to alleviate the ecological burden they bring to cities (Açıkçay, 2015).

During the establishment of university campuses, the objectives for the campus's facilities such as education, recreation and accommodation should first be determined. Then, from macro to micro scale, site selection, determination and evaluation of the land, deciding on the character of the university, development directions and expansion areas should be determined. University campuses are in urban or rural areas where establishment and continuity take many years because they are constantly evolving spatial organizations (Yıldızoğlu, 2006).

As a result of the rapid urbanization process in Turkey, open and green areas are decreasing day by day due to the increase in construction areas. When open and green areas are evaluated in terms of the quality of life of the local people, the presence of these areas in the city brings prestige to the settlement area. University campuses, which are a part of the city, are also important urban design areas that respond to many functional needs such as ecological, economic, aesthetic, recreational and psychological. University campuses located in urban or rural areas significantly affect the urban ecology with their large surface areas. Therefore, structural and plant landscape design studies should be planned at every stage.

Social and cultural activity areas in universities and their active use are directly related to the individual and social development of students. Students both actively participate in and organize social and cultural activities during their education. In this process, they learn to work and have fun together, to participate in community life, and to establish the right relationships with the environment (Erçevik ve Önal, 2011).

Recreation areas in university campuses can be generally defined as buildings and their surroundings used as congress, conference and concert halls called cultural centers, open and covered areas used for shopping and eating and drinking activities, indoor and outdoor sports facilities, open and green areas that allow various active and passive activities. According to Çağlar (1973); the place and importance of recreation areas on campus is an indisputable issue. The spaces and usage areas in this area provide opportunities for students to establish relationships with each other and between different disciplines on campus and to ensure continuity. Recreational areas on campuses provide organic ties between students and faculty members. Thus, students' sociocultural development is supported in addition to their education. A social and intellectual communication environment is created between users (Erçevik ve Önal, 2011).

University campuses have a direct impact on urban ecology with their large settlement areas. In the vegetative design phase of landscape design on university campuses, existing natural data should be evaluated correctly and aesthetic and functional species should be preferred. Plant design within the campus has great importance in terms of creating microclimate.

The fundamental principle of ecologically-based design is sustainability. The basic principles of ecological design are as follows: (Konuk, 1994);

- Regardless of their function, built areas should be considered within the urban ecosystem.
- Built areas should be associated with the critical problems of the city at all scales.
- In a construction area, the opportunities and threats, strengths and weaknesses of the area should be analyzed well.
- The use of renewable energy sources should be encouraged, environmentally harmful wastes and uses should be minimized and eliminated if possible.
- The construction area should be able to reflect the biological, hydrological and geological differences in the environment.
- Most importantly, the existing ecosystem and environmental design within the traditional urban fabric should be sustained.

3. Material and Method

The theoretical basis of the research is the landscape design used in university campuses. Within the scope of this research, it is aimed to examine out-of-town university campuses within the scope of ecological landscape design criteria. In this regard, all kinds of written and visual source materials such as theses, articles and papers related to landscape design, university campuses and campus designs have been evaluated as source material. Another material of the research is the Nuh Naci Yazgan

University campus, which was established in 2009 in the Kocasinan district of Kayseri. Nuh Naci Yazgan University continues its educational activities with 8 faculties, 3 institutes and 1 vocational school. NNYU campus is used by 1321 academic and administrative staff and 2871 students. Satellite images of the NNYU campus are shown in figure 1.

Figure 1. NNYU Campus Area Location in Ertugrul Gazi Neighborhood (Google Earth, 2024)

The NNYU campus landscape, which was selected as a case study area due to its current location, its impact on the spatial development of the city, and its relationship with the nearby shopping mall and City Hospital(Şehir Hastanesi), was evaluated within the scope of ecological landscape planning parameters. The ecological landscape planning parameters developed with reference to the studies of Onur, 2012, Çetinkaya-Karafakı, 2013 and Açıkay 2015 are given in Table 1.

SWOT analysis was used as the research methodology. The landscape of NNYU campus area was evaluated with the SWOT analysis matrix according to natural parameters, infrastructure parameters, transportation parameters, environmental management parameters, design parameters and other parameters, which are ecological landscape planning parameters. The ecological landscape planning parameters used in the assessment are given in table 1.

Table 1. Ecological Landscape Design Parameters (developed from Onur, 2012, Çetinkaya-Karafakı 2013 and Açıkay 2015)

Natural Parameters	Available	Not Available
Topography		
Geology-Hydrology		
Climate		
Vegetation		
Infrastructure Parameters		
Location		
Transportation		
Energy		
Use of Building Materials		
Environmental Management Parameters		
Solid Waste Management		
Wastewater Management		
Clean Air Management		
Use of local materials		

Use of local plant material		
Design Parameters		
Open and Green Space Designs (Recreational Areas)		
On-Campus Circulation		
Use of Plant Materials		
Urban ecosystem and wildlife conservation		

A two-stage method was followed in order to evaluate the NNYU campus area in line with ecological landscape planning parameters.

In the first stage, landscape planning parameters and literature data on campus design were examined and landscape planning parameters were developed in order to perform SWOT analysis in the NNYU campus area, which was determined as the study area. During the development of these parameters, all written and visual sources related to landscape planning were analyzed.

In the second stage, SWOT analysis of the NNYU campus, which is the research area, was carried out within the scope of the landscape planning parameters in table 1. Strengths, weaknesses, opportunities and threats have been identified.

In the conclusion and evaluation part of the research, suggestions were developed in order to make the NNYU campus suitable for ecological planning parameters in line with the SWOT analysis data.

SWOT analysis; It is a method used to identify the strengths and weaknesses of a technique, process, project or subject and to identify opportunities and threats due to external environmental conditions. The aim of this method is to make the most of existing strengths and opportunities by taking into account internal and external factors. Recommendations are developed in a way that minimizes the ethics of threats and weaknesses. For this reason, SWOT analysis was used as an effective method to evaluate the NNYU campus within the scope of ecological landscape design.

4. Research Findings

4.1. Research Area

Nuh Naci Yazgan University campus area, which was chosen as the study area of this research, is located parallel to the northern ring road in the development direction of the city. Due to its location, it is the first place to reach the city and is also located in the direction of the development of the city. Due to its location, it can be seen that the city has been developing in this direction since its establishment in 2008. It is located close to Kayseri City Hospital (Kayseri Şehir Hastanesi) and Kayseri City Terminal (Kayseri Şehir Terminali).

4.2. Spatial Characteristics of the Research Area

The NNYU campus was determined as the study area in this research. NNYU campus constitutes an important focal point for the city due to its location within the city of Kayseri and the development and size of the campus area. The NNYU campus is located parallel to the northern ring road in the north of Kayseri. In addition to academic units, the campus area includes a congress and cultural center, library, indoor and outdoor sports facilities, student social life center, student dormitories, faculty residences, and the faculty of dentistry hospital. The campus offers many recreational activities with its wide open and green areas. In this form, it is an area that meets basic needs such as shelter, transportation and recreation.

The campus area is 14 km from Kayseri city center and 4 km from Kayseri City Hospital. Kumsmall Shopping Center (4.2 km) and Furniture City (Mobilya Kent) Industrial and Trade Area (2.5 km) are located near the campus. With its existing and ongoing infrastructure and transportation facilities, the campus has an important position in the development direction of the city (Figure 2).

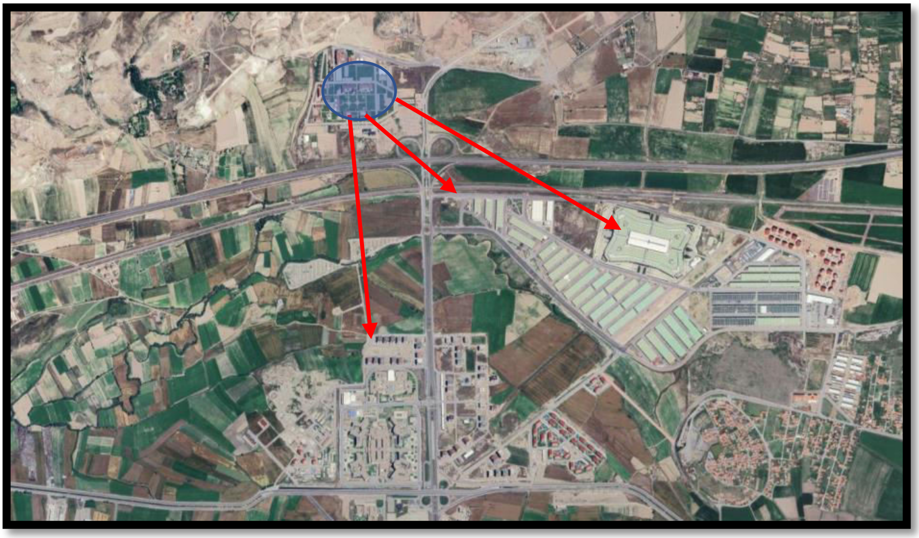

Figure 2. Nuh Naci Yazgan University Location (MTA, 2024)

When the NNYU campus is examined in terms of land form and character; it is a very smooth land compatible with the geographical region it is located in. In accordance with the organic linear settlement model in the campus area, common use areas and other functional units are located on a linear band, while faculty residences and dormitory areas are located at the point where the educational buildings end (Figure 3). In the NNYU campus area, there is a circulation network that can be defined in accordance with the organic linear system and other functions located on both sides. The campus shows a relatively organic development due to its compatibility with the linear system and the buildings constructed later. Vehicular and pedestrian circulation is provided on the entrance and connection roads within the campus area with roads that are compatible with the slope of the land but integrated into the organic linear campus form (Figure 4).

Figure 3. NNYU campus area layout (Anonymous, 2022b)

Figure 4. NNYU campus area overview (Anonymous, 2022b)

4.3. Evaluation of the Research Area According to Ecological Parameters

Topography: The buildings on the NNYU campus are located in accordance with the topographical features. There is a linear open-green area in the center and educational buildings around this area. This open-green space is bordered by the student center. Following the student center, there are dormitories and lodgings, which are structures for accommodation purposes. The maximum slope on pedestrian and vehicle roads within the campus area does not exceed 6%.

Geology: An active fault line runs through the northwest boundary of the NNYU campus area (Figure 5) (Red lines are active fault lines).

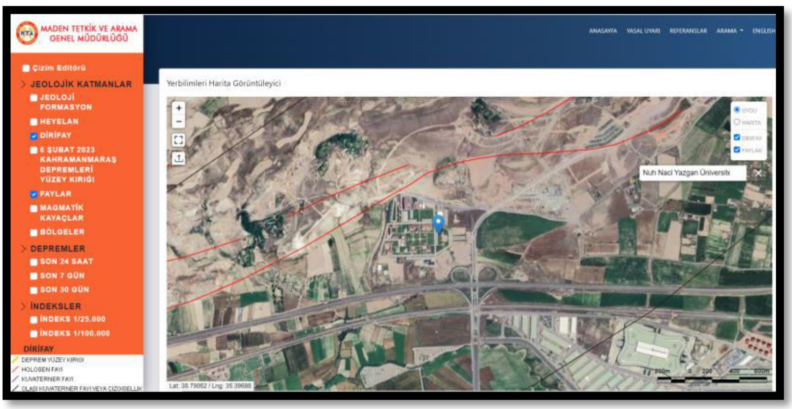

Figure 5. NNYU campus site geological situation (MTA, 2024)

Climate: NNYU campus area has a continental climate prevailing in the Central Anatolia Region. In the region with continental climate characteristics, summers are hot and dry and winters are cold and snowy. However, due to the increasing global climate change in recent years, the number of days with rain-snow precipitation has decreased in winter months, and very high temperature values are measured in summers with increased humidity. The vegetation in the campus area is not sufficient to create a microclimate effect.

Vegetation Plants suitable for the steppe vegetation dominant in the Central Anatolia Region were used in the campus area.In the areas of the campus planned to be developed as forest areas, Pinus sp,Cedrus sp., Picea sp. species were used in the areas of the campus planned to be developed as forest areas, while Prunus ceracifera, Tilia tomentosa, Aesculus hippocastanum, Platanus orientalis, Platanus occidentalis Acer negundo, Fraxinus excelsior, Betula alba, Picea pungens, Cupressus arizonica, Thuja orientalis, Thuja occidentalis, Euonymous japonica aurea, Rosa sp.species with high visual impact and odor effect suitable for the vegetation of the region were preferred.

Location: The campus area is located in the north of Kayseri in the development direction of the city. The city hospital, Kumsmall shopping center, furniture city industrial zone are located nearby (Figure 2).

Transportation: Transportation facilities have improved since 2009, when the campus was first established. With the effect of the commercial and health structures near the campus, a tram line came to the region.

Energy: No sustainable energy source is used in the campus area to support ecological planning.

Local Building Material: Local stone was used as façade cladding material in the buildings within the campus area. In pedestrian circulation areas, key paving stones were applied to provide rainwater passage on the surface.

Solid Waste Management: There are recycling bins related to solid waste management in the campus area. On a weekly basis, the metropolitan municipality collects these wastes from the recycling unit and takes them to the recycling center.

Waste Water Management: There is no wastewater management system on campus.

Clean Air Management: There is no air management system in the campus area.

Use of Local Plant Material: All plants used in the campus area are local species. These plants do not have any adaptation problems. It has air quality enhancing effects.

Open and Green Space Designs (Recreational Areas): There are open and green areas suitable for active and passive recreation that can be used for multiple purposes (large grass areas, sports fields, lecture halls, sitting areas) in the campus area.

On-Campus Circulation: There are designated roads for pedestrian and vehicle traffic and sufficient parking capacity in the campus area. In order to ensure rainwater permeability in floor coverings, different floor coverings and drainage grooves and drainage grills have been used on pedestrian paths (lock paving stone covering) and vehicle roads (asphalt covering). Continuity has been ensured in pedestrian circulation and disabled access solutions are available.

Use of Plant Materials: In the campus area, Pinus sp., Cedrus sp., Picea sp. species were used in accordance with the steppe climate conditions of the region. In the immediate surroundings of the building, Prunus ceracifera, Tilia tomentosa, Aesculus hippocastanum, Platanus orientalis, Platanus occidentalis Acer negundo, Fraxinus excelsior, Betula alba, Picea pungens, Cupressus arizonica, Thuja orientalis, Thuja occidentalis, Euonymous japonica aurea, Rosa sp. species were used.

Conservation of urban ecosystem and wildlife: Since there is no dense construction near the campus area today, natural fauna relatively continues to exist. Shelters are provided for dogs and cats, and their feeding is managed.

Table 2 shows the ecological landscape planning parameters developed within the scope of this study and the SWOT analysis conducted for the NNYU campus area. According to this analysis, opportunities, threats, strengths and weaknesses were identified for the campus.

Table 2. SWOT Analysis of Ecological Landscape Planning Parameters

Natural Parameters	Opportunity/Threat		Strengths/Weaknesses	
Topography	X		X	
Geology		X		X
Climate		X		X
Vegetation		X		X
Infrastructure Parameters				
Location	X		X	
Transportation		X		X
Energy		X		X
Use of Local Building Materials	X		X	
Environmental Management Parameters				
Solid Waste Management		X		X
Wastewater Management		X		X
Clean Air Management		X		X
Use of local plant material	X		X	
Design Parameters				
Open and Green Space Designs (Recreational Areas)	X		X	
On-Campus Circulation	X		X	
Use of Plant Materials	X		X	
Urban ecosystem and wildlife conservation	X		X	

5. Conclusion and Suggestions

As a result of the area analysis and evaluations, it has been determined that the NNYU campus area has the qualities to meet the sustainable and ecological campus criteria in terms of area size, natural parameters, infrastructure parameters, environmental management parameters and design parameters. However, it was determined that some new strategies should be developed in infrastructure and environmental management issues. Factors that pose obstacles to ecological and sustainable campus landscaping arise from the fact that some basic planning and design decisions have not been taken on an ecological basis since the establishment of the campus. Since the campus area management has not been carried out with holistic planning and design decisions, the current ecosystem has been damaged to a certain extent. However, these are not irreversible damages today. It is possible to implement infrastructure and environmental management practices in the campus area in accordance with ecological and sustainable design and planning principles.

The social facilities required for users in the campus area are insufficient. In order for the campus area to be more functional in terms of social / cultural opportunities, facilities that provide opportunities within the scope of ecologically sustainable principles should be developed. While developing these opportunities, practitioners and users' awareness and participation in sustainability and ecology issues should be increased.

The campus area is an area where relatively planned natural parameters such as topography and vegetation, whose main circulation, building areas and reserve areas were determined when it was first established, are used effectively. However, it has been determined that ecological planning and sustainability are lacking in terms of infrastructure and environmental management components, and artistic objects that increase visual quality are also lacking.

As a result, the campus area has significant potential in terms of ecological landscape planning and design principles. The concept of landscape planning and design is an important tool to turn this potential into opportunity.

Acknowledgements and Information Note

The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

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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Development of a Spatial Plant Information System for the Seyitler Campus of Artvin Çoruh University

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1. Introduction

University campuses can be viewed as urban green spaces that benefit various user groups, such as faculty, staff, students, and local residents. These spaces often provide a bundle of ecosystem services that support urban life and green infrastructures (Sarı & Karaşah, 2020).

One of the distinctive features of university campuses, compared to natural green spaces, is their relatively more homogeneous environmental setting regarding landforms, biophysical structure, and species diversity. This feature offers numerous research opportunities to scientists, including ease of access to the land under investigation, rapid and safe field data collection, and the creation of more reliable datasets (Vatandaşlar et al. 2023). Thus, fundamental information on landscape elements can be obtained through traditional ground-based inventory or remote sensing-backed assessment of plants and wildlife species. In addition, the sustainability of green infrastructures necessitates accurate and up-to-date data related to the presence (or absence) of non-native, invasive species and medicinal plants, among others, through well-established monitoring protocols (Sarı & Karaşah, 2020). In this context, developing comprehensive and spatially explicit plant databases may support university administrators and resource planners in their decision making regarding the sustainable management of these critical spaces.

Founded in 2007, Artvin Coruh University (ACU) has potential for a case study as it is located in one of the most biodiverse provinces in Turkey and has a main campus that is in its early developmental stage. So far, dozens of plant species have been used for landscape design as well as to familiarize college students with essential plant material during field courses taught by faculty from the Landscape Architecture and Forest Engineering Departments. However, there is no written or digital documentation regarding the number and names of species, the positions of individuals, plant photos, and essential botanical traits of the plants on the campus. Therefore, developing a Spatial Plant Information System (SPIS) and its dissemination on the web would be beneficial for students, researchers, and locals to access scientific information at no cost other than their time.

The aim of this work is (i) to develop a Spatial Plant Information System (SPIS) for the Seyitler Campus of ACU, and (ii) to make its geodatabase open to the public through a web interface free of charge. The geodatabase not only involves species name and plant photos but also provides information on structural (diameter, height, etc.) and spatial (location on the map) elements for all woody species on the campus. Additionally, this will be the first time a centimeter-level, wall-to-wall orthophoto map of the campus will be created using an Unmanned Aerial Vehicle (UAV). Thus, it is expected that the campus's green structure will be inventoried in this way, which may result in an increase in people's attention to green spaces.

2. Material and Method

2.1. Study area

The Seyitler Campus of ACU is the case study area focused on in this work. Located in Artvin Province in the Eastern Black Sea region (Fig. 1), Seyitler is one of the five campuses of the university. It is 9 km from downtown Artvin and has an altitude of around 580 m above sea level. The Seyitler Campus covers an area of approximately 15 hectares and consists of around 500 individuals from 40 plant families. While some of the individuals were already in the area before the campus was established, most have been planted since 2007. To date, broadleaved species dominate the campus area, and they generally appear to be healthy.

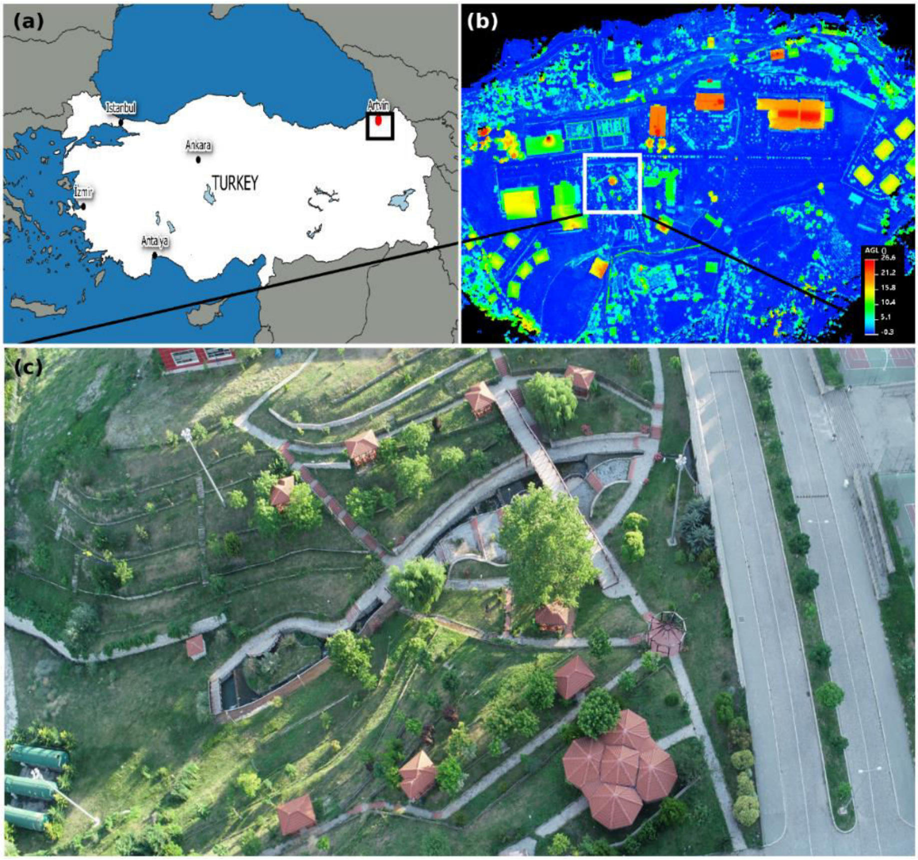

Figure 1. The location of Artvin Province (a), the digital elevation model of the Seyitler Campus created based on UAV data (b), and the aerial photograph of the campus acquired through UAV mapping (c)

2.2. Methods

2.2.1. Field Measurements and Observations

We first measured diameter at breast height (DBH) of all trees on the campus with a DBH larger than 3 cm using a caliper with millimeter precision. Then, the total height of these trees was measured using a digital hypsometer with centimeter (cm) precision. Concurrently, species names were identified, although some ornamental species were unidentifiable by field personnel. In such cases, we referred to previous work conducted on the campus (i.e., Sarı and Karaşah, 2020). All measurements and data were recorded onto inventory sheets according to OGM (2017) and Laar and Akça (2007).

In addition to the common procedures detailed in these sources, we collected coordinates of all individuals on the ground using the Global Positioning Satellite System (GNSS) connected to Continuously Operating Reference Stations (CORS). Although Yıldırım et al. (2011) stated that tree positions could be measured with an accuracy of a few centimeters using this approach, that was not always the case for us, likely due to tree canopy and neighboring stems. Therefore, we had to collect coordinates of some large trees from openings that were as close to the tree stem as possible.

2.2.2. Unmanned Aerial Vehicle (UAV) Flight Planning and Mapping

We used a UAV to map the study area and its surrounding. The platform used was a DJI Phantom 4 with a real-time kinematic (RTK) instrument onboard. Before the flight, several parameters were set on the remote controller, including flight altitude (two flights at 50 and 100 m), overlap ratios (70%), and the average ground sampling interval (between 1.5 and 2 cm depending on the altitude).

The raw data were processed using Agisoft software to produce (i) a three-dimensional point cloud, (ii) a digital elevation model, and (iii) an orthomosaic map of the study area. The point-cloud data were produced by matching the aerial photographs with each other based on the same spots found in neighboring photograph sets. The processed data were then analyzed using the following libraries in R: lidR (Roussel et al., 2020), TreeLS (de Conto, 2020), raster (Hijmans and Etten, 2012), and rGDAL (Bivand et al., 2023). In this way, we were able to classify the data into meaningful objects, such as trees, ground, and buildings.

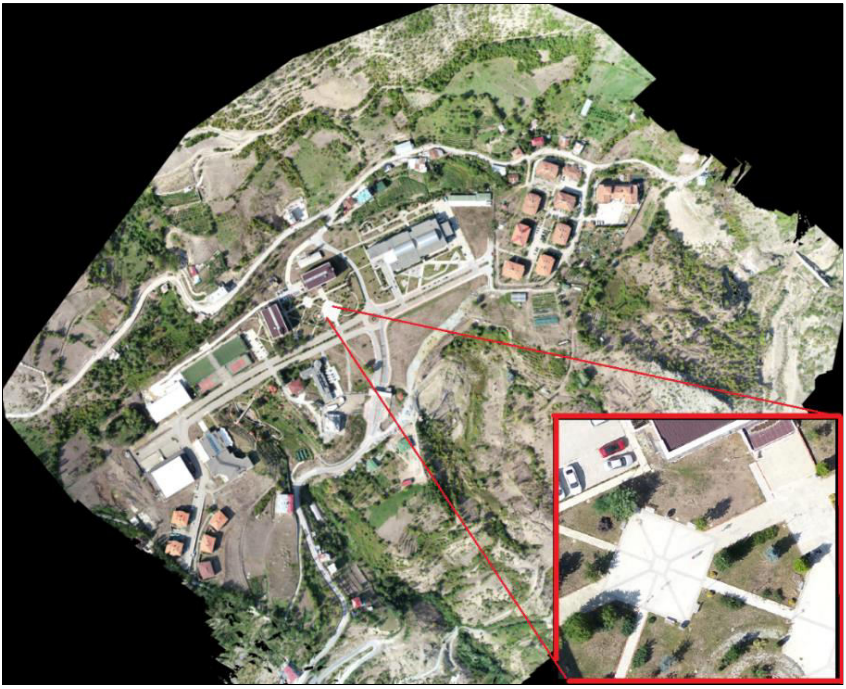

Figure 2. Orthophoto mosaic of Seyitler Campus and its surrounding.

2.2.3. Geodatabase Development

All data obtained from field measurements and UAV flights were imported into ArcGIS 10.2 to develop a spatially explicit database. The GIS layer containing tree and shrub positions had a "point" data type, while the layer containing crown area had a "polygon" type. We did not measure crown sizes on the ground; instead, they were obtained from UAV-based maps. Specifically, we delineated each tree's crown on screen at a 1/3,000 scale and then used the *Calculate* function of ArcGIS to determine the area coverage of individual crowns in square meters (m^2). Finally, a new field was created in the attribute table, and the area information was transferred here along with other attributes such as DBH, height, and species name (both common and Latin names). Thus, the development of SPIS was completed for the ACU Seyitler Campus.

2.2.4. Development of Web Interface

Unless presented through the worldwide web, the SPIS cannot be made available to all users. To this end, we used the Leaflet library as the foundation for the system. Leaflet is a popular open-source JavaScript-based library for creating user-friendly interactive maps. Leaflet includes the mapping features that most developers need and was designed with computing performance and everyday usability in mind. It can run efficiently on both desktop and mobile platforms and can be enhanced with several plugins. In addition to the Leaflet library, we utilized HTML, CSS, and JavaScript. Thus, users will be able to access attribute features along with graphic data on the web interface.

3. Findings and Discussion

3.1. Floristic Characteristics of Plants

A total of 138 woody taxa were identified on the Seyitler Campus, belonging to 43 families (Table 1). The total number of individuals was 511, excluding shrubs and vines. Of the identified taxa, 74 were deciduous (53.6%) and 63 (45.7%) were evergreen. There was also one semi-evergreen individual, which is evergreen in a temperate climate but deciduous in a more rigorous climate. Of the 138 taxa, 103 were Angiosperm (seeds are enclosed within fruits, usually broadleaved), while the rest were Gymnosperm (naked-seeded, usually conifers). The most prevalent taxon on the campus was *Aesculus hippocastanum* L., followed by *Cupressus macrocarpa* Hartw. "Goldcrest". The scientific names of other taxa dominating the campus can be found in Table 2.

The inventory results show that the Seyitler Campus of ACU hosts both a diverse and significant number of woody plants. Nevertheless, other university campuses in Turkey also exhibit rich species diversity. Güler (2019) performed a comprehensive plant inventory on 31 campuses across Turkey and found that the average species richness was 328. While we have identified 43 families in our study area, this number would be much higher if we included herbaceous species such as annual and perennial plants, succulents, and so on. Sarı and Karaşah (2020) state that the landscaping history of the Seyitler Campus does not date back very far and argue that the floristic richness on the campus will enhance over time.

Table 1. Inventory of woody plants identified in the Seyitler Campus

Scientific name of family	# of genera	# of taxa	# of individuals
Altingiaceae	1	1	1
Anacardiaceae	2	3	4
Apocynaceae	1	1	1
Aquifoliaceae	1	1	2
Araliaceae	1	1	1
Asparagaceae	1	2	2
Asteraceae	1	1	1
Berberidaceae	2	3	4
Betulaceae	2	3	12
Bignoniaceae	2	2	14
Buxaceae	1	1	1
Cannabaceae	1	1	1
Caprifoliaceae	2	3	3
Celastraceae	1	1	1
Cornaceae	1	1	1
Cupressaceae	8	19	81
Ebenaceae	1	1	1
Elaeagnaceae	1	1	1
Ericaceae	1	1	1
Fabaceae	4	4	4
Fagaceae	2	3	7
Ginkgoaceae	1	2	3
Hypericaceae	1	1	1
Juglandaceae	1	1	11
Lauraceae	1	1	1
Leguminosae	3	3	14
Lythraceae	1	1	1
Magnoliaceae	2	2	8
Malvaceae	1	2	30
Moraceae	1	2	4
Oleaceae	4	10	29
Onagraceae	1	1	1
Paulowniaceae	1	1	1
Pinaceae	4	14	41
Pittosporaceae	1	2	2
Platanaceae	1	1	1
Rosaceae	10	16	57
Salicaceae	2	5	13
Sapindaceae	3	13	142
Taxaceae	1	1	1
Ulmaceae	1	1	1
Viburnaceae	1	3	4
Vitaceae	1	1	1
TOTAL	**80**	**138**	**511**

Table 2. The most abundant (# >10) taxa on the Seyitler Campus

Scientific name of taxa	# of individuals
Aesculus hippocastanum L.	67
Cupressus macrocarpa Hartw. "Goldcrest"	29
Tilia tomentosa Moench	29
Malus floribunda Siebold ex Van Houtte	24
Acer platanoides L. "Globosum"	20
Cupressus arizonica Greene	18
Prunus cerasifera Ehrh. "Atropurpurea"	17
Acer cappadocicum Gled. "Aurea"	16
Catalpa bignonioides Walter "Nana"	13
Acer platanoides L. "Crimson King"	12
Acer platanoides L. "Crimson King"	11
Juglans regia L.	10
Betula pendula Roth	10

3.2. Structural Attributes of Plants

According to the traditional ground measurement method, the average DBH and height of 432 trees on the campus area were 11.2 cm and 5.3 m, respectively (Table 3). The smallest DBH was measured for *A. hippocastanum* as 3.4 cm, while the largest tree in terms of DBH was *Fraxinus angustifolia* at 65.5 cm. An individual of *Cupressus arizonica* was recorded as the shortest tree on campus at 2.2 m. Conversely, *F. angustifolia* was the tallest tree in our dataset, reaching 21.7 m.

To obtain the crown projection area of the trees, we employed two different remote sensing methods: on-screen digitization through an orthophoto map and 3D analysis of point clouds created from individual UAV images. According to the former method, which may be considered more reliable, the average crown area of the 432 trees was calculated as 8.34 m^2. The smallest crown area was measured for an individual *Acer platanoides* "Crimson King" at 0.13 m^2, while another individual of

Populus nigra had the largest crown area of 131.13 m^2. The crown projection area of this largest tree can be seen on the orthophoto map shown in Figure 3.

Table 3. Descriptive statistics for tree attributes by various measurement methods

Tree attribute	Measurement method	#	Min.	Avg.	Max.	S.D.
Tree height (m)	Traditional field measurements	432	2.20	5.27	21.70	3.02
	3D point cloud analysis	360	2.20	5.61	21.87	3.00
	Measuring the length of tree shadow on orthophoto	401	1.80	5.62	25.00	3.55
Crown projection area (m^2)	On-screen digitizing on orthophoto	425	0.13	8.34	131.13	13.06
	3D point cloud analysis	359	0.12	10.97	113.00	13.23
Tree diameter (DBH) (cm)	Traditional field measurements	432	3.40	11.15	65.50	9.79

A relatively low average DBH (approx. 11 cm, n=432) indicates that campus trees are mostly immature and in their pole developmental stage. This can be attributed to the age of the university, founded in 2007, and the limited history (about 15 years) of plantation practices on the campus. Although some mature trees exist on the campus (with DBH > 50 cm), they are few and can be considered as ‘legacy trees’ that existed in the area before campus development. Based on personal communications with elderly residents in the study area, it is known that some of these legacy trees were planted by local residents, while others naturally regenerated during previous land use activities and grew over time.

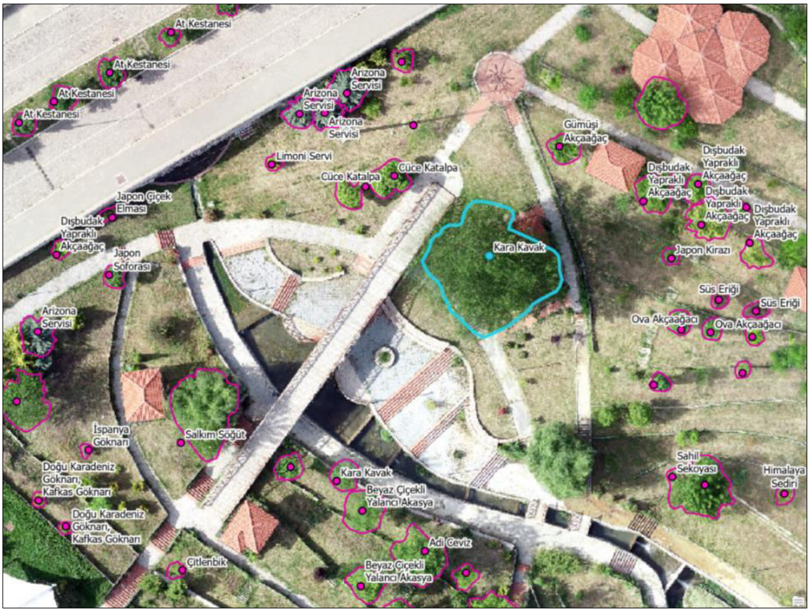

Figure 3. On-screen digitization method based on the orthophoto map of the Seyitler Campus. Tree positions (red dots), crown projection areas (red boundaries), and name tags (local species names in Turkish) are displayed on the GIS database. The turquoise-colored boundary highlights the crown of the largest tree, *Populus nigra*.

3.3. Relationships between Structural Attributes Estimated by Remote Sensing Methods

We observed several statistical relationships between tree attributes traditionally measured on the ground and those estimated using various remote sensing methods. As expected, the strongest correlation was found between tree heights measured on the ground and those estimated based on UAV-derived point clouds ($r = 0.97$; $p < 0.01$). Conversely, the weakest correlation was observed between crown areas digitized on the orthophoto map and those estimated from UAV-derived point clouds ($r = 0.82$; $p < 0.01$). Pearson's correlation coefficients for all tree attributes by the methodology used are summarized in Table 4.

Table 4. Correlative relationships between trees' structural attributes traditionally measured on the ground and estimated by remote sensing

	A	B	C	D	E	F
A	1.00	0.97	0.96	0.83	0.84	0.91
B	0.97	1.00	0.94	0.82	0.84	0.88
C	0.96	0.94	1.00	0.83	0.84	0.91
D	0.83	0.82	0.83	1.00	0.92	0.86
E	0.84	0.84	0.84	0.92	1.00	0.82
F	0.91	0.88	0.91	0.86	0.82	1.00

A: tree height measured on the ground; B: tree height estimated based on point clouds; C: tree height estimated based on tree shadow on the orthophoto map; D: crown area digitized based on orthophoto map; F: crown area estimated based on point clouds; E: DBH measured on the ground.

Aside from examining the relationships between ground-measured and estimated values for the same tree attribute, we also observed significant correlations among different tree attributes. Among them, the relationship between DBH and tree height is particularly important in forest biometry. This relationship allows for the estimation of tree DBHs based on height values retrieved from UAV data, facilitating faster and more efficient campus tree inventory efforts compared to traditional methods, which are often challenging. In the present study, Pearson's correlation coefficient for the DBH and height relationship was approximately 0.90 ($p < 0.01$), indicating that DBH can be reliably modeled using tree heights with an R^2 value of about 0.80. Such levels of accuracy are generally considered acceptable in operational forestry (Vatandaşlar et al., 2023).

3.4. Geodatabase Development and Web Interface

One of the objectives of this project was to make the SPIS publicly accessible on the internet, allowing interested individuals to freely explore the attributes of plants on the Seyitler Campus. To achieve this, all graphical and attribute data related to individual plants were compiled into a GIS database and presented through a web interface using the Leaflet library. General and close-up views from various sections of the Seyitler Campus are shown in Figures 4 and 5.

Currently, users can access the SPIS via the web interface (Fig. 4) to explore the inventoried plants on the campus. Depending on the selected layer, they can locate and identify trees, view high-resolution photographs from different angles, learn about structural attributes and health status, and become acquainted with botanical characteristics (Fig. 5). Due to unavailability of an appropriate server, the SPIS is not accessible on the internet at this time. However, interested parties can request access to the web interface file from the corresponding author.

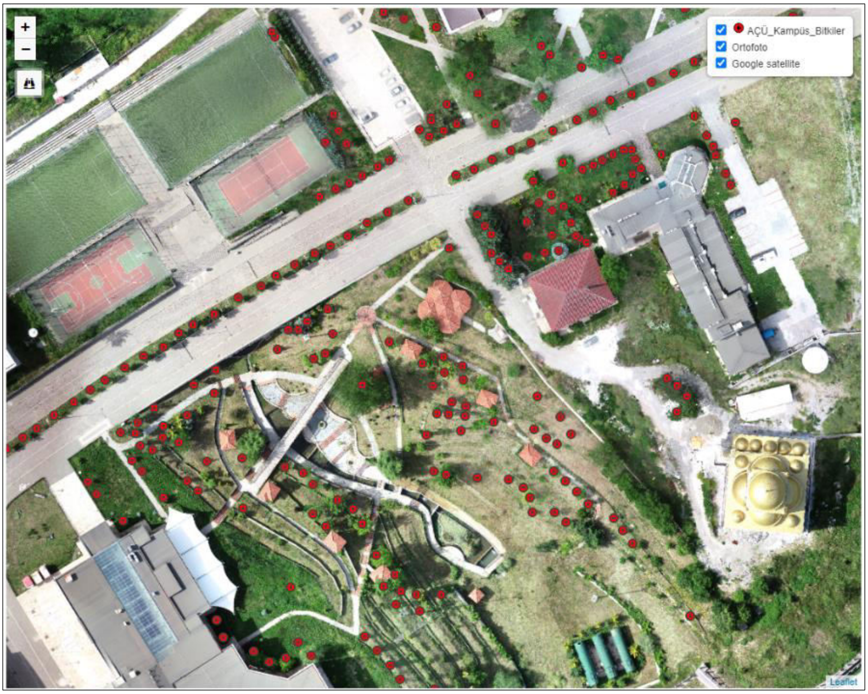

Figure 4. Overview of graphical data on the web interface showcasing the SPIS for a portion of the Seyitler Campus.

Figure 5. Close-up view and attribute data for an individual of *Picea pungens* "Glauca" located in the Seyitler Campus, ACU, as displayed in the SPIS web interface.

4. Conclusion and Suggestions

With 138 woody taxa, and 511 individuals (excluding shrubs and vines), the Seyitler Campus at Artvin Coruh University contributes significantly to Artvin's floristic richness and provides essential ecosystem services for faculty, staff, students, and the local community. Despite its relatively recent establishment in 2007, the campus is expected to continue enhancing its biodiversity and ecological contributions through natural succession and ongoing landscaping activities, such as plantation, restoration, and maintenance. The present study underscores the efficacy of digital technologies and remote sensing methods, including UAV mapping, point cloud analysis, and geodatabase management systems, as promising tools for land measurement and plant inventories. It also confirms minimal disparities between traditional ground measurements and remote sensing-backed estimations regarding the structural attributes of campus trees. Based on the study's findings and assessments, the following recommendations are proposed for researchers focusing on the development of spatial plant information systems (SPIS):

Ensure reliable hosting and server: Prioritize securing a reliable hosting and server infrastructure to ensure seamless access for interested parties to the SPIS.

Consider web interface challenges: Acknowledge that very-high-resolution (centimeter-level) orthophoto maps may pose challenges when presented on a web interface.

Regular data updates: Given the natural succession and changes in vegetation and landscape elements over time, update inventory data underlying the SPIS regularly (e.g., at 5-year intervals).

Expand SPIS functionality: Continuously improve and expand the SPIS by incorporating additional GIS layers, such as roads and buildings, to enhance its utility.

Develop allometric models: Explore the development of individual tree-level allometric models based on the inventory data collected for the SPIS.

Consider contextual limitations: Recognize that while effective for campus environments, the maps, statistical relationships, and geodatabase developed in this project may not directly translate to more complex forest ecosystem settings.

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Author Contribution and Conflict of Interest Declaration

C.V.: Land measurements, GIS database development, on-screen digitization, writing the original draft, and revising the chapter.

D.S.: Identification of plant species, taking plant photographs, data entry regarding plants' botanical traits, writing the original draft, and revising the chapter.

M.Z.: Determining tree positions, UAV flight, UAV data processing, creation of orthophoto mosaic, writing the original draft.

B.K.: Identification of plant species, taking plant photographs, data entry regarding plants' botanical traits.

E.S.: Creation of the Spatial Plant Information System and the development of the web interface, writing the original draft.

There is no known conflict of interest.

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Addressing Sustainable Campus Approach in a Planning Studio: Dokuz Eylül University, Tınaztepe Campus

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1. Introduction

In today's world, development-based common policies and strategies increasingly emphasize the protection and sustainability of environmental resources and values. The concept of “sustainability,” defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987), has become a focal point in addressing urban developments that pose significant risks to environmental resources. This concept has gained prominence as a key element in efforts to transform cities—historically marked by increasingly unhealthy developments since the Industrial Revolution—into more livable places. Consequently, urbanization is being reevaluated in terms of ensuring economic well-being, justice, resource protection and development, and the creation of management mechanisms that promote broad participation and cooperation.

However, the concept of sustainable development is also a problematic concept with the need-based content (Conca & Geoffrey, 2004). The difficulty of responding to the expectation of sustaining economic development without creating irreparable negative changes in the stock of natural resources brings the concept to a critical point (Aruoba, 1997; Allen & You, 2002). In addition, the city itself includes a process that is formed by defragmentation and depletion of natural resources, in other words, by consuming resources. Therefore, to be able to talk about a sustainable development in the urban area, it should not be ignored that the city, which has consumption in its structure, should be limited in certain aspects via spatial arrangement tools such as urban planning. This situation also raises questions about what the limits of spatial intervention will be in urban planning studies.

The spatial context of sustainable urbanization has profoundly impacted on the development of the planning discipline. This has led to the emergence of a shared concept known as “Sustainable Urban Planning,” which plays a crucial role in decision-making processes related to urban land use changes and development. This ecological approach, which emphasizes social benefits and prioritizes cooperation, focuses on the protection of resources and values (Geenhuisan & Nijkamp, 1994; Diepen & Voogd, 2001; Allen & You, 2002; Keleş, 2002). It has guided various studies across different scopes and scales of spatial design, while also raising new questions in urban planning education regarding spatial intervention methods. It is known that there are implementation problems regarding sustainable urbanization, and it is suggested that these problems can be solved by increasing the sustainability knowledge of the students in the education of urban planning discipline (Franz, 1998; Cotgrave and Alkhaddar, 2006; Cubukcu & Eksioglu, 2009). In this context, the authors claim that the courses given in the curriculum of planning schools will expected to increase the knowledge on sustainability, create awareness and provide the ability to reflect it on urban plans.

This study arises from an inquiry into developing students' awareness and knowledge of sustainable spatial planning within urban planning education. Specifically, it assesses students' perceptions of sustainability within the studio framework titled "Sustainable Campus" and evaluates the thematic and conceptual approaches they have applied in project studies throughout the semester. These projects, which have addressed environmental, social, and economic sustainability goals, are divided into various subsections. The study examines the highlighted elements from the projects of nine working groups, by analyzing their spatial solutions and suggestions in relation to their university campus. It also discusses these findings in the context of the broader applications of sustainability in urban planning and, more specifically, in campus design.

2. Sustainable Urbanization Concept in Campus Design

Sustainable urbanization has emerged on the need to balance environmental protection with human development efforts (Tibaijuka, 2008). As Taylor (2003) highlights, ensuring sustainability in human development is not only crucial but also urgent, potentially becoming "a matter of life and death" for individuals and humanity. This understanding forms the bedrock for achieving success in sustainable urban development. According to Bagheri & Hjorth (2007), sustainability represents an ideal in developmental efforts—a dynamic and evolving target that changes as our understanding of socio-environmental systems deepens. This evolving concept reflects the complexity of integrating environmental stewardship with human progress.

One of the objectives of urban sustainable development is to minimize the city's consumption of natural resources and waste production while enhancing its livability and to ensure that urban environments operate within the capacities of local, regional, and global ecosystems (Newman, 1999). Moreover, the concept encompasses the enhancement of environmental, social, and cultural amenities within the city (Kenworthy, 2006). Sustainable urbanization has been defined to focus on three pillars: economy, environment, and society (Allen & You, 2002). By focusing on these aspects, sustainable urban development seeks to create cities that not only thrive in harmony with their surroundings but also contribute positively to the well-being of their inhabitants.

In the discussions on the policy and theoretical approaches, it's stated that urban development should be sustainable. However, there are difficulties in reflecting these policies and approaches on urban plans while creating a sustainable city (Berke & Conroy, 1998, 2000; Cubukcu & Eksioglu, 2009). The studies also state that the first steps can be taken to overcome implementation problems by increasing students' knowledge about sustainability in the education of spatial organization disciplines (Malbert, 1998; Salama, 2002; Cubukcu & Eksioglu, 2009). This study aims to contribute to the examination of the practical implementation of sustainability principles in spatial design, with a particular focus on university campuses. In other words, this study conveys an implementation experience through a "sustainable campus" approach.

A sustainable campus is expected to demonstrate environmental responsibility by emphasizing reduced consumption, renewable energy, recycling practices, sustainable architecture, green infrastructure, and open green spaces (Machado & Davim, 2023). Previous research forms an analogy with 'small cities' and university campuses due to their expansive campuses, large populations, and diverse array of activities and address their sustainability strategies as encompassing environmental management, social responsibility and participation, and the integration of sustainability into research and education (Alshuwaikhat & Abubakar, 2008; Machado & Davim, 2023). Sun et al. (2024) argue that the spatial scale and organization, accessibility, and diversity of campus environments significantly influence user perception and behavior. Cubukcu and Isıtan (2011) indicate that students who perceive their campus environments more positively tend to spend more time on campus. To spend more time on campus, research suggested that the open spaces of campuses should be designed for socialization as well as suitable for learning and teaching activities (Salama, 2008; Tourinho, Barbosa, Göçer & Alberto, 2021; Yaylali-Yildiz, Czerkauer-Yamu & Cil, 2014). Recreational spaces and gardens on campuses are also expected to make same contributions (Uzun, 2022; Baur, 2022). All these campus settings are shown to provide opportunities for relaxation, exercise, and socialization (Uzun, 2022; Baur, 2022), which also create opportunities for sustainability.

Various methods and tools are available for evaluating campus sustainability. A recent review focusing on these assessment tools highlighted that campus sustainability research encompasses multiple dimensions, with the most prominent being environmental, educational, governance, and research (Dawodu, Dai, Zou, Zhou, Oladejo & Osebor, 2022). Another study, which developed a campus sustainability evaluation system, proposed categories including organization and management, energy and resource conservation, environmental friendliness, campus culture, and social outreach (Shuqin, Minyan, Hongwei, Xiaoyu & Jian, 2019). However, not all studies adopt this holistic approach. A research on campus planning has organized the literature into three geographic scales: the campus itself, the campus-community interface, and the larger campus district (Dalton, Hajrasouliha & Riggs, 2018). Their recommendations for university planners include prioritizing site design that enhances student learning and promotes environmental sustainability, while also emphasizing the importance of community interface planning to foster economic growth and minimize environmental impacts (Dalton et al., 2018). This research that is the subject of this book chapter similarly concentrates on the spatial design of campuses and related sustainability issues. The subsequent section describes the sustainable campus criteria that have been sought and evaluated on the Tınaztepe Campus plan, which is taken as the study area by the urban planning students.

3. Material and Method

3.1. Purpose and Structure of the Student Project

The student project titled “Sustainable Campus Design” has been conducted in the "Space and Design" course, spans a project process of 12 hours a week, 14 weeks in total, in the second semester of City and Regional Planning education. The main goal of the course is enabling students to apply the skills that they have gained in the “Basic Design” course that held in the first semester with urban space. The student project, which is carried out in a different urban setting every year, has been conducted for Dokuz Eylül University Tınaztepe Campus (Buca / İzmir) in the 2023-2024 Spring Semester. The Faculty of Architecture building where the course is conducted is also located in this campus.

Tınaztepe Campus (Figure 1) is in Buca district of Izmir province and has a structure that accommodates a total of 16 faculties, institutions and vocational schools which is the largest among other campus areas of Dokuz Eylül University (Green Campus DEÜ, 2024). In the campus area, which has an area of approximately 4.5 million square meters (Green Campus DEÜ, 2024), there are more than 15 educational buildings, a central library, central cafeteria, indoor and outdoor sports areas, technical workshops, a mosque, and an activity center which contains socialization areas such as cinema and cafes. According to 2022 data, approximately 32,353 students are studying on the campus.

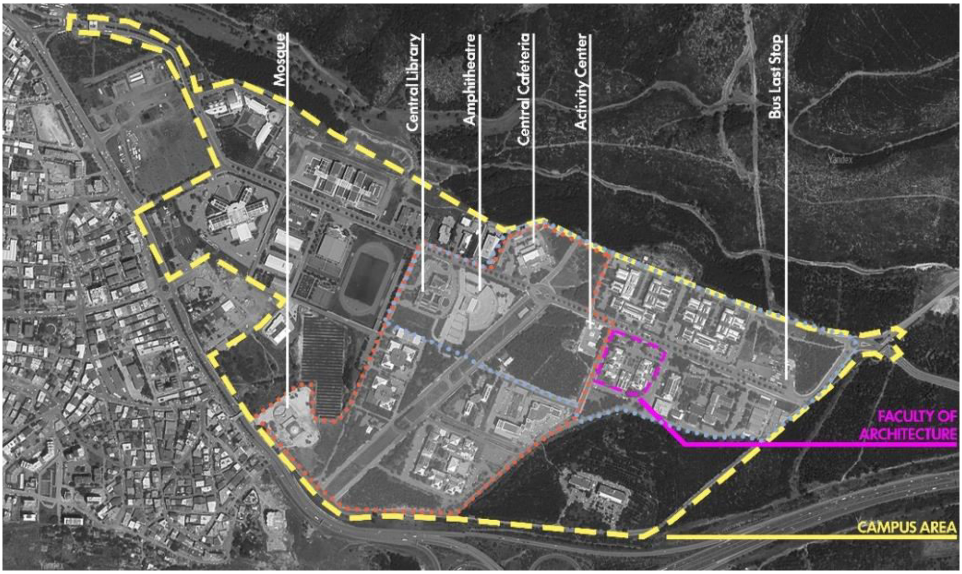

Figure 1. Tınaztepe Campus Area and Project Boundary (Design area is lightened, unmarked structures within this area are educational buildings)

Some sustainability projects have been managed and gathered under the title of "DEÜ Tınaztepe Campus Reduces its Ecological Footprint" as of 2023. In campus area partially projects such as "zero waste campus" and "energy efficient campus" are carried out in the field of engineering. There is a project still ongoing that carried out jointly by the Department of Construction Engineering and the Department of City and Regional Planning for the preparation of the Pedestrian Oriented Campus Transportation Master Plan. In addition, for an energy efficient and competent campus, solar energy panels have been placed in many areas. In addition, engineering sciences are trying to establish water purification units. Although the projects have been partially implemented, there are no completed projects throughout the campus.

Tınaztepe Campus has been expanding for more than 30 years and has become the main campus with the construction of different faculty buildings. The campus area was a forest before the university was settled. This area, allocated from the Ministry of Forestry, had many natural features, but a part of the forest area was destroyed due to the location of university buildings in the area. Additionally, the campus is located on a highly sloping area. The eclectic construction of the transportation system over the years has led to the emergence of vehicle and pedestrian roads that are incompatible with the slope, thus causing an increase in the use of motor vehicles. Further, the campus is located on the periphery of Buca urban area. With the expansion of Buca settlement and the increase in transportation opportunities to the campus, its relationship with the city has strengthened. While the two entrances located in the western part of the campus allow public transportation and pedestrian transportation, the eastern entrance of the campus is provided with a highway connection.

Located in such a natural environment, there are some problems in the campus life of university students and employees. The main reason for this is the limited interaction of the buildings and open spaces within the campus with natural qualities. In the campus, which is built on a very sloping area, pedestrian access is very limited and there are many inadequacies in terms of pedestrian opportunities. In conclusion, it can be claimed that the quality of socialization areas and a sensitive approach on natural qualities are inadequately handled in the campus.

The main goal of the project is to address certain thematic design strategies for the design related issues that has been set forth previously to create a sustainable campus settlement and life at Tınaztepe Campus. It was chosen because the students received education and had the chance to experience and observe all the problems and potentials. A three-stage process has been carried out for this purpose: (1) Defining a Thematic Approach, (2) Analysis and Synthesis, and (3) Settlement Plan at Different Scales.

Defining a Thematic Approach: The first stage of the project, which aims to propose spatial arrangements for a sustainable campus, is to review the literature on university campuses and sustainability, and to find a theme that will emerge about sustainable campus. As a result of this study conducted with large student groups, 9 different thematic approaches have been defined: (1) Social Campus, (2) Self-Sufficient Campus, (3) Green Campus, (4) Accessible Campus, (5) Smart Campus, (6) Campus for All, (7) Holistic Campus, (8) City-Interacted Campus, and (9) Walkable Campus.

Analysis and Synthesis: At this stage, students have been asked to carry out some analysis and synthesis in the context of their thematic approaches. Analyzes have been accomplished in two main groups. The first group includes perceptual analyses, and the second group includes thematic analyses. In perceptual analyses, it has been expected to create a cognitive map of the campus. Thematic analyses, on the other hand, include nine different themes (decided by criticizing them from the students' point of view), and the problems and potentials that arise in this context. At the end of this stage, students have been expected to carry out a synthesis map to create a main framework that would lead to design strategies, considering their thematic approaches.

Settlement Plans at Various Scales: In the study, thematic approaches and analyzes have been generated for the entire campus. However, the designs that produced and detailed at different scales have been executed for the strategic regions determined in the reviews which is addressed in Figure 1. In all layout plans, students have been expected to transform the policies and decisions of the thematic campus approaches into spatial strategies, in other words, to transfer strategic conceptual decisions into spatial design implementations. This entire process has been proceeded and fulfilled over 14 weeks, with project critiques (Figure 2).

Figure 2. Project Reviews

3.2. Preparation of the Data Set Derived from Student Projects

In this study, a method based on content analysis has been conducted to reveal students' awareness of sustainability by making an evaluation of the thematic approaches (discourse) and design productions (action) of the student projects mentioned in the previous section. Table 1 shows the content analyses summary on thematic approaches and the spatial actions. Further, determining the scope that the projects can offer, this table also provides with a brief assessment of the sustainability principles for the Tınaztepe Campus. Thus, this table provided a basis for evaluating the limitations and opportunities of each theme group to realize the main and subheadings of sustainability.

As in Table 1, the aims in the projects of the theme groups can be grouped under 16 different headings. The spatial design tools vary depending on their content and show a different distribution in number. It is observed that a variety of tools are suggested for the aims of "*increasing social interaction*" and "*qualitative and quantitative increase of existing green areas and sports facilities*" in the projects. It is noteworthy that the number of tools for the aims of "*increasing housing opportunities*" and "*increasing public transportation opportunities*" are limited alternatives.

In the relevant literature, it is stated that sustainability should be achieved under three main headings: (1) social, (2) environmental, and (3) economic. In this context, social sustainability contains *urban justice, equality of opportunities, social rights, accessibility of educational health and cultural facilities, comfort / safety, and peace environment*. Environmental sustainability comprises *reducing the pollution, adaptive* *to the climate changes, proper usage of resources, biodiversity, energy efficiency and recycling*. On the other hand, *economic development, equality in sectoral distribution, waste management and disposing, and sustainable energy resources* are the subheadings of economic sustainability. As can be seen, some of the subheadings of the three main sustainability areas described in the literature include policy and theoretical approaches, while others can guide spatial practices.

Table 1. Aims and spatial design tools derived from student projects

Code	Aims	Spatial Design Tools for the Aims
01	**Increasing Socialization/Commerce Areas**	**1a.** Commercial area/market **1b.** Cafe/ Buffet **1c.** Restaurant
02	**Increasing Accommodation Opportunities**	**2a.** Dormitory Building
03	**Strengthening Pedestrian Access and Safety**	**3a.** Shade on Pedestrian Paths **3b.** Regulation of width and height of roads and pavements **3c.** Traffic Lights **3d.** Information Boards
04	**Strengthening Vehicle Access and Safety**	**4a.** Regulation of width and height of roads and pavements **4b.** Traffic Lights **4c.** Parking areas for different vehicles (Cars, motorcycles, bicycles)
05	**Increasing Public Transportation Opportunities**	**5a.** Use of electric vehicles in public transport / Electric charging stations **5b**. New modes of public transport
06	**Increasing Bicycle Access**	**6a.** Bike path **6b.** Electric Bike Charging Station
07	**Regulations for Barrier-Free Access**	**7a.** Regulation of width and height of roads and pavements **7b.** Traffic Lights
08	**Increasing Social and Economic Opportunities**	**8a.** Campus Garden **8b.** Sports Facilities
09	**Increasing Social Interaction**	**9a.** New Seating Areas / Arrangement of Existing **9b.** Open / Closed Area Workshop **9c.** Open-Air Cinema **9d.** Amphitheatre **9e.** Sports Facilities **9f.** Booths **9g.** Space Theme Park and Observatory **9h.** Study Halls / Rooms **9i.** Open / Closed Area Library and Reading Area **9j.** Open / Closed Area Exhibition Area **9k.** AI and robotics workshops **9l.** Digital Exhibition Hall
10	**Increasing Access to Social Interaction Areas**	**10a.** Shaded Areas **10b.** New Pedestrian Paths **10c.** New Vehicle Roads
11	**Development of Buildings Regards on Ecological Sustainability**	**11a.** Solar Panels / Solar Panel Shades **11b.** Green Roofs
12	**Increasing Access to Commercial Areas**	**12a.** New Pedestrian Paths **12b.** New Vehicle Roads
13	**Qualitative and Quantitative Increase of Green Areas and Sports Facilities**	**13a.** New Green Areas **13b.** Artificial Pond **13c.** Playground **13d.** Landscape terrace **13e.** E-Sports Hall
14	**Developing the Landscape Regards on Climate Change**	**14a.** Rain Gardens **14b.** Planting Native Plant Species **14c.** Recycling and Composting Areas
15	**Increasing Resilience in Disaster and Emergency**	**15a.** Emergency Assembly Area **15b.** Intelligent Seating Area / Pergola
16	**Improving Technical Infrastructure**	**16a.** Intelligent lighting and camera system **16b.** Traffic Lights **16c.** Fingerprint and facial recognition systems at building entrances

In this study, it has been determined which of the three main headings and subheadings required for sustainable development correspond to the aims and tools presented in Table 1, and it has been discussed which policies urban planning students could spatialize. In this context, it has been expected that the spatialization and opposite situations of the students would shed light on the reasons for the problems in the implementation of sustainable cities.

4. Findings and Discussion

As reported in the previous section, the student groups that have analyzed the requirements of the sustainable campus determined their thematic approaches in the context of the literature review in the first phase of the project. In this context, 9 thematic approaches have found to guide the designs to be incorporated for the Tınaztepe Campus. Table 1 shows the aims of sustainable campus and design tools in relation to meet these aims. At this stage, a matrix consisting of the thematic approach of 9 different groups and 3 main sustainability headings (and subheadings) has been formed. Table 2 shows how the aims of sustainability headings meet in the relevant sections of the matrix in the context of their themes. It should be noted that some groups have more than one aim and therefore overlap with more than one sustainability heading.

As seen in Table 2, the aims of student groups that guide campus design are mostly related to the headings of “*social sustainability*”. It can be observed that under the heading of Social Sustainability, the aims mostly match the subheadings of “*peace environment*”, “*comfort/safety*”, “*accessibility to educational health and cultural facilities*”.

Another sustainability heading where the thematic approaches of the student groups overlap the most is (as expected) environmental sustainability. Under this topic, it is observed that there are mostly matches in the subheadings of "*adaptive to the climate changes*" and "*energy efficiency*". The title Economic Sustainability has the least number of matching aims. The subtitle most frequently produced for this main title is "*economic development*".

Table 2. Matching Project Aims (Discourses) and Sustainability's Main and Subtitles

Main Titles	Sub Titles	Social Campus	Self Sufficient Campus	Green Campus	Accessible Campus	Smart Campus	Campus for All	Holistic Campus	Campus that interacting with City	Walkable Campus
SOCIAL SUSTAINABILITY	Urban Justice	01 02 12	01 02 12	01 12	01 12	01 12	01 12	01 12	01 12	01 12
	Eqaultiy of Opportunites	03 04	03 04	05 07	04 07	03	03	07	05 07	03 04
	Social Rights	02 09 10	01 02 09	07 09	07 09	07 09	07 09	07 09	07 09	07 09
	Accessibility to Educational Health and Cultural Facilities	01 08 09 13	01 08 09 13	06 08 09 13	01 08 09 13	01 08 09 13	01 08 09 13	01 09 13	15 09 13 13b	01 09 10 13
	Comfort/ Safety	03 04 16	03 04 07 09 15 16	03 04 06 07 09	03 04 07 09	03 04 07 09 15 16	03 04 07	03 04 07 09	03 04 07 09	03 04 07 09 16
	Peace Environment	01 03 04 05 08 09 13	01 03 04 05 08 09 13	03 04 05 06 08 09 13	03 04 05 08 09 13	03 04 05 13	03 04 05 13	03 04 05 13	03 04 05 13	03 04 05 13
ENVIRONMENTAL SUSTAINABILITY	Reducing the Pollution	0	11	11	0	0	0	0	0	0
	Adaptive to the Climate Changes	13	11 13 14	05 11 13 14	13	05 13	13	13	13	11 13
	Proper Usage of Resources	0	11	11 14	0	0	0	0	0	0
	Biodiversity	0	0	14	0	0	0	0	0	0
	Energy Efficiency	0	11	11	0	06 15 16	0	0	0	0
	Recycling	0	0	14	0	0	0	0	0	0
ECONOMICAL SUSTAINABILITY	Economic Development	01 09	01	01 09	01	01	01 09	01 09	01 09 15	01 09
	Equality in Sectoral Distribution	10	10	10	0	0	0	0	0	
	Waste Management and Disposing	0	0	14	0	0	0	0	0	0
	Sustainable Energy Resources	0	11	11	0	0	0	0	0	0

As mentioned, Table 2 addresses the aims of the student groups as a "discourse" related to sustainability. As suggested in the literature, the sustainability discourse not adequately reflected in urban plans is an important problem in terms of the implementation practice of sustainable urbanization. Therefore, as authors we claim that the spatial design tools (actions) that meet the aims in Table 1, must be matched with sustainability headings, resulting in Table 3.

Table 3. Matching Spatial Design Tools (actions) and Sustainability's Main and Subtitles

Main Titles	Sub Titles	Social Campus	Self Sufficient Campus	Green Campus	Accessible Campus	Smart Campus	Campus for All	Holistic Campus	Campus that interacting with City	Walkable Campus
SOCIAL SUSTAINABILITY	Urban Justice	1a 2a 12a 12b	1a 2a, 12a 12b	1a 12a 12b	1a 12a 12b	1a 12a 12b	1a 12a 12b	1a 12a 12b	1a 12a 12b	1a 12a 12b
	Eqaultiy of Opportunites	3b 4a	3b 4a	5b 7a 7b	4a 7a 7b	3b	3b	7a 7b	5b 7a 7b	3b 4a
	Social Rights	2a 9a 10b 10c	2a 9a	7a 7b 9a	7a 7b 9a	7a 7b 9a	7a 7b 9a	7a 7b 9a	7a 7b 9a	7a 7b 9a
	Accessibility to Educational Health and Cultural Facilities	1a 1b 1c 8b 9b 9c 9e 13a	1a 1b, 1c 8b 9h, 13a	6a 8a 8b 9e 13a	1b 8b 9e 9j 13a	1b 9c 9h 9k 9l 13a 13e	1b 9b 9h 9j 9f 9d 13c 13d	1b 9j 9d 13a	9b 9i 13a 13b 15b	1b 9d 9i 10a 13a
	Comfort/Safety	3a 3b 3c 4a 4b 16b	3a 3c 4a 7a 7b 9a 15a 16b	3a 3b 4a 7a 7b 6a 9a	3a 3b 4a 7a 7b 6a 9a	3a 3b 3d 4a 7a 7b 15b 16a	3a 3b 4a 7a 7b	3b 4a 4c 7a 7b 9a	3b 4a 4c 7a 7b 9a	3a 3b 3d 4a 7a 7b 9a 16b
	Peace Environment	1a 1b 1c 3b 4a 5b 8b 9b 9c 9e 13a	1a 1b 1c 3b 4a 5b 9h 9g 13a	3b 4a 5b 6a 8b 9e 13a	3b 4a 5b 8b 9e 13a	3b 4a 5b 13a 13e	3b 4a 5b 13a	3b 4a 5b 13a	3b 4a 5b 13a 13b	3b 4a 5b 13a
ENVIRONMENTAL SUSTAINABILITY	Reducing the Pollution	0	11a	11a	0	0	0	0	0	0
	Adaptive to the Climate Changes	13a	11a 13a 14b	5a 11a 13a 14b	13a	5a 13	13a	13a	13a	11b 13a
	Proper Usage of Resources	0	11a	11a 14a	0	0	0	0	0	0
	Biodiversity	0	0	14b	0	0	0	0	0	0
	Energy Efficiency	0	11a	11a	0	6b 15b 16a	0	0	0	0
	Recycling	0	0	14c	0	0	0	0	0	0
ECONOMICAL SUSTAINABILITY	Economic Development	1a 1b 1c 9c	1a 1b 1c	1a 1b 1c 9c	1a 1b 1c	1a 1b 1c	1b 9f	1b 9c 9j	1a 9b 15b	1a 1b 1c 9c
	Equality in Sectoral Distribution	10b 10c	10b 10c	10b 10c	0	0	0	0	0	
	Waste Management and Disposing	0	0	14c	0	0	0	0	0	0
	Sustainable Energy Resources	0	11a	11a	0	0	0	0	0	0

When the relationship between the objectives in Table 3 and the sustainability principles is examined, it is seen that there is a match with almost every one of the social sustainability subheadings. In other words, all theme groups have spatial suggestions within the scope of "*social sustainability*", which is also expected in terms of "aims". In this section (parallel to the results in Table 2), it is seen that spatial design tools were developed under the subheadings of "*comfort / safety*", "*accessibility to educational health and cultural facilities*" and "*peace environment*".

The second title with the most spatial suggestions is "*environmental sustainability*". In this title, it is observed that all student groups have developed spatial design tools suitable for the subtitle of "*adaptive to the climate changes*". Although not for all groups, it can be observed that some student groups have also presented spatial suggestions under the title of "*energy efficiency*". Among the sustainability theme groups, the least suggestion has been made with the theme groups achieved the least with their suggestions was "*economic sustainability*" and within this scope, all theme groups developed suggestions under the subheading of "*economic development*".

The theme group that realized all the sub- and main headings of sustainability within the scope of its suggestions was the "Green Campus". This shows that the research and examinations have been conducted by this theme group have been realized in relation to sustainability. This theme group was followed by groups working with the themes of "Social Campus" and "Self-Sufficient Campus".

When we evaluate which main headings of sustainability all theme groups can realize and under which subheadings, we see that the main heading of "*Social Sustainability*" is realized by all theme groups together with its subheadings; the main heading of "*Environmental Sustainability*" can be realized only under the subheading of "*Adaptive to the Climate Changes*" and the main heading of "*Economic Sustainability*" can be realized only under the subheading of "*Economic Development*". In other words, student groups can spatialize policy areas related to sustainability under sustainable campus themes only through the areas (subheadings) mentioned above. From this perspective, the spatial design tools that urban planning students can produce for environmental and economic sustainability lag behind social sustainability.

5. Conclusion and Suggestions

In the almost two hundred years of modern urbanization history, it is observed that spatial development strategies have been put forward using pragmatic tools based on economic development rather than a natural and ecologically sensitive background. In the last fifty years, awareness of the global crisis has become more evident. In this awareness, the transition of urban planning and design strategies to a restorative and sustainable region has become inevitable to manage and overcome the crisis. Sustainability discussions have flourished in such a context.

As is known, the most basic scheme of structuring a sustainable existence for humans is the hierarchy of human needs proposed by Maslow in 1954. Of course, it is important for humans, as a part of nature, to meet their most basic existence needs. However, beyond this, the necessity of taking other elements of natural existence into consideration has become a problem that cannot be ignored.

The advanced content of this requirement is clearly seen in the United Nations 2030 sustainable development goals, which is one of the crystallized frameworks of sustainability (United Nations, 2015). Goals include almost the entire pyramid of Maslow's hierarchy of needs, considering all other elements of nature. In this perspective, basic needs are also effective in structuring sub-scale spatial development decisions.

This transition to restorative and sustainable praxis is also important in examining this awareness in the field of spatial sciences education. As a matter of fact, the project designed with the focus on "Sustainable Campus" in the Space and Design studio in the 2023-2024 spring semester has been an important environment for this analysis.

Taking a closer look at the analytical tools used in this study: As can be seen in Table 2 and Table 3, where the thematic aims and spatial design tools of the student groups are examined, the students brought forward suggestions related to sustainability under many main and subheadings. However, a striking point here is regarding the subheadings for which no suggestions were made. The titles that were not suggested by most of the student groups were "*reducing the pollution*", "*proper usage of resources*", "*biodiversity*" and "*recycling*" under the main title of "*environmental sustainability*"; and "*waste management and disposing*" and "*sustainable energy resources*" under the main title of "economic sustainability".

The reason for this situation may be perceived as that the subheadings in question cannot be adapted for a campus area. However, the subheadings in question can be produced and supported through many tools that include spatial arrangements such as reducing the use of motor vehicles, increasing the existence and quality of green areas, and ensuring the collection of recyclable materials. It is considered that this situation may be related to the fact that the students do not have sufficient knowledge or, even if they have knowledge, they have not encountered sufficient examples of how this knowledge can be applied to city plans. This result shows that the spatial arrangement disciplines need to bring a revision to their curriculum in a way that will provide applied knowledge about sustainability.

These results, obtained within a semester-long project study, show that projects created with the concept of sustainability should be examined in terms of the sensitivities they contain based on goals and tools. It also reveals that the relationship established with the concept is need-based and shaped according to the perception of the planner or designer group. This result includes many discussions in the field of urban planning and requires different searches in the structuring of education to achieve the goal of a healthier life and future.

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Evaluation of Campus Quality of Life (QCL) Through Space Syntax Analysis: The Case of Ordu University

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1. Introduction

The role of university campuses in the development of young individuals and societies cannot be underestimated. These institutions, which provide a nurturing environment for students of all ages, equip them with the professional knowledge and skills necessary to navigate the social, cultural, and psychological challenges of adulthood. A multitude of factors influence the efficacy of educational and training initiatives and the caliber of academic life at the university. One such factor is the quantity and quality of university buildings and open spaces, which play an integral role in campus life. A significant portion of campus life occurs in open spaces, where educational activities are conducted. These spaces play an integral role in campus social life. Consequently, the dimensions, formal attributes, and configuration of campus open spaces exert a considerable influence on the quality of campus life. In this regard, the quality of life on campuses is inextricably linked to the concept of quality of life itself and the physical characteristics of habitable spaces (Mohammed, Mandour & Baker, 2023; Younis & Younus, 2024).

According to Maslow (1970), the concept of quality of life is best understood within the context of the hierarchy of needs. The hierarchy of needs posits that individuals have five primary categories of needs: physical, safety, social, value, and self-actualization. The physical category encompasses the basic necessities of food, water, and shelter. The safety category includes protection and health. The social category pertains to the fundamental human need for belonging and connection within a community. The value category represents the intrinsic human desire for respect and recognition. Finally, the self-actualization category encompasses the pursuit of personal growth and fulfillment. For individuals, the fulfillment of basic needs at each stage of life and a sense of life satisfaction are crucial indicators of quality of life. These indicators are shaped by the physical and psychological conditions of individuals, their social relationships, and the well-being of the places they live in (Dissart & Deller, 2000).

The campus population, comprising students and academics, has a variety of needs, including those related to educational activities, food and beverage, accommodation, recreation, entertainment, and transportation. The design of campuses can be evaluated in terms of their ability to facilitate the fulfillment of individuals' needs, assurance of their safety, and the creation of memorable experiences. This evaluation can be conducted within the context of campus quality of life (Younis & Younus, 2024).

The aim of this study is to examine the morphological characteristics of university campuses, which serve as the setting for students' academic pursuits and contribute to their preparation for the future, in the context of quality of life. Consequently, the study concentrates on open spaces, where the majority of campus activities occur and which constitute a significant element of the campus morphology. The quality of life was evaluated through a sequential analysis of the spaces.

1.1. Spatial Development of Campuses and Quality of Life

The term "university" is derived from the Latin word "universitas," which in turn is derived from the word "univarsitates." According to Sönmezler (1995), universitas signifies an autonomous collective of individuals unified by a common set of interests. Universities occupy a significant position in the preparation of individuals for the future and their social, cultural, and psychological development. Additionally, they contribute to the level of culture and awareness within society (Erçevik & Önal, 2011). The foundations of universities can be traced back to the "Akedemia" (400 B.C.) and the "Lyceum" (387 B.C.) of ancient Greece. It is known that in the Middle Ages, these institutions were mostly aimed at training people for religious or administrative authority. Then, with the development of Christianity in Europe, educational institutions began to emerge around the churches. These institutions settled in Europe, bringing with them Roman law and Greek philosophy (Sönmezler, 1995). The first universities in the West, as we know them today, were established in the 11th and 12th centuries in urbanized areas of Europe. The first established universities-the University of Bologna (Italy, 1000), the University of Paris (France, 1150), and the University of Oxford (England, 1168)-had recognizable settlement patterns within the urban fabric (Erçevik & Önal, 2011; Baird, 2012).

According to Larkham (2000), the relationship of campus morphologies to the city is defined by three different models: self-sufficient, sprawling, and distributed. These buildings, regardless of their typology, are important urban components that shape students' lives and affect their standard of living. In this regard, it is important to plan the campus morphology in a way that supports the development of students' skills and creative abilities and encourages social interaction (Mohamed et al, 2023).

Many studies in the literature have evaluated the impact of university campuses on students from different perspectives. For example, there are studies that examine the impact of the use of open and green spaces on campus on the quality of life (McFarland, Waliczek & Zajicek, 2008; Hipp, Gulwadi, Alves & Sequeira, 2016), the improvement of the quality of campus life (Tamiami, Khaira & Fachrudin 2018), the measurement of noise pollution on campus (Yeşil & Güzel, 2023), and the impact of the physical characteristics of the campus on academic performance Hajrasouliha & Ewing, 2016; Hajrasouliha, 2017).

In addition, there are many studies in the literature that examine campuses using the space sequence method. For instance, studies using the space syntax for campus open space design (El-Darwish, 2022), measuring campus walkability (Lo, Ko & Ko, 2015), evaluating campus roads (Arslan & Şıkoğlu, 2015; Körmeçli, 2022), measuring user activity in campus outdoor spaces (Kuzulugil, Ünsal, Aytatlı & Yıldız, 2022), examining campus morphology (Yıldız, Çil & Can, 2015; Güneş & Gökçe, 2022) and addressing the relationship between the campus and the city (Gümüş, 2020).

2. Material and Method

2.1. Material

The main material of this study is Ordu University Cumhuriyet Campus within the borders of Ordu province which is located in the eastern Black Sea Region of Turkey. Ordu province, with an area of 5,961 km^2, is located between 40^o-41^o north parallels and 37^o-38^o east meridians (Anonymous, 2024). Ordu province received the status of "metropolitan" with the Law No. 6360 of the Official Gazette dated December 6, 2012

(Anonymous, 2012). Altınordu district is the central district of Ordu province. The resident population of the district is approximately 225,349 people as of 2024 (TURKSTAT, 2024). However, this population increases even more during the fall and spring semesters of the university with the arrival of students from outside the city. Cumhuriyet Campus, located in the Altınordu district, is approximately 8 km from the city center (Figure 1).

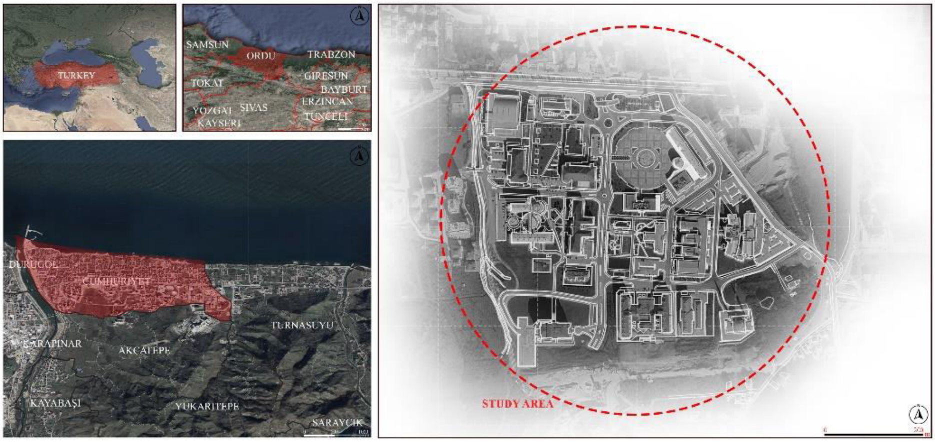

Figure 1. Study Area

Cumhuriyet Campus covers an area of approximately 22 ha. The campus, as of 2024, has 10 faculties, 3 institutes, 1 college, 1 research laboratory, dormitory buildings, administrative units and social facilities such as stationery, canteens and mosques (Figure 2).

Figure 2. Ordu University Cumhuriyet Campus

It continues its education, training and research activities with 1222 academic members, 380 administrative members, 315 permanent employees and 17.496 students (Anonymous, 2023).

2.1. Method

In this study, field investigations were conducted and the spatial syntax method was used to evaluate the impact of the morphological characteristics of the campus open spaces and the current conditions of the campus structural elements on the campus quality of life. The current master plan of the campus was used to calculate the basic parameters of the spatial sequence method. The accessibility level of the campus movement networks consisting of vehicular and pedestrian roads was analyzed using the spatial syntax method. The connectivity and integration values of the space syntax method are the basic parameters that reveal the centrality of the movement networks within the system and measure the ease of access of people to these networks, and thus the accessibility of the networks. When calculating these parameters, it is first necessary to create an axial map of the area, including the longest and least number of axes (Arslan & Şıkoğlu, 2015). In the process of obtaining axial maps and performing alignment measurements, the campus plan was converted to .dxf format and transferred to depthmapX 0.8.0 software (DepthmapX Development Team, 2024). Connectivity, global and local integration (radius 3) values were obtained from the axial maps obtained in the software. These maps were visualized using QCIS 3.36.1 geographic information system software (QCIS Development Team, 2024).

3. Findings and Discussion

In the study, the space syntax method was used to determine the most suitable areas for mobility and social interaction in Ordu University Cumhuriyet Campus. Figure 3 shows the general view of the Cumhuriyet Campus where the space syntax analysis was performed.

Figure 3. General View of Campus (Anonymous, 2023)

A high connectivity value, which indicates how many axes an axis intersects in total, can be used as an important sign of the quality of spatial accessibility, as well as an indicator in determining the points of attraction for people's spatial preferences and social interactions (Hillier & Hanson, 1984; Yeşil, Karabörk, Özkul & Güzel, 2024).

The connectivity values of 309 axes in the study area are range from 1 to 22. The main transportation axis of the campus and the axis crossing it perpendicularly have the highest value. The main campus transportation axis of the campus in the north-south direction starts from the campus entrance gate and ends with the Rectorate building. The other high-value east-west lateral road leads to the square, which is the largest open area of the campus and where the campus is connected from the surrounding roads (Figure 4).

Figure 4. Connectivity

According to Hanson & Zako (2005), there is a positive correlation between global and local integration values and the quality of life of inviduals in the analysis of the spatial morphology with space syntax.

The global integration values of 309 axes in the study area are range from 0.516727 to 2.49434. The highest integration values were measured at the primary and secondary transportation axes (Figure 5).

Figure 5. Global Integration [HH]

The literature on space syntax shows that the global integration value is higher in the main transportation networks of cities, while the local integration value is an important data to determine pedestrian movement (Gümüş & Yılmaz, 2022). The local integration value (radius 3) was obtained to determine the ease of pedestrian movement of students in campus and their preferences for space choices. According to the results of the analysis, the local integration values of the axes are in the range from 0.3333 to 3.718. The main transportation axes of the campus received the highest local integration value. Areas where transitions are limited, such as parking lots near buildings, have the lowest local and global integration values (Figure 6).

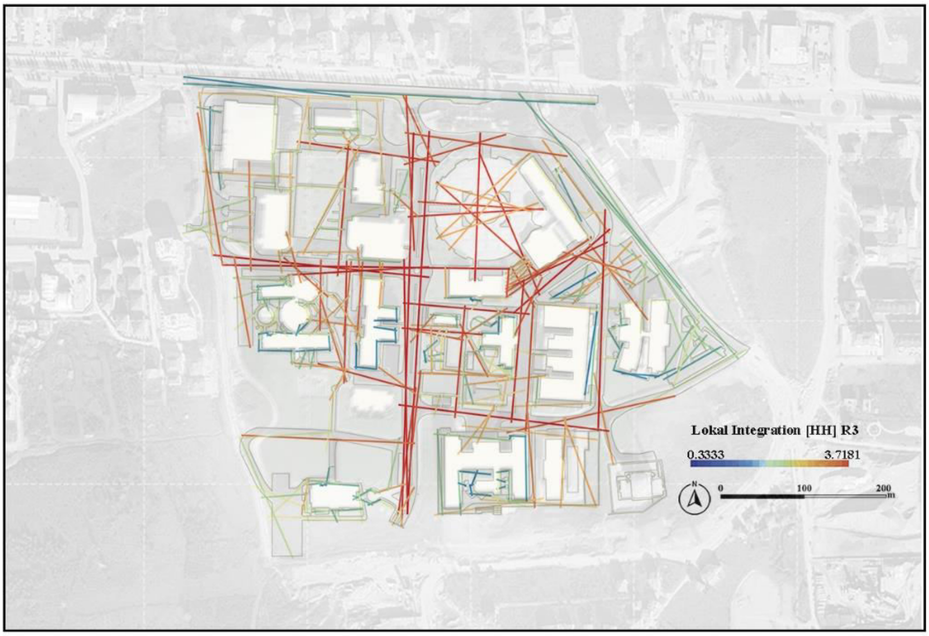

Figure 6. Local Integration [HH]R3

Figure 7 shows the visualization of the north-south and east-west transportation axes of the campus, which are the most intensively used and have the highest values in all analyses. These major campus circulation axes organize pedestrian and vehicle movement and provide access to faculty, administrative and social buildings. These areas of campus movement are supported by sensitive surfaces, directional signs, plastic objects and landscaping to facilitate movement and enjoyment for users.

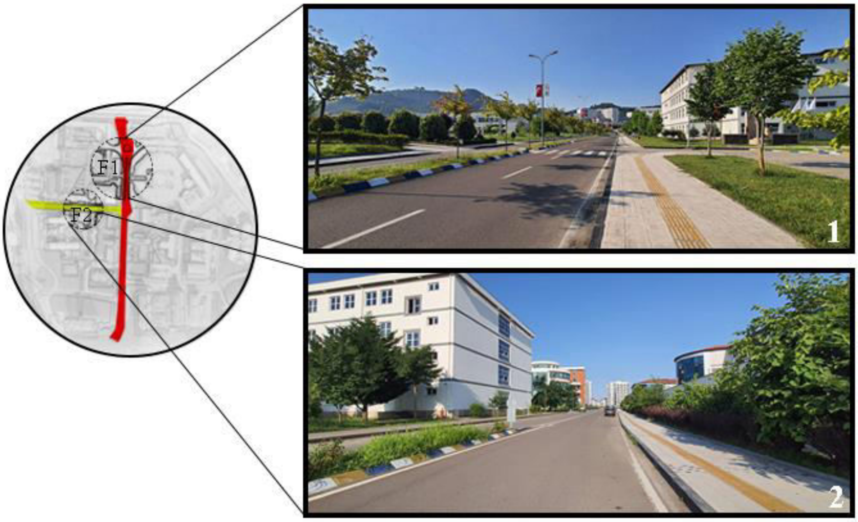

Figure 7. F1: North-south axis of transportation, F2: East-west axis of transportation

4. Conclusion and Suggestions

University campuses, which are important components of the urban fabric, host a large group of people, especially students. Campuses, which provide the campus population with educational, training, social and cultural aspects and play a role in changing society by contributing to the development of individuals, should be places where the physiological, social and psychological needs of campus users are met. Physical characteristics such as height, width, organization or complexity of spaces affect the spatial quality and livability of the space.

Spaces where people can move freely, find their way around easily, and interact with each other are characteristics of livable spaces. These qualities are also very important in campus design. Students, who spend most of their days in campus open spaces, attribute different functions to campus open spaces, such as continuing educational activities, resting, or socializing. The fact that the open spaces on campus are conducive to user mobility and that the transportation axes are designed in such a way that people can conveniently get together has a direct impact on campus life.

The spatial syntax method used in this study examines the mobility of users between spaces and the potential for people to congregate in spaces. Mobility in the open spaces of the campus is mainly provided by pedestrians and vehicles. For this reason, the connecting roads of the campus that are suitable for pedestrian and vehicle use were identified and transferred to the depthmapX 0.8.0 software, and the syntactic analysis was performed. According to the syntactic analysis, the main transportation axes of the campus received the highest values in all three values of connectedness, global and local integration. The main campus circulation axes are the areas with the highest pedestrian and vehicular use. These thoroughfares have school entrances and are the primary source of mobility on campus, connecting the city to the campus. At the same time, these roads provide access to all faculties, social and administrative buildings on campus.

According to the connectivity analysis, the connectivity score of the two transportation axes was higher than the surrounding area. These points indicate the potential of the campus as a center of attraction. It is known that the square and the Atatürk monument are located on these high connectivity axes and are used as meeting points for university events (Figure 8).

Figure 8. Atatürk monument

According to the integration analysis, the values were close to each other on all roads within the campus. According to the integration values, it can be said that movement can be easily realized throughout the campus.

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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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Potential of Sustainable Agricultural Practices in University Campuses

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1. Introduction

In the process of climate change and adaptation, which has been on the agenda recently, universities around the world are taking the initiative to increase the sustainability and self-sufficiency of their campuses. In this process, interest and knowledge about encouraging agricultural production on campus and implementation studies are also increasing. Integrating agricultural production into university campuses is the way forward. It brings both a transition to holistic and environmentally friendly practices and a new perspective and application area for feeding the increasing population in recent years.

Universities can contribute to local food systems and reduce their carbon footprint by using their existing land for agricultural purposes. This provides students access to fresh food while encouraging them to form a deeper connection with the food they consume and the land they live in through hands-on learning experiences. Clearly, the population engaged in farming in rural areas is getting older, and young people are increasingly disinterested in agricultural production (White, 2012). This experience gained during university will also effectively transfer knowledge to future generations.

The United Nations World Food Programme estimates that approximately one billion people worldwide are malnourished. Across the globe, up to 783 million people do not have enough food. 47 million people in 54 countries are at 'emergency' or worse levels of hunger (World Food Program, 2024). By 2050, the world's growing global population will require an estimated 60% more food than is produced. It is clear that the current rate of food production is unsustainable. With the global population set to rise to over 6 billion by 2050, and 90% of this growth occurring in developing countries, the demand for food will outstrip supply. Currently, 1.3 billion tons of food are lost or wasted every year, while land and water resources are limited. It is therefore imperative that alternative ways to increase food production on the limited land and water resources must be found (Da Silva, 2022).

Currently, 11% of the world's total land surface is used as arable land, and global estimates show that there is no more space on Earth for agricultural land. By 2040, the capacity of agricultural land can only be increased by another 2%. It is clear that, according to the United Nations' prediction for 2050, 86 % of the developed world's population will live in cities (FAO, 2017). This makes it inevitable that food production must be shifted to urban areas. It is clear that university campuses have the potential to offer various agricultural production forms and alternatives. This would encourage holistic education on campuses and set an example to society, while also spreading sustainability awareness.

The origins of agricultural production at the university level date back to the 19th century. In addition to practice farms and production areas on universities that provide agriculture and animal husbandry education - such as Faculties of Agriculture or Natural Sciences- Universities are also offering opportunities for students from different programs to get involved in agricultural projects through clubs, elective courses, and various initiatives. Agricultural practices on university campuses (regardless of agriculture-related undergraduate practices) are essential for reducing the carbon footprint, increasing food sustainability, and providing students with hands-on learning experiences through participatory approaches and knowledge exchange-based solutions. Expanding agricultural opportunities and practices on university campuses is crucial for shaping a more sustainable future.

This chapter brings together a collection of information on sustainable campus agriculture and addresses the trend of integrating agricultural production experiences on university campuses to support sustainability efforts and promote holistic education. Starting with a university-based examination of the historical roots of agricultural production, the development and advantages of agricultural practices intertwined with educational initiatives will be assessed. It is aimed to highlight how agricultural practices on university campuses - independent of agricultural-related degree practices - reduce carbon footprints, increase food sustainability, and provide students with hands-on learning experiences through participatory approaches and knowledge exchange-based solutions. Examples will illustrate the importance of the symbiotic relationship between academia and sustainable agriculture and how universities can lead by example. Agricultural opportunities on university campuses are crucial for shaping a more sustainable and interconnected future.

2. History of Farming on University Campuses

Agricultural education is the systematic and organized instruction and training -both theory and practice- given to pupils, agriculturists, or individuals interested in the scientific, economic, and technical aspects of agriculture and the management of land, the environment, and natural resources, as well as animal and plant husbandry. A popular interpretation of agricultural education is to include either programs for training extension workers or, most commonly, field programs directed at small farmers (Anderson, 1984).

The objectives of agricultural education include building a skilled agricultural workforce through the training and preparation of future farmers and agricultural professionals, promoting sustainable and responsible agricultural practices, enhancing food security, developing cutting-edge agricultural technologies, contributing to rural economic development and growth, and strengthening the link between urban and rural farming communities (Schultz et al., 2008).

Historically, farming techniques and knowledge have been passed down through oral traditions. The history of farming on university campuses dates back to the 19th century, when the first agricultural colleges were established to develop agriculture and animal husbandry. The Royal Agricultural College (RAC), later change the name to Royal Agricultural University (RAU), the first agricultural college in the UK, was founded in 1845 in Cirencester, England. It was founded through public subscription, with the support of wealthy landowners and farmers. It was granted a Royal Charter by Queen Victoria in the same year (Royal Agricultural University, nd).

The spreading of agricultural knowledge as academic education was formalized in the United States in the 19th century with the Morrill Acts. In the United States, the Morrill Act of 1862 provided for the establishment of experimental farms as part of land-grant colleges and campuses, many of which had agricultural programs parallel to Britain shown in Figure 1 (Crawford,1925).

Figure 1. Above: Royal Agricultural University the first agricultural college founded in 1845, Royal Agricultural University (nd). Left: Studley Castle Horticultural College for Women in Britain, 1910 (Thomas, 2012). Right: Colorado State University at Denver in 1909 (Jeracki, 2019)

This led to the rapid growth of agricultural education and extension efforts across the country in the late 19th century. The University of Nebraska developed its agricultural program by establishing an arboretum and experimental farm on its campus grounds, and other early land grant universities such as Purdue and Cornell followed by establishing active agricultural research and teaching facilities on their campuses (Cheesbrough, 1966).

It has gradually grown over the years to incorporate a wide range of scientific subjects related to animals, plants and crops, soils, management, food, land, natural resources, and the environment, and agricultural education schools have proliferated around the world. By the early 20th century, colleges of agriculture and their associated farms and experimental plots had become a common feature on many university campuses and became centers for agricultural education, research, and outreach to local farming communities (Gwyn & Garforth, 1984). Throughout the 1940s, 1950s, and 1960s, agricultural researchers at these universities pushed the boundaries of scientific knowledge in areas like crop breeding, pest control, and farm machinery. The land-grant system's three-part mission of research, teaching, and extension was critical to the modernization of American agriculture during this period (Living History Farm, nd).

The integration of farming into academic settings not only enhances students' understanding of food systems and environmental management, but also contributes to food security, and community involvement in agricultural production is expanding. By exploring the historical foundations of farming on university campuses, we can better grasp the contemporary significance of these agricultural endeavors and the abundant opportunities they offer for research, education, and sustainable practices.

3. Benefits of Farming on University Campuses

It can be said that there are many benefits to agricultural practices on university campuses. Firstly, by growing food locally, universities can reduce the often-discussed carbon footprint associated with food transport. They can also avoid dependence on external food supplies. Campus initiatives that involve students in agricultural production are one of the most effective ways to promote food sustainability and environmental responsibility. Furthermore, integrating agriculture into university campuses can be used to create a more self-sufficient and interdependent community, contributing to local food resilience and security.

The proliferation of campus-based farming practices today, and their ability to provide students with both a practical and enjoyable educational experience, enables the development of more environmentally conscious individuals for both the institutions and the communities around them. As universities focus more on sustainability practices, campuses are becoming models of environmental management and education shown in Figure 2 (Werley, 2019).

These student-run farms are invaluable for providing local fresh produce, but their future viability is crucial for the countless other benefits they offer to local food systems and campus communities. They offer a unique educational space, enhance the ecological health of the land, and inspire the next generation of sustainable growers. While campus farms often host classes across a range of departments throughout the semester, there is also ample opportunity for learning outside of the classroom.

Figure 2. Above left: Kasetsart University in Thailand Builds an Innovative Vertical Edible Garden on Campus (Alimurung,2012). Above right: Students at work in the high tunnels at Knox College's campus farm in Galesburg, IL (Kulers,2023). Below left: DePauw students harvest potatoes on the campus farm. (Kulers,2023) Below right: The Towne's Harvest Garden is a five-acre diversified vegetable and educational research farm supporting a student-run, community-supported agriculture program at Montana State University (Towne's Harvest Garden, nd)

In summary, the main benefits of farming on university campuses include:

- Providing hands-on learning opportunities for students across various disciplines, such as agriculture, engineering, computer science, and business (Greatrix,2016).
- Providing fresh, locally grown produce to campus dining halls and cafeterias throughout the year. Improve the quality and nutritional value of the food served to students (Freight Farms,2021; Kulers,2023).
- Attracting a new generation of students who care about sustainability and transparency in the food system (Freight Farms,2021).
- Creating transparency in the campus food system by allowing students to see where their food is coming from and how it is produced (Freight Farms, 2021; Kulers,2023).
- Educating students about sustainable agriculture, the food supply chain, and the importance of local and organic farming (Phipps, et al., 2008; Kulers,2023).
- Promoting sustainable farming practices that have positively impact on the local environment, such as reducing food waste, composting, and using renewable resources. (Kulers,2023).
- Inspiring the next generation of farmers and food producers by giving students real-world experience in operating a farm (Phipps, et al., 2008).

- Having partnership opportunities with Neighboring Restaurants and Schools. Integrating campus farms with dining services to provide a reliable, local source of produce and reduce the environmental impact of long-distance food transportation (Chen,2024).
- Showing the University's commitment to sustainability.

Overall, university farms offer a range of educational, sustainability, and community benefits that can transform the campus experience for students. There are clear benefits for campus food systems provided by student-led farming operations, but these benefits are felt more broadly when examining the bigger picture. According to FAO, The average farmer worldwide is getting older every year, carrying deep implications for our food supply in the not-so-distant future (FAO, 2017). Campus farms pose a promising solution to this issue by raising the next generation of food producers, providing inspiration, support, and a safe environment to experiment and grow key knowledge and skills, backed by the ongoing support from University Campuses.

The implementation of agricultural programmes on university campuses faces a number of challenges that require innovative solutions, including the need to prioritise climate-smart options and co-design farming systems with local stakeholders to ensure sustainability and scalability. Drawing on the methodological framework proposed by Andrieu et al. (2019), which highlights the importance of engaging stakeholders in the co-design of climate-smart farming systems, universities can leverage their academic resources and collaborations with farmers, scientists and NGOs to develop tailored solutions. By addressing these challenges through participatory approaches and knowledge exchange, university campuses can unlock the full potential of agricultural programmes and contribute to sustainable agricultural practices on their campuses.

4. Farming Initiatives on University Campuses

A number of colleges and universities have working farms on their campuses that are used for research and learning purposes, particularly for students with an interest in agricultural education. These farms provide hands-on learning opportunities, as well as jobs for students and sustainable food for the campus community.

Trent University in Canada has a Trent Vegetable Gardens (TVG) located rooftop of the Environmental Sciences Complex consisting of 20 individual plots in a 2-hectare field garden. TVG supports applied education, workshops, and research and is a resource for the university and the community. The campus initially used the rooftop garden for research, and it later became a learning space for students in the school's Food and Agriculture Programme, measuring the efficiency of rooftop farming and comparing rooftop yields with those from more traditional farmland. The student committee organizes volunteer gardeners, selects plants, and distributes the produce. Most of the food goes to the Seasoned Spoon Café, a student-run, independent vegetarian co-operative on campus that partners with the Trent Community Research Centre for community-based academic research. As a result of years of production on the roof, it also provides valid data for other roof gardens, such as microclimate creation, sun and wind protection, irrigation, mulching, etc. (Trent University, nd).

Another symbiotic relationship between academic institutions and sustainable agricultural practices is illustrated by success stories of agricultural initiatives on university campuses. Innovative projects supported by entrepreneurial library staff (Dorsey et al. 2012) who use their research and organizational skills demonstrate how universities can create new spaces in emerging fields of science such as sustainability. In addition, university researchers have used funding sources, such as the University of Maine's MEIF system (Maine Economic Improvement Fund, nd), to support agricultural initiatives and provide campuses with the personnel, equipment, and facilities necessary to conduct research. These initiatives contribute to the academic community's knowledge base and serve as practical examples of sustainable agriculture. Figure 3 shows the direct selling experiences of schools.

Figure 3. Left: Fulton Farm stand at Wilson College. The Fulton Farm is a working farm of seven acres of cultivated land, on which students raise nearly 50 different varieties of fruits, vegetables, flowers and herbs (Wilson College, nd) Right: The University of Vermont's weekly farm stand. A 97-acre Catamount Educational Farm models sustainable farming practices through a working vegetable and fruit farm. Students are integral in carrying out all activities on the farm, from planting to marketing (The University of Vermont, 2024)

By integrating agricultural activities with academic pursuits, universities not only educate students about sustainability but also capitalize on the potential to actively engage in effective environmental management.

In summary, implementing agricultural practices on University Campuses includes **Curriculum Integration of Agricultural Practices** through various subjects, including biology, environmental science, and technology, and allows students to conduct experiments to test the effects of different growing conditions on plant health, analyze the data collected by the Greenery, and present their findings in class.

Extra-curricular activities such as gardening clubs or environmental groups can also support agricultural practices. These programs offer students additional opportunities to engage with technology, collaborate, and develop leadership skills. It can also help to foster a sense of community within the school, as students work together to achieve a common goal.

Universities can use **agricultural practices** to engage the community by inviting parents, local businesses, and community organizations to participate in educational programs and events. This can help foster a shared commitment to sustainability and education and build stronger links between the school and the community.

5. Site Selection Considerations For Successful Student Farms

Site design is a process of intervention involving the sensitive integration of circulation, structures, and utilities within natural and cultural environments. The process encompasses many steps from planning to construction, including initial inventory, assessment, alternative analyses, detailed design, and construction procedures and services.

This section is intended to illustrate the physical considerations for successful site selection for the University's Student Farms in terms of landscape design. It does not focus on the biophysical requirements such as sun exposure, wind direction, soil quality etc. that are also essential for a comprehensive site analysis. There are some of the physical site selection criteria that can be used for successful student farms include:

- Size: The site must be of an appropriate size for the needs of the project. The total size of the farm should accommodate pedestrian ways and structures such as workspace and parking areas, growing fields and greenhouses, and stations in addition to a site for post-harvesting processing. Storage sheds and composting structures must be provided with the necessary space and appropriate seating in the proposed area (VanWieren, 2018).
- Topography/Existing Physical Conditions: Relatively flat terrain is optimal. Agricultural production is also possible in areas with certain slopes, but taking measures against the risk of soil and water erosion and terracing requires extra workloads. The hills, existing trees and vegetation, shading, and accessibility to the site should match the project's needs (Kelley, 1990).
- General Accessibility: The farm should be easily accessible from all parts of the campus, enabling students to quickly access the site whenever needed (VanWieren,2018).
- Proximity of Related Structures and Buffer: Constructing related structures, such as animal housing, close to each other can save time and labor during management activities, compared to distant structures that can be more labor-intensive. There must be

sufficient separation between adjacent uses. The distance from residential houses, sports fields and dog parks can significantly reduce the likelihood of conflict (VanWieren, 2018).

- Visibility and Appearance: The appearance of the farm should be in keeping with the context of the campus landscape. Traditional campus landscapes are characterised by lawns, deciduous trees and ornamental beds. Similarly, traditional agricultural landscapes tend to be tidy and organised. The farm should be located in a visible and attractive area of the campus to attract student interest and involvement. It is important to avoid hidden or secluded locations (VanWieren,2018).
- Vehicle Access: Adequate access must be available for a van, mini truck, or similar sized vehicle.
- Site Access: Nearby public transit access is desirable. Also access to existing utility lines such as water and electricity hookups are important.
- Security: The farm site should be in a secure location to protect against potential threats, such as predators or intruders, which could result in significant losses.
- Water source: The proposed site must be close to a drinking water source. Sites with nearby water fountains and washroom facilities will make it much more feasible to install a water source for a garden.
- Drainage: Selecting an area with proper drainage is crucial to prevent water damage and avoid damp conditions that can promote pathogen growth. In modern agriculture, efficient drainage systems

play a key role in ensuring high productivity and sustainability. As farming practices evolve, the importance of advanced drainage technology in optimizing crop yields and maintaining soil health is becoming increasingly apparent.

- Site Context and Connections: The farm should be connect with a community kitchen, food-serving organization, or educational facility around the campus. The farm must relate to the context of the site. The farm design and programming must include and address issues of access, inclusion, and diversity of underrepresented groups (Gočová, nd).
- Geographic Distribution: It is good to know if there are other urban agriculture projects nearby. It would also be great to find out where in the city there are areas that could benefit from food or garden projects (Gočová, nd).
- Materials: Explore the possibility of reusing material from nearby projects or campus operations (Gočová, nd).
- Land Acquisition: City and University policies need to be encouraged to provide for 'urban farmsteading' type programs which would support farmers in obtaining land and allow them to build equity (VanWieren,2018).
- Farmer (Student) Preferences: Incorporating student preferences, such as sheltered areas or other specific needs, can enhance the overall success and engagement of the student farm project.

6. Campus Agriculture Alternatives for Student Farms

Campus agriculture is one of the urban farming practices that have emerged as an alternative to today's diminishing and polluted fertile agricultural lands. Campus agriculture contributes to the creation of a socially sustainable environment by involving the campus community. Agricultural practices play an active role in raising campus awareness of issues such as pollution, global warming, sustainability, water and energy efficiency through conferences, lectures and community meetings. At the same time, supporting local production reduces logistics costs, fuel costs, storage costs, and carbon emissions. Increasing pollination opportunities by creating new green and agricultural areas in an urban context is another important factor in environmental sustainability. Whether looking to supply sustainable food, jumpstart modern agriculture curriculums, encourage student engagement, or simply grow the best greens around, universities around the country are relying on different alternatives from community gardens to hydroponic container farms to create impactful farm-to-campus programs.

Private Gardens: Food production areas in the front or back garden, attic, courtyard, balcony, wall, windowsill, or basement of single or multi-family dwellings. The products produced are generally for personal consumption. Small areas in front or back of the University Buildings be connected.

Show Gardens: Small-scale food production by a local government, organization, or business for public demonstration purposes only in private or public spaces in residential, commercial, or mixed-use areas. Products produced are usually donated (Hodgson et al., 2011) University campuses have better opportunities to meet show gardens with students and local citizens.

Community Gardens: Areas planted, cultivated, and managed by groups for small to medium-scale food or ornamental production on private or public land in residential areas, in contiguous or separate plots. The horticultural activities and products are used for consumption or education. However, depending on local government regulations and the purpose of the garden, sales may also be made on or off-site. Depending on its size, a community garden can produce enough food to fulfill a portion, if not all, of the gardeners' fresh produce and herb needs during the growing season. (Korgavuş & İnan, 2022). Community gardens on college campuses give students access to nature and an opportunity to tend to - and be nurtured by - the outdoors.

Corporate Gardens: Areas planted, cultivated, and managed by an organization or business for small- or large-scale food production and ornamental plant cultivation on private or public institutional land (schools, hospitals, workplaces, hospices) in residential, commercial, or mixed-use areas. Horticultural activities are usually carried out for educational, therapeutic, or public service purposes, and the products produced are used for donation and consumption. Depending on local government regulations, products are sold inside or outside the garden, the organization's markets and shops, to financially support the activities of the garden (Korgavuş & İnan, 2022). There are some examples of community and corporate gardens at Figure 4.

Figure 4. Above: The Brock University community garden is a great example of what companion planting may look like (D'Souza, 2018). Left: Kingsborough Community College Community Farm and Garden (CFG) provides valuable learning opportunities by promoting gardening, growing nutritious and sustainable food, and cultivating a greater sense of community (Kingsborough Community College, nd). Right: The UBS runs a corporate farm for student projects in the City of Vancouver (The University of British Columbia, nd)

Rooftop Gardens: Rooftop agriculture can be briefly defined as a form of urban agriculture where food is grown on green roofs on top of buildings. In addition, there is the concept of Building Integrated Agriculture (BIA), which involves the placement of hydroponic greenhouse systems on building interiors, rooftops, building perimeters, and the concept of Zero Land Farming includes all types of urban agriculture that do not use agricultural land or open space. Rooftop agriculture represents the idea of using roofs for agricultural or horticultural purposes. This practice contributes to local food production by maximising the potential of rooftops on University campuses (İnan & Korgavuş, 2023).

Figure 5. The largest urban rooftop farm in Asia with 22,000 m² green roof project located on top of Thammasat University's Rangsit Campus Building served for education and research, social responsibility, cultural landscape protection, sustainability and recreation purposes (Landprocess, 2023)

Edible Landscape: Areas where food-producing plant elements are used by individuals or businesses in the design of private or public open spaces in residential, commercial or mixed-use areas. According to Ling et al. (2018), edible landscaping is an approach that integrates productive and edible plants (vegetables and fruits) and ornamental plants into traditional designs. The main aim of edible landscapes is to reintegrate food production into urban life and connect food production systems with urban green spaces and encourage a more active lifestyle. An example of edible garden implementation at Hacettepe University in Türkiye is shown in Figure 6.

Figure 6. For the edible garden project planned for campus agriculture, the pots are to be planted by relevant persons and farming community members at Hacettepe University Faculty of Fine Arts (Hacettepe University, 2022)

Hydroponic Container Farms: Hydroponics is the technique of growing plants using a water-based nutrient solution rather than soil, and can include an aggregate substrate, or growing media, such as vermiculite, coconut coir, or perlite. A container farm is a commercial-scale, modular, hydroponic farm built inside a shipping container that provides the controlled environment solution to grow hyper-local produce 365 days a year. Some universities started to add the hydroponic container farms operation to the campus dining program with hydroponic container farms shown in Figure 7.

Figure 7. Freight Farms operation to the campus dining program with hydroponic container farms in Clark University (Freightfarms, 2024).

Hobby Beekeeping/ Beekeeping: Small-scale breeding of honey bees for personal use in gardens, parks, gazebos or unused areas of public land. Products produced are used for personal consumption, education or donation (Hodgson et al., 2011). Beekeeping and honey production activities are expanding and enhancing the Farm Food Program while providing new educational opportunities for faculty and students.

Recreational Husbandry and Poultry Farming: Areas where poultry farming is carried out together with agricultural or non-agricultural activities for personal use in private gardens or plots on residential, mixed-use or other public land seen in Figure 8 (Hodgson et al., 2011).

Figure 8. Left: Jenner Farm summer agroecology program in Skull Valley, Arizona (Prescott College Jenner Farm, nd). Right: Chicken Coop at Stonehill College Farm in Easton, Massachusetts (Stonehill College, nd)

Urban Farms/Urban Periphery Farms are include horizontal and vertical soilless, container, hydroponic aquaponic systems, Large-scale food, ornamental plants, beekeeping, poultry, and aquaculture systems at University campuses and differ either the campus settlement located in urban or urban periphery. There are also animal husbandry practices in University Campus Farms seen in Figure 9.

Figure 9. The Sheep Unit and Horse Barn on the University of California at Davis Campus (Ucdavis, nd)

Hybrid Urban Agriculture (Usually social enterprises and student clubs) is a combination of various agricultural activities for individual consumption, education, donation or commercial purposes food production, ornamental plants, beekeeping, aquaculture, cattle and poultry farming.

7. Design Considerations for Successful Students Farms

The sustainable approach to site planning and design goes beyond combining and comparing site inventories. A sustainable process attempts to determine the relationship between site factors and how those factors will adapt to change for design considerations. The programmatic requirement and environmental characteristics of sustainable design will vary greatly, but the following areas should be considered in site selection:

1.The Farm (Organization) Center: When designing a campus farm, priority should be given to creating a program when preparing the land use diagram. In this program, a farm center should be determined as the starting point of the design. This center should include the junction point of other land uses determined for the farm and the management units. The units and warehouses where the materials required for landscape maintenance and management are stored should also be located in this center. Administrative activities should include a communication hub with an office, a message or task board, a meeting area, and a visitor entrance.

2. Gathering Areas: It is very important to provide a variety of small and large meeting and event spaces for small and large groups to serve various educational and social functions. These spaces can be designed as multi-purpose areas. They can be in different locations and sizes, both indoors and outdoors, depending on the suitability of the site. It can be an important advantage to be close to the centre of the farm and to have a transit relationship. Landscaping elements such as seating, shading, tables and chairs for gathering and flat areas reserved for space use such as kitchen/cafeteria are very important in the design of gathering places.

Figure 10. Above left and right: University of Oregon Urban Farm shading structures at gathering places (University of Oregon, nd). Below left: Chatham University Eden Hall Campus farm to table Cafe (Mithun Design, 2016). Below right: UC Davis Arboretum and Public Garden Courtyard, featuring a student working in the shade of a wooden awning and hammocks among the garden's blooming flowers and towering trees (UCDavis Arboretum, 2024)

3. Attractions: Attracting people to the land on campus student farms is important for engaging students in sustainable food systems projects and for demonstrating agricultural strategies that attract people. Attractions can be defined as demonstration plots with unique, artistic or aesthetic features that draw people to the site. Drawing people to the site through attractive design is important for building awareness of the farm and for community outreach. The most common design elements used to create effective attractions are an inviting entrance area used gates, arbors, fences and signs, flower gardens and plant demonstrations with ornamental plants and seasonal flowers, and well-crafted landscape features (VanWieren, 2018). Strategies such as rain gardens, green roof gardens, themed raised beds, butterfly and pollinator gardens can be designed for this purposes. The entrance, garden beds and green houses of Stanford University shown in Figure 11.

Figure 11. Stanford University Educational Farm (Bay Tree Design, 2020)

It is essential for sustainability that the attractions are combined to create a strong farm identity and character, and that they are well maintained to remain effective.

4. Student Projects: Student projects can be defined as student research plots, experimentation spaces, and independent projects or studies. These projects connect students, school communities, and local farms to improve student nutrition and academic outcomes, as well as strengthen local food systems, economies, and communities. These projects address a range of practices from integrating trees, forests, and agricultural production for education to connecting meaningfully and exploring holistic strategies for health and renewal (Shebitz, et al.,2017).

Figure 12. Left: Kids from School Gardening Program in the Ecological Garden at the UC Davis Student Farm (Agricultural Sustainability Institute, nd). Right: The Kean University SUST 4300 course students and Faculty constructing the Medicinal Plant Garden at Liberty Hall Farm (Shebitz, 2017)

5. Compost Areas: The Campus Farms are living-learning labs where students engage in hands-on experiences through food grown by students for students. The compostable items from campus or supported initiatives mixed with leaves and other yard waste for compost producing. The resulting compost would be used by the Campus Farm to grow food that is consumed on campus shown at Figure 13. The areas location reserved for composting procedure is need to be accommodate truck circulation and have a convenient access to large production spaces.

Figure 13. Above Left: Students working for Western Michigan University Composting Project (Batbold, 2020). Lower Left: University of Brighton Community Composting Program in England support and training to volunteers to help them set up and manage compost schemes in their neighbourhood (Brighton & Hove Food Partnership, 2024). Right: Students working on University of Mississippi Compost Program (Ignite, nd)

6. Landscape Features: Designed to provide intimate spaces for individuals to small groups for conversation, observation or solitude, they are scattered throughout the farm site. These landscape features include seating, viewpoints and terraces, and structures that provide a sense of enclosure and shade (VanWieren, 2018) . Figure 14 shows a site plan of small-scale integrated farming sample in Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia.

Figure 14. A) garden office, B) warehouse, C) composting station, D) organic waste counter, E) goats barn, F) rabbit barn, G) nursery station, H) ornamental plants station I) open field, J) greenhouse (Dewi Ni Kadek E. S. and Umami, A. 2023)

The design of a campus farm is a crucial aspect of agro-farming. It involves planning, researching, and implementing various aspects of farming to ensure that the farm is productive, efficient, and sustainable. When designing the campus farm, all the key factors that can affect the farm's productivity and sustainability should be considered including soil quality, crop selection, animal husbandry, water management, equipment selection, farm layout, pest control, market demand, labor management, and environmental sustainability in the long run.

8. Conclusion

One of the main features defining a university is its strong ties to national as well as international academic and research networks, together with meeting requirements for research and development by labor markets. They play an important role in sustainability education, empowering global citizens for sustainable development and helping to shape tomorrow's economic and political leaders and managers.

A sustainable university is an educational institution that educates global citizens about sustainable development, offers solutions and alternatives to pressing societal challenges, and reduces the environmental and social footprint of campus activities. Universities committed to sustainability also have aspects such as achieving a zero carbon footprint in education, research, campus practices, empowering students and staff to take action on sustainability, and raising community awareness. The relationship between universities and society creates new opportunities for a closer and more equal relationship. This can create new possibilities for a greater sense of shared public culture and address the idea of a thriving university. One of the most important sustainability issues today is food security and food sustainability. Rapid population growth, migration from rural areas to urban areas, pressures on natural resources and increasing problems such as climate change reveal the importance of agricultural production and the existence of interested and sensitive people trained in this field in the coming years. It is very important for universities to be a guide in agricultural production, both in the courses and researches they give and in their efforts to increase public participation and public awareness. Sustainable agriculture on campus is characterised by a holistic approach to resource and ecosystem management. This includes practices that maintain soil health, minimise water use and reduce pollution, while supporting biodiversity and long-term agricultural productivity.

University campuses have various potentials at this point. Some universities around the world have established student-run farms that serve as living laboratories, providing hands-on experience in sustainable farming techniques and supplying fresh produce to campus dining facilities. Living labs have become popular at many universities and student-run farms are no exception. While equipping students with practical agricultural skills, these campus initiatives are also working to make operations on campus more sustainable. There is also an increasing number of academic programs that are dedicated to sustainable agriculture and which place a more interdisciplinary emphasis on their curricula, in addition to hands-on practical experiences. The programmes aim to equip students with knowledge necessary for addressing environmental issues and fostering sustainability in their future professions. Universities can influence communities for adoption of sustainable practices and foster a culture of environmental responsibility by integrating sustainability into their educational mission and operational strategies. Additionally, the Universities can inspire students to bring sustainable practices into their personal lives and thus contribute locally; this also helps promote a sustainability culture. Campus agriculture projects perceptually set students within nature and challenge assumptions of the human/nature relationship, especially around the aspect of agriculture. So, besides educational course materials, practical experience along with sustainable agronomic practices can provide a great set of options to work upon by existing experts, practitioners, and educators in the agriculture sector and contribute to sustainability.

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Both authors contributed equally to the e-book section. There is no conflict of interest.

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Contribution of Campus Green Spaces to Urban Green Spaces in the Context of Sustainable Development Goals

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1. Introduction

The global challenges associated with ensuring a favorable enhancement of living standards for forthcoming generations are considerable and complex (Sachs, et al., 2020). The world is currently facing a multitude of environmental challenges, including climate change and global warming. These developments have transformed the concept of sustainability from a relatively straightforward concern into a critical agenda item. The adoption of the 2030 Agenda for Sustainable Development by UN member states in 2015 was a major milestone in the global pursuit of sustainable development. The Agenda presents a holistic and interconnected strategy for sustainable development, addressing the interrelated aspects of 'planet, people, peace, prosperity and partnership'. Furthermore, the organization pledges to pursue sustainable development through a harmonious and balanced approach that considers environmental, social and economic sustainability in an equitable manner (UN, 2015). As the 2030 deadline for achieving the Sustainable Development Goals (SDG) approaches, there is an increasing recognition of the critical need to tackle climate change and address the interconnectedness of environmental, individual, and societal well-being. In light of these developments, it is imperative to enhance the ability of society to address these intricate challenges. Universities can make a pivotal contribution by incorporating the SDG into their curricula and underscoring them in higher education, thereby equipping students who possess the essential knowledge and skills are well-prepared to effectively tackle these urgent challenges (Sachs, et al., 2020). Given their significant societal position and primary responsibilities in generating and spreading knowledge, higher education institutions are called upon to undertake a crucial part in achieving the SDGs (Ketlhoilwe & Velempini, 2019). Owens (2017), emphasized the crucial responsibility of universities in integrating the SDGs into their fundamental operations including education, research, management and governance, and social leadership and argued that universities should adopt a more comprehensive approach to SDG integration that extends beyond mere environmental concerns in the curriculum. A growing number of universities are integrating sustainable development into their organizational frameworks, encompassing academic program, operations, research, outreach, assessment and reporting (Sachs et. al., 2020). While SDGs are applicable to all countries, they are not legally binding. Consequently, higher education institutions and all other stakeholders must collaborate collectively to achieve the SDGs. Furthermore, the SDGs are prioritized differently across various countries and world regions. This is evidenced by the manner in which countries present their progress in achieving the SDGs through voluntary national reviews. It is incumbent upon higher education institutions to recognize these differences and to determine which SDGs are most relevant to them in terms of targets and indicators (Calderon, 2021). In this regard, it is important to consider the interdependence of some SDG targets with others, as this may provide insights into the optimal approach to achieving these goals (Stafford-Smith, et al., 2017).

In considering the impact of universities on the attainment of SDGs, the concept of a 'Green Campus' also emerges as a pertinent issue. A literature review on this topic indicates that the concepts of sustainability, which include the environmental, economic, and social dimensions, and green campus development are interdependent and mutually supportive (Zhu, Zhu, & Dewancker, 2020). The campus areas of higher education institutions which encompass open public spaces and natural environments in addition to their buildings, demonstrate considerable potential with regard to environmental sustainability, both in terms of the area within their borders and the city in which they are situated. In a study conducted by Abakumov & Beresten (2023), states that this campus area in question could be designated a Green Campus, given the presence of a robust environmental infrastructure. They have identified several key components that should be included in this infrastructure, including sustainable transportation systems, waste management program, energy/heat/water saving technologies, green building principles and practices in construction, land cover monitoring, and green economy activities campuses and cities are characterized by a self-governing organization, a distinctive historical and cultural background, multipurpose infrastructure, a security force and legal system and independent communication systems. Additionally, they encompass spaces that facilitate human well-being, including parks, outdoor recreation facilities, gardens and tree-lined streets that contribute to green infrastructure (Eagan, Keniry, & Schott, 2008). Both university campuses and cities are furnished with a comprehensive infrastructure and an array of essential services. The public spaces designed for social interaction, transportation networks, energy and waste systems are comparable. Consequently, a university campus can be employed as a case study for the implementation of green systems in urban environments (Choi, Oh, Kang, & Lutzenhiser, 2017).

University campuses, which frequently encompass expansive green spaces, serve as indispensable partners in the advancement of sustainability and the prudent stewardship of these resources. The enhancement of green spaces on university campuses in order to foster sustainability is aligned with the objectives of the new global agenda (Brandli, Salvia, Rocha, & Reginatto, 2019). This study investigates the influence of green campuses on sustainability strategies, practices in their surrounding urban environments and the cities they inhabit. Specifically, it evaluates the contribution of green campuses to urban green spaces in the context of SDGs. To this end, the study comprises the following steps:

(1) This study is examined the various university sustainability assessment, ranking and rating systems in order to analyze and compare the contributions of universities to sustainable development and their sustainability efforts.

(2) The indicators of the four most widely used systems (QS-SR, GreenMetric, STARS, THE-IR) that can facilitate to the development of sustainable green spaces are selected and presented in Table 1. The indicators that express a similar measurement to the rankings were associated with certain keywords and Sustainable Development Goals (SDG). As a result, the study identified which Sustainable Development Goals (SDGs) are supported by the sustainability efforts related to green spaces at the universities. It also determined how these green space

strategies are evaluated across four different sustainability assessment tools.

(3) The 2030 Agenda for SDGs was subjected to examination, with goals and indicators that can contribute directly to the sustainability of green spaces being selected. The selected targets and indicators were interpreted in a manner that allows universities to realize them within their own scope (Table 2).

(4) Based on the THE Impact ranking (THE-IR), universities that have demonstrated success in achieving the Sustainable Development Goals were selected for further analysis. Their actions and strategies in relation to the selected targets were examined in greater detail (Table 3, 4, 5). In conclusion, the role of universities in utilizing the potential of their green spaces to encourage various local stakeholders including civil society, local authorities, governmental and commercial sectors to create sustainable urban green spaces is discussed.

2. Sustainability Assessment Tools in the Development of Sustainable Universities

Since the 1972 Declaration on the Human Environment emphasized the essential role of HEIs in advancing sustainable development, numerous declarations, charters, and policy statements have since focused on the sustainability efforts of these institutions. Some of the latest examples include, the ‘People’s Sustainability Treaty on Higher Education’, ‘United Nations Higher Education Sustainability Initiative (HESI)’, the ‘G8 University Summit: Statement of Action’ the ‘Copernicus Charter 2.0’ (Alghamdi, Heijer, & Jonge, 2017). While a number of declarations provide valuable guidance for universities on how to contribute to sustainable development, they lack specificity with regard to the steps that should be taken in each area of sustainability. To address this gap, several assessment tools have been created over the past two decades with the objective of assisting universities in the implementation and measurement of their sustainability efforts in a more effective manner (Burmann, Burmann, Guijarro, & Oliver, 2021).

Despite their widespread availability, university rankings are often the subject of criticism due to the unsystematic categories, indicators and methodologies employed in their construction. The existing literature frequently identifies a lack of clarity regarding the selection of specific evaluation methods or indicators, the validation process, the decision-makers behind the criteria, and the overall transparency and reflectiveness of the decision-making process. (Galleli, Teles, Santos, Freitas-Martins, & Junior, 2022).

It is possible to identify a number of indices that have been developed with the intention of quantifying the contribution made by HEIs to sustainable development. The most significant of these are the UI Green Metric (UI-GM), the Times Higher Education Impact Rankings (THE-IR), the QS-Sustainability Rankings (QS-SR), the Sustainability Tracking, Assessment and Rating System (STARS) and the Higher Education Sustainability Initiative (HESI).

2.1. UI GreenMetric World University Ranking

The UI GreenMetric World University Rankings (UI-GM) is an annual ranking of universities based on their green campus initiatives and environmental sustainability practices, established by the University of Indonesia in 2010. The ranking is based on a conceptual framework that encompasses environmental, economic and equity considerations. An annual sustainability survey is conducted for organizations.

The UI GreenMetric employs a six-category, 51-indicator framework to evaluate universities' policies and performance. These categories are: Setting and Infrastructure (SI), Energy and Climate Change (EC), Waste (WS), Water (WR), Transportation (TR), and Education and Research (ED). The relative importance of each category is indicated by a weighting factor (Figure 1).

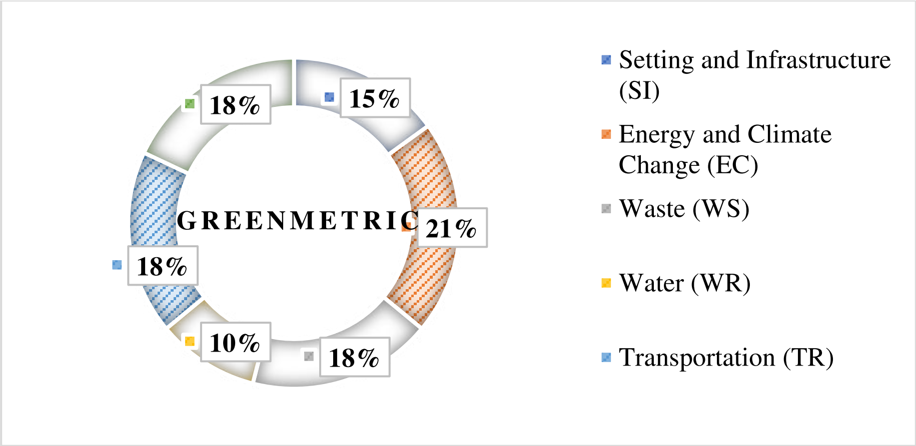

Figure 1. Main Categories and scores of UI GreenMetric (Prepared by the author)

The categories comprise a range of indicators, each designed to assess a specific aspect of a HEI' sustainability performance. A score is allocated to each indicator based on the data provided, and these scores are aggregated to obtain an overall score for the respective category. Subsequently, the surveyed institutions are ranked according to their overall total score, as well as their score for each category (Boiocchi, Ragazzi, Torretta, & Rada, 2023).

There are no conditions or fees associated with participation. The data is submitted by the institutions via an online questionnaire, and it comprises the data that they have accumulated over the preceding 12 months, in accordance with the specified data collection schedule. In some cases, evidence is required in order to verify the data that has been uploaded. As indicated in the recently published 2023 ranking, 1183 universities from 84 countries participated (GreenMetric, 2023).

Despite the assertion by UI GreenMetric that its criteria and indicators address the SDGs, the organization lacks a system for measuring the achievement of the SDGs.

2.2. Times Higher Education Impact Rankings

The Times Higher Education (THE) World University Rankings, which commenced in 2004, present a list of the globe's most esteemed universities, with a particular focus on their research capabilities. Subsequently, The Impact Rankings (THE-IR) which measures the sustainability performance of universities are started to publish in June of each year, commencing in 2019. The THE-IR is the sole global league table that assesses universities in accordance with the SDGs. The ranking employs calibrated indicators to facilitate balanced and exhaustive comparisons across four principal domains: teaching, research, outreach and governance.

THE-IR aims to THE-IR aims to evaluate how effectively universities are working towards achieving the SDGs. The ranking applies a method that combines measures of research output, ongoing metrics (such as equity data for students and staff) and an evaluation of institutional policies (including their public availability). Research metrics are taken directly from Scopus, while the other data comes from the participating universities. To be considered for inclusion in the overall ranking, universities must submit data on SDG 17 (Partnership for the Goals) and at least three other SDGs (Calderon, 2023).

SDG 17 constitutes 22% of the total score, while each of the additional SDGs accounts for 26%. This enables universities to be evaluated according to different sets of SDGs, contingent on their areas of specialization. In order to account for minor differences and ensure fairness, scores for each SDGs are normalized so that the maximum score is set at 100 and the minimum at 0. The scaled scores thus identify the areas of strongest performance for each university (THE, 2024). In the event that a metric necessitates the presentation of evidence, a series of questions is posed. A score is awarded based on the extent to which the evidence provided addresses the specified question. A score of one is awarded for a complete answer, half a score for a partial answer, and no score is awarded for an answer that does not address the question (THE, 2022).

The ranking is open to any university offering undergraduate or postgraduate education. While research activities are included in the evaluation method, there is no minimum requirement for research activity in order to participate. The free platform for submitting data is accessible via a registration process. The data may be requested for different time periods. In general, data from two years prior to the publication year of the ranking are requested. To illustrate, data up to

2019 or 2020 is accepted for the THE-IR 2022 ranking (THE, 2022). In 2024, 2152 universities from 125 countries/regions participated in the ranking, while in 2023, 1705 universities from 115 countries took part.

2.3. QS Sustainability Rankings

The Quacquarelli Symonds World University Rankings are an annual publication, initiated in 2004 by Quacquarelli Symonds Ltd., a company established in 1990 with its headquarters in London. Following the termination of its partnership with THE in 2009, QS began publishing its own rankings (Baccini, Banfi, Nicolao, & Galimberti, 2015).

The QS-Sustainability Ranking (QS-SR) has been published annually since 2022. The QS-SR is comprised of nine lenses and 53 metrics, with three distinct categories: social impact, environmental impact, and governance. The weighting of each metric and category is indicated in Figure 2.

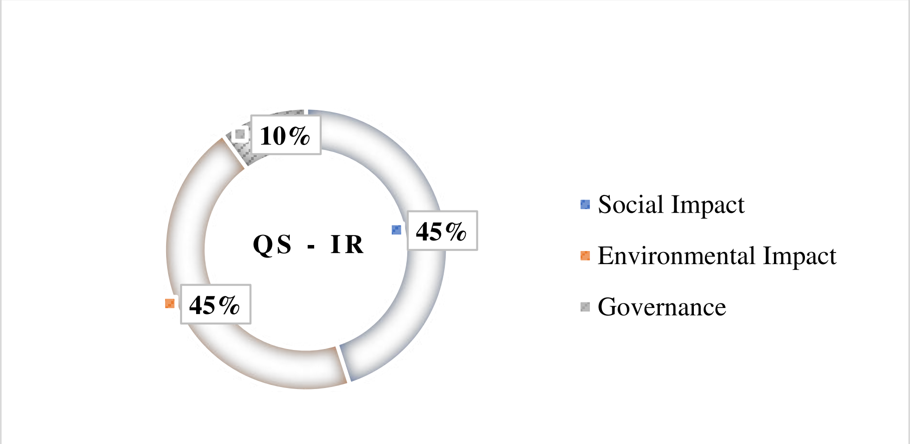

Figure 2. Main Categories and scores of QS Sustainability Ranking (Prepared by the author)

The calculation of each category and total score is based on a 100-point scale. The data is collated from a variety of sources, including bibliometric data from Elsevier's Scopus, the results of the QS academic reputation surveys and data from other external entities. Approximately 17 percent of the data is obtained directly from the universities in question (Calderon, 2023).

In order to participate in the QS - SR, universities must first qualify for the 'QS Rankings by Region, QS World University Rankings or QS Rankings by Subject.' In order to be eligible for inclusion in the rankings, institutions must demonstrate a none-zero score in the 'Research Impact on SDGs for Environmental Research' metric within the Environmental Impact category. Furthermore, institutions must attain a non-zero score in at least two of the four SDG metrics which are; (1) Research Impact on SDG for Equality, (2)Research Impact on SDG for Education, (3)Research Impact on SDG for Employment and Opportunities, (4)Research Impact on SDG for Health and Wellbeing, within the Social Impact category (QS, 2024).

It is incumbent upon institutions to upload their evidence in accordance with the various formats available on the QS HUB portal. With regard to all data provided by institutions, it is required that the academic year preceding the ranking cycle be covered. In 2023, 700 universities were included in the ranking, with approximately 1,400 universities participating in 2024 (QS, 2024).

Measures research impact on the SDGs through 5 metrics: (1) Research Impact on SDGs for Equality, (2) Research Impact on SDG for

Education, (3) Research Impact on SDG for Employment and Opportunities, (4) Research Impact of SDG for Health and Wellbeing, (5) Research Impact on SDG for Sustainable Research.

The lowest level of participation from universities in high-income countries is observed in GreenMetric (21%), in comparison to THE-IR (41%) and QS-SR (79%). QS-SR's high-income countries participation is due to research output requirements and reputation surveys, favoring elite institutions. THE-IR has broader income group representation (Calderon, 2023).

2.4. The Sustainability Tracking, Assessment & Rating System (STARS)

STARS is an optional, self-assessment framework developed for colleges and universities to evaluate their progress in sustainability (AASHE, 2024). The system was initially conceived in 2006 in response to a request from the Higher Education Associations Sustainability Consortium (HEASC) which consists of professional associations across the United States. The Association for the Advancement of Sustainability in Higher Education (AASHE) was tasked with developing a comprehensive rating system for campus sustainability. This system was subsequently developed over the period from 2006 to 2009, and its inaugural comprehensive version was released in 2010 (Calderon, 2023).

In order to participate in STARS, an institution must document its sustainability initiatives and performance, and submit a report in order to receive public recognition. Two categories of reports are available for submission: scored and unscored. A scored report necessitates a paid subscription, a cover letter from a senior executive, and undergoes a review by AASHE staff prior to publication and subsequent assignment of a Gold, Bronze, Silver, or Platinum rating. An unscored report does not necessitate a subscription, an executive cover letter, or an AASHE staff review and is designated a STARS Reporter. An unscored report can be submitted on an annual basis for the purpose of updating information without affecting the existing rating (AASHE, 2024).

The total score awarded to an institution reflects the percentage of points achieved in the four categories of assessment: 'Academics', 'Engagement', 'Operations', and 'Planning & Administration'. (Figure 3).

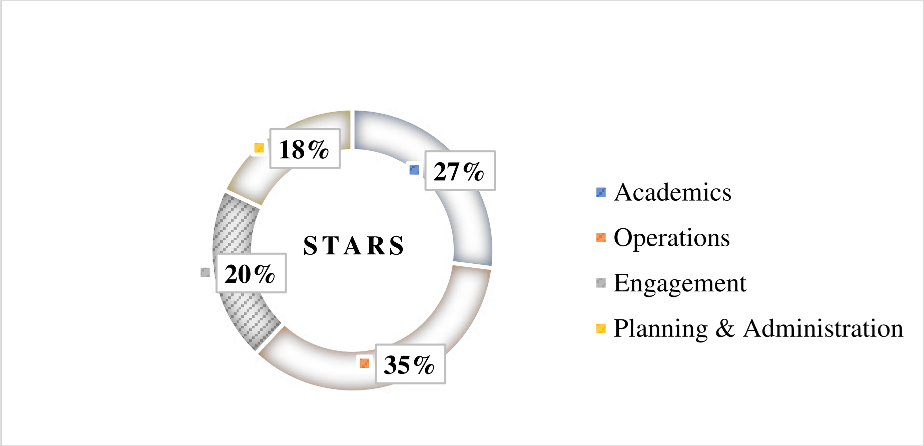

Figure 3. Main Categories and scores of STARS (Prepared by the author)

In addition, institutions may receive up to 10 supplementary points for exemplary "Innovation & Leadership" initiatives, which are incorporated into their cumulative score. According to AASHE (2024), because higher education fulfills a crucial function in advancing sustainability through teaching, research, and public engagement, STARS credits in these areas are particularly important for measuring global impact. Institutions can also use SDG targets to guide their STARS reporting.

2.5. The Higher Education Sustainability Initiative (HESI)

The Higher Education Sustainability Initiative (HESI) is a collaborative partnership between various United Nations entities and the higher education community, established in preparation for the United Nations Conference on Sustainable Development (Rio+20 in 2012). HESI is presently led by the United Nations Department of Economic and Social Affairs (UN DESA) and SULITEST (*an online multiple choice assessment tool aimed at evaluating and enhancing the knowledge of students, faculty and staff regarding sustainability issues*). Additional UN collaborators encompass 'the UN Environment Program', 'the UN Global Compact's Principles for Responsible Management Education initiative', 'UNCTAD', 'the UN University', 'UNESCO', 'UN-HABITAT', 'UNITAR' and 'the UN Office for Partnerships' (HESI, 2022).

Annually, HESI convenes a global forum as a distinctive event in conjunction with the High-level Political Forum on Sustainable Development (HLPF), the principal platform of the United Nations for monitoring and evaluating the 2030 Agenda for Sustainable Development on a global scale. The objective of this forum is to underscore the pivotal function of higher education in the pursuit of sustainable development. On an annual basis, the HESI organization establishes Action Groups with the objective of addressing themes that are associated with higher education and sustainable development. These groups leverage the collective expertise of the HESI community, which typically includes multiple organizations and contributors. The findings are subsequently made available on the HESI website and disseminated throughout the network. In 2024, the designated Action Groups focus on the following themes: ‘The Future of Higher Education and Artificial Intelligence’, ‘The University Leaders Group, the Student Action Group: rankings, ratings, and assessments’, ‘Education for Green Jobs’ and the ‘SDG Publishers Compact’ (HESI, 2022).

HESI is supporter the 'International Green Gown Awards' which acknowledge outstanding sustainability initiatives implemented by universities and colleges globally (HESI, n.d.). The International Green Gown Awards, in collaboration with Allianz Global Investors and supported by the UN Environment Program, are open to all universities and colleges worldwide, with no entry fee required. The application consists of 2 stages. In the first stage, the details of the project and the university to be submitted for the specific categories, as well as the selection of an SDG target that the project meets, are submitted online via Google Forms. Categories set for 2024: 'Creating Impact', '2030 Climate Action', 'Benefitting Society', 'Nature Positive', 'Diversity, Equity & Inclusion in Sustainability', 'Next Generation Learning & Skills', 'Sustainability Institution of the Year', 'Student Engagement'. In Stage 2, the jury members' questions about the application in Stage 1 are answered (Green Gown Awards, n.d.).

This paper describes the categories and indicators of university sustainability assessment, ranking and rating systems, including STARS, UI GreenMetric, QS-SR and THE-IR, in the context of green campus. Table 1 shows the indicators that are directly related to the planning, transformation, protection and sustainability of green spaces.

Table 1. Indicators related to sustainability of green spaces (QS, 2024), (GreenMetric, 2024), (AASHE, 2024), (THE, 2024)

Sustainability Assessments, Rating, Ranking Systems	Indicators
QS-SR	▪ Member of an officially recognized sustainable group ▪ Climate change commitment (staff perception) ▪ Publicly available strategy or policy on sustainable procurement and investment ▪ Student Society focused on Environmental Sustainability ▪ Renewables Generated Onsite ▪ Academic Reputation in Earth & Environment ▪ Alumni Impact for Environmental Sustainability – Public and Third Sector ▪ Climate Science and/or Sustainability Courses ▪ Research Impact on SDG for Sustainable Research ▪ Sustainable Research National Statistics ▪ Research Center with an Environmental Sustainability Focus ▪ Policy Citations (Environmental) ▪ Dedicated staff / team for Sustainable Development
UI GREENMETRIC	▪ Total area on campus occupied by cultivated vegetation ▪ The proportion of sustainability courses to the total number of courses/subjects ▪ University-run sustainability website ▪ Sustainability report ▪ Count of sustainability-related community service initiatives arranged and/or participated in by students ▪ Number of sustainability-related startups

	▪ Number of events related to sustainability ▪ Number of scholarly publications on sustainability ▪ University waste management program focused on Reduce, Reuse, and Recycle (3R) principles ▪ Organic, inorganic and toxic waste treatment
STARS	▪ Proportion of academic departments offering sustainability courses ▪ Published sustainability course listings ▪ Assistance for academic staff in incorporating sustainability into the curriculum ▪ Programs for applied sustainability learning ▪ Sustainability outreach and communications ▪ Proportion of campus stakeholders engaged through sustainability outreach and communications ▪ Student sustainability organization ▪ Staff sustainability network or engagement program ▪ Sustainability-focused staff training ▪ Proportion of employees involved in sustainability activities ▪ Water use systems designed for water recovery and reuse ▪ Organic landscaping and grounds maintenance services ▪ Proportion of ecologically managed green areas relative to the total green areas managed ▪ Waste Generation and Recovery.
THE- IR	▪ SDG 4 (Quality Education), ▪ SDG 7 (Affordable and Clean Energy), ▪ SDG 11 (Sustainable Cities and Communities), ▪ SDG 12 (Responsible Consumption and Production), ▪ SDG 13 (Climate Action), ▪ SDG 15 (Life on Land).

As illustrated in the table, the indicators associated with the sustainability of green areas of campuses in the analyzed rankings are grouped under the following keywords: 'education and research', 'community engagement', 'energy, waste and water management', and 'biodiversity and ecosystem services'. These keywords are then matched with the SDG they can influence: 'education and research' and SDG 4 (Quality Education), 'Community Engagements' and SDG 11 (Sustainable Cities and Communities), 'Energy, Waste and Water Management' and SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 7 (Affordable and Clean Energy), 'Biodiversity and Ecosystem services' and SDG 15 (Life on Land). In matching these, SDG that could be directly related to the keywords were matched, with due consideration for the fact that SDG are also interconnected.

3. Sustainable University Campuses and Urban Green Spaces

The involvement of HEIs in SDGs offers a number of advantages, including the formation of new partnerships, access to additional funding opportunities and a growing demand for education that is focused on the SDG. Furthermore, this engagement contributes to the definition of higher education institutions as responsible and globally conscious institutions. Kestin, et al., (2017) set out five steps to enhance the involvement of universities with SDGs. These are:

- An assessment of the current activities of universities.
- The development of capacity and the fostering of a sense of ownership for the SDGs.
- The determination of priorities, opportunities and gaps.
- The incorporation and implementation of the SDGs into university strategies, policies and plans.
- The monitoring, evaluation and communication of the actions taken by universities regarding the SDGs.

Universities have gained the trust of various stakeholders as a result of their long history of conducting thorough research and engaging with the community. This trust makes them ideal partners for addressing environmental issues, affording them a distinct advantage in achieving the SDGs (El-Jardali & Fadlallah, 2018). Consequently, universities are well positioned to incorporate sustainable development and global goals into their operational activities and strategic planning.

Universities can advance the incorporation of SDGs by focusing on local and regional sustainability projects. It is stated that 65% of the Sustainable Development Goals agenda cannot be fully realized without the participation of urban and local actors (Catalyst & Adelphi, 2015). Therefore, it is essential for local governments to actively participate in the execution of the 2030 Agenda.

Among the 232 indicators of the 2030 Agenda's 17 goals and 169 targets, a number of concrete indicators were identified that can be related to the planning and execution of sustainable green spaces. Based on these indicators, a series of targets that can contribute to the development, protection and planning of sustainable green areas are proposed in Table 2.

Table 2. Determined indicators for sustainable green spaces (prepared by the author based on UNSD, 2024)

Underlying Targets of the 2030 Agenda for Sustainable Development	**Recommended Indicators for Sustainable Green Areas**
4.7, 4.7.1, 12.8, 13.3.1	• Facilitating the acquisition of knowledge and skills among students, educators, and society to advance sustainable development • Providing education in global citizenship
7., 7.2.1	• Production, development and application of clean and renewable energy technologies. • Enhance the ratio of renewable energy in total final energy consumption.
11.3, 11.4, 11.7	• Planning inclusive, participatory, sustainable, accessible and safe public green spaces.
11.6, 11.6.1	• Reducing the negative environmental impact of cities per capita, with emphasis on waste management, including air quality. • Solid waste management, removal of hazardous waste from the soil, enriching the soil by recycling organic waste.
13.1, 13.2, 13.3	• Strengthening resilience and adaptive capacity to climate-related hazards and natural disasters. • Incorporation of climate change measures into planning processes • Training and awareness raising on climate change alleviation, adjustment and early warning systems
15.	• Preventing the loss of ecosystem and biodiversity by protecting natural habitats in green space planning.

The role of university campuses in advancing and practicing sustainability is of great importance, particularly given their often-extensive green spaces. Such green areas serve as exemplars of sustainable practices, offering students and faculty the opportunity to engage with and learn about these practices in a first-hand manner. By optimizing these green spaces, universities can enhance the ecological health and aesthetic value of their campuses, while also providing tangible benefits such as improved air quality, biodiversity conservation, and climate regulation. Furthermore, the dedication to the sustainable utilization of green spaces is in accordance with the objectives of the recently established global agenda, particularly the SDGs. By incorporating sustainability into the planning and operations of their campuses, universities demonstrate their commitment to the responsible management of natural resources. This can encourage similar practices in surrounding communities and contribute to broader regional and national sustainability initiatives (Brandli, Salvia, Rocha, & Reginatto, 2019).

To understand the strategies and policies of universities that are successful in sustainability rankings, this study examines the examples of Western Sydney University, Manchester University and Queen's University through a literature review. Universities were selected if they were in the top five of The Impact rankings between 2024 and 2019, were located on different continents, had urban campuses, and had large green areas on their campuses. The data obtained by examining the sustainability reports, websites and related documents of the universities are presented in the tables (Tables 3, 4, 5).

3.1. Western Sydney University

Western Sydney University operates a number of campuses across Greater Western Sydney, each of which offers a distinctive environment and a range of facilities. The Parramatta and Parramatta City campuses are situated in contrasting settings. The former is located within a heritage parkland setting, while the latter is situated in an urban central location. The Penrith campus, situated at the base of the Blue Mountains, encompasses an area of 158 hectares and includes the communities of Kingswood and Werrington. proximity to Richmond and the Blue Mountains.

Figure 4. Bankstown City Campus of Western Sydney University (Walker Corporation website)

The Bankstown campus is notable for its integration of university buildings with native gardens (Figure 4). The Liverpool City campus is a contemporary facility that offers a range of amenities, while the Campbelltown campus provides convenient access to the Southern Highlands and Canberra. The largest campus, the Hawkesbury campus, encompasses 1,300 hectares and is situated in close. All campuses are linked by complimentary shuttle services to local transport hubs.

Table 3. The key sustainability initiatives undertaken by the Western Sydney University (Western Sydney University, 2023)

SDG	**Western Sydney University**
SDG 4: Quality Education	• Education for Sustainability (EfS) guide: It is a comprehensive sustainability teaching and learning guide for academics and staff in schools. • 'The Creativity and Cultural Wellbeing for Communities' subject on communities and sustainable living practices. • 'Venture Makersan' program supports an entrepreneurial culture that is aligned to the SDG. • Learning experiences that include travel to various countries, particularly in the Indo-Pacific region. • Western supports its candidates to further develop specific SDG aspects of their PhD projects.
SDG 7: Affordable and Clean Energy	• In 2023, the university purchased 100% of its electricity from recognized renewable sources, achieving zero carbon electricity footprint (scope 2 emissions). • The Bankstown City campus earned 6 Star Green Star certification (*issued by Green Building Council Australia*) with water management system. • The university has several Green Star-rated buildings, which adhere to high standards of energy efficiency.
SDG 11: Sustainable Cities and Communities	• Sustainability courses open to all. • Membership in international university associations where sustainability and social responsibility projects are carried out. • Founding member of "Urban Innovation and Entrepreneurship

	competition" which has a specific focus on the Sustainable Development 2030 agenda. • Urban Transformations Research Centre (UTRC) which works on solutions for destructive climate-change related impacts on urban environments.
SDG 12: Responsible Consumption and Production	• Western decarbonizes its endowment funds and benefit from Mercer's (*an international consultancy organization*) Net Zero target and pathway.
SDG 13: Climate Action	• Climate Positive by 2029 and Carbon Neutral by 2023. (Western Joined the United Nations-led 'Race to Zero for Universities and Colleges) • Western has pilot target of Carbon Positive by 2025 for Hawkesbury campus. • Certified by Climate Active (*it is an Australian government program*) as Carbon Neutral for business operations in 2022. • Australasian Campuses Universities Towards Sustainability (ACTS) Green Gown Award in the 'Climate Action' category. • Bronze member of the NSW Government's Sustainability Advantage program (*the program assisting organizations to become sustainability leaders through*). • Planting 15,000 native plants to help reduce temperatures on the Hawkesbury campus. • Smart Irrigation Management for Parks and Cool Towns (SIMPaCT) research project that addresses climate change impacts, specifically urban overheating. (*it manages the irrigation of Bicentennial Park at Sydney Olympic Park*). • 'The Hawkesbury Institute for the Environment' conducts research on climate changes. • Western is a core partner in the NSW (New South Wales) Decarbonization Hub.
SDG 15: Life on Land	• Conservation of endangered bushland on campus. • Biodiversity and habitat restoration projects.

Western Sydney University's initiatives are aligned with SDGs, with a particular focus on entrepreneurial skills and international experience in relation to SDG 4, notable achievements in renewable energy in the context of SDG 7, an emphasis on innovation and entrepreneurship in the context of SDG 11, a prioritization of sustainable finance and food justice in the context of SDG 12, a proactive approach with ambitious short-term goals and specific projects in the context of SDG 13, and a prioritization of habitat restoration in the context of SDG 15.

3.2. University of Manchester

The University of Manchester's central campus, located in Manchester, England, serves as a vibrant hub for academic and research activities. Although the university is primarily based at this single campus, it also encompasses a diverse array of buildings and facilities across the wider area.

Figure 5. The University of Manchester's main campus, Gilbert Square (The University of Manchester Website)

The campus comprises a combination of historic and contemporary architectural styles, including the renowned John Rylands Library, the Whitworth Art Gallery, and the Manchester Museum. The campus houses a number of faculties and departments, including those specialising in science, engineering, and the humanities. These are equipped with cutting-edge facilities and resources. The campus's central location provides convenient access to the city's cultural, social, and commercial opportunities, thereby enhancing the student experience. Furthermore, the campus offers modern student accommodation and a comprehensive range of recreational facilities, fostering a vibrant and interactive academic environment.

Table 4. The key sustainability initiatives undertaken by the University of Manchester (Manchester T. U., 2023), (Manchester T. U., 2024)

SDG	**University of Manchester**
SDG 4: Quality Education	• Courses are offered to promote inclusive, sustainable, and equitable education. • The university has over 600 academics focused on sustainable energy challenges. • Various study programs, including units on renewable energy and clean technology, educate students on energy generation technologies. • ‘The Manchester Energy and Environment Society, established by students, seeks to increase awareness of issues related to the energy and environment sector among university students and public. • Global Development Institute conducts interdisciplinary research and international co-operation on the biggest challenges the world faces. • University Living Lab: Engages students in real-world sustainability projects linked to the UN SDG. • Sustainable Cities MOOC course that educates a large number of students worldwide on urbanization and sustainability. • Over 4,500 student engagements with units on SDG 13, with 97 direct and 18 indirect courses related to climate action.

	• The University's environmental sustainability engagement program that asks students to take sustainable actions.
SDG 7: Affordable and Clean Energy	• Environmental and Green Chemistry unit: Chemistry undergraduates learn about advancing cleaner chemical reactions and alternative fuels. • The university has a policy on divesting from carbon-intensive industries. • The Department of Electrical and Electronic Engineering carries out studies to manage the electricity network more sustainable. • Ensured 100% of electricity consumption is backed by Renewable Energy Guarantees of Origin (REGO) certification (*issued by International Energy Agency)* since 2021.
SDG 11: Sustainable Cities and Communities	• The Urban Living Labs approach employs partnerships to tackle location-specific challenges by experimenting with various types of sustainable infrastructure. • The 'Clean Air for Schools program', which measures and analyses the clean air quality of schools, was implemented.
SDG 12: Responsible Consumption and Production	• Sustainability, Consumption and Global Responsibilities unit, exploring responses to sustainability challenges by consumers, businesses, and governments. • UOM (University of Manchester) has implemented strategies to reduce waste and promote recycling on campus. • UOM has initiatives to tackle food waste, including partnerships with local food banks and charities to redistribute surplus food. • UOM emphasizes sustainable procurement practices, ensuring that goods and services purchased support ethical and environmental standards. • UOM prioritizes suppliers who demonstrate strong sustainability credentials.
SDG 13: Climate Action	• Net Zero Pledge: Commitment to promote Manchester's climate change target of zero carbon by 2038. • Fossil Fuel Divestment: Ending investments in fossil fuel reserve and extraction companies by 2022 and decarbonizing all investments by 2038. • The university is a collaborator in Grow Green, a partnership aimed at enhancing urban livability, sustainability, and business prospects through greener city initiatives
SDG 15: Life on Land	• Manchester Museum Vivarium is dedicated to the conservation of reptiles and amphibians. • In 2022, existing biodiversity survey was carried out on the main campus

The University of Manchester has extensive initiatives aligned with the Sustainable Development Goals. For SDG 4, it offers a wide range of specialized courses and practical engagement opportunities. In SDG 7, it achieves notable milestones in renewable energy use and excels in practical implementation and certification. For SDG 11, it emphasizes community engagement and practical research. The university leads in SDG 12 with comprehensive waste management and sustainable procurement practices. In SDG 13, Manchester focuses on long-term goals and community-based solutions. For SDG 15, it excels in biodiversity research and conservation efforts.

3.3. Queen’s University

Queen's University, situated in Kingston, Ontario, is primarily administered from its main campus, which features a harmonious blend of historic and modern architectural styles and offers a picturesque view of Lake Ontario (Figure 6).

Figure 6. Queen’s University (Queen’s Gazette website)

The central campus encompasses a multitude of academic buildings, research facilities, libraries (such as Stauffer Library) and student amenities. It also offers a comprehensive range of student services, including on-campus residences, dining facilities and health services, as well as recreational amenities such as the Athletics and Recreation Centre. Cultural and community resources, such as the Agnes Etherington Art Centre and the Queen's University Archives, further enrich the campus environment, enhancing the academic and student experience.

Table 5. The key sustainability initiatives undertaken by the University of Queen’s (University Q. , 2023)

SDG	Queen’s University
SDG 4: Quality Education	• Queen's integrates interdisciplinary sustainability studies into various programs. • Queen's initiatives provide practical educational experiences through projects integrated into coursework within the green industry. • University Biological Station (QUBS) facilitates education and research in biology and related fields, aiming to preserve local land and water ecosystems and their biodiversity. • The Sustainable Living Series educates the public on sustainability, including energy efficiency.
SDG 7: Affordable and Clean Energy	• The Queen’s Centre for Energy and Power Electronics Research specializes in advancing energy-efficient power electronic technologies. • The Institute for Energy and Environmental Policy (QIEEP) conducts research that informs and supports government policies related to energy efficiency and sustainability. • Environmental Management Policy exceeds environmental legislation obligations and includes energy efficiency standards for building renovations and new constructions. • Several campus buildings, including the School of Kinesiology and Goodes Hall, are LEED and LEED Gold certified. • Master of Earth and Energy Resources Leadership program provides education on natural resource management and sustainable energy engineering.

	• The Queen's Solar Design Team builds autonomous homes for research and education on sustainable living and solar energy. • The Conservation and Demand Management Plan details specific strategies for enhancing the energy efficiency of buildings and outlines plans for generating renewable energy.
SDG 11: Sustainable Cities and Communities	• University Campus Master Plan aligns with the City of Kingston's vision and policies to ensure mutual benefits from planning decisions. • Institute for Sustainable Finance (ISF) collaborates with private and public sectors to advance sustainable finance initiatives in Canada • Student-led sustainability conferences that engage the community on sustainability issues. • Snodgrass Arboretum: Established to recognize unique tree species, this arboretum offers self-guided tours on campus. • The School of Urban and Regional Planning partners with public and private organizations to address the challenges of rapidly evolving urban environments.
SDG 12: Responsible Consumption and Production	• The Conservation and Demand Management Plan implements building standards and policies to reduce water usage, energy consumption, and greenhouse gas emissions. • The Open Plastic project develops microbiological technology to break down plastic waste into recycled products. • Initiatives that encourage the reduction of single-use waste by offering financial incentives. • The Waste Audit Report identifies ways to improve waste diversion and recycling, and the Waste Wizard app helps users determine proper disposal methods. • Mindful Move-Out: This initiative helps students sustainably donate, trade, and recycle items during move-out. • The Procurement Policy ensures that products and services are acquired ethically and sustainably.
SDG 13: Climate Action	• Queen's Climate Action Plan: Aims to decrease greenhouse gas emissions and attain carbon neutrality by 2040. • Queen's is a member of the University Climate Change Coalition and the Matariki Network of Universities, to advance sustainability and climate action globally. • The Dunin-Deshpande Queen's Innovation Centre offers incubation programs for startups focusing on low-carbon technologies.
SDG 15: Life on Land	• The Queen's University Phytotron (a *phytotron is a controlled research greenhouse designed for studying the interactions between plants and their environment) offers* facilities for plant research and other biological applications. • Queen's University promotes sustainable use of campus land through its Campus Master Plan, which includes guidelines for the

	conservation and restoration of ecosystems associated with the university.

Queen's University has implemented a series of comprehensive initiatives that are aligned with the SDG. With regard to SDG 4, the program places particular emphasis on interdisciplinary and experiential learning. In relation to SDG 7, the institution provides a complementary approach to clean energy initiatives through the integration of advanced research in energy technologies. In regard to SDG 11, the institution employs a balanced approach that integrates planning, finance, and public education. With regard to SDG 12, the emphasis is on the practical reduction of waste and the dissemination of information to the general public. With regard to SDG 13, the institution's approach is characterized by a commitment to pioneering research and international collaboration. In the context of SDG 15, the program combines research with sustainable land-use planning.

3.4. Results of the Analysis

Three universities- Western Sydney University, the University of Manchester and Queen's University - have extensive initiatives aligned with the Sustainable Development Goals.

In regard to SDG 4, it is notable that all three universities have made efforts to integrate sustainability into their curricula. However, the University of Manchester has distinguished itself by offering a comprehensive range of specialized courses and practical engagement opportunities, which sets it apart from the other institutions. Western Sydney University places greater emphasis on the development of entrepreneurial skills and international experience, whereas Queen's

University places greater emphasis on interdisciplinary and experiential learning.

In relation to SDG 7, Western Sydney University and Manchester have achieved significant milestones in the utilization of renewable energy sources. Queen's University enhances its clean energy initiatives with advanced research in energy technologies. While Manchester and Western excel in practical implementation and certification, Queen's University provides a robust research component.

In regard to SDG 11, Western Sydney University places significant emphasis on innovation and entrepreneurship, whereas the University of Manchester places greater emphasis on community engagement and practical research. Queen's University presents a balanced approach that integrates planning, finance and public education. The distinctive methodologies employed by each university contribute to enhancement of sustainable urban development, with particular strengths evident in the areas of innovation (Western), community engagement (Manchester), and comprehensive planning (Queen's).

In relation to SDG 12, the University of Manchester is a prominent institution in the area of comprehensive waste management and sustainable procurement practices. Western Sydney University has a notable focus on sustainable finance and food justice, while Queen's University places significant emphasis on practical waste reduction and public education. Manchester's comprehensive policies serve as an exemplar for comprehensive sustainability practices, whereas the other two universities offer more targeted initiatives.

In regard to SDG 13, Western Sydney University has adopted a proactive stance, setting forth ambitious short-term objectives and delineating specific projects. In contrast, Manchester University has placed its emphasis on long-term goals and community-based solutions. Queen's University has showcased its dedication to climate action through pioneering research and international collaboration. Each university has exhibited a profound dedication to climate action, with varying timelines and focal points.

In regard to SDG 15, Manchester University is a leading institution in the fields of biodiversity research and conservation. Western Sydney University places a significant emphasis on habitat restoration, while Queen's University integrates research with sustainable land-use planning. The University of Manchester's prominence in conservation research and Western Sydney University's practical restoration initiatives are complemented by Queen's University's comprehensive planning approach.

In conclusion, the green space activities of these universities contribute to urban green spaces in a number of ways:

- Western Sydney University's biodiversity and habitat restoration projects serve to enhance the resilience and ecological diversity of local green spaces. The introduction of native species contributes to the reduction of urban heat islands and the enhancement of air quality.
- The University of Manchester's nature-based solutions to climate change, exemplified by the Grow Green Project, provide scalable

models for urban areas to integrate green spaces that provide ecosystem services and enhance urban resilience.

- Queen's University's sustainable campus land use and conservation efforts serve as a model for urban green space management, promoting biodiversity and ecological health in urban environments. The Phytotron's research can inform urban horticulture and green infrastructure projects, ensuring that urban areas benefit from advanced plant science research.

In addition to improving the green spaces on their campuses, universities offer invaluable insights and methodologies that can be applied to the development of urban green areas, contributing to the creation of cities that are healthier and more sustainable.

4. Conclusion and Suggestions

The role of university green spaces in enhancing urban sustainability is of great importance. They function as microcosms for sustainable practices that can be scaled to larger urban settings, thus contributing to the enhancement of sustainable urban development. Such spaces contribute to environmental sustainability in multiple ways. They promote biodiversity, conservation, and habitat restoration, and they also serve as living labs for research and education. The incorporation of green spaces within academic institutions, as exemplified by initiatives at Western Sydney University, the University of Manchester, and Queen's University, illustrates their capacity to serve as drivers for broader urban sustainability initiatives. These institutions are at the vanguard of the field, exemplifying the deployment of green infrastructure, nature-based solutions and sustainable land use as means of addressing urban challenges such as climate change, loss of biodiversity and pollution.

The contribution of university green spaces extends beyond their immediate environment. They provide vital ecosystem services, enhance the urban green infrastructure, and offer models for sustainable urban planning and development. By aligning their green space initiatives with the Sustainable Development Goals, universities can exert a considerable influence on urban areas, thereby enhancing urban resilience, sustainability, and inclusivity.

In conclusion, it is crucial to underscore the significance of collaboration, sustainable practices, interdisciplinary research and community engagement in order to enhance the influence of university green spaces on urban green spaces.

- It would be beneficial for universities to form partnerships with local authorities, businesses and community groups with a view to sharing resources and encouraging wider participation in sustainability efforts.
- It is recommended that proven models of green space initiatives be extended and adapted to urban areas through the dissemination of knowledge through publications and events.
- The encouragement of interdisciplinary research can facilitate the resolution of complex sustainability issues, while the implementation of regular monitoring can ensure the effectiveness of these initiatives.
- Furthermore, the involvement of the local community can be enhanced through the implementation of educational programs and

participatory planning initiatives. Ultimately, universities should promote policies that facilitate sustainable urban development, encompassing green infrastructure and conservation practices, and leverage their research to inform policymaking.

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Towards a Sustainable and Green IZTECH Campus: A Rainwater Harvesting Best Management Practice in İzmir, Türkiye

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1. Introduction

Due to climate change long-term droughts and urban floods caused by increasingly heavy rains have been experienced in many places around the world. The Mediterranean Basin, where Türkiye is also located, is among the regions expected to be most affected by climate change. Unfortunately, Türkiye faces the prospect of becoming a water poor country by 2050.

Throughout the World, many universities undertake a crucial role in promoting the issues of climate change adaptation and resilience. Universities that aim at sustainability principles as places that contribute to society stand out from others by differentiating their corporate identity; and that can use their campus settings as a living laboratory where research and studies on these issues to be carried out play a leading role in society in producing creative solutions.

1.1. Climate Change, Water Resources and IZTECH

This study discusses the case of Izmir Institute of Technology (IZTECH) in climate change adaptation and water resources, and aims at presenting a Best Management Practice in IZTECH Campus as a pioneering example to other University Campuses in Türkiye.

IZTECH has also joined the universities that aim to raise awareness on issues such as being a green and climate-friendly campus in our country. As a result of its efforts, “Izmir Institute of Technology (IYTE) has succeeded in becoming the 153rd best university in the world in the International GreenMetric 2023 ranking, which evaluates universities in areas such as sustainability, education and research” (URL-1, 2023).

It is located in a natural setting in the Cesme-Karaburun Peninsula near the Gulbahce Village to the west of Izmir city center (Türkiye) since the beginning of 2000 (Figure 2), in the mostly arid eastern Aegean Sea region where water stress has become a significant issue. According to Izmir Water Report 2024, "the annual amount of usable water per person in Izmir is around 1,000 m^3. This amount, which indicates water scarcity, reveals the importance of water management in Izmir".

IZTECH conducts research, education and engagement in the water resources arena and also hosts exemplary rainwater harvesting Best Management Practices (BMPs). IZTECH already offers an Interdisciplinary Graduate Program on International Water Resources and is a part of WATER4ALL, a program co-funded by Marie Skłodowska-Curie Action (MSCA), "to equip doctoral candidates in water arena with a distinctive combination of research skills...The program aspires to produce the water experts of the future while driving innovation in the field of sustainable water management" (https://water4all.iyte.edu.tr).

Having aimed at becoming sustainable and green, IZTECH established a Green Campus Coordinatorship. There are implementations of production of green energy through a wind turbine in the Campus, planting native vegetation in its Campus, retrofitting existing buildings with energy saving devices and water-efficient fixtures and equipments, installing PV panels on the roof of the swimming pool, reducing use of potable water by recycling treated wastewater of the Campus for non-potable uses such as landscape irrigation. The construction of Green Infrastructure BMPs in IZTECH are also another step in making it more sustainable and resilient which has been visited by different groups as an exemplary project in Izmir and which helps setting a positive example through leadership in demonstrating innovative solutions to campus environmental concerns.

1.2. Nature Based Solutions and Green Infrastructures

As settlements develop, soil is covered with asphalt, concrete, and buildings; and natural vegetation is removed. These impervious surfaces do not allow water to infiltrate into the ground when it rains; and rainfall runs off these impervious surfaces, causes floods on streets, increases erosion, increases the rate of runoff, picks up pollutants such as automobile oil and herbicides that create non-point source pollution (NPS) and carries them into receiving waters. Traditionally most settlements have dealt with increased runoff from impervious surfaces through the use of “grey infrastructure,” including concrete channels and pipes which treats stormwater runoff as waste and removes it as quickly as possible in order to reduce flooding. This grey infrastructure prevents infiltration and creates dangerous runoff, maximizes flooding downstream, destroys wildlife habitat, does not address water quality issues, and serves only one function at high cost (Watershed Management Group, 2012).

As an alternative to conventional rainwater collection systems, innovative systems called Green Infrastructure (GI) as Nature based Solutions (NbSs), which aim to minimize the difference between pre- and post-construction surface runoff, have been widely used to tackle the climate change related issues in both arid and wet regions throughout the World.

GI addresses the issue of NPS through bioretention, the use of vegetation and soils to clean stormwater runoff (Figure 1).

The Environmental Planning Agency of the US describes Green Infrastructure as "Green Infrastructure refers to a set of practices that mimic natural processes to retain and use stormwater. By promoting infiltration, evapotranspiration, and harvesting throughout the landscape, green infrastructure preserves and restores the natural water balance. Though many green infrastructure practices were first developed and applied in temperate regions, green infrastructure is perhaps even more relevant in arid and semi-arid climates. Communities, researchers, and design professionals in these water-limited regions are increasingly recognizing green infrastructure as a cost-effective approach not only to stormwater management, but to water conservation as well" (EPA, 2010, p.2). Furthermore, "Green infrastructure (GI) refers to constructed features that use living, natural systems to provide environmental services, such as capturing, cleaning, and infiltrating stormwater; creating wildlife habitat; shading and cooling streets and buildings; and calming traffic" (Water Management Group, 2016, p.4). In these implementations, GI reduces and treats stormwater at its source. To do this soil and vegetation are used to infiltrate and filtrate the rainwater; impermeable surfaces are reduced and rainwater is soaked into the soil, captured and stored to be reused to serve different purposes.

"Blue and Green infrastructure (BGI) is a very effective tool for effectively managing the water flow through the urban watershed as it allows for retention and infiltration on various scales, and thereby increases resilience to drought as well as to urban flooding in case of cloudbursts; it bears greatpotential to slow downstream rainwater flows and consequently reduce peaks (Rambol, 2016, p.128)."

These facilities, also commonly called Low Impact Development (LID) Techniques or Stormwater Best Management Practices (BMPs), are briefly as follows: collecting and storing rainwater above or below ground, rain gardens, bioswales, stormwater retention areas, reducing impermeable surfaces, returning channelized streams to their natural state, use of local and native plants with low water consumption and the use of effective irrigation techniques (Figure 1) (EPA, 2000; CNT, 2010).

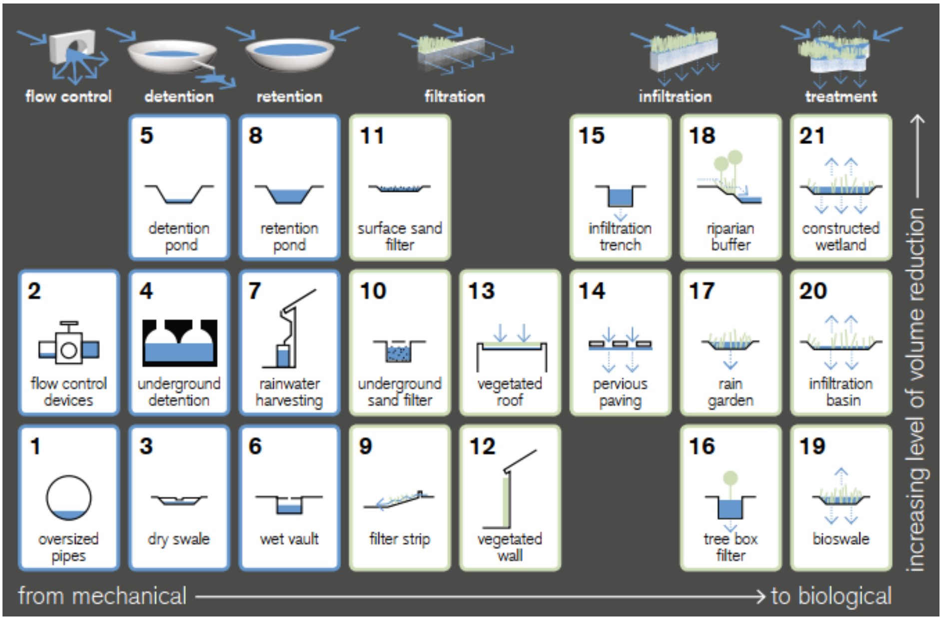


Figure 1. LID Facilities (University of Arkansas Community Design Center, 2010, p. 142)

2. Material and Method

This is a descriptive study which introduces and discusses a stormwater Best Management Practice near the Department of General Culture building in IZTECH Campus (Figure 3 and 4). To do so it discusses the

GI/NbS concepts first, characteristics of IZTECH campus, implementation process including testing soil conditions, design of green infrastructure facilities, construction process, main actors and discussion of the results. Finally, the study concludes with recommendations to make the IZTECH Campus more compatible with the natural environment in which it is located, in an environmentally responsible manner, to support the natural water cycle and reduce use of fresh water which is getting drastically limited in the region.

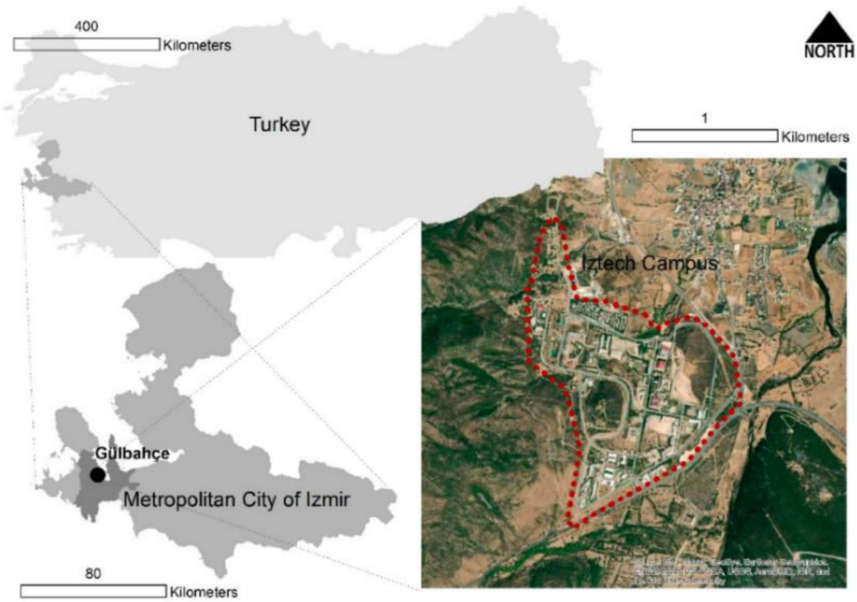


Figure 2. Location of IZTECH Campus (Salata,S., Couch, V., 2022)

Figure 3. IZTECH Campus Site Plan and location of the General Culture Building (Modified from Couch et al., 2023, p.11)

Figure 4. The General Culture Building and the BMPs

Google Earth Image dated 10.16.2023

3. Findings and Discussion

Since the area where IZTECH is located has become increasingly dry due to climate change, this study reviews Nature Based Solutions that considers rainwater as a non-renewable water source, and discusses realization process of Green Infrastructure Best Management Practices (BMPs) including rainwater harvesting as a way to tackle water stress in IZTECH campus.

3.1. IZTECH Campus

IZTECH Campus covers approximately 8,600 acres, 32 acres of which is the built up area which is dedicated to education and research. The built-up area of the Campus is constructed on the eastern slope of a rocky mountain which was covered with mostly maquis and some wild olive trees, both very common vegetation in the Aegean Region (Couch et al, 2023). Short streams flow through the campus after rain mostly between the months of October and May. During the summer, the campus experiences high temperatures, long term drought, and wildfires around and within the Campus of which the most recent one took place on June 8th, 2024 in the Campus.

Unfortunately the effects of climate change are observed in the region. As the temperatures are rising "The Eastern Mediterranean region is highly vulnerable to climate change and experiences effects such as increased drought, flash flooding, and loss of biodiversity... With climate change, the summer temperatures in this region are increasing, and there are long periods of drought coupled with less frequent but more intense rain events" (Couch et al, 2023, p.2).

3.2. Nature Based Solutions/Green Infrastructure Best Management Practice in Izmir Institute of Technology Campus

A rain garden, a bioswale and two water tanks for rainwater harvesting from a rooftop are the implemented BMPs in IZTECH Campus. Below, these techniques are defined in detail.

A rain garden (or bioretention cell) is a planted depression designed to infiltrate stormwater runoff, but not hold it. A rain garden is commonly known as a bioretention facility. Stormwater pollutant mitigation is accomplished through phytoremediation processes as runoff passes through the plant and soil community (Figure 5).

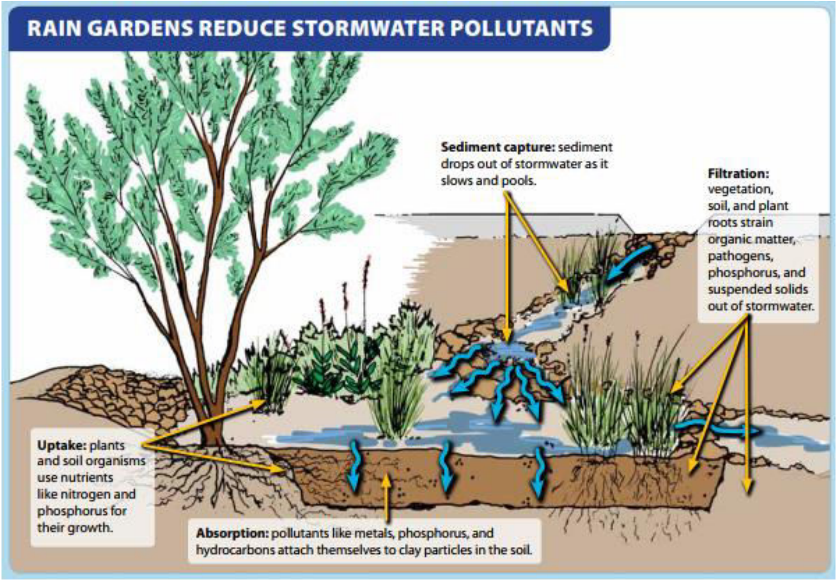


Figure 5. Conceptual Section of a Raingarden

(Watershed Management Group, 2016, p.19)

Rain gardens combine layers of organic sandy soil for infiltration, and mulch to promote microbial activity. Native plants are recommended based upon their intrinsic synergies with local climate, soil, and moisture conditions without the use of fertilizers and chemicals. Rain gardens are best applied on a relatively small scale. They work well along driveways and in low lying areas of a property (University of Arkansas Community Design Center, 2010, p.178).

A bioswale is an open, gently sloped, vegetated channel designed for treatment and conveyance of stormwater runoff. Bioswale is a bioretention device in which pollutant mitigation occurs through phytoremediation by facultative vegetation. Bioswales combine treatment and conveyance services, reducing land development costs by eliminating the need for costly conventional conveyance systems. The main function of a bioswale is to treat stormwater runoff as it is conveyed, whereas the main function of a rain garden is to treat stormwater runoff as it is infiltrated. Bioswales are usually located along roads, drives, or parking lots where the contributing acreage is less than five acres (University of Arkansas Community Design Center, 2010, p.182) (Figure 6).

As linear features, they are particularly well suited to being placed along streets, sidewalks and parking lots. A dry swale, or grassed swale, is an open grassed conveyance channel that filters, attenuates, and detains stormwater runoff as it moves downstream (University of Arkansas Community Design Center, 2010, p.150). Bioswales are vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another. Vegetated swales slow, infiltrate, and filter stormwater flows. Use of drought tolerant native planting (indigenous species) is also an approach to landscaping that uses naturally grown plants unique to the locale. If native plants grow under local conditions, they don‘t need support.

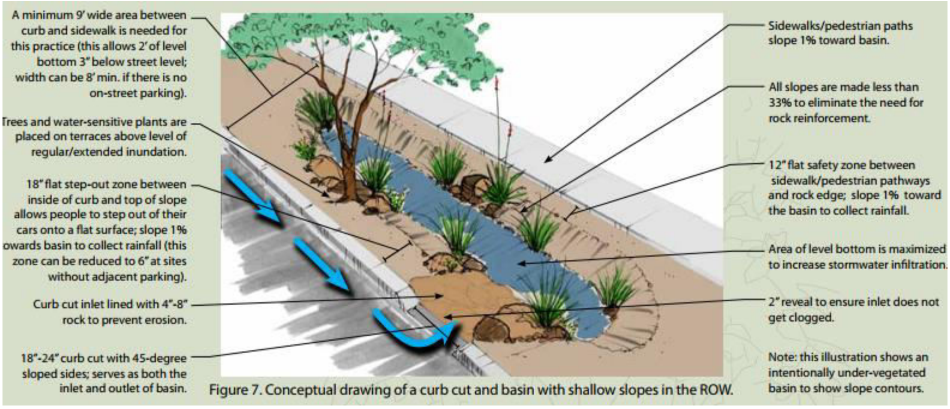


Figure 6. Conceptual Drawing of Bioswale

(Watershed Management Group, 2016, p.45)

Rainwater harvesting involves collection, storage, and reuse of runoff from roofs which reduces runoff volume and peak flows (University of Arkansas Community Design Center, 2010, p.158). It could be implemented both on the surface using rain barrels or beneath ground using cisterns. This practice is particularly valuable in arid regions, where it could reduce demands on increasingly limited water supplies.

3.3. The Design and Implementation Process

Main actors in the process were IZTECH President's Office Rainwater Harvesting Working Group made of academics from different disciplines including Department of City and Regional Planning, Department of Architecture, Department of Environmental Engineering; University's Office of Construction Works and Campus Landscape architect; Izmir Metropolitan Municipality Water Resources Research and Implementation Center (IMWRRIC) team (Please see the Acknowledgement in the end); and Urla Rotary Club that focused on raising public awareness on limited water resources in the year of 2022.

The design of the green infrastructure facilities (rain garden, bioswale and rainwater tanks) have been carried out mainly by the Izmir Metropolitan Municipality Water Resources Research and Implementation Center team led by Alim Murathan, also overseen by Dr. Nicel Saygin from IZTECH.

Here the preliminary works, soil analysis, design of the green infrastructure facilities, and construction process is described (Figure 14 and Figure 15).

3.3.1. Preliminary Works

The process started in March 2022 including several meetings on reviewing exemplary cases, discussions of alternative places where the project would take place and in what scale, which green infrastructure facilities would be used and so on. At the end of long discussions, the Department of General Culture Building and particularly its rooftop was chosen for collecting rainwater to be stored.

3.3.2. Soil Analysis

IZTECH Campus has mostly clay soil which has a very low infiltration rate.For the implementation of GI facilities, a soil leakage test was carried out in the area and based on the results, permeable sandy soil was added. We had to specially design our green infrastructure/NbS using “engineered soils”, which have particular ratios of added materials like sand (30% topsoil, 30% turf, 40% sand), which more easily absorbs water than clay.

3.3.3. Design of the green infrastructure facilities

Firstly, two 3-ton polyethylene tanks are installed to collect rainwater from the 235 m² General Culture Department Building rooftop which are connected to a raingarden. The annual potential rainwater amount in the project is calculated as approximately 118 m³. During extremely heavy rains, the water overflowing from the tanks is directed to the nearby rain garden. The harvested rainwater from the roof is used for open space irrigation with the help of the hydrophore connected to the tanks (Figure 7).

Based on values of roof area, roof coefficient and capacity of the water tank, and monthly rain 142,8 (mm); potential rain capacity is calculated as 7.14m^3 and expected rainwater to be harvested monthly is 5.710,39 liters (Table 1).

Table 1. Monthly potential rain volume to be harvested

	Database		
Roof Area (m2)	50		
Roof Coefficient	0,8		
Water Tank Capacity (m3)	6		
	Monthly Rain (mm)	**Potential Capacity (m3)**	**Expected Rainwater to be Harvested (lt)**
	142,8	7,14	5.710,39

IMWRRIC

Secondly, a four-meter-wide rain garden was also implemented in an area of 12 m² in the open space adjacent to the General Culture Building. It is made of layers of 25 cm deep creek rocks, topped by 20 cm deep plant soil mix, and topped by a 5 cm deep mulch mix to keep the soil moist (Figure 8).

Figure 7. Two Rooftop Rainwater Storage Tanks and Connection to the Rain Garden

It stores 4.45 m³ of water and leaks/seeps it into the ground with the rain garden and leakage ditch application is planned according to 2 years and 24 hours of rainfall falling on 73 m² of the total roof area. During extremely heavy rains, the water overflowing from the tanks is connected and directed to the nearby rain garden facility (Figure 10) (URL-2, 2023).

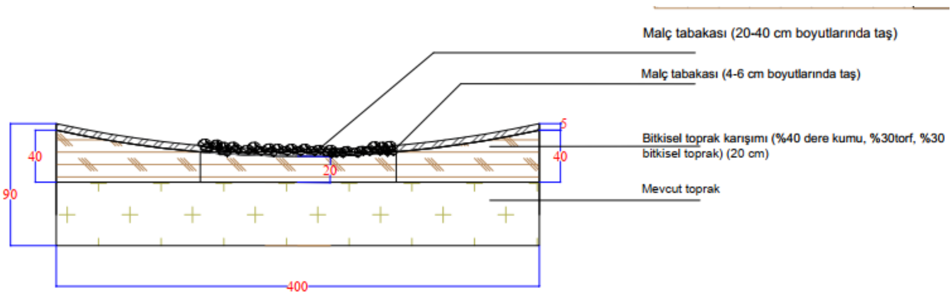


Figure 8. Raingarden Section by IMWRRIC

Table 2. Calculations of Raingarden Harvesting

INFILTRATION SIZING CALCULATOR – İYTE RAINGARDEN			
24 Hour Rain			
24 Hour Rainfall Depth =	61	millimeter	
Drainage Surface Area =	100	square meters	
Drainage Area Runoff Coefficient =	0,9		
Soil Infiltration Rate Below Garden =	16	millimeter / hour	
Desired Maximum Ponding Depth =	300	millimeter	
Facility Surface Area =	12	square meters	
CALCUALTED DESIGN CRITERIA – RAIN GARDENS			Rainfall Distribution
Maximum Ponding Depth in Rain Garden =			5,96 inches
Depth of Water Left in Rain Garden After 30 Hours =			0,00 inches
Is Rain Garden Area Adequately Sized?			DOĞRU

IMWRRIC

Thirdly, a nearby concrete drainage channel has also been renaturalized by removing the concrete and converted into a bioswale which allows stormwater to infiltrate into the soil and the groundwater aquifers underneath. This three-meter-wide and 126 m² bioswale is made of a meandering natural drainage path within a linear channel with layers of creek stones with a drainage pipe at the bottom, 20 cm deep plant soil mix, 35 cm swale is topped with a layer of mulch to keep the soil moist (Figure 9). In order to create more water storage volume in the area with a 6% slope, a gravel bed was created, and in order to slow down the water flow rate, meandering curves were created in the direction of flow and supported with large stones. It is aimed to provide up to 35m3 of water daily to the groundwater with the rain garden and biological ditch planned by calculating the rainwater falling on the 625m2 basin area.

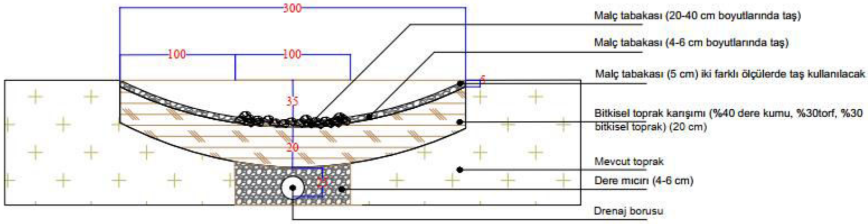


Figure 9. Bioswale Section by IMWRRIC

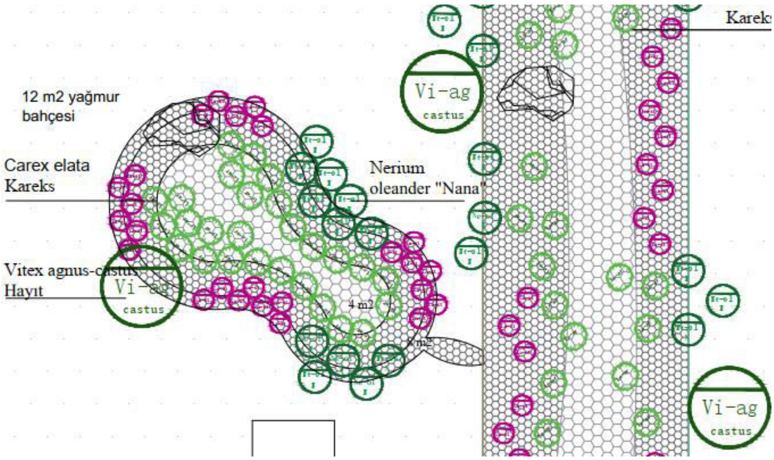
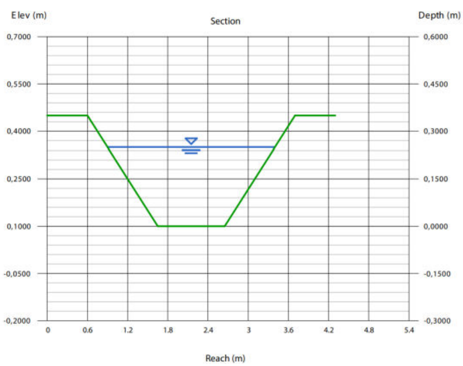


Figure 10. Partial Site Plan showing the raingarden and its connection to the bioswale by IMWRRIC



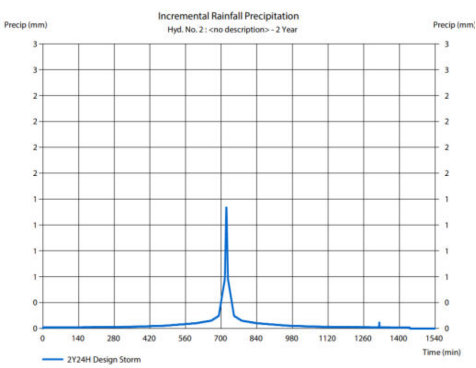


Figure 11. Bioswale Section IMWRRIC

Figure 12. Rainfall Precipitation IMWRRIC

Table 3. IZTECH Bioswale Project Dataset

İYTE BIOSWALE PROJECT

Trapezoidal		Highlighted	
Bottom Width (m)	= 1,0000	Depth (m)	= 0,2500
Side Slopes (z:1)	= 3,0000, 3,0000	Q (cms)	= 0,9474
Total Depth (m)	= 0,3500	Area (sqm)	= 0,4375
Invert Elev (m)	= 0,1000	Velocity (m/s)	= 2,1654
Slope (%)	= 2,0000	Wetted Perim (m)	= 2,5811
N-Value	= 0,020	Crit Depth, Yc (m)	= 0,3292
		Top Width (m)	= 2,5000
Calculations		EGL (m)	= 0,4892
Compute by:	Known Depth		
Known Depth (m)	= 0,2500		

IMWRRIC

Table 4. IZTECH Bioswale Watershed Analysis Values

Hiyetograf Raporu

SU KAYNAKLARI ARAŞTIRMA VE UYGULAMA MERKEZİ

IZTECH BIOSWALE REPORT

WATERSHED ANALYSIS

Hydrograph type	= Runoff	Peak discharge	= 0,010 cms
Storm frequency	= 2 yrs	Time to peak	= 722 min
Time interval	= 1 min	Hyd. volume	= 31,1 cum
Drainage area	= 0,060 hectare	Curve number	= 98*
Basin Slope	= 6,0 %	Hydraulic length	= 42 m
Tc method	= User	Time of conc. (Tc)	= 3,00 min
Total precip.	= 61,10 mm	Distribution	= Custom - Izmir
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(0,019 x 98) + (0,040 x 98)] / 0,060

IMWRRIC

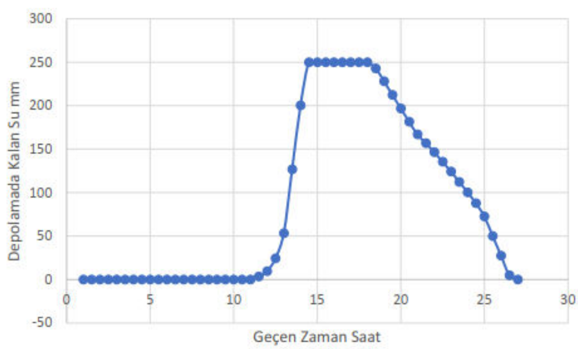


Figure 13. Bioswale Storage Graphic by IMWRRIC

Plants that have been used both in the rain garden and the bioswale, which are native to the area and more resilient to drought, include: Lavandula stoechas (karabas otu), nerium oleander (kısa boylu zakkum),Vitex agnus-castus (hayıt), and leymus arenarius (leymus) (Table 5).

Table 5. Vegetation Used in the Rain garden and the Bioswale

Bitki Sembolü	Bitki Adı	Birimi	Miktarı
Vi-ag castus	Vitex agnus-castus Hayıt	Adet	13
Ne-ol N	Nerium oleander Nana Kısa boylu zakkum	Adet	50
la-st	Lavandula stoechas Karabaş otu	Adet	132
Le-ar	Leymus arenarius Leymus	Adet	240
Yapısal sembol	**Malzemenin Adı**	**Birimi**	**Miktarı**
	Dere mıcırı (5-10cm)(4m2*0.05m)	m3	4,7
	Dere mıcırı (15-30cm)(8m2*0.05m)	m3	1,6
	Karışım toprak (%40 dere kumu, %30 torf, %30 bitkisel toprak) (126m2*0,20 cm)	m3	25.2
	Yıkanmış kırma taş	m3	5,25
	Drenaj borusu 3-4cm)(42*0.50*0.25m)	m	42
	Mevcut toprak		

Bioswale

Bitki Sembolü	Bitki Adı	Birimi	Miktarı
Vi-ag castus	Vitex agnus-castus Hayıt	Adet	1
Ne-ol N	Nerium oleander Nana Kısa boylu zakkum	Adet	12
la-st	Lavandula stoechas Karabaş otu	Adet	24
Le-ar	Leymus arenarius Leymus	Adet	27
Yapısal sembol	**Malzemenin Adı**	**Birimi**	**Miktarı**
	Dere mıcırı (5-10cm)(4m2*0.05m)	m3	0,2
	Dere mıcırı (15-30)(8m2*0.05m)	m3	0,4
	Karışım toprak (%40 dere kumu, %30 torf, %30 bitkisel toprak) 0,35 cm	m3	4,2
	Yıkanmış kırma taş	m3	0,5
	Drenaj borusu 3-4cm)(4*0.50*0.25m)		
	Mevcut toprak		

Rain garden

(Izmir Metropolitan Municipality Water Resources Research and Implementation Center-IMWRRIC)

The construction process

The construction works started in September 2022 and was completed towards the end of October 2022. First, the concrete was removed off the drainage channel, then design of the raingarden and bioswale were drawn on the soil and ditches were digged. Lastly, layers of 25 cm creek rocks, topped by 20 cm plant soil mix, and topped by a 5 cm mulch were placed mix to keep the soil moist and vegetation are planted (Figure 15).

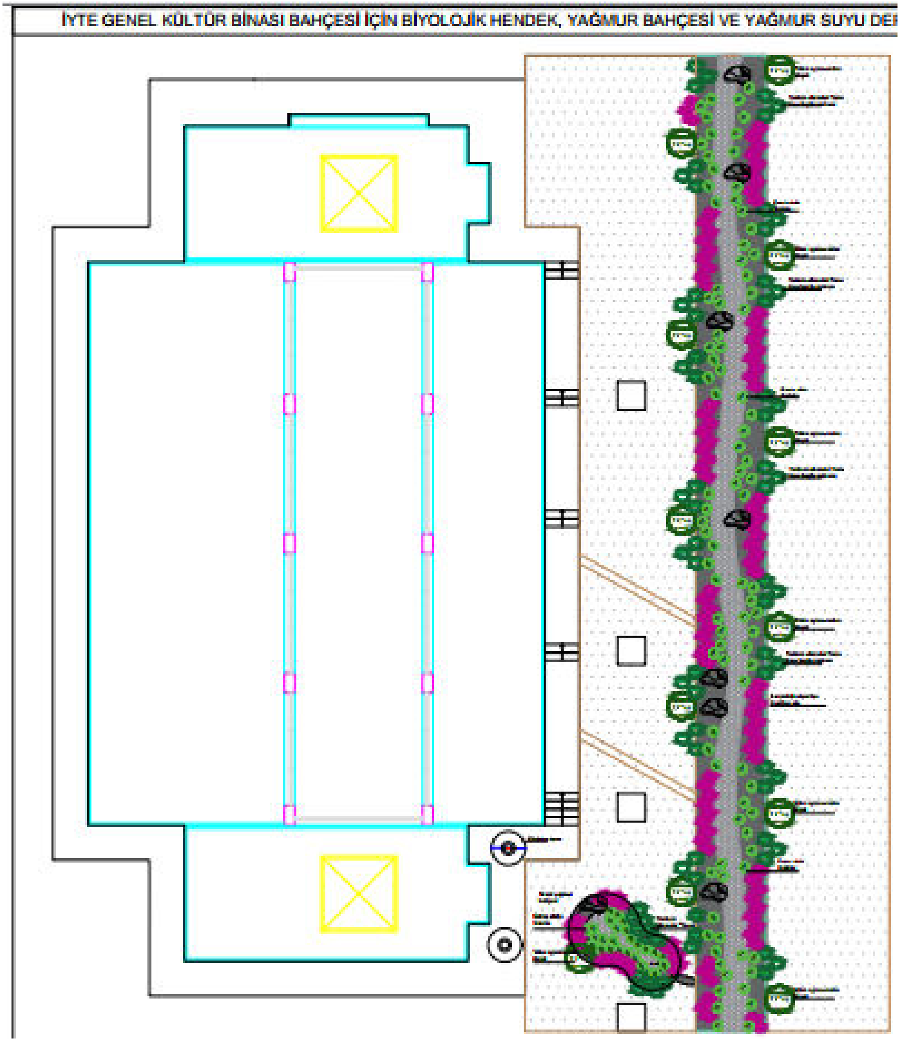


Figure 14. Site Plan of the Rainwater Harvesting Best Management Practices in IZTECH Campus by IMWRRIC

a.Area before the implementation 07.19.2022

b.Removal of the concrete drainage 09.20.2022

c.Preparations for the implementation 09.24.2022

d.Placement of rocks and the vegetation 10.08.2022

e.System in place 10.08.2022

f. GI Facilities view from south 10.08.2022

g. Installation of the Information Panel 01.10.2023

h.Tanks are full and vegetation is growing 05.20.2024

Figure 15. Construction Process (All photos are taken by the author)

An information panel was also placed in the demonstrative GI Best Management Practice area introducing the rainwater storage tanks, raingarden and the bioswale and providing information on how the system works (Figure 16). Since the construction, there have been some obstacles such as intervention of wildlife from the natural setting of the Campus multiple times.

Figure 16. Information Panel in Detail by IMWRRIC

4. Conclusion and Suggestions

In this study, the implementation of Green Infrastructure rainwater harvesting facilities in IZTECH Campus as an exemplary best management practice is presented. These facilities provide multiple benefits of reducing stormwater runoff and flooding, reducing expensive gray infrastructure construction and water treatment needs, improving water quality, increasing groundwater recharge, reducing fresh water use, increasing biodiversity and providing cooling effect. The rooftop rainwater collected in the tanks have been used for landscape irrigation purposes which reduced the use of diminishing fresh water resources.

The Green Infrastructure BMPs in IZTECH have been visited by different groups as an exemplary project and set a positive example through leadership in demonstrating innovative solutions to environmental concerns.

The recommendations put forward here aim to make the IZTECH Campus more compatible with the natural environment in which it is located, in an environmentally responsible manner, to support the natural water cycle by feeding the ground aquifers and cause a decrease in potable water consumption.

For example, future work might include directing stormwater runoff from an adjacent sloped concrete roadway. In the beginning of a pedestrian path towards the Dormitories, located next to the Stormwater Best Management Practices (in front of the basement entrance of the General Culture building), the impermeable concrete surface and excessive water accumulation occurs due to the slope from the access road which seriously hinder a highly used pedestrian passage as it is seen in Figure 17 below.

The Construction Works of the University installed drain grates to the right of the GI demonstration area where surface runoff accumulates but it doesn't help much as it is seen in the photo. It is possible to eliminate the problem here with a simple solution such as making cuts in the curb stones and convey the runoff to reach the Green Infrastructure BMPs. Thus, the stormwater that runs off on he slopedroadwill be directed to the adjacent permeable soil surface, thus returned to the natural water cycle, and the heavily used path will be provided for pedestrian use.

Figure 17. Stormwater runoff accumulation near the BMPs

(by the author)

Additionally, de-paving the parking areas and making them permeable could be easily carried out throughout the Campus. More practical solution would be retrofitting existing parking lots by GI practices such as incorporating a bioretention basin (bioswale) at the end of the parking area or in between rows of parked cars to provide water infiltration such as in Figure 18. Another recommendation is not planting artificial grass which results in constant water consumption. Instead of artifical grass, surface covering native species that are tolerant to the drought and more resilient should be used. Implementing these and more nature based solutions will bring a holistic experience to IZTECH Campus in terms of raising awareness on innovative stormwater runoff solutions and set an inspiring model for other campuses as well as cities.

Figure 18. University of Arizona retrofit in a parking lot (Watershed Management Group, 2016 p.35)

Since the city of Izmir experiences water stress, green infrastructure practices such as the ones (rain garden, bioswale and rooftop rainwater harvesting) constructed in IZTECH Campus would set beneficial cases to be replicated throughout the city where surfaces are completely sealed off and urban floods occur when it rains.

Acknowledgements and Information Note

The article complies with national and international research and publication ethics.

Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

There is no conflict of interest.

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