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THE IMPORTANCE OF SMART CAMPUSES IN THE CONTEXT OF BOYD COHEN WHEEL AND SUSTAINABLE ENVIRONMENTAL DIMENSION

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Keywords	Abstract
<i>Aksaray University, Smart Campus, Smart City, Sustainability.</i>	The global climate change and the elements of the increasing consumption have led to the risk of emerging environmental deformation in cities. In light of these parameters, it is the matter that campuses, which are a core component of cities, are also affected. Today, universities prefer to use the Boyd Cohen Wheel to develop their campuses in terms of the sustainable environment as in cities. Because campuses are small-scale cities in terms of many ways, studies to be conducted in these areas can set a model for smart cities as well. There are also several approaches in literature and practice related to the process of conversion to smart campuses. This study aims to examine the idea of 'smart campus' and its relationship with 'smart city' by focusing on examples from Aksaray University. In this context, approaches to a sustainable environment in university campuses are discussed.

AKILLI KAMPÜSLERİN BOYD COHEN ÇEMBERİ VE SÜRDÜRÜLEBİLİR ÇEVRE BOYUTU BAĞLAMINDAKİ ÖNEMİ

Anahtar Kelimeler	Öz
<i>Aksaray Üniversitesi, Akıllı Kampüs, Akıllı Şehir, Sürdürülebilirlik.</i>	Artan nüfus değişimleri, küçük ve büyük ölçekli şehirleri etkilemektedir. Özellikle, bina yapımı ve yerleşimlerde, konfor, enerji verimliliği, atık kontrolü, çevreye uyum ve yüksek teknoloji artık temel ihtiyaçlar arasına girmiştir. Küresel iklim değişikliği ve artan tüketim unsurları, şehirlerde çevresel deformasyon oluşması riskini de beraberinde getirmiştir. Bu parametreler ışığında kentlerin temel bir bileşeni olan kampüslerin de etkilenmesi söz konusudur. Günümüzde üniversiteler kampüslerini kentlerdeki gibi sürdürülebilir çevre açısından geliştirmek için Boyd Cohen Çemberini' kullanmayı tercih etmişlerdir. Kampüsler birçok yönden küçük ölçekli şehirler olup bu alanlarda yapılacak çalışmalar potansiyel olarak akıllı şehirlere de örnek oluşturabilir. Akıllı kampüslere dönüşüm süreci ile ilgili literatürde ve uygulamada çeşitli yaklaşımlar da bulunmaktadır. Bu çalışma mevcut literatürün 'akıllı kampüs' kavramını nasıl kapsadığını ve 'akıllı şehir' ile ilişkisini Aksaray Üniversitesi Kampüsünden örneklerle incelemeyi hedeflemektedir. Bu kapsamda, üniversite yerleşkelerinde, katı atık ve su yönetimi, ulaşım, aydınlatma ve enerji verimliliğinin artırılması hususlarında yaklaşımlar tartışılmıştır.

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1. Introduction

The population of cities is growing by factors such as birth and migration; therefore, “the proportion of the population living in cities, which is 54% in 2015, is expected to rise to 60% by 2030 and 66% by 2050” (Villegas-Ch et al., 2019; Swilling et al., 2018). With this unstoppable growth, consumption is increasing and many environmental concerns are emerging in individuals. The environmental concerns that cities will face today and in the future can be outlined as follows: Population growth, climate change and global warming, health, declining resources, pollution, increased energy requirement, and the need for communication. The negative effects of rapid consumption of ecological resources due to the global growth and increasing population have paved the way for many cities to be smart cities in the world (Barcelona, Singapore, Copenhagen, etc.) (Bi et al., 2017; Huang et al., 2015; Yang, 2015). The rapid population growth, especially in large cities, leads to many problems. These problems adversely affect the economic and social life in the cities, as well as reduce the life quality of the city residents and reduce the brand and competitiveness power of the cities. At this point, since it has the potential to generate rational solutions for urban problems, the Smart Cities approach emerges as an important project implemented by countries and international organizations. Technological developments in recent years also lead to a technological transformation in our lives (Jiayu et al., 2019; Kayapınar Kaya et al., 2019). So much so that, technology affects almost all areas of our lives and surrounds us, consciously or unwittingly. Both because of this technological change and because of the sustainable environment phenomenon, the campuses that are an indispensable part of the cities also receive their share from this change (Gorgulu and Kocabey, 2020; Fortes et al., 2019; Bhatia, 2018; Ferraris et al., in press; Koç, 2014). Campuses have always been home to growth, production, innovation, and awareness due to their dynamic structures. The “smart campus” was first introduced in the early 2000s (Vasileva et al., 2018). Smart campuses should be well designed in addition to their environmental and rational dimensions. With a holistic approach, the smart campus should be created as a mixed, compact, well-connected, well-structured, living, green campus in an urbanized environment (Figure 1).

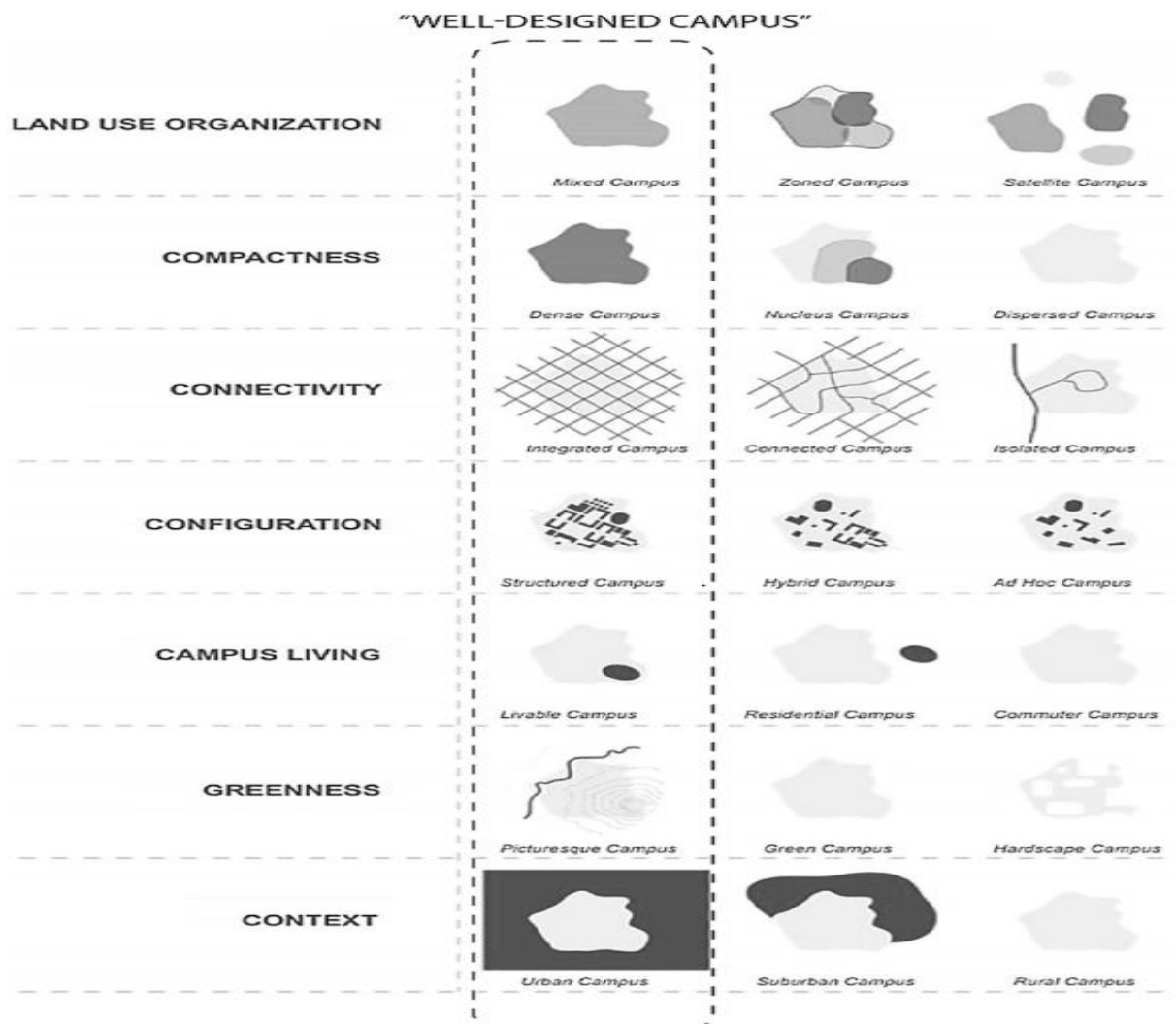


Figure 1. Campus form dimensions (Hajrasouliha, 2017).

Universities are the most important areas that contribute to the development of a modern lifestyle in societies through sustainable and ecological studies. Therefore, sustainable university, sustainable and ecological campus practices have become a rapidly growing trend worldwide. “The sustainable and ecological campus” concept can be expressed as campuses that are environmentally sensitive, minimize energy consumption, have effective waste management, use nature-friendly products and materials, and contribute to sustainable development. With the sustainable and ecological campus applications, the university will be able to stand on its own feet economically, resist global climate change and environmental problems, and perform social responsibility tasks by raising awareness of the community. In this study, which is about smart campus and smart city parameters, the concept of ‘smart city’ is discussed first and then applications in Aksaray University (ASU) campus are examined within the context of the ‘smart campus’ concept.

2. Boyd Cohen Wheel and The Components of Smart Cities

While the definition of a smart city is made in the world and Turkey according to a wide variety of commissions and unions, the concept of smart city incorporates some concepts such as sustainable city, connected city, the competitive city, brand city, digital city, livable city, ecological city, green city, and low carbon city (de Souza et al., 2020; General Directorate of Geographic Information Systems, 2019; Guerrieri et al., 2019; Ardito et al., 2019). A smart city is expressed as a sustainable city where technological facilities and data are utilized at the most advanced level in order to improve the life quality of its inhabitants and to use the resources effectively and efficiently, and where all the individuals of the city are integrated with the city management (Neirotti et al., 2014). The smart city is founded on two key criteria (sustainability and communication). With its easy-to-follow fiction, Boyd Cohen's Smart City Wheel has the potential to inspire new projects for smart cities. According to this approach, which is also adopted by the European Union, smart cities consist of 6 components (Figure 2): smart mobility/transportation, living, governance, environment, economy, and people (General Directorate of Geographic Information Systems, 2019; Cohen, 2018; Gasco-Hernandez, 2018; Yaqoob et al., 2017; Yoshida et al., 2017; Liu, 2015). Since these components are applications that feed and develop each other, handling of these components in a holistic way through a systematic approach in smart city design will increase the effectiveness in practice.



Re-designed by Manuchis.

Figure 2. Boyd Cohen's Smart City Wheel (General Directorate of Geographic Information Systems, 2019).

As the interest in sustainable campuses has increased, sustainable international indexes have begun to be used as well. These are the Green League, Environmental and Social Responsibility Index, Green Star, and GreenMetric assessment methods (Puertas and Marti, 2019; Özdoğan and Civelekoğlu, 2019; Ragazzi et al., 2017; Suwartha et

al., 2013). Among these, the most widely used and the first in sustainable campus applications is the GreenMetric ranking model (Marrone et al., 2018). Among the main reasons for the emergence of the GreenMetric ranking model, there are many factors such as increased environmental issues (water pollution, soil and air pollution, etc.), rapid depletion of non-renewable energy sources, drought resulting from global warming, decrease of biodiversity, changes in seasons and climate, deterioration of ecological balance, etc. In the GreenMetric model put into practice by the University of Indonesia in 2010, green measurement categories and indicators were developed to ensure that higher education institutions were environmentally conscious and sustainable. This model, consisting of 6 main categories and 53 indicators in total, was structured to include issues of environmental and ecological sensitivity, economics, and teaching (Table 1). The indicators were campus placement, substructure, energy and global warming, waste and water management, ecologic transportation opportunities, and teaching, respectively (Kayapınar Kaya et al., 2019). Through this model, it was aimed to raise awareness among university administrators and employees on issues such as “global warming”, “energy”, “water management and saving”, “waste recycling”, and “green transportation and environment”. In campus, by applying some practices such as “saving energy”, “greenhouse gas emission reduction and adaptation policy”, “in-campus carbon footprint rate”, “Green and smart building applications”, and “energy-efficient equipment usage”, which are under the main category of “energy and climate change”, universities aim to reduce the factors that can cause global warming.

3. Smart Campus and Aksaray University

There are many index studies published in the context of Smart Campus. However, not all of the studies conducted touches on all the components of the Smart Campus (Figure 3). Generally, universities around the world and in our country have focused on the GreenMetric model, intelligent environment, and life components within the scope of Boyd Cohen's Smart City Wheel. In addition, there is a wide variety and new research about Smart Campus in the literature (de Souza et al., 2020; Guerrieri et al., 2019; Ardito et al., 2019; Ampudia-Renuncio et al., 2018; Gasco-Hernandez, 2018; Yoshida et al., 2017; Alvarez-Campana et al., 2017; Yaqoob et al., 2017; Liu, 2015; Wu and Yin, 2015).

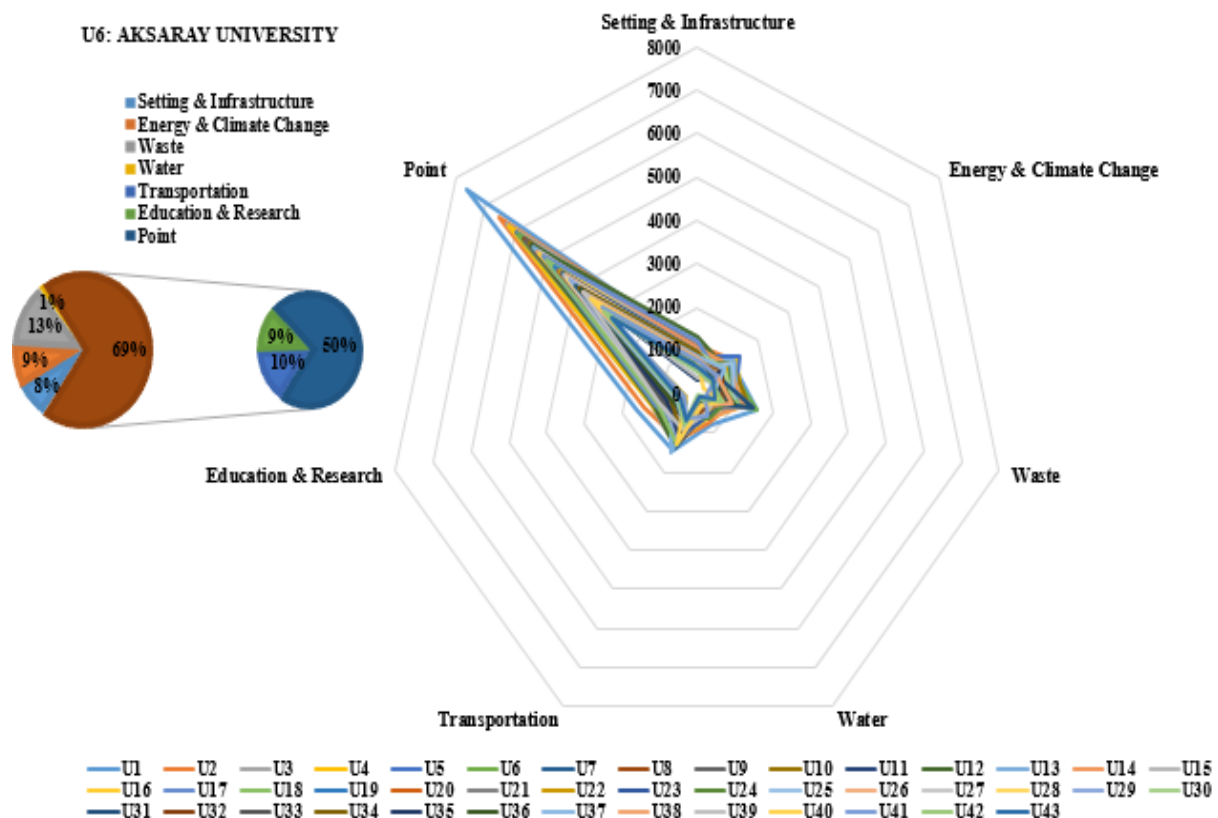


Figure 3. Six-factor GreenMetric model rating of ASU campus

3.1. Water Management and Saving

It is clearly mentioned on international platforms that water scarcity will be one of the major problems of the coming centuries in every region of the world on a global scale, and therefore the lives of billions of people depend on the rational and correct management of water. Today, supplying of water is becoming a major problem due to

some reasons such as the rapid increase of the population, increasing water needs in all areas, unconscious consumption, and the pollution of clean water sources (Amaral et al., 2020; Washington-Ottombre et al., 2018). Therefore, instead of being a pollutant, domestic wastewater has become a source of water that can be used by reevaluating. With their staff, student capacity, classrooms, laboratories, social facilities and dormitories, university campuses are also the areas causing emerging of a significant amount of wastewater. Water management and saving is expressed as the development, distribution, and use of water resources, which are used within the campus, in a planned and programmatic manner. For this purpose, effective use of water should be ensured by establishing a campus water footprint. Green field irrigation is being attempted to apply by recycling the low-contaminated wastewater which is defined as “grey water” in the literature and which originates from the sinks of the units (faculty, refectory, dormitory, administrative unit etc.) in ASU campus (Figure 4). In addition, grey water analysis and treatment methods continue to be developed within the scope of undergraduate theses in the ASU Environmental Engineering Department.

Table 1. GreenMetric model ratings at universities in Turkey (UI GreenMetric, 2019).

University	Setting & Infrastructure	Energy & Climate Change	Waste	Water	Transportation	Education & Research	Puan
U1	1050	1150	1575	800	1425	1600	7600
U2	1100	1200	900	750	1175	1425	6550
U3	1075	1050	1125	525	1325	1200	6300
U4	775	1300	1200	600	1175	1200	6250
U5	850	1400	975	575	1200	975	5975
U6	900	1025	1575	150	1225	1050	5925
U7	975	975	975	450	1400	975	5750
U8	875	975	1050	500	1275	1050	5725
U9	875	1100	900	500	1250	1050	5675
U10	900	1175	1350	200	1325	625	5575
U11	1050	675	1125	450	1225	975	5500
U12	1325	925	450	250	1350	1175	5475
U13	775	1225	1050	100	1525	725	5400
U14	1050	1050	1200	625	625	750	5300
U15	925	800	900	575	1125	925	5250
U16	850	875	975	500	1100	900	5200
U17	1200	700	675	525	925	1100	5125
U18	650	650	1125	200	1275	1075	4975
U19	725	1050	900	350	825	850	4700
U20	900	825	600	500	925	825	4575
U21	850	675	1500	350	800	375	4550
U22	800	975	825	450	950	525	4525
U23	950	475	825	550	1050	625	4475
U24	650	1125	750	650	550	700	4425
U25	525	1150	975	100	1125	525	4400
U26	825	850	675	400	1025	600	4375
U27	875	675	675	350	800	975	4350
U28	850	825	450	250	1125	775	4275
U29	575	575	900	100	1175	900	4225
U30	950	900	975	0	900	300	4025
U31	300	650	1500	200	1075	300	4025
U32	850	800	675	400	750	450	3925
U33	850	650	825	100	600	900	3925
U34	950	650	375	225	975	725	3900
U35	325	825	525	275	1075	825	3850
U36	800	575	975	200	625	675	3850
U37	850	900	375	300	800	550	3775
U38	800	650	900	300	725	400	3775
U39	375	475	450	500	925	1025	3750
U40	775	225	675	300	1275	300	3550
U41	775	650	225	550	650	325	3175
U42	525	450	675	150	800	475	3075
U43	600	500	450	100	700	450	2800

U1: Istanbul Technical University; U2: Erciyes University; U3: Middle East Technical University; U4: Ozyegin University; U5: Cyprus International University; U6: Aksaray University; U7: Zonguldak Bulent Ecevit University; U8: Ege University; U9: Yildiz Technical University; U10: Hitit University; U11: Akdeniz University; U12: Cukurova University; U13: Afyon Kocatepe University; U14: Sabanci University; U15: Ondokuz Mayıs University; U16: Bartin University; U17: Ankara University; U18: Cappadocia University; U19: Yeditepe University; U20: Dokuz Eylul University; U21: Anadolu University; U22: Inonu University; U23: Sivas Cumhuriyet University; U24: TOBB University of Economy and Technology; U25: Istanbul Sabahattin Zaim University; U26: Tokat Gaziosmanpasa University; U27: Bogazici University; U28: Düzce University; U29: Marmara University; U30: Ataturk University; U31: Galatasaray University; U32: Baskent University; U33: Süleyman Demirel University; U34: Kadir Has University; U35: Kto Karatay University; U36: Bolu Abant İzzet Baysal University (BAIBU); U37: Cankaya University; U38: Eskisehir Technical University; U39: Niğde Ömer Halisdemir University; U40: Bilkent University; U41: İğdır Üniversitesi; U42: Kilis 7 Aralık University; U43: Izmir University of Economics

3.2. Waste Control and Zero Waste Applications

The problem of solid waste, which is a big problem on the way to becoming a smart city and is increasing day by day, also creates negativities within the campuses (Abdelaal, 2019; Shuqin et al., 2019). To deal with this negative effect, waste must be managed effectively. The development of recycling methods and techniques for plastic, glass and paper types of waste that can be recycled within the campus is the first step for the waste management. Through the Integrated Waste Management, students and staff of the university should be informed about the methods of disposal of solid wastes emerging in the campus and works should be carried out in all faculties

(Bahçelioğlu et al., 2020; Adeniran et al., 2017). For this purpose, based on zero waste target, applications were carried out in all areas of ASU campus as seen in Figure 5. When these activities are associated with the city where the university is located, it is seen that there is a mutual interaction. Good practices for the collection, transportation, and disposal of waste will serve as an example for the city and will create an encouraging and motivating effect.



Figure 4. Irrigation and landscaping practices at ASU campus



Figure 5. Zero Waste Management Practices at ASU Campus

3.3. Energy Efficiency and Transportation

In fact, what targeted with increasing of energy efficiency and with transportation is to reduce emissions that lead to air pollution to a minimum or even zero if possible. In terms of sustainability, the applications of smart campuses and cities are multifaceted. These are listed as more use of buildings and transportation vehicles that utilize the alternative energy sources and the energy more efficiently and taking measures that will reduce CO₂ emissions (Attard et al., 2020; Ridhosari and Rahman, 2020; Adedeji et al., 2019; Jokinen et al., 2019; Okeniyi et al., 2018). An average of 90% of human life is spent in buildings (home, workplace, etc.); the results of the studies conducted in this context have also revealed that approximately 60% of the world's energy consumption is due to buildings. Therefore, numerous green building certification systems (LEED, BREEAM, etc.) have been developed on an international and national scale (Golbazi et al., 2020; Wang et al., 2020; Ding et al., 2018; Shan and Hwang, 2018;

Tan et al., 2014). Among these systems, LEED stands out compared to other certification programs. As a green building, the library on the ASU campus has been designed in this way and made available to the active use of students 24 hours a day. Within the library, the wireless network system, motion-sensitive lighting and faucet systems, etc. have been used (Figure 6). In addition, by using environment-friendly materials in campus buildings and improving the solid and liquid waste management, contribution to environmentally sensitive and ecological campus applications is ensured. In terms of energy efficiency, it is considered to use exterior solar panels in buildings to be constructed on the ASU campus. In this way, ensuring the savings in electricity and natural gas use is targeted. Besides these, the lighting systems on campus are also energy efficient and the design of the roads has been made in this way. Motion-sensitive, photocell luminaires have been preferred in order to save energy in lighting systems located both indoors and outdoors. Card pass consisting of radio frequency identification (RFID) systems are used in the campus of Aksaray University, in order to provide security and automation for vehicle entrances and exits with building entrances and exits. In addition, there are gas and smoke detectors in all rooms, classes and laboratories in order to ensure fire safety in buildings.



Figure 6. ASU library (green building example) and lighting systems

In order to solve the air pollution problem, multifaceted scientific research projects are presented for creating a clean air space on campus (Mesquita et al., 2020; Yalciner Cal and Aydemir, 2018; Mehta et al., 2017). To ensure clean air space on campus, the use of fossil fuel vehicles needs to be reduced and instead of them, environment-friendly vehicles need to be made prevalent. For this reason, the use of bicycles in on-campus transportation has been made prevalent at the ASU campus (Figure 7). In addition, diverting individuals to public transport is emerging as another alternative. As shown in Figure 7, in addition to ecological practices, directions and gathering points are clearly indicated in the campus in order for the possible various natural disasters such as earthquakes. As a result, for a sustainable environment, it is necessary both to protect nature and to resolve the problems that nature can create in the best way.



Figure 7. Bicycle parking points and emergency meeting area on ASU campus

4. Result and Discussion

In the light of current developments and data, it is a known fact that the cities that are the indicator of civilization today will have important problems if the patterns of life, environment, energy, transportation, and consumption do not change. The most important of the things that need to be done to prevent cities from falling into this situation is to implement the “smart city” approach. In order to achieve this, it is required that the transformation of the University campuses into green and sustainable settlements must be accelerated primarily and they must act as laboratories in the transition of cities to the smart city model. However, one point to be considered here is that basing of both the city and the universities on smart components depends on the human factor. Therefore, it should be ensured that awareness of people is raised about this issue and practices are developed in this direction. In this context, the establishment of network systems to ensure the relations between the city and the university and creating databases are important in terms of the flow of information. Seminars and events should be organized for the city to be impressed from the smart campus practices and the implementation of innovative technologies (green building, solar panels, etc.) for environmental protection, and spreading of them throughout the city should be ensured. In this study, smart campus-related works carried out at the ASU campus were evaluated. In the direction of smart environment and living criteria that are in the Boyd Cohen Wheel, the categories of waste management, transportation, energy and water management in the campus were evaluated in terms of both their impact on the city and the sustainability of the campus. As a result of the investigations, it was concluded that although there are deficiencies in our country regarding the Smart Campus, campuses are of great importance today in terms of being a brand city. As a result, it can be said that because campuses are in various ways model cities, works to be conducted in these areas can set an instance for smart cities as well.

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Conflict of Interest

No conflict of interest was declared by the authors.

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