



## Land Assessment in Sustainable Campus Planning: The Case of Bursa Uludağ University Görükle Campus

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### Abstract

Increasing demand for higher education causes rapid changes in the land cover and use of university campuses. The increasing demand for higher education causes rapid changes in the land cover and utilization of university campuses. As a response to these changes, sustainable campus planning was born and has become a very popular concept today.

Sustainable campuses, which should be established by considering many factors such as directing campus physical development, protecting natural resource values, and responding to needs, should serve as a model for all other physical constructions with their unique characters. In the study we conducted with this approach, Bursa Uludağ University Görükle Campus, which has 14.26 km<sup>2</sup> of land, was examined as a sample area to make decisions on topographical features and land uses in university campuses. As a result of the measurements and analyzes, it was determined that 43.73% of the land is made up of green areas (forest-woodland-garden and anthropogenic (shaped by human hands)). The land has a high percentage (44.61%) of slopes of 2-6 degrees (gently sloping-undulating) and 32.81% of the land has a southern aspect. The most common soil group in the land is vertisol soils. As a result of the investigations, it was seen that the campus is suitable for landscaping works in terms of slope, aspect and soil characteristics.

**Keywords:** Sustainability, campus, land use, anthropogenic landscape area

### 1.Introduction

Higher education institutions, whose existence is attributed to ancient times and institutionalization to the Middle Ages, consist of a single structure established in cities in the early days. Due to the rapid increase in the world population, the changes in the physical plans of the cities and the increase in the population working in the industry, university campuses that are compatible with the social and physical environment were needed. Due to this rapid increase in population, the change in the direction of the city's development and the increase in the number of university students caused the campuses to need large areas (Ercevik & Onal, 2011; Vural et al., 2019). While the campuses, which are known to shape the development of the city, were initially planned outside the city, they began to be planned as integrated with the city over time. University campuses, which serve as social spaces for both the city and its inhabitants, are seen as an opportunity for the growth and development of cities.

Sustainable university campuses, which try to develop more sustainable and fair interactions between people and nature, communities and generations, are gaining more and more importance with each passing day by encouraging the concepts of ecological health, human welfare and sustainable systems, as well as minimizing environmental damage (Washington-Ottombre et al., 2018; Gomez & Derr, 2016). Universities around the world today support the integration of sustainability through policy, research, curriculum and infrastructure (Filho et al., 2020).

Sustainable university campuses that meet the needs of today without limiting the needs of future generations should be planned as complex structures with various functions equipped to meet some basic needs (such as work, nutrition, shopping, entertainment,



sports, recreation, and health) apart from research and education activities. It is necessary to establish strong relations between the functions of these complex structures. This will be possible by acting with a systematic order and a sustainable approach in the planning phase of the settlements, which are subject to changes in people, curriculum, structure, environment, land and landscape with each passing day (Lidsky, 2002; Buyuksahin Siramkaya & Cinar, 2012).

Identifying and effectively evaluating existing resources of campus topography; will help to make the right planning decisions and to use resources in a sustainable way (Derbentoglu, 2021). The campuses are a good reflection of the cities on a small scale, as they provide a physical environment that can set an example for urban change and development with the success they achieved in the implementation of plan decisions (Yildizoglu, 2006; Altun & Zencirkiran, 2021).

To ensure the sustainability of all-natural and cultural landscapes on the campus, the current and future needs of the campus should be determined, and the social and cultural structure and development level of the region should be taken into account. Master plans produced by taking into account social and cultural interactions and the targets for them and the activities to be carried out to achieve this goal (such as protection of natural resources and ecosystem, controlled and limited use of areas) should be planned accurately and completely (Vural et al., 2019; Sermet & Ozyavuz, 2018).

University campuses consist of natural and cultural landscape elements, and a large part of the areas outside the buildings are open and green areas. The open green areas of the campus consist of natural areas such as forests, ponds, rocks, and anthropogenic areas such as transportation axes, entrances and exits, gardens, outdoor seating areas, and sports and playgrounds (Aciksoz et al., 2014). While these areas add aesthetic value to the campuses, they also have many different missions such as establishing a connection between the users and their environment, providing an environment for physical developments, and providing vehicle-pedestrian circulation within the campus (Ertekin & Corbaci, 2010; Yilmaz & Irmak, 2012; Vural et al., 2019).

In this study, maps that can be used as a base for the sustainable campus approach were created in Bursa Uludag University Görükle Campus. Making use of these maps is aimed to examine and evaluate the land use and topographic features, structures and green areas in detail and to develop suggestions.

## **2. Materials and Methods**

### **Material**

This research was carried out in Bursa Uludag University Görükle Campus and the topographical data of the campus constitutes the main material of the research.

Working area.

Bursa Uludag University Görükle Campus is 18 km away from the city centre of Bursa, located in the Marmara Region of Turkey. It lies between 40°13'26" latitude and 28°52'14" longitude and covers an area of 14403.3 decares (Aksoy & Ozsoy, 2004; Sevimli, 2021).

### **Method**

The study started with obtaining scientific information on the subject from domestic and foreign sources. Based on the information obtained; land use, slope, aspect, hydrology, soil, settlement and anthropogenic landscape areas (road, parking lot and green areas around the settlement areas) maps were created by using the ArcGIS program to set an example for the realization of environmentally friendly and sustainable planning in Bursa Uludag University Görükle Campus.

In the ArcMap 10.2.2 3D program, slope and aspect maps were created using the digital elevation model of the campus, 10m x 10m pixel-sized raster format. Slope layers Slope

classes included in the Soil and Land Classification Standards Technical Instruction; 0-2%: Straight or nearly straight, 2-6%: Slightly curved-corrugated, 6-12%: Medium-slope slightly wavy, 12-20%: Steeply sloping wavy, 20-30%: Very steeply sloping hill, % 30-45: Steep, 45% and above: Very steep was used (URL-1).

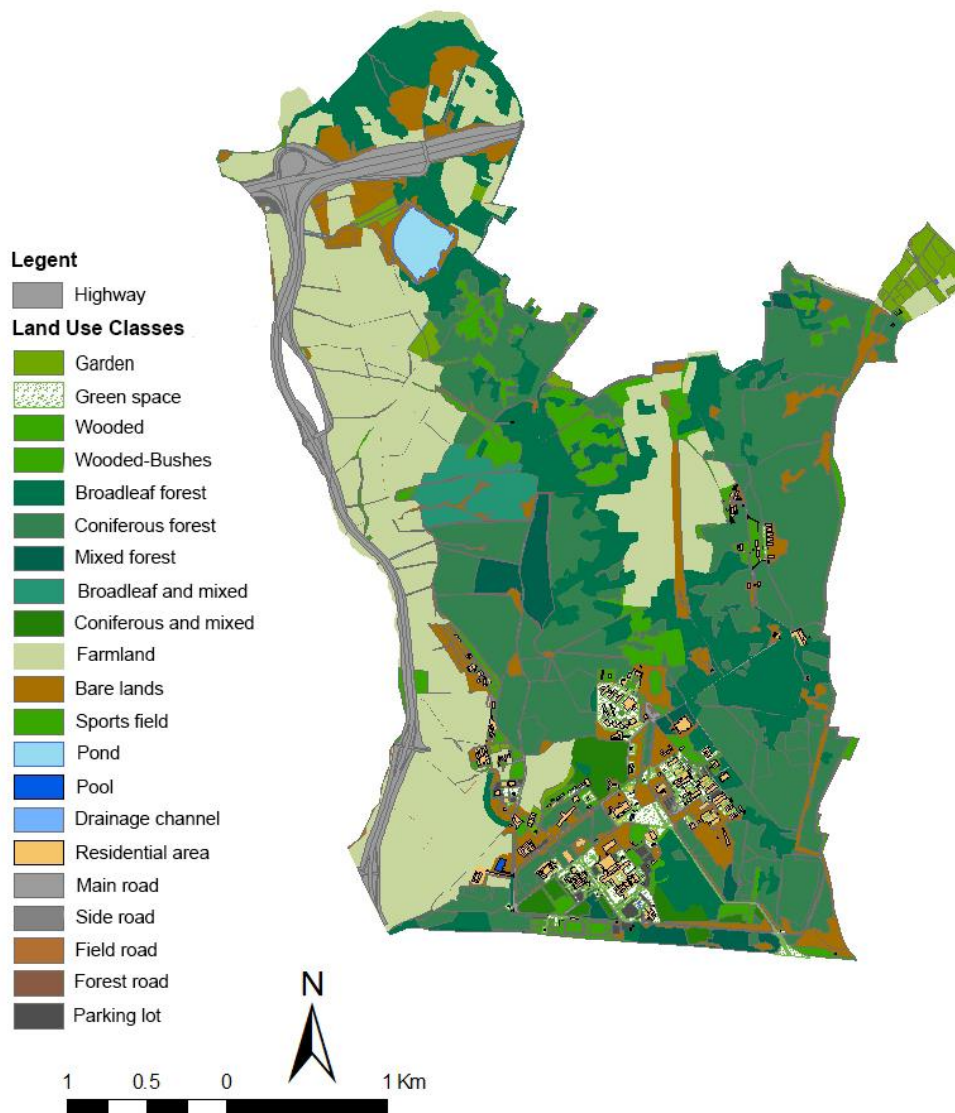
In the formation of Large Soil Groups (LSG) and Land Use Capability (LUC) Classes (I-VIII. Classes), the classifications found in the Soil and Land Classification Standards Technical Instruction were taken into consideration (URL-1).

The open drainage channels and pond on the campus are shown on the hydrological map created by performing hydrological modelling (Allaby & Allaby, 1999), which is defined as the characterization of the real hydrological features and the system in the GIS environment.

## Findings

### Land Use and Topographic Features

Based on the measurements made on the site plan of Bursa Uludag University Campus, it was determined that the campus land is 14.26 km<sup>2</sup> and a land use map of the area was created (Figure 1).



**Figure 1.** Bursa Uludag University land use map



The areal values of the land use classes created for Bursa Uludag University Görükle Campus are given in Table 1.

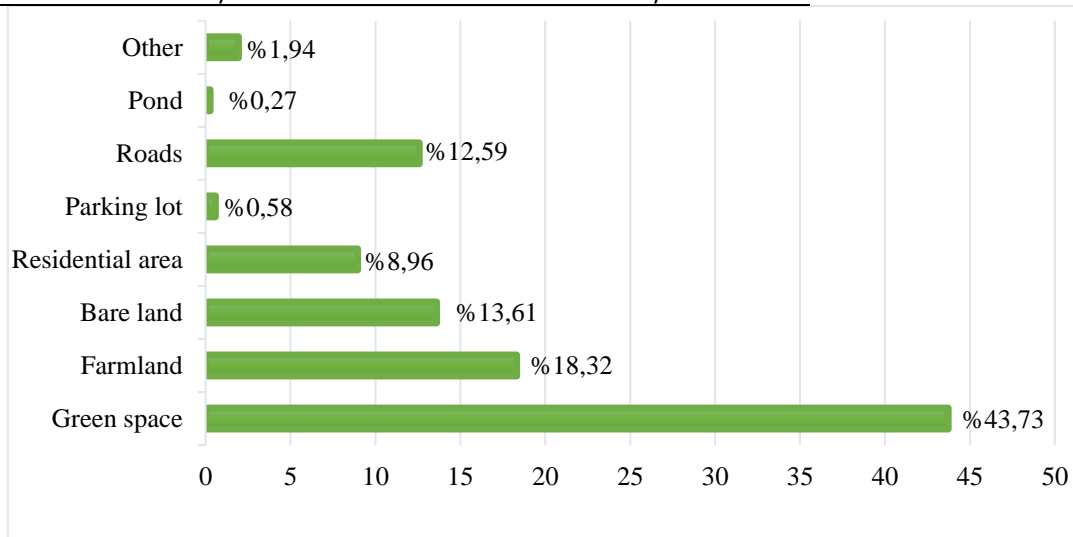
**Table 1.** Bursa Uludag University Campus land use classes area values

Land Use Classes	Area (km <sup>2</sup> )	Land Use Classes	Area (km <sup>2</sup> )
Garden	0,39	Pond	0,04
Green space	0,45	Pool	0,001
Wooded	0,33	Drainage channel	0,27
Wooded-Bushes	0,68	Residential area	1,28
Broadleaf forest	1,68	Highway	0,27
Coniferous forest	2,33	Main road	0,13
Mixed forest	0,26	Side road	0,32
Broadleaf and mixed forest	0,01	Field road	0,28
Coniferous and mixed forest	0,07	Forest road	0,80
Farmland	2,61	Parking lot	0,08
Bare lands	1,94	Other	0,01
Sports fields	0,05		
<b>Total (km<sup>2</sup>)</b>		<b>14,26</b>	

It has been observed that the existing green areas (forest-woodland-garden and anthropogenic landscapes) in the campus are 6,24 km<sup>2</sup> in total and cover 43.73% of the campus, followed by agricultural lands and bare lands in size (Table 2, Figure 2).

**Table 2.** Distribution of Bursa Uludag University Görükle Campus land uses

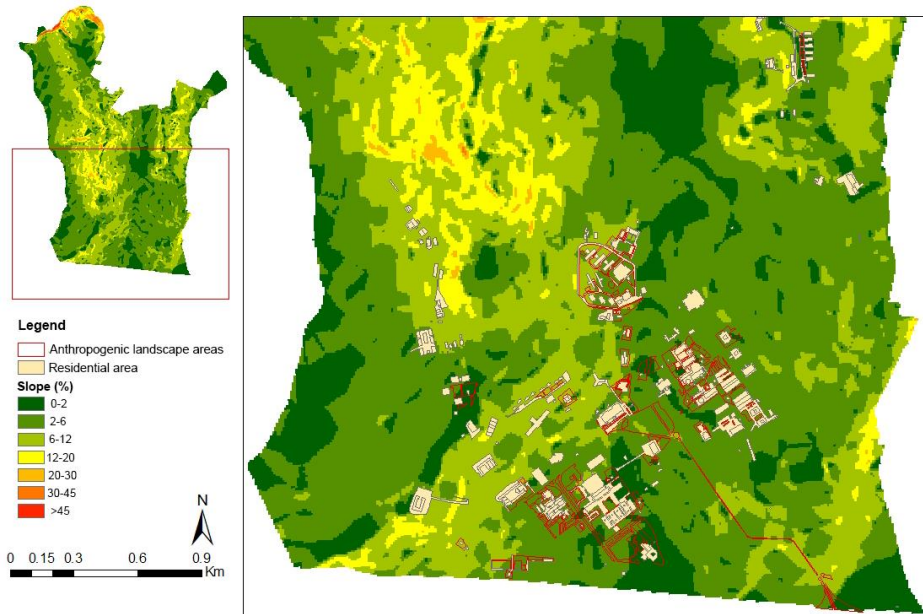
Land Use Classes	Area (km <sup>2</sup> )	Land Use Classes	Area (km <sup>2</sup> )
Green space	6,24	Parking lot	0,08
Farmland	2,61	Roads	1,79
Bare lands	1,94	Pond	0,04
Residential area	1,28	Other	0,28



**Figure 2.** Distribution of Bursa Uludag University Görükle Campus land uses

### Slope

The slope map of the campus was created using numerical data (Figure 3).



**Figure 3.** Bursa Uludag University Görükle Campus slope map

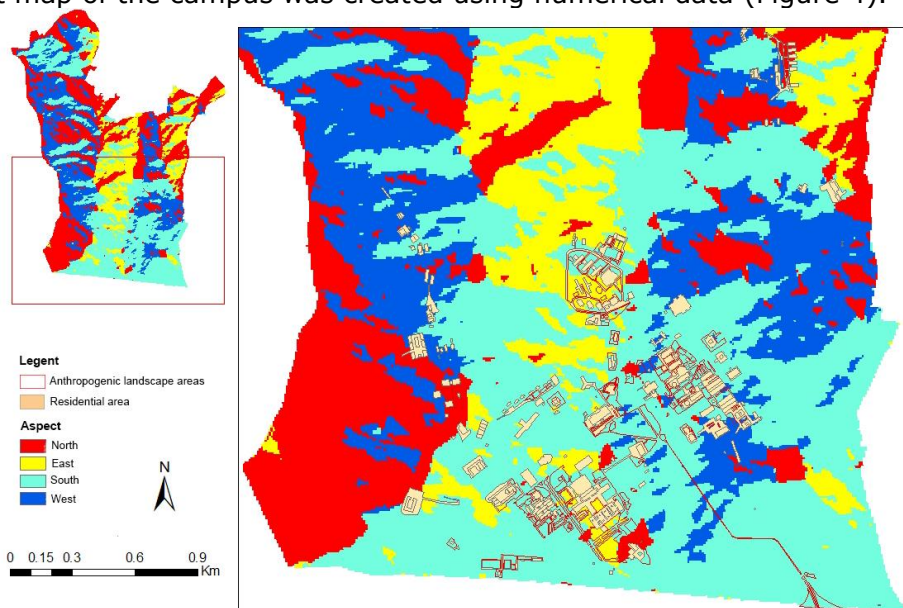
According to the campus slope map, which was created using numerical data and includes seven slope degree groups (Figure 3), it was determined that the majority of the campus lands were located in 0-2, 2-6 and 6-12 degree slope groups. It has been observed that 44.61% of the lands have a slope of 2-6 degrees (slightly inclined-corrugated), and 15.41% of them have a slope of 0-2 degrees (flat or nearly flat) (Table 3).

**Table 3.** Bursa Uludağ University Campus land slope grades and distributions

Slope Grades	Rate(%)	Slope Grades	Rate (%)
0 - 2 (Flat or nearly flat)	15,41	20 - 30 (Very steep slope-Hill)	1,36
2 - 6 (Slightly curved-corrugated)	44,61	30 - 45 (Steep)	0,43
6 - 12 (Medium sloping- slightly wavy)	29,99	> 45 (Very Steep)	0,10
12 - 20 (Steep sloping-Wavy)	8,08		

### Aspect

The aspect map of the campus was created using numerical data (Figure 4).



**Figure 4.** Bursa Uludag University Görükle Campus aspect map

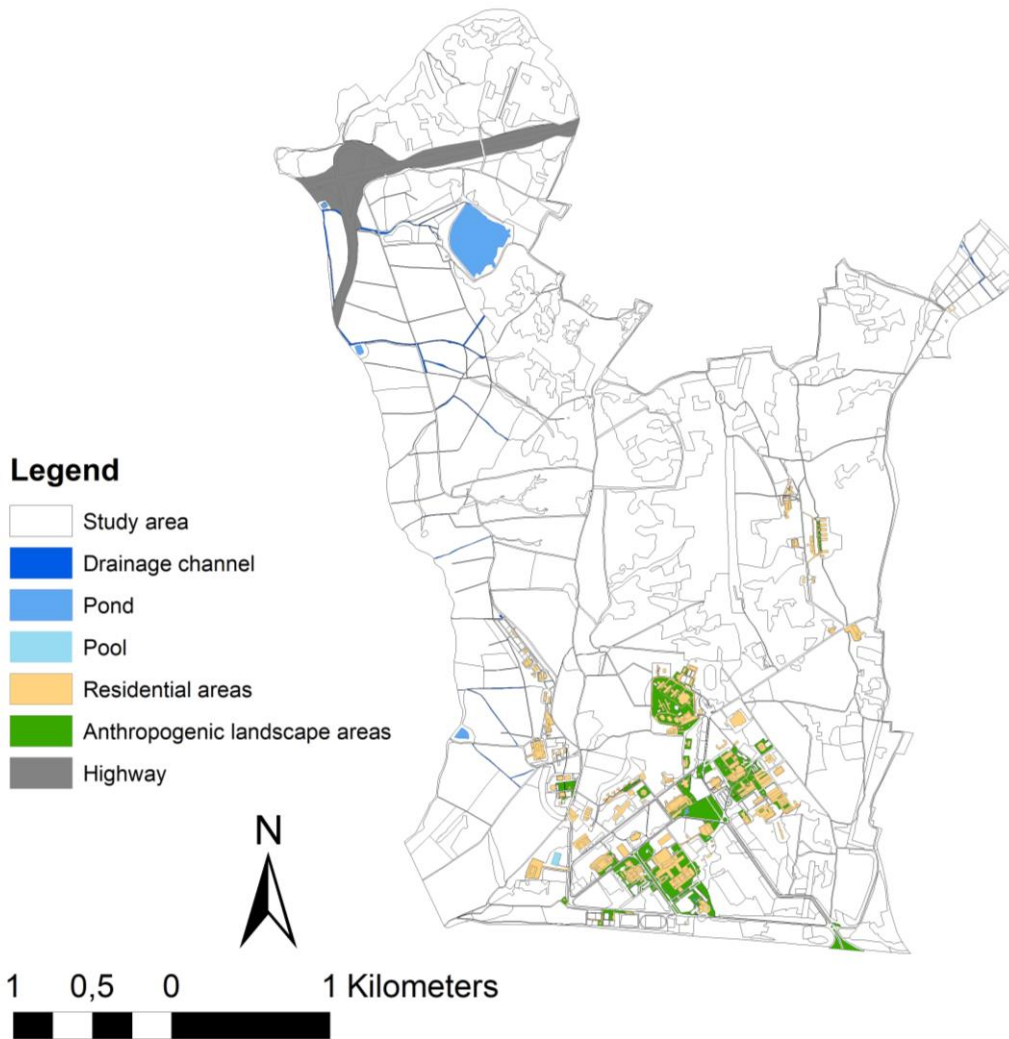
According to the campus aspect map, which includes four different view groups (Figure 4), it has been determined that 32.81% of the campus lands are south-facing and 30.20% are north-facing lands (Table 4).

**Table 4.** Bursa Uludağ University Campus land aspect distribution

Aspect	North	East	South	West
Rate (%)	30,20	13,65	32,81	23,34

### Hydrology

The open drainage channels and the pond on the campus are included in the created hydrology map (Figure 5). Open drainage channels are located within the agricultural areas used by the Faculty of Agriculture. The pond (Yolçatı - Göbelye) located within the campus covers an area of 3.8 hectares.



**Figure 5.** Bursa Uludag University Görükle Campus hydrology map

### Soil

It has been determined that there are three different types of major soil groups (MSG) in the territory of the campus evaluated according to land use capability (LUC) classes and major soil groups (Table 5).

**Table 5.** Bursa Uludag University Görükle Campus soil map mapping unit explanations

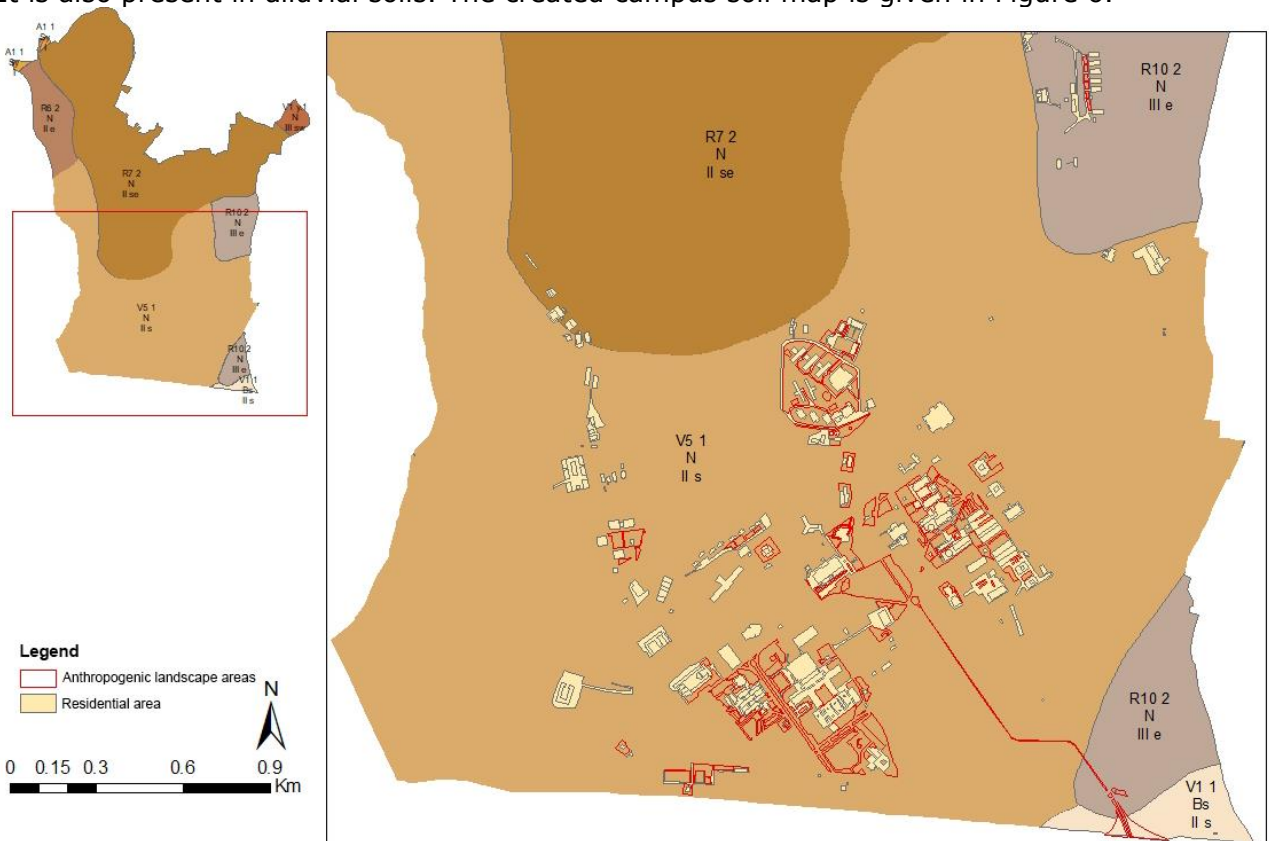
Mapping Unit	MSG*	Slope combination	depth	Degree of erosion	CLU*	LUC*
V5. 1 N II s	Vertisol	%2-6 sloping-deep		None - very little	Fallow	II
V1. 1 Bs II s	Vertisol	%0-2 sloping-deep		None - very little	Garden	II
V1. 1 N III s w	Vertisol	%0-2 sloping-deep		None - very little	Fallow	III
R6. 2 N II e	Rendzina	%2-6 sloping medium-deep		moderate	Fallow	II
R7. 2 N II se	Rendzina	%2-6 sloping-shallow		moderate	Fallow	II
R10. 2 N III e	Rendzina	%6-12 sloping medium-deep		moderate	Fallow	III

Mapping Unit	MSG*	Texture class	drainage	Degree of erosion	CLU	LUC
A1.1 Sy I	Alluvial	well drained		None - very little	Irrigated agriculture	I

**MSG\*:** Major Soil Groups **CLU\*:** Current Land Use **LUC\*:** Land Use Capability

Vertisol and Rendzina were found to be the most common soil groups in the campus lands. It is also present in alluvial soils. The created campus soil map is given in Figure 6.



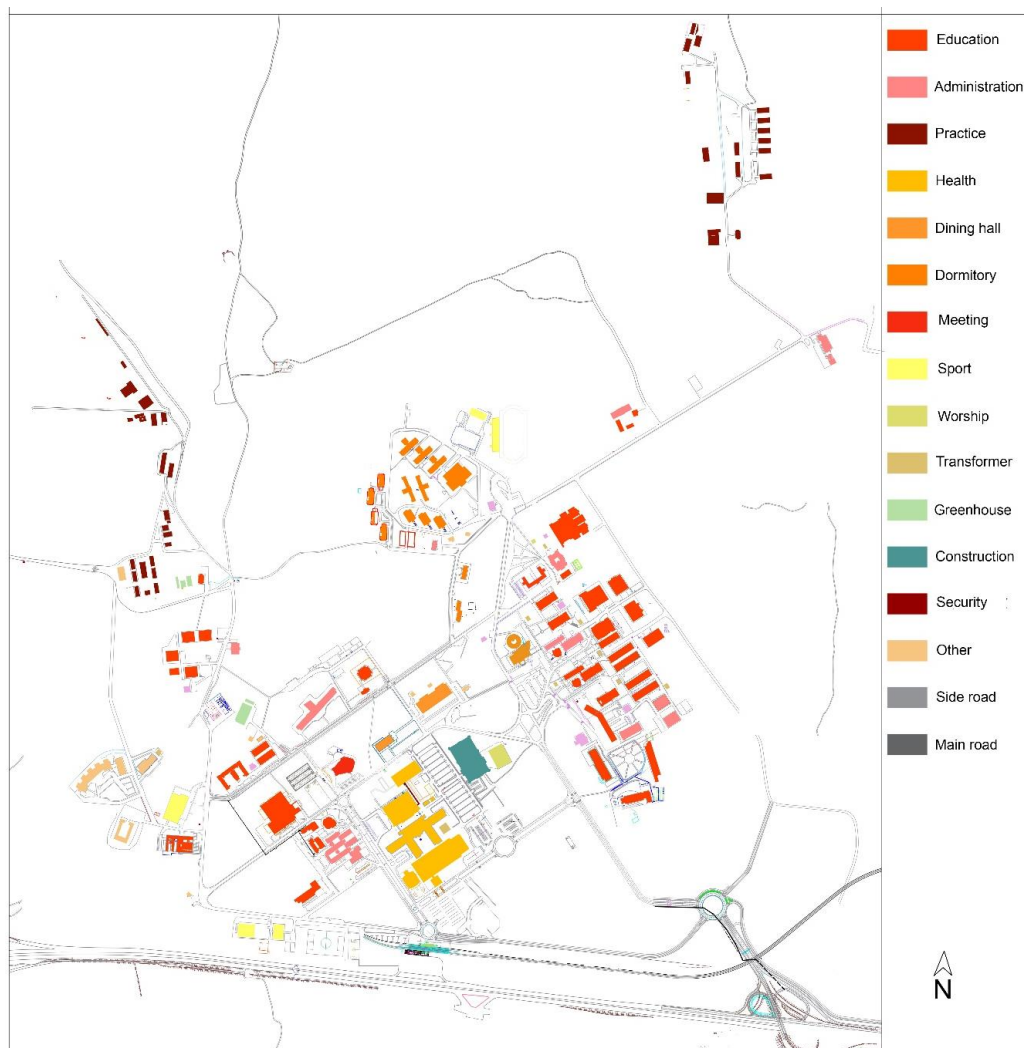
**Figure 6.** Bursa Uludag University Görükle Campus soil map

## Buildings and Green Space

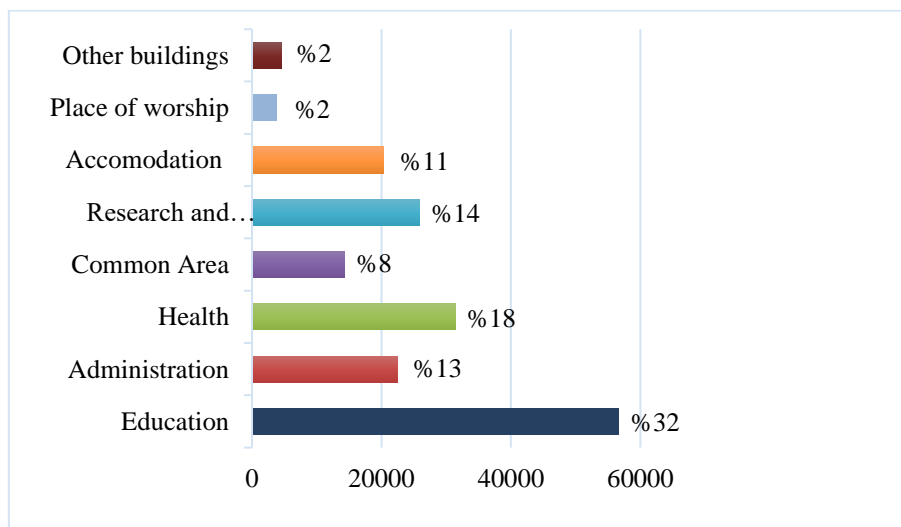
### Buildings

Structures belonging to the units on the campus; education, administration, health, research and practice, common area, accommodation, place of worship and other buildings were handled in 8 different classes and a settlement plan was created (Figure 7). It has

been determined that the buildings on the campus have a floor area of 179429.7 m<sup>2</sup> and 32% belong to education buildings and 18% to health buildings. The proportional distribution of the areas of the buildings is given in Figure 8.



**Figure 7.** Bursa Uludag University Görükle Campus settlement plan



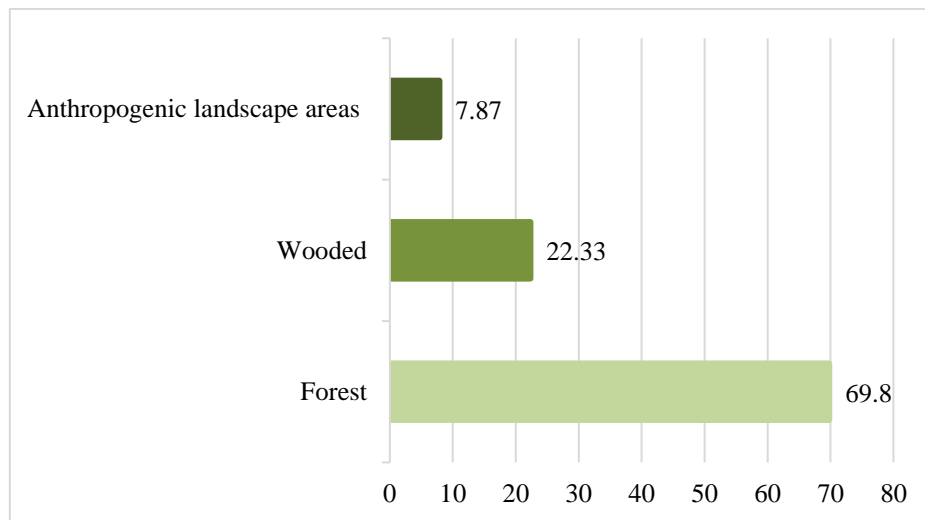
**Figure 8.** Proportional distribution of buildings in Bursa Uludag University Görükle Campus residential areas



## Green Spaces

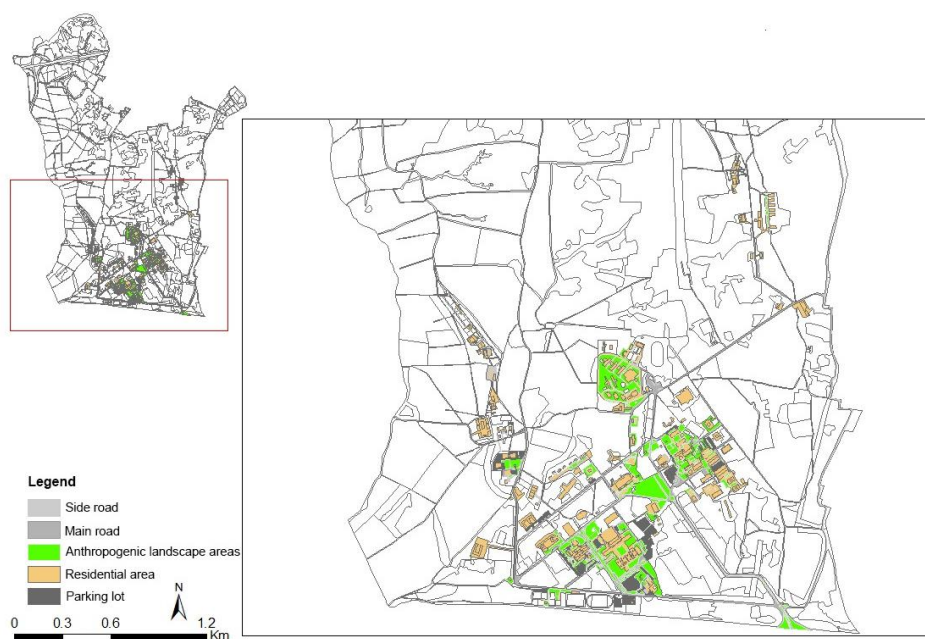
It has been observed that the green areas of the campus consist of some plant communities listed below:

1. When the campus is classified in terms of forest, woodland and anthropogenic landscape areas, it is seen that forest lands occupy a large area (Figure 9),
2. Forest cover consisting of non-native coniferous species (such as *Pinus pinea* L., *Pinus brutia* Ten., *Cupressus sempervirens* L., *Cupressus arizonica* Green., *Cupressus macrocarpa* Gord.),
3. Forest cover consisting of coniferous and deciduous tree species,
4. Forest cover consisting of non-native deciduous trees (such as *Acer* sp., *Fraxinus* sp., *Salix* sp., *Populus* sp.),
5. Bushy areas formed by natural species,
6. Settlements and their immediate surroundings, common areas and anthropogenic landscape areas shaped by their connections.



**Figure 9.** Bursa Uludağ University Görükle Campus green spaces distribution

It has been determined that the anthropogenic landscape areas identified in the campus cover an area of 490839.9 m<sup>2</sup> and these areas are shown in Figure 10.



**Figure 10.** Bursa Uludağ University Görükle Campus anthropogenic landscape areas

The anthropogenic landscape areas of the campus are mostly (67.91%) lands with a slope of 2-6%.

**Table 6.** The slope grades and distributions of the anthropogenic landscape areas of Bursa Uludağ University Görükle Campus

Slope Grades		Distribution (%)
0 - 2	(Flat or nearly flat)	16,74
2 - 6	(Slightly curved-corrugated)	67,91
6 - 12	(Medium sloping- slightly wavy)	15,31
> 12	(Steep sloping-Wavy)	0,04

It has been determined that 71% of these areas have south and 18% eastern aspects. Although soil structure changes have occurred in anthropogenic landscape areas, it has been observed that these areas are generally located in vertisol and rendzina soil groups (Figure 6).

### Discussion and Conclusion

University campuses should be planned to meet the basic needs of students and staff, as well as contribute to their physical, social and cultural development such a planning approach will be possible by determining and analyzing the basic topographic information of the campus and evaluating it. In this study, which shows the current state of the land topography of Bursa Uludag University Görükle Campus, land uses that are thought to be used as a base in the sustainable planning of the campus, slope, aspect, hydrology, soil, settlements and green area analyzes were carried out (Figure 1, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7).

As a result of the analysis, it was seen that 43.73% of the land cover of Bursa Uludag University Görükle Campus, which has a total area of 14.26 km<sup>2</sup>, consists of open green areas (Figure 2). 37.34% of the open green spaces consist of coniferous forests and 26.97% of broad-leaved forests. (Table 1). In a study carried out in 2004, it was concluded that 56% of Bursa Uludag University Görükle Campus is covered with natural or afforestation forests, and coniferous forests form a large part of these forest areas. In the same study, it was stated that 4.46% of the campus belongs to the parking lot, buildings and roads (Aksoy & Ozsoy, 2004). In the last 20 years, while the green areas of the campus have decreased, the hard floors have increased and 22.13% of the campus has been reserved for road-car parks and buildings.

Lands with a slope of 0-2 degrees, defined as flat or nearly flat, make users feel comfortable and safe. In these areas, where there are no natural factors preventing mobility, designers can easily shape buildings, parking lots, sports fields and anthropogenic landscape areas (Üneş & Kozkurt, 2021). When the Bursa Uludag University Görükle Campus lands were evaluated in terms of the degree of slope, it was determined that the majority of the lands were slightly sloping-corrugated and moderately sloping, slightly wavy lands (Table 3). It can be said that the lands belonging to the campus are suitable for landscaping in terms of slope status.

The aspect, which varies according to the topographic features, plays a vital role in the development of plants, just like water, sun exposure and humidity (Goudie, 2004). Turkey exhibits the northern hemisphere aspect characteristics, which are cooler than the southern slopes. On north-facing slopes, water-holding factors are weak, and vegetation develops more in these areas as the moisture in the soil is retained for a long time after precipitation (Delibas et al., 2015; Karayusufoglu, 2010). The lands belonging to Görükle Campus; It has been determined that 32.81% face south and 30.20% face North (Figure 4, Table 4). There are agricultural lands in the north-facing areas of the campus. In the south-facing areas, there are forests, residential areas and anthropogenic landscape areas.



Sustainable use and management of water in the settlements are important for preserving the soil structure and preventing floods. The climatic conditions of Bursa, especially the increase in precipitation in December, January, February and October (URL-2), and the existing hydrological resources in Bursa Uludag University Görükle Campus should be considered in the development of proposals regarding the sustainable planning and implementation process of the campus (Figure 5). An accurate drainage system should be planned to meet the recreational needs of the campus users at all times of the year. The absence of a properly planned drainage system on the campus may damage the structural and vegetal elements in the campus as well as hinder recreational activities.

Depending on the climate, topography and main material differences, various large soil groups were formed on the campus. As a result of the campus soil analysis (Figure 6), it is seen that the majority of the campus soils are heavily textured, dark-coloured, 2-6% inclined, deep vertisol soils that generally shrink in the dry season and expand in the rainy seasons. According to the results of the previous research for Bursa province, although there is no problem in terms of salinity in these soils, all cultural plants can be grown without any limitations (Tümsavas, 2003; Tümsavas & Aksoy, 2008).

In the sustainable planning of the settlements, which are almost like a city, the quality and quantity of the settlements, which are important for meeting the basic needs of the students and supporting their physical and social development, should also be analyzed correctly. Bursa Uludag University Görükle Campus has a settlement system located in the centre of the campus, with its residential areas and building diversity (education, administrative, health, common area, research and application, accommodation, worship) constituting 8.96% of its total land (Figure 5, Figure 6, Figure 10).

Open green spaces constitute 43.73% of the land in Bursa Uludag University Görükle Campus (Figure 2). In scientific studies, it has been accepted that 15 m<sup>2</sup> of green space is required per person on the campuses (Konsol, 2001). This rate is 113.24 m<sup>2</sup> in Görükle Campus. Although the green areas on the campus are well above the required amount, more than half of these areas (69.8%) are forested lands, while 7.87% are anthropogenic landscape areas (Table 6; Figure 9). The amount of anthropogenic landscape area per capita on the campus is only 8.09 m<sup>2</sup>. The anthropogenic landscape areas in the campus consist of 71% south facing (Figure 4), 67.91% lands with 2-6% slope (slightly inclined corrugated) (Table 6) and generally vertisol and rendzina soils (Figure 6). Depending on the availability of soil type, many landscape plants can live in these areas with a slight slope and long sunshine duration. Considering all these criteria (slope, aspect, soil), it can be said that Bursa Uludag University Görükle Campus is suitable for realizing sustainable landscape designs.

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