ISTANBUL TECHNICAL UNIVERSITY ★ CIVIL ENGINEERING FACULTY

DESIGN AND IMPLEMENTATION OF ITU-CAMPUS INFORMATION SYSTEM – UNDERGROUND INFRASTRUCTURE EXAMPLE WITH OPEN SOURCE GIS SOFTWARE (QGIS)

UNDERGRADUATE DESIGN PROJECT

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PREFACE

In this thesis, the foundations of Istanbul Technical University Campus Information System (ArıGIS) were laid.

We would like to thank our esteemed professor Prof. Dr. Tahsin YOMRALIOĞLU, who did not spare his interest and support in the planning, research, execution and formation of our thesis, benefited from his vast knowledge and experience, and shaped our work in the light of scientific foundations with his guidance and information. To our teachers Res.Asst. Muhammet Oğuzhan METE and Res.Asst. Doğuş GÜLER, who meticulously took care of every stage of our work, to M.Sc Firdevs YOMRALIOĞLU, who provided their knowledge and assistance during the creation of the system, and our dear friends who did not spare us their support even for a moment during this difficult thesis process. We would like to thank all our family members, who have always been there for us, for their financial and moral support throughout our education life.

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ABBREVIATION

GIS	**:** Geographic Information System
CIS	**:** Campus Information System
İTÜ	**:** İstanbul Technical University
CGI	**:** Computer Generated Imagery
ESS	**:** Extended Service Set
GARCH	**:** Generalized Autoregressive Conditional Heteroskedasticity
HCA	**:** Hierarchical Cluster Analysis
Mbps	**:** Megabits per second
SWAT	**:** Soil and Water Assessment Tool
UMN	**:** University of Minnesota
ARIGIS	: İTÜ Campus Information System
OSM	**:** Open Street Map
TUREF	**:** Turkey National Reference System

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ITU-CAMPUS INFORMATION SYSTEM DESIGN AND IMPLEMENTATION WITH OPEN SOURCE GIS SOFTWARE (QGIS): INFRASTRUCTURE EXAMPLE

SUMMARY

Campus Information System (CIS) provides easy access to up-to-date and accurate information for the use of university students, lecturers and other users who may need it. In this project, a Campus Information System (ArıGIS) was developed through QGIS software, which covers the entire Istanbul Technical University (ITU) Maslak-Ayazağa Campus. In this context, a PostgreSQL database that can be used by people in different disciplines through their own private passwords was created and integrated into the QGIS program with the PostGIS extension. It was also backed up and stored in the Amazon AWS database. The data to be used while creating the Campus Information System were obtained from the field studies carried out on the campus, the Department of Construction Affairs and some online data resources (e.g., OpenStreetMap), and were organized and developed with the studies carried out. The data obtained were divided into two groups as infrastructure and superstructure, in this way a more effective work was achieved. Then, various analyzes were carried out with the help of the generated data. As a result, ArıGIS was created and a Campus Information System was created on the web, which can be used by administrative units for various purposes and accessed by students and other users who may need it. With this project, the foundations of a forward-looking Campus Information System that are open to development were laid.

AÇIK KAYNAKLI CBS YAZILIMI (QGIS) İLE İTÜ-KAMPÜS BİLGİ SİSTEMİ TASARIM VE UYGULAMASI : ALTYAPI ÖRNEĞİ

ÖZET

Kampüs Bilgi Sistemi (KBS), üniversitelerdeki öğrencilerin, öğretim görevlilerinin ve ihtiyaç duyabilecek diğer kullanıcıların kullanımı açısından güncel ve doğru bilgiye kolay erişim sağlar. Bu projede İstanbul Teknik Üniversitesi (İTÜ) Maslak-Ayazağa Kampüsü'nün tamamını kapsayan QGIS yazılımı aracılığıyla bir Kampüs Bilgi Sistemi (ArıGIS) geliştirilmiştir. Bu kapsamda farklı disiplinlerdeki kişilerin, kendilerine ait özel şifreler aracılığıyla kullanabileceği bir PostgreSQL veri tabanı oluşturuldu, POSTGIS uzantısı ile QGIS programına entegre edildi. Aynı zamanda Amazon AWS veri tabanında da yedeklenerek depolandı. Kampüs Bilgi Sistemi oluşturulurken kullanılacak veriler kampüs içerisinde yapılan arazi çalışmalarından, Yapı İşleri Daire Başkanlığı'ndan ve bazı online kaynaklardan (OpenStreetMap) temin edildi ve yapılan çalışmalar ile düzenlendi ve geliştirildi. Elde edilen veriler altyapı ve üstyapı olarak iki gruba ayrıldı, bu şekilde daha efektif bir çalışma gerçekleştirilmesi sağlandı. Ardından oluşturulan veriler yardımıyla çeşitli analizler gerçekleştirildi. Sonuç olarak ArıGIS oluşturularak web üzerinden hem yönetim birimlerinin çeşitli amaçlarla kullanabileceği hem de öğrencilerin ve ihtiyaç duyabilecek diğer kullanıcıların erişebileceği bir Kampüs Bilgi Sistemi oluşturuldu. Bu proje ile geliştirmeye açık ileriye yönelik bir Kampüs Bilgi Sistemi'nin temelleri atıldı.

1. INTRODUCTION

Information is one of the most important resources for surviving and continuing to live in today's world. Obtaining, producing, processing and storing data is critical in the steps towards the future. With the acceleration of technological developments, technology is also advancing rapidly. Every step from obtaining information to processing information takes less time as a result of technological developments. The fact that the data is fast has made it easier to process with larger and more comprehensive data. The development of technology leads to an acceleration of data processing and perception, but also makes a great contribution to development in all areas. Developments in different fields also enable more data production and data to be changed in a more serial manner. These changes also highlight the issue of the topicality of the data.

Universities are institutions that should be pioneers in the fields of science and technology, first in their own countries and then around the world. One of the most urgent problems facing today's organizations is to provide access to information when necessary. Existing information archived without a regular organization can cause problems. In addition, today's institutions are willing to produce new information from current information at the right time to have the right information at the right time. These standards apply to universities and various other institutions (Geymen et al., 2008). Istanbul Technical University (ITU) is also a reputable institution that has signed many valuable studies both in our country and internationally. It requires the university to produce, store and process information in the administrative, academic and social fields and that this information is available to the necessary people and institutions. The necessity of a system where these data will be connected and presented with spatial dec and where they are accessible to everyone cannot be ignored. Istanbul Technical University, where there is an active campus life, needs a campus information system (CIS) that will serve in all areas. As Sarı, Erdi, and Kırıloğlu have mentioned, this concept, also known as the Campus Information

System (CIS), can basically be defined as a system that provides access to all organs, geographical assets, and also attribute data of a university campus.

In today's conditions, where the existence of data, as well as its topicality, is of critical importance, the task of this system will be, first of all, to accelerate and facilitate the development of the university. Then, using the system, keeping it up-to-date, improving it, its shortcomings and benefits will be observed. In the light of this information, it will first be an example for other universities and institutions in our country, and then it will be an important study on the development of the information system in the international area.

With the help of geographic information system (GIS) techniques, operations such as collecting, storing, updating, controlling and analyzing and viewing information about the earth for a specific aim can be easily performed. According to Kahraman, Karas and Rahman (2011), the GIS-based Campus Information System exists in many universities to serve various aims. This integrated system for the collection of spatial and non-spatial data at the university and its subunits consists of 4 organ: hardware, software, data and users. These spatial and non-spatial data can be stored, researched, processed and presented to decision makers using technologies. For this reason, GIS techniques are very effective for creating a Campus Information System. This campus information system, which will be created, will provide services for students, staff, academicians and visitors. With open source software (QGIS), it is easy to deliver spatial and non-spatial data to users. A system should be created that is accessible to everyone via the internet and convenient for updating the data belonging to the ITU campus.

1.1. Definition of the Problem

In many areas in Turkey in conjunction with a technical college, and the college that accept students from abroad, which is internationally recognised and preferred in the ITU as well as for students and academic staff to meet the needs of visitors there is a lack of administrative and campus Information System. The construction, enrichment and updating of such a system with data from different fields will be used and benefited by different people in different fields. Geymen, et al. (2008) stated that Geographic Information Systems (GIS) is a technology used to solve such problems in Turkey and around the world. As a result of these factors, the use of Geographic Information

Systems is increasing rapidly all over the world, including Turkey. Universities are the first institutions that come to mind when it comes to information. In order for universities to provide the services they need, it is necessary to establish an information system within the university.

Users can be divided into 4 main groups. One of these groups is the group of students. When spatial problems and solutions are mentioned, the first problem that comes to mind is the transportation problem. Creating a route to the point that is intended to be reached can be given as an example of one of the transportation problems. This problem can be solved with a campus information system, where a solution will be established. First of all, when transportation is considered, it is necessary to define the bus and metro lines that will be used to reach the campus into the system. Public transportation routes are recorded in the system by defining the ring routes and routes within the campus. In addition to adding vehicle paths within the campus, pedestrian and bicycle paths should be defined. Adding the locations of vehicles such as bicycles and electric scooters that are rented on campus to the system and keeping them updated is one of the solution ways.

After the transportation roads and vehicles, the definition of parking places for cars, bicycles and rental vehicles and the determination of transportation places to these areas, as well as showing them on the map, also defining the transportation routes to these specific areas and accessing all these on a single map and system will be thanks to the campus information system.

After the main transportation problems, the problem of the accessibility of the places that students need academically by the students and the ability to reach the spatial locations of these places can be emphasized. The most practical way would be to use the campus information system for this. Because in this system, where a lot of data is collected from different fields, there is a school student system and information that will come from there. Where and when academic pursuits can be solved, who the relevant people are should be accessible through a single system.

In addition to academic work, the locations of places that require urgent transportation, such as hospitals, should be accessible as quickly as possible. The collection of this information under a single system will facilitate this work. It is very important that the information mentioned is up-to-date, because incorrect or incomplete information in an emergency situation can lead to negative consequences.

Grocery stores, shopping venues, coffee shops, dining halls and restaurants, and locations, and information systems and the data to the host with this place-to-date campus information, students do not lose time with information about the whereabouts of where they would meet the requirements.

Speaking of the student group, one of the most important needs is the location and timeliness of the faculties and classrooms. After the course selection is made, only the name of the classroom and the name of the faculty building. their information will be available. But there will be no route showing how to get there. Thanks to the campus information system, information on how to access classrooms will be easily accessible. The changes made by the person giving the course related to the course, especially the change related to the location of the place where the course will be processed, will be accessible firsthand. Transportation of courses to the laboratory in application courses or surveys on campus, etc. in case of classes, location information will be easily shared and students and lecturers will be provided with convenience.

In addition to such tasks as informing about the place of processing of courses, students can easily be reached thanks to the information system of exam places. In fact, grievances can be eliminated because last-minute changes can be easily entered into the system and the student can also reach them.

The mentioned transport-related problems are a general problem. The proposed system solutions are suitable for everyone's use and are accessible.

The needs of lecturers for the system are similar to those of students. The two groups have common problems such as difficulty in getting to shopping places or getting to hospital locations. On the other hand, there is a student-course system currently used in universities. There is a lack of a system containing spatial data due to this. Thanks to this spatial system, classrooms, exams, etc. such problems can be solved.

From an administrative point of view, additions can be made regarding the necessity of the system. The administrative has to decide on technical processes such as infrastructure and superstructure works, structures to be built or demolished, the newly opened shops, dining hall, student affairs and access to roads, issues such as new roads. These decisions should be made in the most effective way and the problems should be solved in the most effective way. Having a system which the highest benefit will be provided and the price / performance ratio can be observed will pave the way for initiatives and projects to be carried out on campus. All this chain reaction will benefit both students and lecturers. With the benefit provided by the system to these units, the university will be developed and it will be ensured that exemplary steps will be taken.

In general, the display of deficiencies in technical works and the studies carried out through a single system will also facilitate the decision of which areas to invest in. In infrastructure studies, having location-based information of infrastructure units will ensure that these areas will be put to work quickly when work will be done.

Visitors can be considered as the end user group. As mentioned before, ITU is a large university that receives applications in bachelor's, master's and doctoral fields both from home and abroad. For this reason, there is no doubt that there is a need for a system where people who want to get information about the university can obtain this information. Information such as places to stay, transportation to classrooms, meals and visits, especially transportation to the campus, should be accessible through the campus information system. With the campus information system, the work of foreign students will be accelerated and they will get accurate and up-to-date information.

On the other hand, the campus information system can be used not only for those who want to study at the university, but also for people who want to visit research laboratories or units such as incubation centers on campus. People working in venture offices can benefit from this system.

Nowadays, it is quite necessary that the data becomes of great importance and that the data be kept organized and up-to-date. Otherwise, technological change may lose momentum. In order not to fall behind in this technological race, it is necessary to establish a campus information system.

1.2. Aim of the Study

The aim of the study is to create a Campus Information System belonging to the Ayazaga Campus of Istanbul Technical University. It is planned that this Campus Information System, which is intended to be created, will have a database that contains all kinds of data in the structure and infrastructure of the campus. By organizing, processing and analyzing these data, it is aimed to design a campus system that all users can easily access online. This system will be easily updatable.

1.3. Methodology

The development of the Campus Information System on QGIS consists of several stages. The first step of the study is to obtain data from various literatures and previous studies. The next step is to collect datas about the Ayazaga Campus of Istanbul Technical University. These include DEM data, topographic data, superstructure and infrastructure data, road, building, bridge, green area, sports field, etc. data can be given as examples. The next step is to transfer the collected data to the open source GIS software (QGIS) and analyze it with the help of the PostgreSQL database, which can be spatially characterized with the PostGIS plugin. The data is processed and analyzed with the help of QGIS software. The last step is to create a Campus Information System which can be accessed online by everyone at the Ayazağa Campus, and put it at the service of the users.

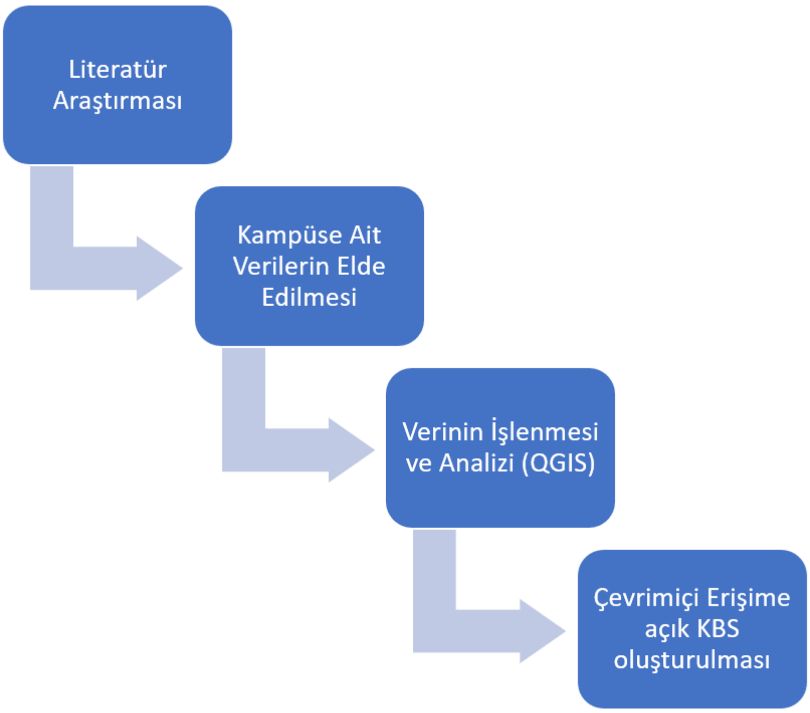

Figure 1.1 : Methodology of the Study (Bi, 2016).

1.4. Literature Research

Universities located in cities are the most effective institutions in the development of this city, and it is extremely important that these institutions use information in the most efficient way. GIS-based campus information systems are being developed and used in many advanced universities around the world (Bilgilioglu et al., 2011).

The use of internet cartography has become more and more heard in Turkey and has been adopted by people. New application areas have emerged. In particular, the use of institutions in applications and projects has increased and there is a need for competent people in this field. Internet-based geographic information systems are of critical importance in terms of being a solution tool, since it has become very easy for the public to access these maps with the Internet. Internet applications of campus information systems, with their easy accessibility, guide students from various cities and attract great attention. (Sarı, Erdi, and Kırtıloğlu, 2011).

Bassam et al. (2017), as mentioned by smart campus, is the product of the rapid development of GIS technology, computer network technology and internet of things technology. At the same time, they also stated that the three main elements of the smart campus system are personalized services, information services, and environmental platforms. In addition, they have also schematized the spatial database content.

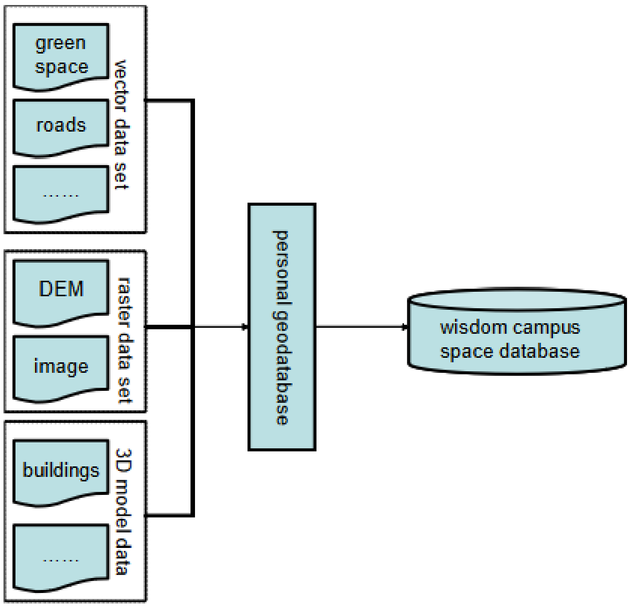

Figure 1.2 : Spatial Database Scope (Bi, 2016).

Dinç (2018) stated that the provincial component created the Internet-based Geographic Information System and that these components are the client and server components. Client components are components that enable data to be accessed and used. Map and GIS applications are the elements that make up these clients. He said that QGIS is a GIS application and that it is a program that is suitable for processing and analyzing data. Dinç (2018) also stated that the map client acts as a frame when creating a web map. The server-side components are Databases and PostGIS/PostgreSQL components.

2. BASIC CONCEPTS AND DEFINITIONS

2.1. Basic Concepts

Geographic Information System : A geographic information system (GIS) is a system for creating, managing, analyzing, and mapping various types of data. GIS connects data to a map by combining location data with other types of descriptive information. Geographical information systems provide a basic science of mapping and analysis. People can understand linkages and spatial situations more easily with the help of GIS. Higher efficiency, better management, and more precise decision-making are all advantages of better communication. According to Bilgiliolu (2011), GIS, is a technological system that allows for the inquiry, analysis, and storage of both geometric and non-geometric data according to specified standards.

Campus Information System : It is a system that allows all functions on any university campus to query their spatial and non-spatial assets, geographic information, and characteristics. Thanks to this system, students or academic staff from outside the city can be questioned in spatial or qualitative terms via the universities website (Sarı, Erdi and Kırtioğlu, 2011)

Data Dictionary : A set of names, properties, and definitions for data stored in a database, as part of a project, or as part of an information system. It describes the meanings and purposes of data elements in the context of a project and gives advice on how to understand, accept, and represent them. Metadata about data objects is also provided via a Data Dictionary. The scope and attributes of data components, as well as the rules for their usage and application, can all be defined using metadata in a Data Dictionary.

QGIS : It is a free and open-source geographic information system (GIS) program that includes data display, editing, and analysis capabilities, as well as cross-dec support. It was previously known as "Quantum GIS."

Data : It is the name given to a piece of raw data that has not been processed. Measurement, experiment, observation, counting, and study are all methods for collecting data. It is developed as a consequence of a topic's research, discussion, collecting of knowledge, and reasoning. It is raw data that has not been processed or systematized to the point where it cannot be interpreted.

Database : It is a collection of data that is saved and retrieved electronically on a regular basis. Small databases can be stored in a file system, while large databases are hosted in computer clusters or cloud storage. The design of databases, data modeling, representation and efficient data storage, query languages, and the security and privacy of sensitive data, including formal techniques to support concurrent access to distributed computing and fault tolerance issues and practical issues, including the covers.

Spatial Database : It is any kind of data that directly or indirectly refers to a particular geographical area or location. Spatial data, also known as geospatial data or geographic information, can represent a physical object numerically in a geographic coordinate system. Spatial data includes location, shape, size and orientation.

Vector Data : It is vector data that are defined as graphical representations of the real world. There are three main types of vector data. These are points, lines and polygons. The connection points form lines, and the connection lines that form a closed space form polygons.. Vectors are used in the figure to present generalizations of objects or features on the Earth's surface. Vector data and shapefiles (.the file format, known as shp), is mostly vector data.since it is stored in shp files, it is sometimes used interchangeably.

Raster Data : These are the data presented in a pixel grid. Each pixel in a raster has a value, such as a color or a unit of measure, to convey information about the item in question. Rasters typically refer to images. However, in the spatial world this may refer specifically to orthoimages, which are photographs taken from satellites or other weather devices. The raster data quality varies depending on the resolution and the task to be performed.

Non-Spatial Data: Non-spatial data is information that is not constrained by any geometric constraints.

Qualification Data : It contains the definition or measurement of a geographical feature on a map. It refers to detailed data combined with spatial data. Attribute data helps to obtain meaningful information of a map. For example, the name of the building, the area of the building, the number of floors, the number of rooms, etc. as

PostGIS : PostGIS is a database extension for PostgreSQL that allows users to capture GIS (Geographic Information Systems - GIS) entities in the database. It's open source software. PostGIS contains capability for analyzing and processing GIS objects, as well as support for GiST-based R-Tree spatial indexes. Functions for analyzing and processing GIS information are included.

2.2. Concepts Related to the Functions of GIS

Data Storage and Management : The database created with GIS can be stored in different media such as hard disk, DVD, USB drive, online drive, as well as in the cloud. The spatial database can be updated regularly, acquiring new sources of input from time to time. This is the most advantageous function, since all the data is in digital form, so it is very easy to update the data and reduces the data redundancy.

Data Integration : The use of a geographic information system (GIS) allows to connect and combine data from many sources. As a result, GIS may be used in combination with other methods to map variables and evaluate new variables and factors.

Data Conversation : It is a very important function, as it facilitates better analysis of data collected from different sources. It can be converted to tiff format like jpeg file, converting the projection through geo-referencing so that all the data is in the same projection system. The data can be converted from raster to vector, such as image to polygon/line, or vice versa from vector to raster, such as polygon to raster format. The data can also be converted from raster to raster or vector to vector data according to the need for software and analysis.

Data Analysis : The data can be analyzed by applying appropriate mathematical or statistical algorithms on the data to create new information/maps. Buffer analysis, proximity analysis, and interpolation process to generate DEM, etc. as it depends entirely on the requirements of the users.

Data Modelling : Many simulation models on data may be generated using GIS functions to generate relevant information for planning, such as flow modeling, urban growth forecasting, and so on. In order to properly evaluate the property, it also includes tools for constructing 2D and 3D models of the earth's surface.Many mathematical and statistical methods can be used for modeling in GIS.

Display : It is the function of presenting the results in various forms, such as numerical maps, printed maps, tables and graphs. It completely depends on the user's need to view the data in different formats.

3. PERFORMED WORKS

3.1. Preparation of the Database

Before starting the studies, there is a need for a common database that is easy to access, view and update data quickly. The QGIS software we used in the ArıGIS project also supports many spatial formats, including PostGIS. This extension provides convenience in the execution of the project. In the ArıGIS project, a connection to Amazon's cloud system was provided with PostGIS as a database extension. The data to be worked on started to be stored in the database created over Amazon's cloud system, via the QGIS program.

3.2. Layers

In QGIS program, different types of data are stored in different layers. There are three types of data types. These are: point, polygon and line. Spatial data are divided into these three categories according to their properties. For example, data such as road and wastewater line are stored in layers with line data type, data such as building and pavement are stored in layers with polygon data type, data such as valve and poi are stored in layers with point data type. The coordinate reference system of the project is determined as TUREF/TM30 EPSG:5254. All generated data are defined in this reference system. A study area including ITU Ayazağa campus has been determined for the ArıGIS project. Corner coordinates of the working area: 417033.772 - 4551425.371: 419682.169 - 4553536.987. The campus data is divided into two groups as superstructure and infrastructure. The data layers in the superstructure are: buildings, open spaces, monument-sculpture, point of interest and technokent boundary layers. Data layers in the infrastructure: transportation, transportation-buffer, pavement, wastewater line, wastewater manhole, bicycle park, parking lot, natural gas, power line-transformers, fiber cable, drinking water-potable valve, irrigation line, storm water, heating layers.

3.2.1. Infrastructure

3.2.2. Transportation Layer

Transportation is the transfer of an object or person from one location to another. The transportation layer includes the paths that a person or object uses while changing location. This layer includes vehicle paths, pedestrian paths, cycle paths, shared paths (a road used for both cars and bicycles) and footpaths. The road network in the campus is quite developed. Campus users can easily reach their destination. The road data of the campus was obtained from satellite images and orthophotos by digitization method and with the help of data given by ITU Construction Affairs Department. In the attribute table of the transportation layer, there are parameters such as road type, road length, road name. The data dictionary of the transport layer is shown in the table.

Table 3.1 : Data Dictionary of Transportation Layer.

	Alias	**Type**	**Length**
ID	Verilen otomatik ID	integer	-1
Yol Adı	Yolun adresteki ismi	string	-1
Yol Genişliği	Yolun genişliğini belirtir	float	-1
Kaplama Cinsi	Yolun malzemesini belirtir	string	-1
Yol Kullanım Türü	Yolun hangi vasıtalara hizmet ettiğini belirtir.(araç, yaya)	string	-1
Yol Tipi	Yolun tipini belirtir. (cadde, sokak)	string	-1
Yol Uzunluğu	Yolun uzunluğunu belirtir.	float	-1
Yol Kodu	Yolun kodunu belirtir.	integer	-1
Yapım Tarihi	Yola ait yapım tarihini içerir.	Qdate	-1
Bakım Tarihi	Yola ait bakım tarihini içerir.	Qdate	-1
Şerit Durumu	Yola ait şerit sayısını belirtir.	integer	-1

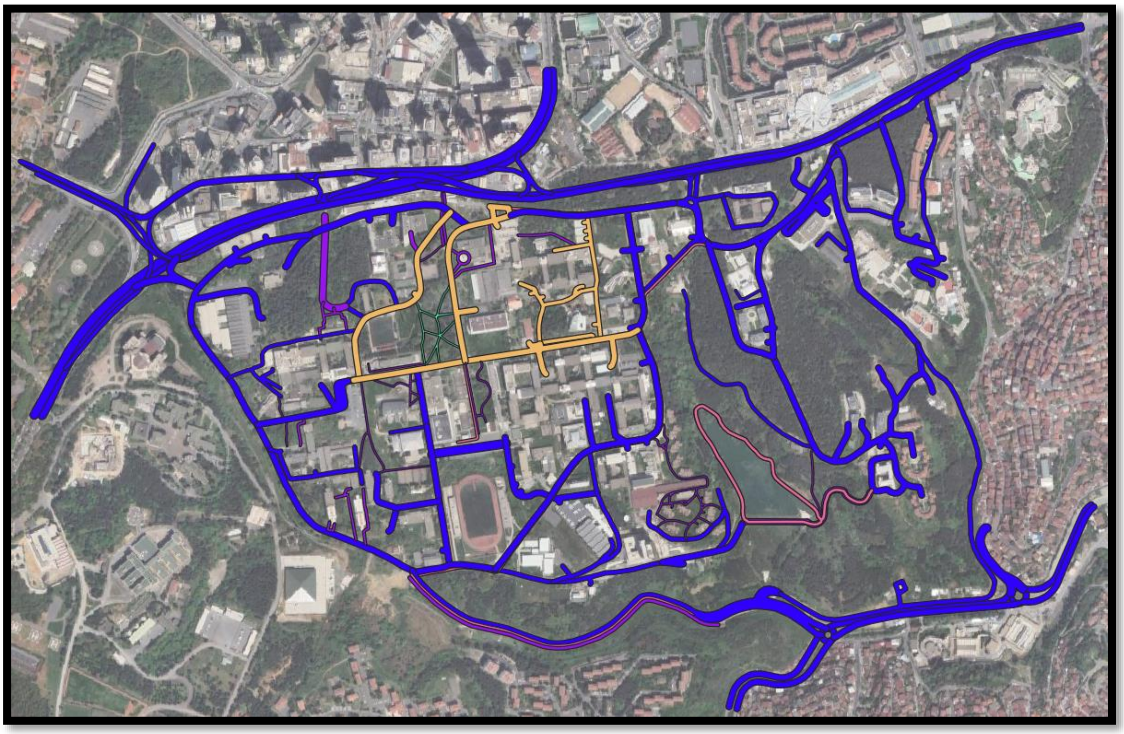

Figure 3.1 : General View of Transportation Layer.

3.2.3. Sidewalk Layer

The Sidewalk is the road reserved for the comfortable and safe movement of pedestrians on the streets and avenues. Sidewalks are often built high from piles of stones and driveways. In addition to the walking paths, there are many sidewalks in the campus. The sidewalks data on campus were obtained from several different data sources. Chief among these is the ITU Construction Works Directorate, which is the most important reference source. The data from the Directorate of Construction Affairs was of line type. However, it was decided to show the Sidewalk data as a polygon in order to avoid confusion with the road, pedestrian and bicycle path data. The sidewalks data on campus were obtained from several different data sources. Chief among these is the ITU Construction Works Directorate, which is the most important reference source. The data from the Directorate of Construction Affairs was of line type. However, it was decided to show the sidewalk data as a polygon in order to avoid confusion with the road, pedestrian and bicycle path data. Google Sattelite and OpenStreetMap maps were used as reference for digitization to convert line type data to polygon type. While creating the sidewalk data, care was taken not to overlap the road data and the building data. Building entrances, parking lot entrances, stairs are not included in the sidewalk data. Data were collected to fit the definition of sidewalk. After obtaining the digitized polygon sidewalk data using the available line type sidewalk data and reference maps, the Directorate of Construction Affairs was consulted to check their accuracy. Corrections were made after the examinations were made. The sidewalk data has been finalized in the database. The total sidewalk surface in the campus is 48192.4781 m2. Sidewalk heights and widths vary from place to place. Studies on these data features will be continued in the future.

Table 3.2 : Data Dictionary of Sidewalk Layer.

Field	Type	Length	Precision	Comment
id	int4	-1	0	
kald_yukseklıgı	float8	-1	0	
kald_malzemes	varchar	16	0	
kald_alani	float8	-1	0	

Figure 3.2 : General View of Sidewalk Layer.

3.2.4. Car Parks and Bike Park Layer

Car parks and bike parks indicate areas where vehicles and bicycles can be parked. These layers show where the vehicles and bicycles in the school can be parked in the form of a polygon. Parking lot and bicycle parking data were obtained from the ITU Construction Department and data from orthophotos. In the parking layer, there are parameters such as parking capacity and parking type.

Table 3.3 : Data Dictionary of Car Parks and Bike Park Layer.

	Alias	Type	Length
ID	Verilen otomatik ID	integer	-1
Park Türü	Parkın türünü belirtir. (elektrikli araç parkı, otopark)	string	-1
Araç Kapasitesi	Otoparka ait araç kapasitesini belirtir.	integer	-1

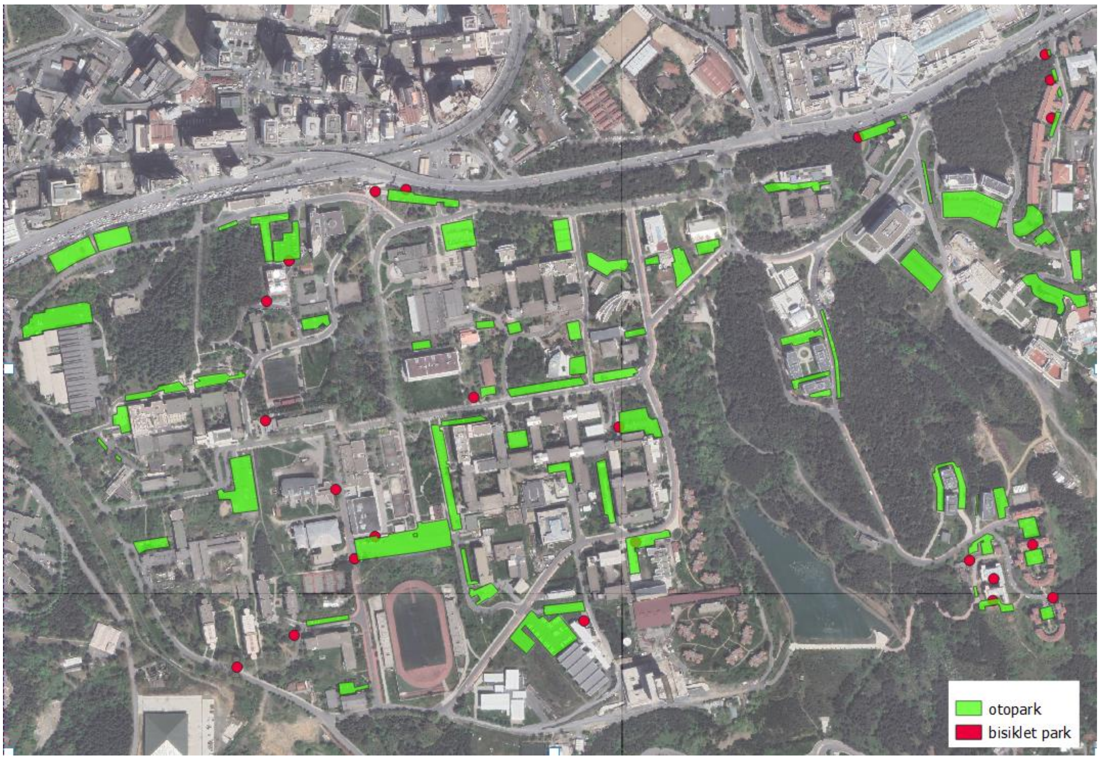

Figure 3.3 : General View of Car Parks and Bike Park Layer.

3.2.5. Electrical Cable and Transformer Layer

Electrical energy has become an indispensable necessity today. It is very important to transmit electrical energy to every building and structure in homes, schools, workplaces and of course on campus. Electricity in Turkey Turkey Electricity Transmission A.Ş. (TEİAŞ) is distributed by the institution. When the power line map is examined, it is seen that the cables are gathered at certain points. These are transformers. The full name of the transformer is transformer. It serves to transform the quantities of electrical energy. Energy transmission and distribution is done with transformers in the campus. Electrical Cable and transformer data were obtained from ITU Construction Works Directorate. It was transferred from the CAD file type to the QGIS environment and edited. There are 10kV and 35kV electrical cables and transformers in the campus.

Table 3.4 : Data Dictionary of Electrical Cable Layer.

Field	Type	Length	Precision	Comment
fid	int8	-1	0	
kilo_volt_cinsi	varchar	254	0	
kablo_uzunlugu(m)	float8	-1	0	
kablo_cinsi	varchar	32	0	
kablo_kesiti(mm2)	varchar	32	0	

Table 3.5 : Data Dictionary of Transformer Layer.

Field	Type	Length	Precision	Comment
fid	int8	-1	0	
kilo_volt_cinsi	varchar	254	0	
trafo_numarasi	varchar	6	0	
trafo_cinsi	varchar	26	0	
trafo_guc	varchar	32	0	

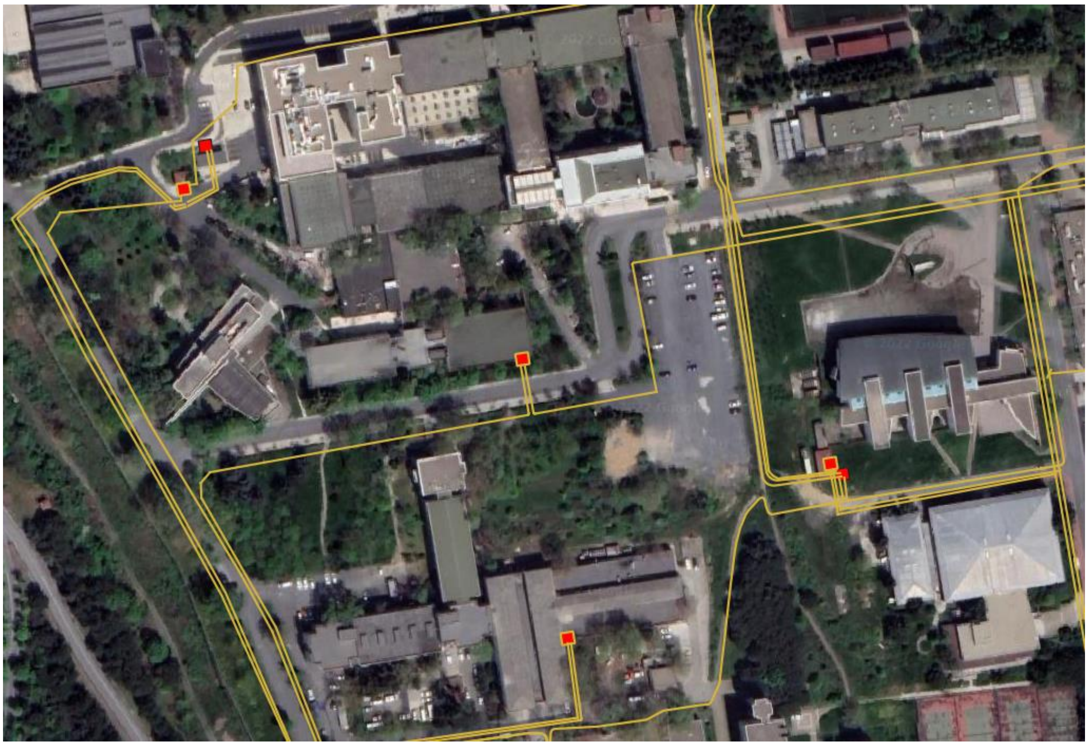

Figure 3.4 : General View of Electrical Cable and Transformer Layer.

3.2.6. Fiber Cable Layer

Fiber Cable is the name given to the cables that have glass inside and easily direct the light passing through them. These cables send data using light signals as opposed to electrical signals. In the fiber cable layer, there are data such as the cable types of the fiber cables, the areas where the cabinet is located, the drilling locations and diameters. Fiber Cable is the name given to the cables that have glass inside and easily direct the light passing through them. These cables send data using light signals as opposed to electrical signals. In the fiber cable layer, there are data such as the cable types of the fiber cables, the areas where the cabinet is located, the drilling locations and diameters.

Table 3.6 : Data Dictionary of Fiber Cable Layer.

Field	Alias	Type	Length
ID	Verilen otomatik ID.	integer	-1
Linewidth	Çizgi kalınlığını belirtir.	float	-1
İşlev	Verinin işlevini belirtir.	float	-1
Kablo cinsi	Kablonun cinsini belirtir.	string	-1
Delgi çapı	Belirli noktalardaki delginin çap bilgisi.	string	-1

Figure 3.5 : General View of Fiber Cable Layer.

3.2.7. Natural Gas Layer

Natural gas is a kind of combustible gas mixture of fossil origin in the earth's crust. It is a petroleum derivative. It takes the second place after crude oil in the order of importance as a fuel. Today, natural gas has been put into the service of humanity with advanced transmission methods. The natural gas, which is widely used in our homes and workplaces, is supplied to the buildings in the campus via a distribution line. The data of the natural gas line was obtained from the ITU Construction Works Directorate. T.C. natural gas line and related data. It was created by the Ministry of Energy and Natural Resources. The data is not publicly available, it is hosted by the responsible institutions. The results of this study with the natural gas line will not be open to the public or students, and will be shared with the Directorate of Construction Affairs. Only the Directorate and the persons responsible within the scope of the work will be able to update the data. Natural gas line data is of line type. After the data obtained from Construction Works in AutoCAD file type was transferred to the QGIS environment, arrangements were made. The representation in the CAD data and the representation in the GIS environment differ. In the CAD environment, data-related information is displayed by writing to the screen in the form of text, while many features of the point line and polygon data can be displayed on the attribute table in the GIS environment. Although it is thought that the information of CAD data is made easier to display in this way, GIS data is of the type that we can call smart data. GIS provides us with an environment where we can enrich data-related information and thus perform various analyzes. The natural gas line data, which comes as a CAD file type, has been prepared in a CAD mentality and needs to be arranged for its use in the GIS environment. Information about the natural gas line data has been added to the attribute table. Some information is not included in the table due to the lack of information about their use. After the completion of the study, the data information will be updated by people who have knowledge about the technical data.

Table 3.7 : Data Dictionary of Natural Gas Layer.

Field	Type	Length	Precision	Comment
fid	int8	-1	0	
boru_capi(mm)	float8	-1	0	
hat_uzunlugu(m)	float8	-1	0	
hat_ismi	varchar	35	0	

Figure 3.6 : General View of Natural Gas Layer.

3.2.8. Heating Layer

Heating data consists of a pipeline laid to meet the heating needs of some buildings on the campus. Data regarding the heating line were obtained from ITU Construction Affairs Directorate. Necessary arrangements have been made. Data information has been updated from the tables. Missing information will be updated by people interested in technical work.

Table 3.8 : Data Dictionary of Heating Layer.

Field	Type	Length	Precision	Comment
fid	int8	-1	0	
layer	varchar	254	0	
hat_uzunlugu(m)	float8	-1	0	
boru_capi(mm2)	float8	-1	0	
kullanim_durumu	varchar	19	0	
isi_kapasitesi	float8	-1	0	

Figure 3.7 : General View of Heating Layer.

3.2.9. Irrigation Line Layer

The irrigation line contains the data of the pipes and pump building used to distribute the water taken from the pond on the campus to various places on the campus. Irrigation line data was obtained from ITU Construction Affairs Department.

Table 3.9 : Data Dictionary of Irrigation Line Layer.

	Alias	Type	Length
ID	Verilen otomatik ID	integer	-1
Kuyu numarası	Kuyunun numarasını belirtir.	İnteger	-1
işlev	Verinin işlevini belirtir.	string	-1
Boru yarıçapı (mm)	Sulama borusunun yarıçapını belirtir.	string	-1

Figure 3.8 : General View of Irrigation Line Layer.

3.2.10. Rain Water Layer

Rain Water indicates the water collected from the gratings as a result of pouring rains. The storm water layer contains data such as the direction of the water flow where the storm water lines pass. The data of the rain water layer was produced with the data obtained from the ITU Construction Department.

Table 3.10 : Data Dictionary of Rain Water Layer.

	Alias	Type	Length
ID	Verilen otomatik ID	integer	-1
Akış yönü	Suyun akış yönünü belirtir.	string	-1
işlev	Verinin işlevini belirtir.	string	-1

Figure 3.9 : General View of Rain Water Layer.

3.2.11. Drink Water and Valve Layer

Drinking Water contains the data of clean water on campus. The drinking water layer includes data such as the directions of pipes carrying water, the locations of wells and tanks, and the water capacity of the tanks. The drinking valve layer, on the other hand, contains the data of the points where the valves are located in the campus and the valve names. The data of the drinking water and Drinking Valve layer were obtained from the ITU Construction Department.

Table 3.11 : Data Dictionary of Drink Water Layer.

	Alias	type	length
ID	Verilen otomatik ID	integer	-1
işlev	Verinin işlevini belirtir.(kuyu,depo)	string	-1
Depo kapasitesi (ton)	Su deposunun maksimum kapasitesini belirtir (ton)	integer	-1
İçme hattı çapı	Hattın çapını belirtir.	string	-1

Table 3.12 : Data Dictionary of Valve Layer.

	Alias	type	length
ID	Verilen otomatik ID	integer	-1
Vana adı	Vananın adını belirtir	string	-1

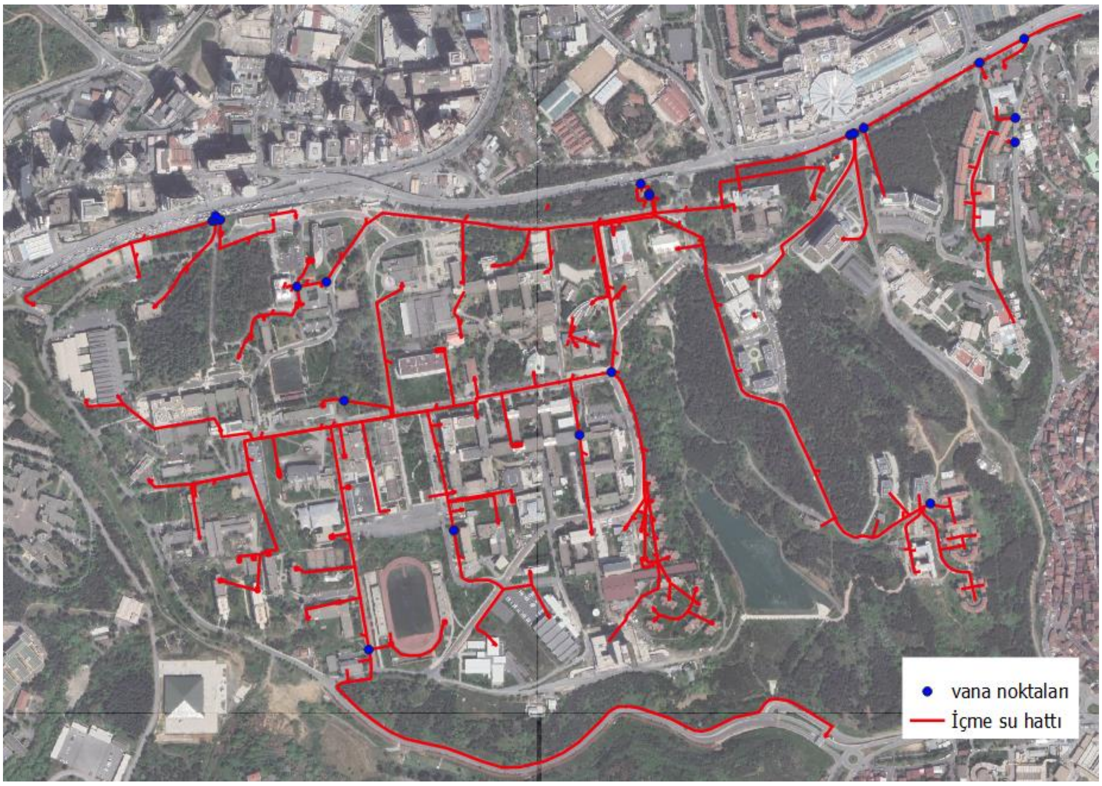

Figure 3.10 : General View of Drink Water and Valve Layer.

3.2.12. Wastewater and Manhole Cover Layer

Wastewater and Manhole Cover Layer The wastewater coming out of the buildings in the campus and the wastewater coming from the manhole covers on the roads are collected and disposed of in the wastewater line. The data related to the wastewater line were obtained from the ITU Construction Affairs Directorate. The data type of the wastewater line is line. The data type of the manhole covers is transferred to the program as point. There are deficiencies in the information about the data. After the completion of the project, the tables will be filled by the relevant technical staff.

Table 3.13 : Data Dictionary of Wastewater Layer.

Field	Type	Length	Precision	Comment
id	int4	-1	0	
hat_uzunlugu(m)	float8	-1	0	
boru_capı(mm2)	float8	-1	0	
akıs_yonu	varchar	16	0	

Table 3.14 : Data Dictionary of Manhole Cover Layer.

Field	Type	Length	Precision	Comment
id	int4	-1	0	
fid	int8	-1	0	
rogar_kapagı_capı	float8	-1	0	
rogarkapagı_cinsi	varchar	15	0	

Figure 3.11 : General View of Wastewater and Manhole Cover Layer.

4. SERIES OF ANALYSIS

Analyzes can be made using the data in the layers of the superstructure and infrastructure produced in the ArıGIS project. Besides being open source, QGIS software is suitable for easy spatial analysis.

4.1. Analysis 1

Marking of vehicle roads with width less than 5 meters within the campus.

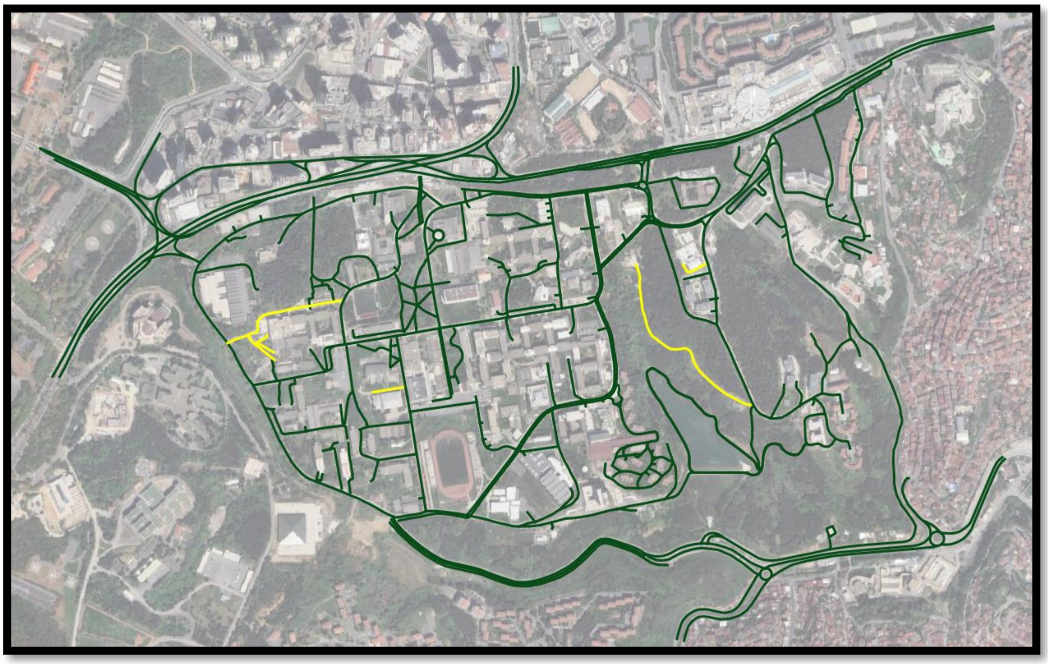

Figure 4.1 : Analysis 1.

4.2. Analysis 2

There are 2 types of paths for cycling on campus. These are bike paths and shared roads. The total road length suitable for bicycle use within the campus has been determined as 6865.23 meters.

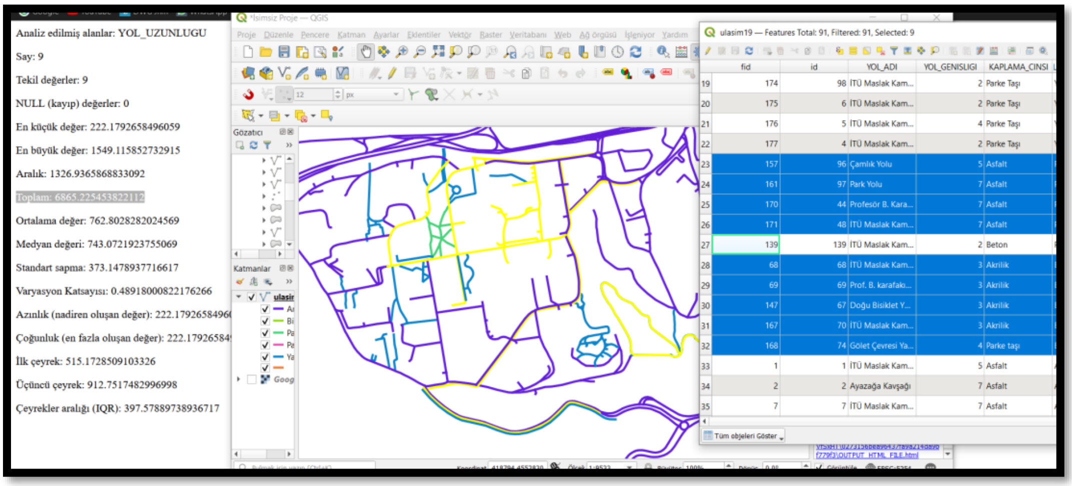

Figure 4.2 : Analysis 2.

4.3. Analysis 3

There are 65 different parking lots on the ITU Ayazağa Campus. Analysis of these parking lots with a capacity of more than 100.

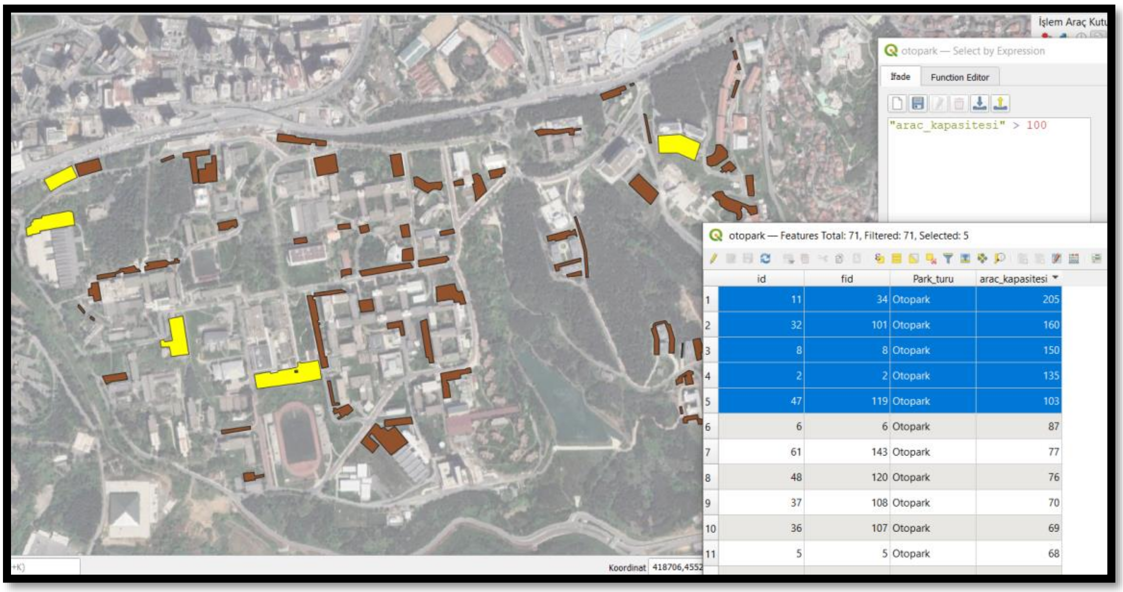

Figure 4.3 : Analysis 3.

4.4. Analysis 4

Analysis of the connection points of the car parks with the roads, that is, the car park entrances or exits.

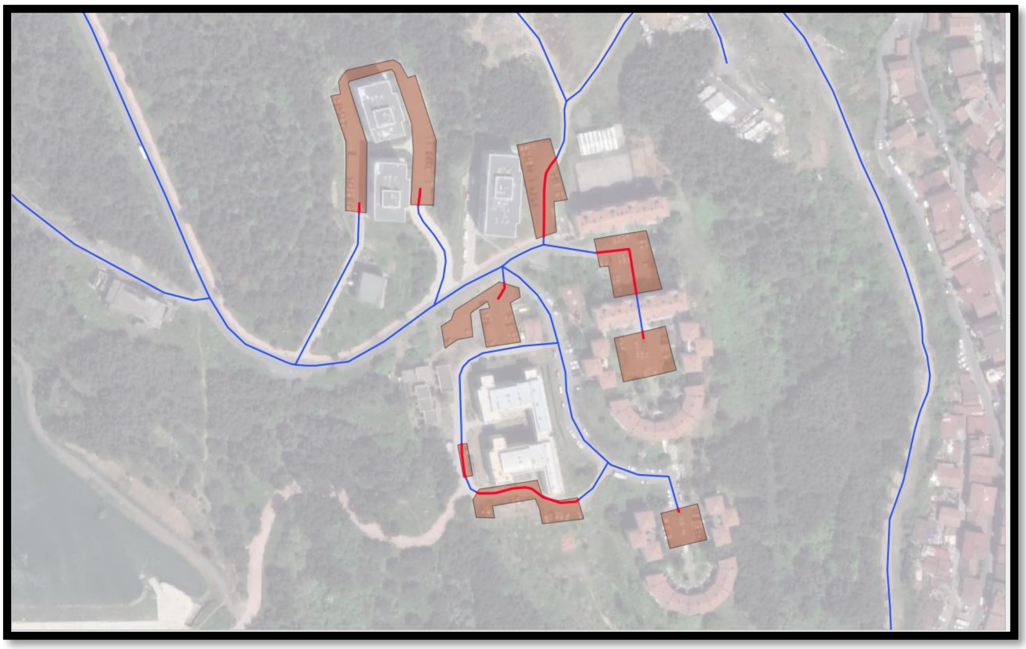

Figure 4.4 : Analysis 4.

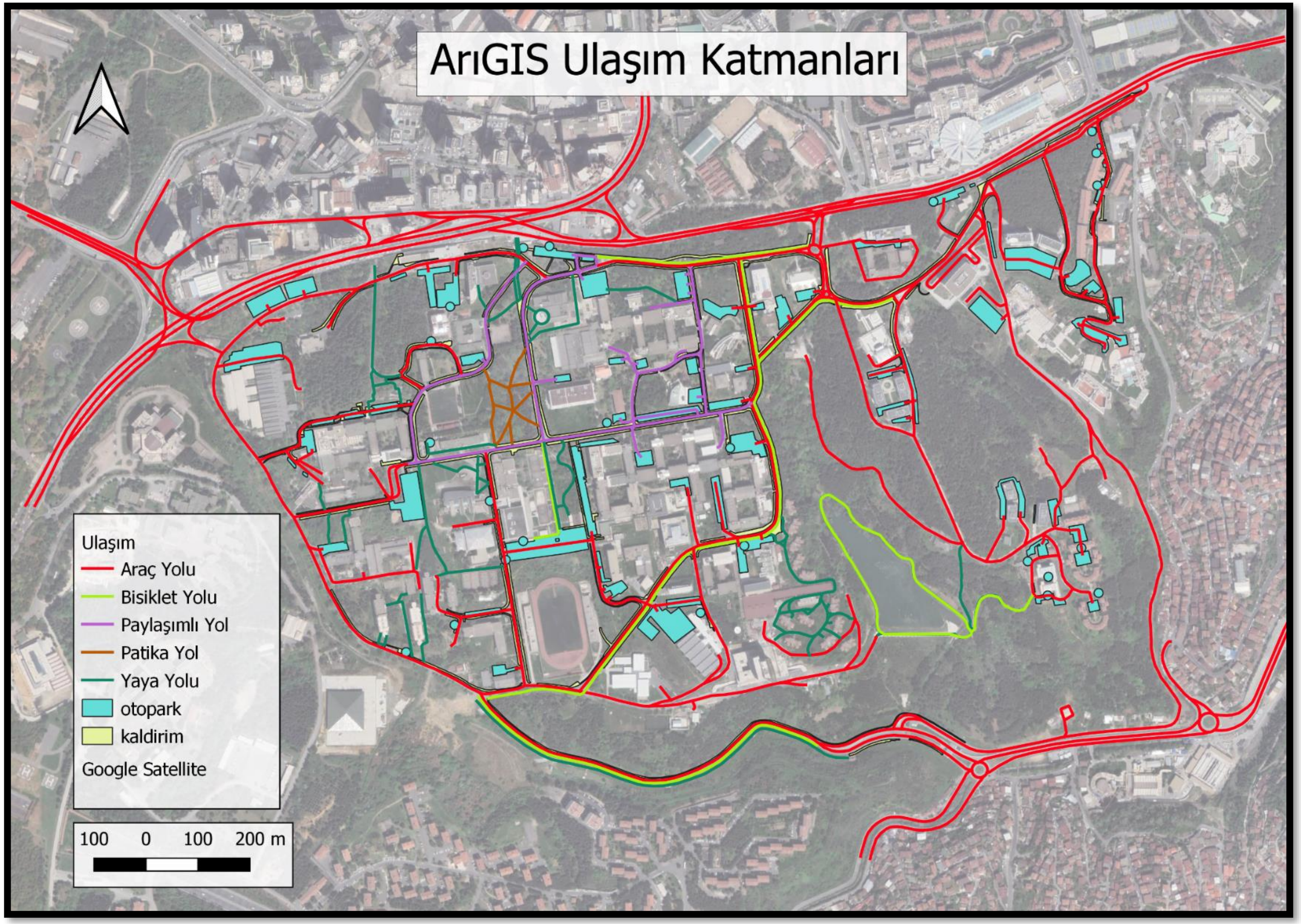

Figure 4.5 : Map of ArıGIS Transportation Layers.

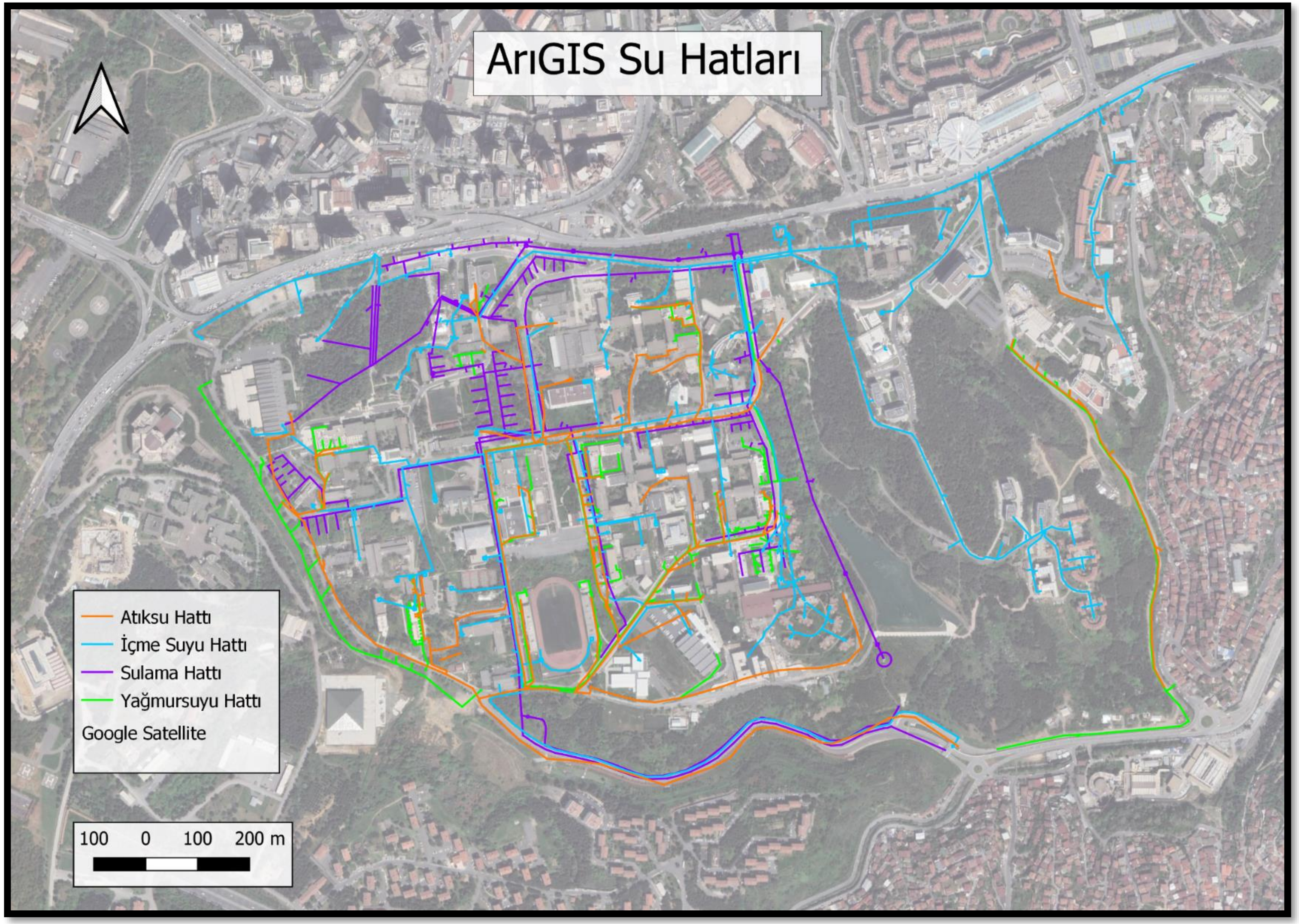

Figure 4.6 : Map of ArıGIS Water Lines.

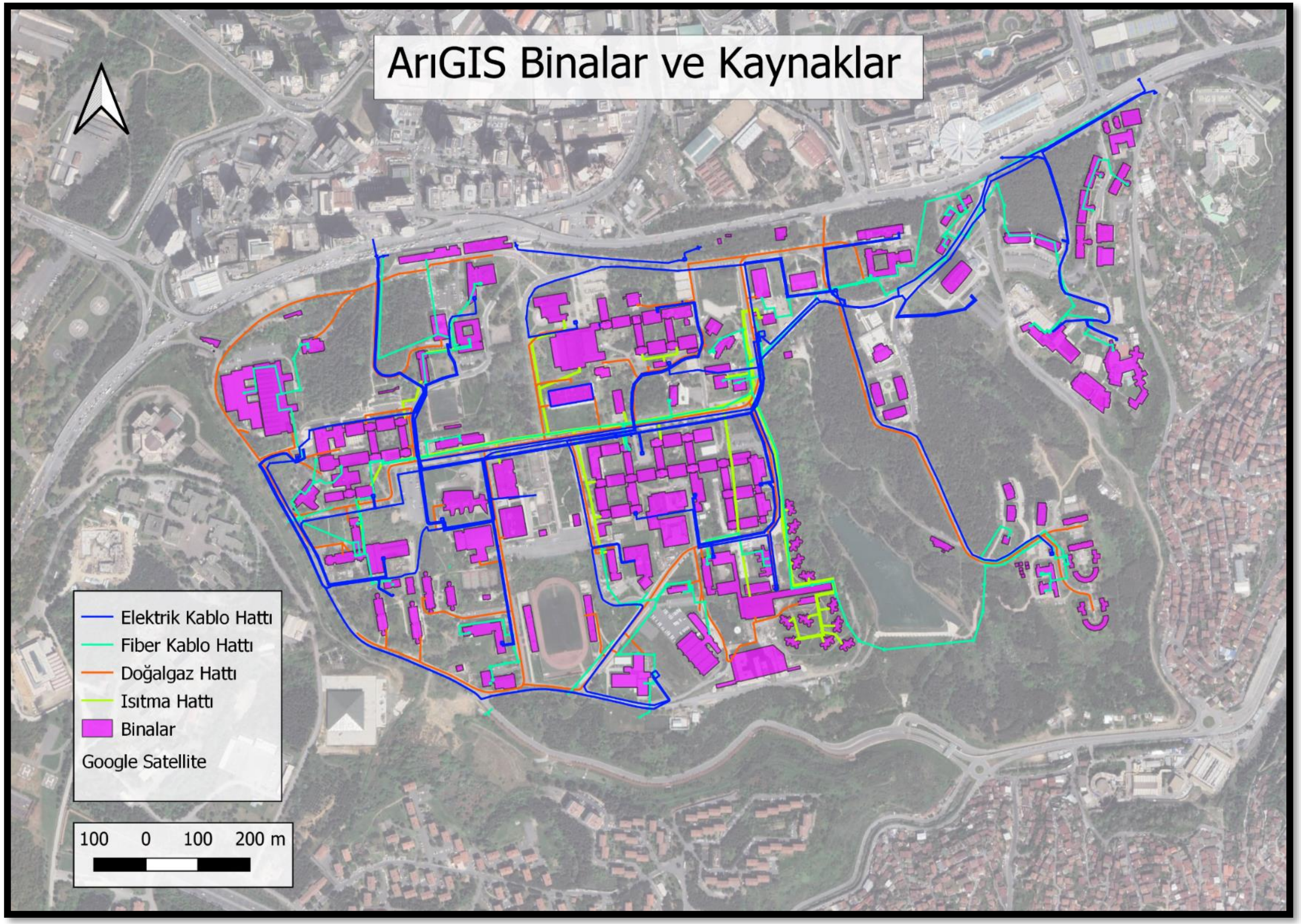

Figure 4.7 : Map of ArıGIS Buildings and Resources.

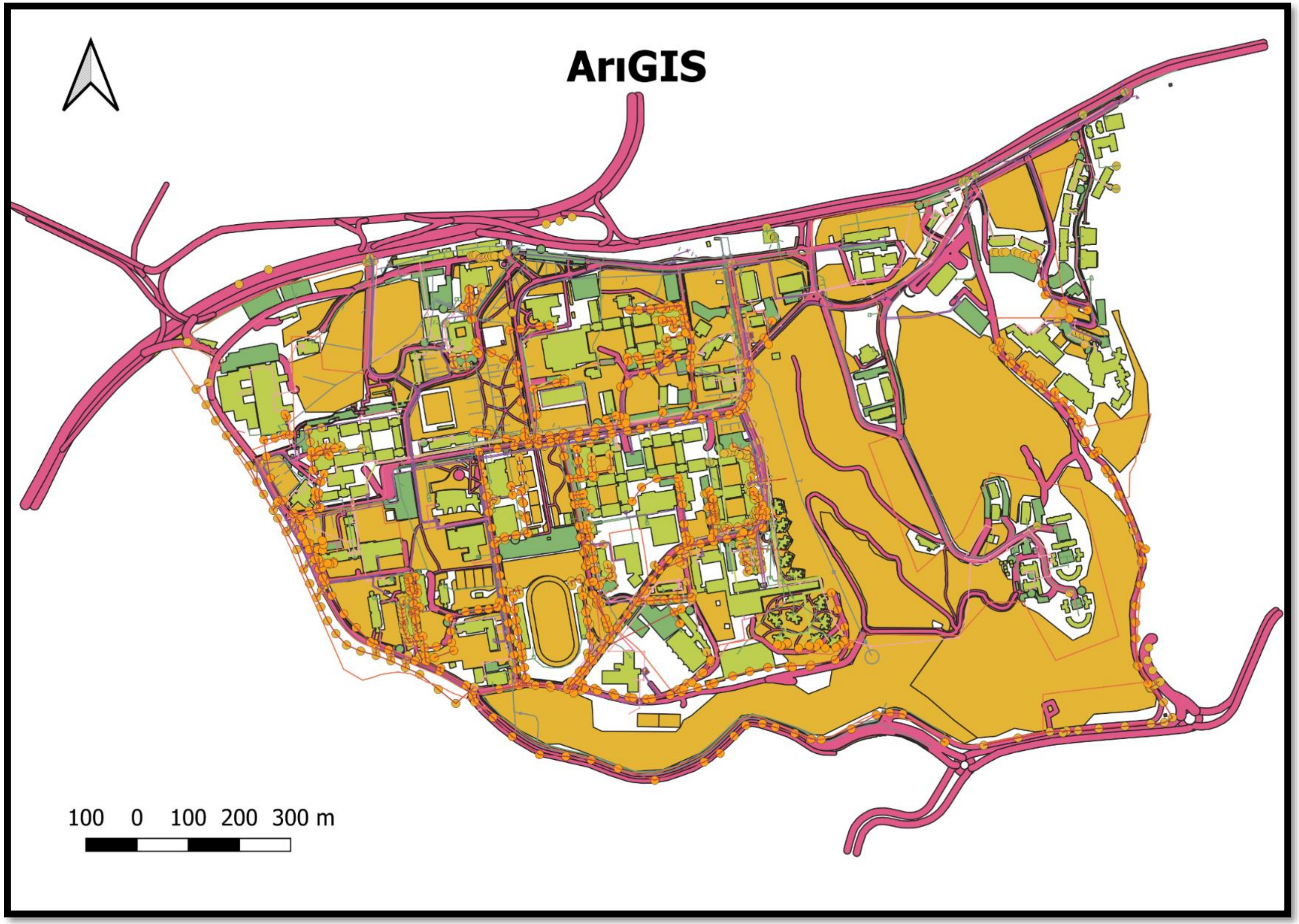

Figure 4.8 : Map of ArıGIS

5. CONCLUSION AND RECOMMENDATIONS

Within the scope of the ArıGIS project, the foundations of the KBS of Istanbul Technical University were laid. During the project, the data obtained from various sources was developed and edited using QGIS software. The layers created with the edited data were stored in the Amazon AWS database with the PostGIS plugin. The layers classified as Superstructure and Infrastructure have been made easy for people with access to the database and able to edit the data. In total, 6 different layers were created for 17 superstructures for infrastructure.

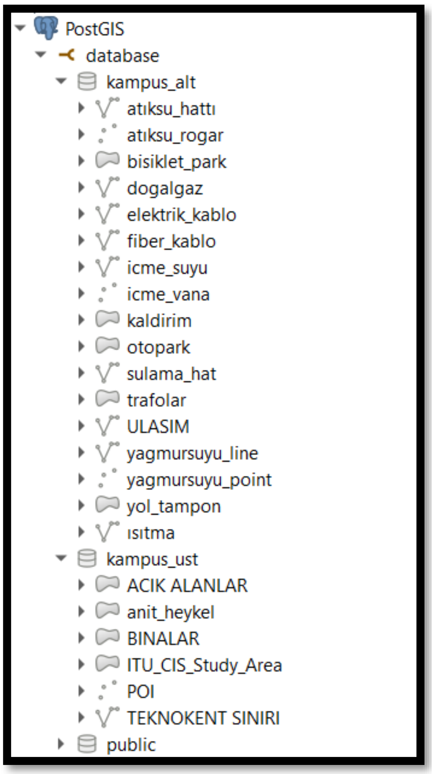

Figure 5.1 : ArıGIS Layers.

In this project, the foundations of ArıGIS CIS belonging to ITU Ayazağa Campus were laid. The data that has been organized and layered can be easily accessed by the relevant persons in the ITU Construction Department and can make improvements on this data. Infrastructural and superstructural changes in the real campus can also be applied to the layers in the ArıGIS database and the CIS can be kept up-to-date. This CIS created in 2D can also be a base for a KBS that can be created in 3D. This CIS can be developed with 3D indoor mapping methods.

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