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Digital Documentation in Cultural Heritage Sites; A Case Study in Ortahisar Trabzon

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Abstract

The determination of approaches to conservation on historical sites is based on the principles that have been accepted on an international level. While these principles define the tangible and intangible values of the cultural heritage to be protected as a whole, they have also brought conservation actions to a holistic, participatory and continuous dimension. The initial and most delicate phase of the conservation process, which commences with registration and identification, is the documentation stage. Over time, techniques related to documentation have evolved, with traditional measurement methods being superseded by digital methods. These methods, which provide rapid, precise data in original coordinates, constitute a crucial foundation for research conducted in protected areas. Ortahisar, currently the central district of Trabzon, is one of the oldest settlements in the city. The area was designated as two protected zones, designated I and II, in 1985, and a conservation plan was prepared in 1986. In this study, the documentation work carried out in the Trabzon Ortahisar Protected Area in 2012 is examined, and the techniques, equipment and work processes used, and the final products obtained, are shared.

Keywords: *Cultural heritage, digital documentation, conservation, laser scanning, modelling.*

Kültürel Miras Alanlarında Dijital Belgeleme: Trabzon Ortahisar Örneği

Öz

Tarihi alanlardaki korumaya ilişkin yaklaşımlar uluslararası kapsamda kabul edilen ilkelerle belirlenmektedir. Bu ilkeler korunması gerekli kültürel mirasın somut ve somut olmayan değerleriyle bir bütün olarak tanımlarken, koruma eylemlerini de bütüncül, katılımcı ve sürekliliği olan bir boyuta taşımıştır. Trabzon'un günümüzde merkez ilçesi konumunda olan Ortahisar kentin en eski yerleşim alanlarından biridir. 1985 yılında I ve II nolu iki sit alanı olarak tescillenen alan için 1986 yılında koruma amaçlı imar planı yapılmıştır. Bu çalışmada Trabzon Ortahisar Sit Alanında 2012 yılında yapılan belgeleme çalışmaları incelenmekte, kullanılan teknik, ekipman ve iş süreçleri ile elde edilen sonuç ürünler paylaşılmaktadır. Trabzon Ortahisar sit alanında yapılan Yenileme Alanı Avan Projesi kapsamında yapılan belgeleme çalışmaları, dijital metotlar üzerinden incelenmiştir. Bu kapsamda sokak halihazır ölçümleri ve sokak siluetlerinin belgeleme çalışmaları, kullanılan teknoloji, iş akışı, verilerin değerlendirilmesi ve sonuç ürünler üzerinden ele alınmıştır.

Anahtar kelimeler: *Kültürel miras, sayısal belgeleme, koruma, lazer tarama, modelleme.*

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1. Introduction

The architectural cultural heritage that needs to be protected may not always be monumental or a single building scale. National and international principles regarding conservation have set forth definitions regarding conservation at the building complex, street or urban scale. The Convention for the Conservation of the World Heritage signed in 1972 defined cultural heritage as monuments, building complexes and sites of outstanding universal value (Republic of Turkey Ministry of Culture and Tourism, 1982).

The 1993 Icomos Guidelines on Education And Training in The Conservation of Monuments, Ensembles and Sites (1993) stated that the heritage to be protected includes historical buildings, historical areas and towns, archaeological sites and their contents, as well as historical and cultural landscape areas (ICOMOS, 1993). The 1996 Icomos Principles for the Recording of Monuments, Groups of Buildings and Sites document defines cultural heritage as the structures, groups of buildings that constitute the historical and built environment and areas with heritage value (ICOMOS, 1996). Law No. 2863, which determines the rules regarding the definition, registration and conservation of cultural assets in our country, defines cultural assets as “all movable and immovable assets above ground, underground or underwater that are related to science, culture, religion and fine arts from prehistoric and historical periods or that have been the subject of social life in prehistoric or historical periods and that have original scientific and cultural value”, and also defines “Sit” as “cities and city ruins that are the products of various civilizations from prehistory to the present and reflect the social, economic, architectural and similar characteristics of the periods they lived in, places where cultural assets are densely located, that have been the subject of social life or where important historical events have taken place and areas that need to be protected with their natural features that have been determined” (Republic of Turkey Ministry of Culture and Tourism, 1983). Within the scope of the same law, the principles regarding the preparation of projects for cultural assets that need to be protected and the preparation of “Conservation Plan” and “Urban Design Project” for Site Areas have also been determined by regulations (ICOMOS, 1996).

The conservation and sustainability of urban fabric, defined as a site or having site characteristics, is significant in terms of preserving urban identity. This is a social responsibility. In the context of urban conservation, it is essential to protect cultural assets while implementing functional changes and additions that meet current needs of the community. In addition, new urban designs should be created in a way that is integrated and harmonious with the existing urban fabric. As one of the urban areas under protection in Türkiye, Trabzon Ortahisar Area stands out with its number of cultural assets, city walls and unique topography.

In the current period, digital technologies and even artificial intelligence have begun to be used in the field of conservation, as in every field. The initial stage of the process is the documentation of conservation. The necessity for rapid and precise documentation, coupled with the demands of the modern age, has rendered digital documentation an indispensable component. The utilization of laser scanning technologies in digital documentation within an urban setting has become a prevalent practice. This system, which facilitates the precise acquisition of land data in a relatively short time, allows for the evaluation of data in two and three dimensions and enables the development of gaming, virtual reality (VR), and augmented reality (AR) applications.

In the process of digitizing cultural heritage, data can be obtained from a variety of sources, including the air, mobile devices, or ground level, using 3D laser scanning systems. In the context of architectural detail, ground scanning technology is the most rapid and dependable method. Laser scanning systems can document single structures, such as mosques, tombs, domes, and examples of civil architecture, as well as natural or man-made structures, including caves and archaeological sites. The use of digital methods, such as laser scanning, in data acquisition has also facilitated the transfer of the digital model of the structure to the office environment.

Conversely, the acquisition of point cloud data from laser scanning, coupled with the preparation of a 3D model that accurately reflects the material and texture of the space in question, and the ability to visit this model virtually, will facilitate the promotion and accessibility of cultural assets, while

simultaneously ensuring their conservation. The study on the Trabzon Ortahisar I and II Protected Areas presents the documentation methods used and the results of the project on the use of digital documentation methods in urban protected areas.

2. Material

2.1. Documentation of Cultural Heritage

The Venice Charter, which is regarded as the inaugural document in the field of conservation theory to gain a place in the historical process and global acceptance, defines the concept of a historical monument and the principles of conservation. It also states that "all sciences and techniques that can help conservation should be utilized" (ICOMOS,1964). The World Heritage Convention, which was signed in 1972, expanded the concept of heritage to be protected to include not only monumental structures but also building groups and urban archaeological textures. This reveals the principle of taking legal, scientific and technical measures in the processes of determining, protecting, preserving and presenting the heritage (Republic of Turkey Ministry of Culture and Tourism, 1982). The 1993 Icomos Guidelines on Education and Training in the Conservation of Monuments, Ensembles and Sites place considerable emphasis on the importance of sufficient documentation for the understanding of monuments, groups or areas and their related environments, which is a fundamental aspect of conservation (ICOMOS, 1993).

The objective of the protective measure is to "preserve the original qualities." The initial stage of the process is to document the current condition of the heritage in question. The ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites (1996) elucidates the fundamental reasons, responsibilities, planning measures, contents, management and sharing issues pertaining to the recording of cultural heritage. It underscores the significance of recording the heritage. The necessity of documentation is underscored to care the intrinsic qualities of the heritage in maintenance and repair activities, to comprehend the authentic values of the heritage, and to ascertain all forms of interventions made or to be made on it (ICOMOS, 1996). Furthermore, it highlights the fact that documentation, due to its capacity to include both tangible and intangible evidence, can also contain information that contributes to an understanding of the heritage and the values associated with it (ICOMOS, 1996).

The process of protecting cultural heritage commences with identification studies. Nevertheless, the initial stage of conservation activities is documentation. The fundamental objective of a conservation project is to collate data on the physical condition of the structure prior to any action or intervention (ICOMOS, 1999).

The recording process encompasses a range of activities, including drawing, photography, film, measurement, reporting, and analysis. Computer-aided design (CAD) drawings have been employed for decades in the development of conservation projects, which often entail survey, restitution, and restoration operations. While traditional measurement tools, such as meters, laser meters, and levels, remain integral in the assessment of survey drawings that serve as the foundation for these endeavors, their usage is contingent upon the scale of the project.

As previously stated, the range of cultural heritage elements that require conservation has broadened. The focus has shifted towards the production of projects at the level of the building group, street, avenue or urban scale. In the context of urban design projects or street rehabilitation projects produced in urban sites, it has become increasingly important to document the interrelated building blocks or groups in a manner that accurately reflects the context and texture of the surrounding area. The documentation methods and the type of documentation produced must be appropriate to the nature of the heritage, the purposes of the record, the cultural context and the available financing or other resources. According to the characteristics of the field of study, various forms of documentation may be preferred, including photographs (from the air or land), photogrammetry, geophysical survey, maps, measured plans, drawings and sketches, or other traditional and modern technologies (ICOMOS, 1996).

2.2.Digital Documentation

The legislative framework of Law No. 2863 has incorporated novel technologies employed in the documentation of cultural assets, which are defined as "advanced documentation techniques" (Republic of Turkey Ministry of Culture and Tourism, 2024). The process of measuring a structure, group of structures, or an area by photogrammetry or laser scanning is defined as the "digital documentation" method.

Digital documentation represents a comprehensive hardware and software system that captures and measures building information in digital data, which is then visualized in digital three-dimensional (3D) models (Fortenbarry, 2018). Digital documentation methods can be classified into two distinct categories: photogrammetry and laser scanning technologies. Nevertheless, the integration of software allows for the combination of data obtained from the two distinct methods (Figure 1).

Since the end of the twentieth century, those engaged in the field of conservation have commenced the integration of digital technologies. In the late 1990s, the use of photogrammetry and laser scanning became prevalent in this field. In 1995, the University of Texas pioneered the use of laser scanning technologies on an immovable cultural asset (Fortenberry, 2019). Digital documentation methods are secure, reversible and expedient techniques that guarantee the preservation of the physical characteristics of historical sites without any impairment (Akçam Ergin, 2023).

In the field of conservation, three-dimensional point cloud data obtained from three-dimensional laser scanners are employed in two-dimensional and three-dimensional drawings and modelling. The photogrammetry method is employed in surveys for the purpose of obtaining realistic textures. Furthermore, it offers rapid and high-quality visual data to product of 3D city models. The software developed in accordance with the photogrammetry method now permits the direct production of solid models and the generation of point clouds from the data obtained. Consequently, both methods can be employed in conjunction with one another.

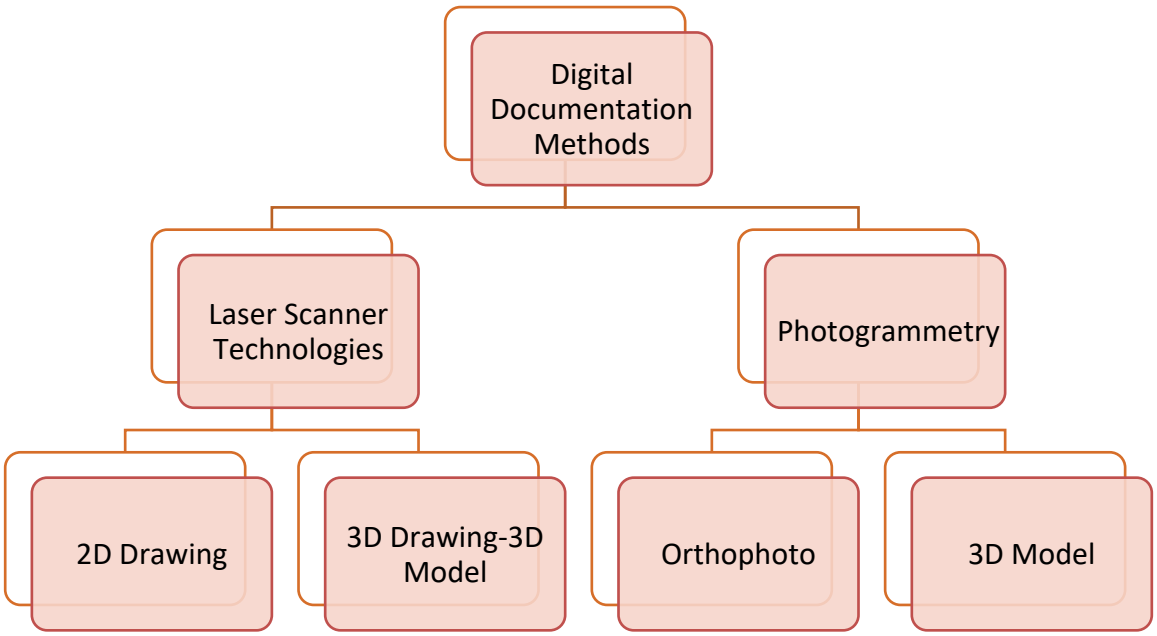


Figure 1. Digital Documentation Methods (By authors).

2.2.1. Photogrammetry methods

Photogrammetry is a measurement method comprising techniques for interpreting, measuring and modelling objects according to their images. The method was initially employed by the architect Alberth Meydenbauer in 1858 (Fortenberry, 2019). In the present day, photogrammetry is employed through the processing of data obtained from the ground or from the air with high-resolution cameras and software.

Terrestrial photogrammetry is a highly applicable method for the creation of three-dimensional models of specific objects. Such models may prove useful in the creation of a 3D archive and in responding to the various purposes of documentation. In photogrammetry, the results can be presented expeditiously, preceding other operational measures in the conservation process. In comparison to analogue methodologies, this approach is safer as it does not necessitate direct contact and yields a substantial quantity of data due to the remote acquisition of data (Hassani, 2015).

2.2.2. Lidar methods

Laser-based systems are classified as lidar technology. As with photogrammetry, this method can be employed in terrestrial, aerial, or mobile applications. Terrestrial laser scanning is a frequently preferred method in studies within the scope of cultural heritage. Laser scanners have a wide range of applications, from the documentation of small buildings to the documentation of large complexes within the field of cultural heritage. The technology and software associated with this method are subject to ongoing development. Furthermore, it offers benefits in the context of street rehabilitation and urban conservation studies, as it enables the collection of coordinated data with minimal error margins in real time.

In the field of architectural documentation, the combination of laser scanning with photogrammetry can facilitate the acquisition of more accurate results, particularly in contexts where the need for precise detail is paramount. The enhanced resolution of laser scanning enables the generation of a comprehensive model; however, this necessitates a greater input of human resources for the collection of data and the assessment of point clouds. Laser scanning is a more costly method than photogrammetry, primarily due to the expense associated with data acquisition and measurement (Kersten, 2006).

The advent of terrestrial scanning methods, airborne and mobile lidar technology, and UAV data collection has enabled the integration of data obtained through disparate methods at the point of data collection in the field. A workflow method is employed for the integrated utilization of terrestrial scanning, terrestrial photogrammetry and drone photogrammetry techniques. In accordance with the characteristics of the study area, airborne LiDAR, mobile LiDAR and drone LiDAR technologies are also employed. The hybrid method, which integrates all data with the georeferencing method, enables the holistic digitalization (digital twin) of cultural assets or cultural texture.

2.3. Trabzon I and II No. Protected Area

Trabzon, the most populous city in the Eastern Black Sea Region, has a history of serving as a port city, with a demographic composition that has been shaped by the influence of various communities and civilizations. It is highlighted that the city has consistently occupied a pivotal strategic location throughout its history, a fact reflected in its geography, politics, military history and cultural heritage. The city has a rich and valuable cultural heritage that has been preserved and carried forward to the present day. The historical artefacts that have survived to the present day are predominantly from the Byzantine and Ottoman periods. When the structures that have survived to the present day are taken into consideration, it can be said that the architectural structure stock accumulated by this process began with Trabzon Castle, which date to the Byzantine period. However, it can be observed that a period of 1,500 years can be seen in the city today. The Ottoman period structures of the city were built in the last 500 years (Özen et al., 2010).

It is acknowledged that the city has been the subject of planning activities since 1938. The Lambert plan saw the inner castle and its surroundings organized as an archaeological park area. In accordance with the city's port city identity, street widening works were carried out, and apartment buildings were initiated. The surrounding area of the monuments was opened and individual interventions were suggested, which resulted in the loss of examples of civil architecture (Özen et al., 2010). In 1974, the area comprising the Ottoman-period historical works in the Aşağı Kale and Çarşı neighborhood was designated a Conservation Area in accordance with the provisions of Law No. 1710, as reflected in Decision No. 8195 dated 14 December 1974, adopted at the 251st meeting held on 13 December 1974 (Figure 2) (Aysu, 1977).

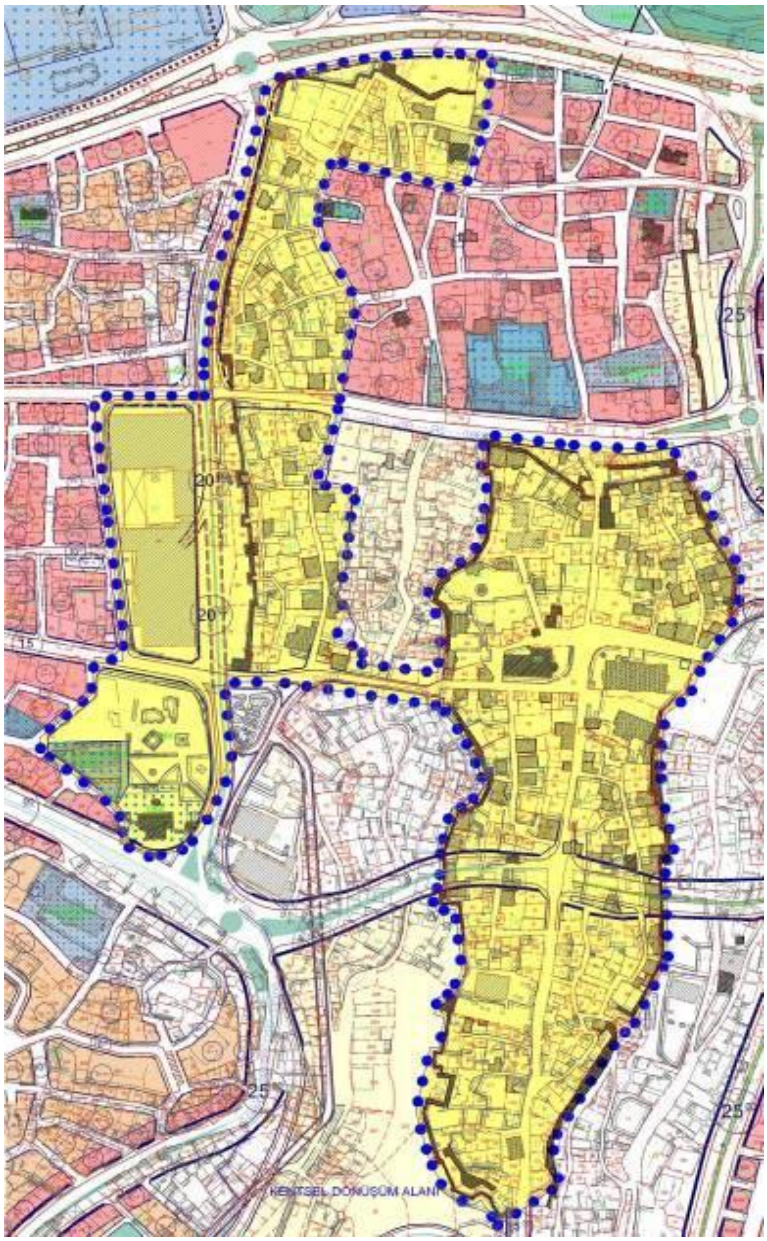


Figure 2. The boundaries of the Conservation Area determined within the framework of the law numbered 1710 and the decision numbered 8195 dated 14.12.1974, in the meeting numbered 251 of the Supreme Board of Immovable Antiquities and Monuments (GEAYK) of the Prime Ministry of the Republic of Türkiye, dated 13.12.1974 (Trabzon I and II Site Conservation Plan ,1989).

It has been established that the extant structures are distributed across the city, exhibiting a variety of architectural styles. These include examples of monumental and civil architecture. The types of structures can be enumerated as mosques, fountains, inns, baths, churches, city walls, bridges, aqueducts, monasteries, shrines, public buildings, mansions, numerous houses, and other building groups (Bimtaş , 2013).

The Trabzon Conservation Plan report, dated 2013, indicates that there are a total of 25 urban, natural and archaeological sites in Trabzon province. Additionally, there are a total of 983 registered immovable cultural assets within the city, 482 of which are located within the central district, and 115 within the study area, which encompasses sites I and II in the city center of Trabzon (Table 1). This figure represents 11.7% of the total number of registered structures in Trabzon province and 23.9% of the total number of registered structures in the central district of Trabzon. The area represents the historical core of the city of Trabzon and contains significant artefacts that reflect the city's historical development (Figure 3). The area contains a variety of architectural features, including city walls, bridges, mosques, madrassas, public buildings, baths and residential structures (Benli & Kan, 2023).

Table 1. Number I and Number II Site Architectural Heritage Analysis (By Authors)

ARCHITECTURAL HERITAGE ANALYSIS	Number of Building		TOTAL NUMBER
	SITE I	SITE II	
REGISTERED HERITAGE (MONUMENTS)	7	10	17
REGISTERED HERITAGE (Traditional residential building)	25	59	84
NEW BUILDING ON REGISTERED HERITAGE SITE (Traditional Residential Building)	5	8	13
NEW BUILDING ON REGISTERED HERITAGE SITE(Monumet)	1	0	1
TOTAL NUMBER	**38**	**77**	**115**



Figure 3. Trabzon Ortahisar SITE I & II: Registered Architectural Heritage (Authors Archive; Bimtaş, 2013)

3. Method

The data presented in this article is based on the experiences gained by the authors during their work between 2010 and 2013. The objective of this work was to preserve and promote the cultural heritage of Ortahisar through the development of cultural tourism, a role which the authors fulfilled as project managers in 2013. Specifically, the project entailed an examination of the protected area, an updating of the current base map, the preparation of preliminary urban design projects for the entire renewal area, the production of a three-dimensional representation of the current situation and a design-oriented city model, the preparation of survey, restitution and restoration projects for one cultural asset (the Old Governorship Building from the Republic Period), and the restoration of the Old Governorship Building.

In this study, data pertaining to the aforementioned project was employed for analysis. The authors participated in the study in the capacity of project managers. In the study, conventional and digital methods were employed concurrently in the documentation process due to the expansive dimensions of the area, the presence of cultural assets, and the constraints of time. This article provides an overview of the digital methods employed in the documentation of cultural heritage, with a particular focus on the methods and product outputs utilized in the Ortahisar project. The authors examined the

duration, data quality and potential of these methods, which are particularly suited to the context of urban conservation to ascertain their ability to create a healthy base for the studies. In this context, the concept of digital documentation and the methods used in the field of conservation will be discussed in detail. This article will present an overview of the Trabzon Ortahisar Area, including its architectural, cultural and geographical characteristics. It will also describe the documentation process carried out in the area, with reference to the workflow and final products.

4. Findings and Discussion

The Urban Protected Area was designated in the Trabzon Province Centre in accordance with the decision of the Immovable Antiquities and Monuments High Council dated 13 November 1980 and numbered A-2509. The Trabzon Historical Urban Protected Areas were designated as protected areas I, II and III, with the borders of which delineated on the map. This designation was made by the Immovable Cultural and Natural Assets High Council on 4 September 1985, and the decision number was 1426. Furthermore, the 'Castle Protected Area / Trabzon Walls Protected Area' was designated by the conservation plan decision, encompassing the surrounding area of the walls and extending to the boundaries of Protected Area II. The study area encompasses both Urban Protected Areas I and II. The combined area of Protected Areas I and II is 19 hectares to facilitate the accurate and comprehensive documentation of the area's historical topography, advanced documentation methods were employed.

4.1. Data Collections Process

A total of 115 registered structures have been identified within the area, comprising examples of both monuments and civil architecture. In the context of the aforementioned project study, which is detailed in the Material and Method section, a further 14 structures were proposed for registration. In addition to the existing registered structures within the study area, those deemed to be in keeping with the surrounding environment were also identified. As part of the study, a foundation was established for the current conservation zoning plan for the area, a survey of the registered cultural assets was conducted, and an urban design preliminary project for the entire area was prepared.

I and II sites were identified and examined within the scope of preparation for the conservation zoning plan. Conventional terrestrial laser scanning methods were used in data collection and analysis studies. In this context, scanning and process studies were carried out with a laser scanning team consisting of a Surveying Engineer (3 people) and a Surveying Technician (9 people). In addition, in the project studies, measurements and survey drawings were made by 6 conservation expert architects and 12 restorers using conventional methods. In the analysis studies, a team of 6 urban planning experts, 2 conservation experts, architects and 2 landscape architects took part (Figure 4).

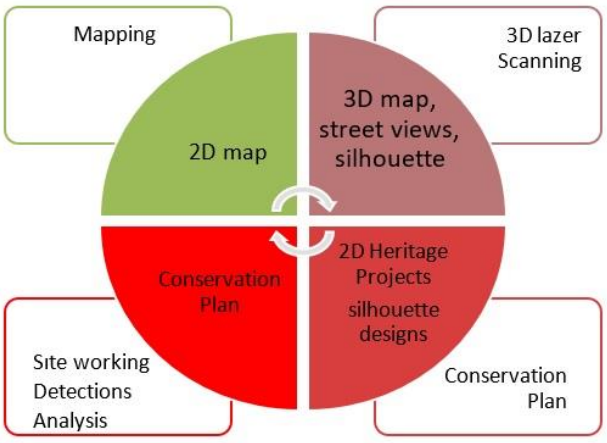


Figure 4. Working groups and system (By Authors, 2024)

4.1.1. Base Map Studies

In the context of conservation plan studies, it is of paramount importance to utilize an up-to-date and accurate base. The creation of base plans is achieved through the application of photogrammetric methods or ground map readings. However, it should be noted that in photogrammetric maps, the boundaries of parcels and buildings may not be fully visible in instances where the area in question is situated beneath trees or in the shade. The current deficiencies in Ortahisar Site areas have been duly addressed (Figures 5 and 6).

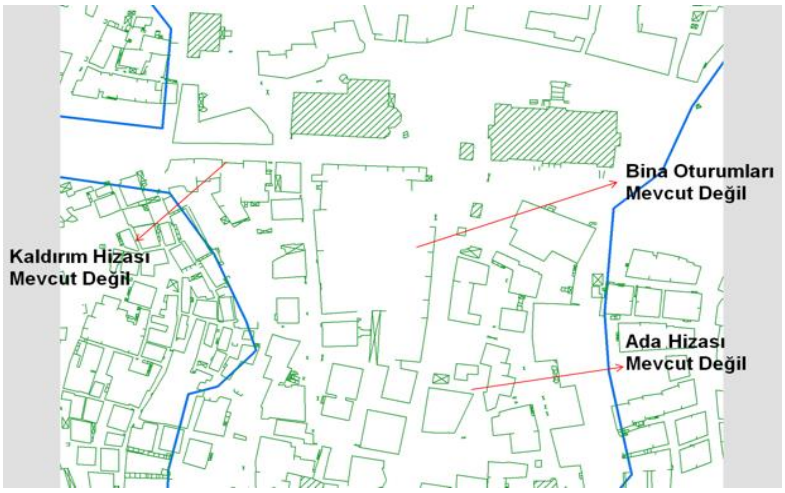


Figure 5. Areas with completed deficiencies in the site No. I (Authors Archive; Bimtaş, 2013)



Figure 6. Areas with completed deficiencies in the site No. I (Authors Archive; Bimtaş, 2013)

4.1.2. Street Silhouettes and cultural heritage

To create a three-dimensional digital inventory of all structures and equipment, a range of sophisticated surveying instruments were employed, including terrestrial laser scanners, digital cameras with sufficient resolution, and positioning sensors. In planning the fieldwork, the laser scanner to be used for 3D data recording was selected based on two factors: the size of the structures in the region and the fineness of the details on them. To ensure the precision of the measurements, the scanning values and sensitivity were adjusted according to the detail density of the structures.

In this context, outdoor scans were performed with scanners that had a scanning distance of at least 25 m and a fast-scanning capacity, with the ability to scan approximately 500.000 points per second. In the detailed laser scans of the building surface and indoor scans, scanners with 360º horizontal and 270º vertical scanning, digital camera integration, ±6 mm positional accuracy, 2 mm point density, and 4.000 point/sec scanning density were utilized. It was of particular importance to scan a portion of the previous station at each station. As the terrestrial laser scanner has an independent coordinate system at each station point, to combine the sessions conducted from different points and to transfer the

scans to the country coordinate system, three paper or metal targets previously placed in the study area were scanned in each session. Prior to commencing the scanning process, the requisite scanning parameters were entered into the HDS4500 and HDS3000 terrestrial laser scanners using the Cyclone5.2 software, developed by Leica. This process was repeated for each session. Subsequently, the scanning surface to be scanned was selected using scanning windows. During the scanning process, the targets to be used in the merging and positioning were scanned with greater frequency.

Furthermore, photographic documentation of the structures in the area was conducted using digital cameras with a resolution of 5 megapixels, with the objective of coloring the scans and utilizing them in drawings. A measurement plan was devised prior to the scanning process. A total of 500 sessions (stations) were conducted, with an average spacing of 20 metes between each station. A total of 15 days of work were conducted, with two teams of three individuals and two scanners, resulting in 12 sessions completed daily. Once the scanning process was complete, the subsequent phase of the project commenced, namely the processing of the data obtained. Initially, scans that were superfluous to the model and contributed to an unwieldy file size were removed. Subsequently, the point cloud data obtained from all sessions were combined in the local coordinate system. This process was conducted with the assistance of targets that were scanned in conjunction with at least one target from the other session in each session. (With mm precision) Subsequent to the fieldwork, the remaining office work, which can be summarized as cleaning unnecessary scans, merging (registration) and coordinating the point clouds, lasted approximately 10 days. In this study, a total of 9.664 metes of road and an average of 9.180.800 m² of building surface were scanned in a 19-hectare area, including 17 islands and 5.709 metes in the protected area. In addition, 14 islands and 3.955 metes in the protected area (Sıte II) II were included (Table 2).

Table 2. Measured street lengths of protected areas I and II (on a per-block basis)(By Authors)

Site I		**Site II**	
BLOCK NUMBER	STREET LENGHTS	BLOCK NUMBER	STREET LENGHTS
127	1028	66	182
128	140	62	662
126	489	887	337
122	207	63	270
121	92	61	516
120	188	102	273
119	158	105	108
118	170	103	104
117	152	109	488
116	553	188	98
129	320	77	187
128	469	80	376
130	152	76	267
110	706	78	87
124	218		
111	78		
114	589		
TOTAL	5709 mt	TOTAL	3955 mt

The point cloud data was subsequently transferred to the office environment, where it was allocated coordinates for the entire site area and for each island individually (Figures 7 and 8).



Figure 7. Site No. I, 3D frame drawing based on Terrestrial Scan (Authors Archive; Bimtaş, 2013)

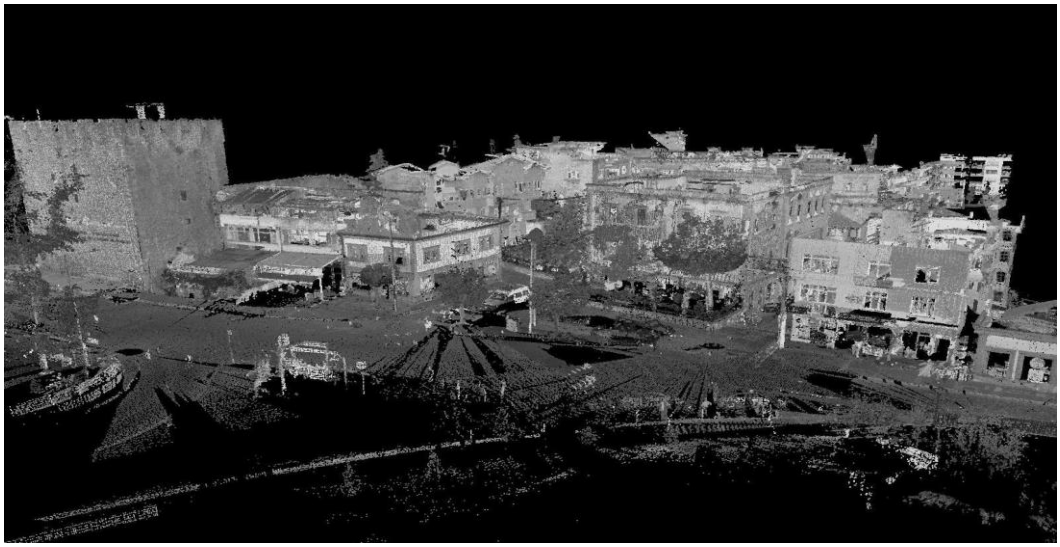


Figure 8. Site No. I, Terrestrial Scan-3D Point Data (Authors Archive; Bimtaş, 2013)

4.2. Drawing and modelling process

Once the data acquisition phase was concluded, the data obtained from each scanner was subjected to preliminary processing using dedicated software. This phase is comprised of several sub-phases, including data analysis, merging, georeferencing, separation, and data transfer for subsequent phases. The data processing software is capable of recording data in ASCII format (xyz, pts and ptx formats).

The advanced processing phases of the data consist of four sub-phases, which are as follows:

- 2-D or 3-D CAD drawings on laser point cloud,
- 3-D building modeling and visualization,
- Creation of a virtual city model and
- Preparation of street silhouettes and block-based design proposals
- Integration into GIS

4.2.1. 2D Drawings

In urban conservation areas, urban design studies are conducted at scales of 1/200 and 1/500 in conjunction with the plan for the sustainable advancement of the conservation process. The 3D point cloud data obtained in the Trabzon study was employed for the purpose of obtaining street silhouettes and island plans. In the two-dimensional drawing stage, an intermediate software program (Zmap) was

employed that is capable of opening and processing both laser and photographic data simultaneously. This software facilitates the generation of orthophotos when necessary, as well as the opening and recording of data in PTX or XYZ format and the transfer of data to AutoCAD (in either DWG or DFX format). The vector drawings obtained from this software were imported into AutoCAD and used in the production of projects that needed to be created in accordance with the conservation principles (Republic of Turkey Ministry of Culture and Tourism, 2024), as illustrated in Figures 9, 10 and 11.

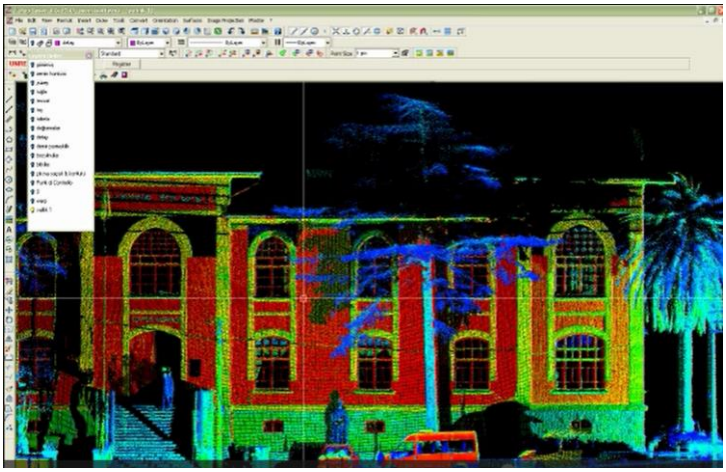


Figure 9. Colored Point Cloud data (Authors Archive; Bimtaş, 2013)

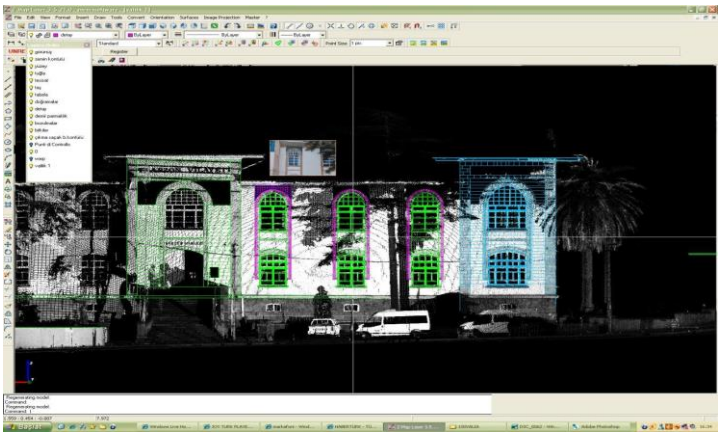


Figure 10. 3D frame drawing based on Point Cloud data of the same building (Authors Archive; Bimtaş, 2013)

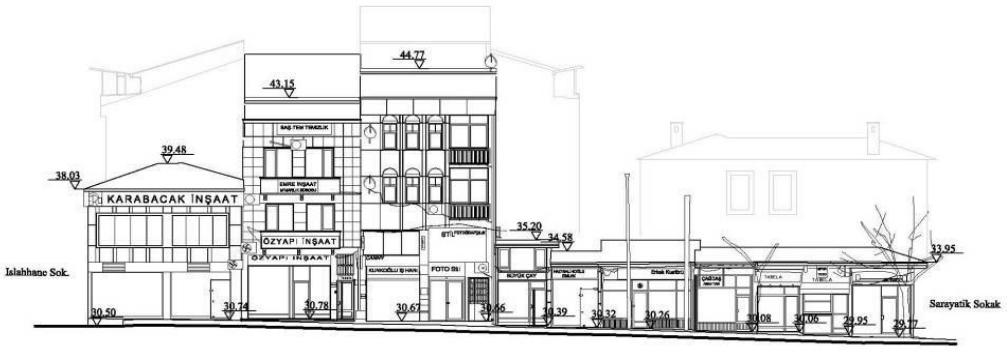


Figure 11. An example of a street silhouette drawings based on terrestrial scan (based on point cloud 4.2.2. Drawings in 3 dimensions)

In the three-dimensional drawing phase, an intermediate software program (Zmap) was employed that is capable of opening and processing both laser and photographic data simultaneously. This software can match the data, create orthophotos when necessary, open and record data in ptx or xyz format, and transfer the data to AutoCAD (in dwg or dxf format)(Figure 12 and 13). The software permits the creation of three-dimensional drawings based on point cloud data, the generation of building details

in distinct layers, and the manipulation of laser data in three dimensions and display in varying data densities (Figure14). The software is capable of opening and performing operations on laser data up to 500 megabytes at a time. Vector drawings created in the intermediate software used have been converted into a format that can be opened in AutoCAD (Figure 15).

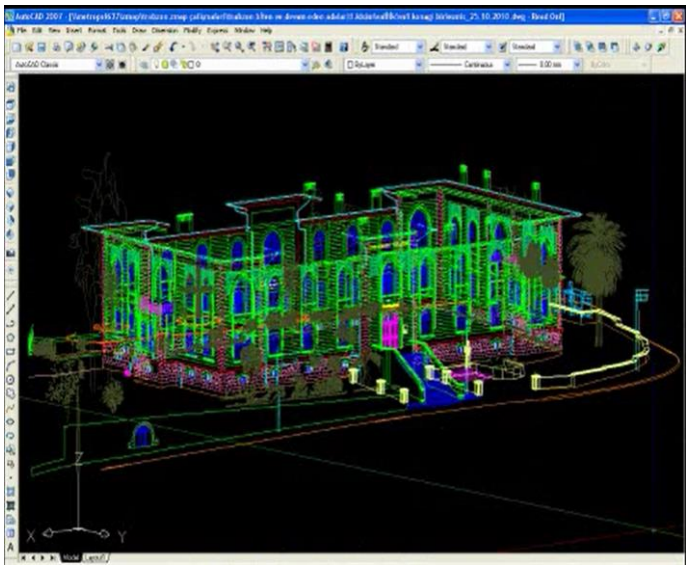


Figure 12. 3D Vector drawing (Authors Archive; Bimtaş, 2013).

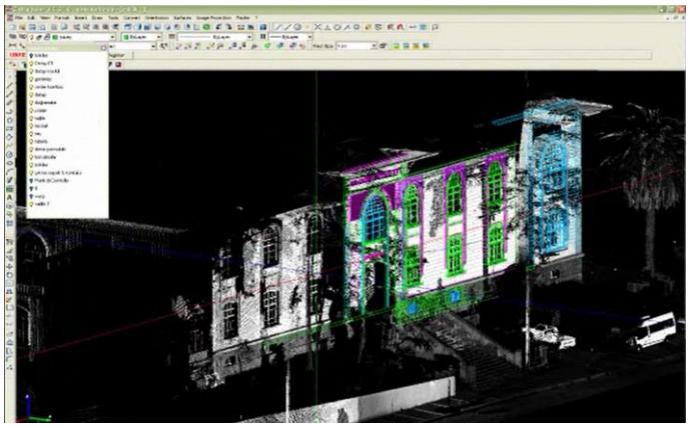


Figure 13. 3D Vector drawing from point Cloud (Authors Archive; Bimtaş, 2013).

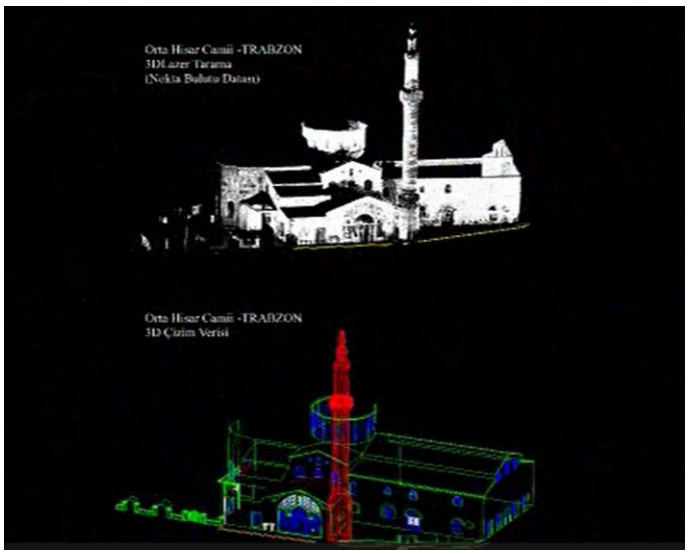


Figure 14. 3D point cloud model and vector 3D model (Authors Archive; Bimtaş, 2013)

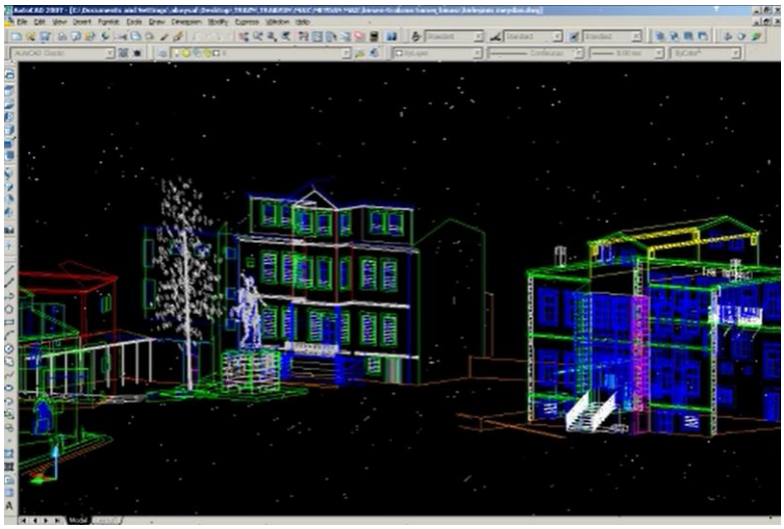


Figure 15. 3D vector drawing from point cloud data (Authors Archive; Bimtaş, 2013)

4.2.2. Modelling

Laser scanning data is geographically positioned and characterized by a high degree of accuracy. a true-to-scale representation of the area can be generated from the resulting point cloud. A 2D vector drawing or solid model can be created from point cloud data. In the Ortahisar study, point cloud data was modeled in the 3ds max program.

In the Ortahisar project, a solid model was produced from three-dimensional computer-aided design (CAD) drawings created from terrestrial laser scanning data. At this juncture, the 3ds Max software was employed (Figure 16 and 17). Texture dressing, shading and interactive editing were conducted using real surface data in the modelling process (Figure 18). An integrated model was created using data from the whole area based on islands and regions.

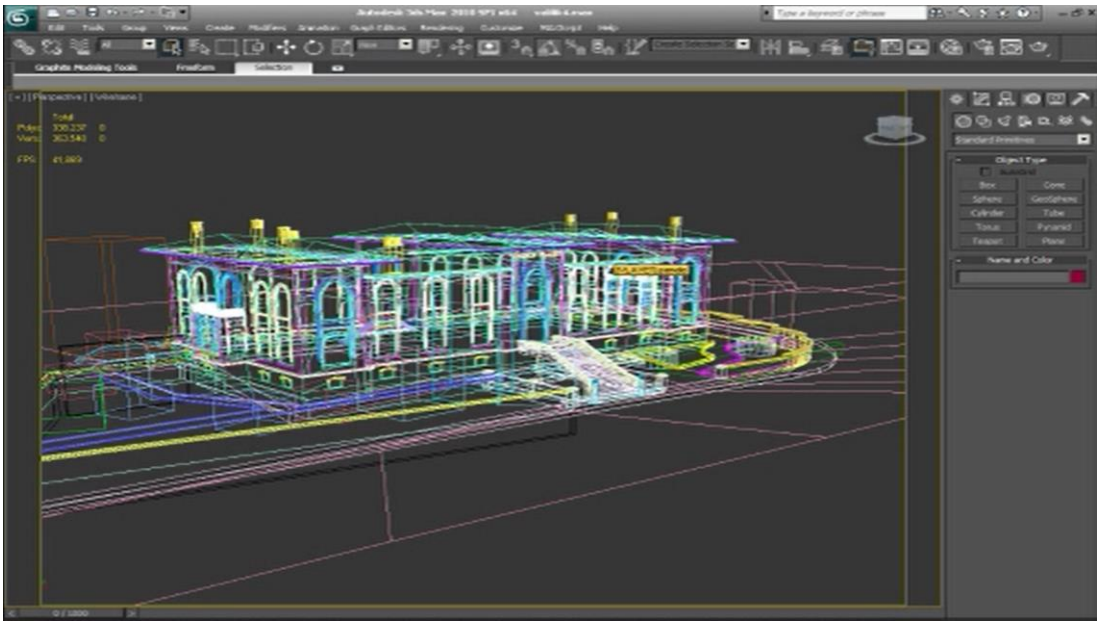


Figure 16. 3D vector drawing from point cloud data in 3Ds max (Authors Archive; Bimtaş, 2013)

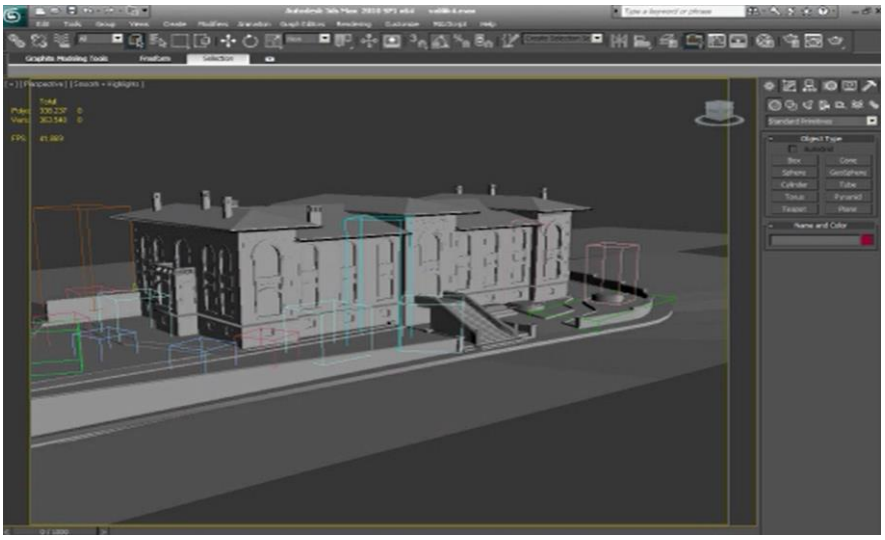


Figure 17. 3D solid model , 3DSmax (Authors Archive; Bimtaş, 2013)



Figure 18. 3D solid model with textures, 3dSmax (Authors Archive; Bimtaş, 2013)

4.2.3. Aploading Data into GIS System

The process of entering data into a geographic information system (GIS) is a fundamental aspect of spatial data management. Geographic information systems (GIS) constitute an interface that integrates data acquisition methodologies and information processing technologies (Duran & Toz, 2003). The system enables the interrogation and investigation of data collected from the field by matching it with location information. The system allows for the querying of information pertaining to the island, parcel, and structures in layers on a single screen. In the context of conservation studies, the fact that authorized institutions maintain their archives on this platform facilitates access to all information gathered in the field from a single source. Furthermore, the platform enables the querying of archive information and details of previous interventions. In the Ortahisar study, all data collected from the outset was processed into the geographic information system (Fig 19 and 20). This encompassed current plans, board file data, historical photographs and maps, other oral and written documents and drawings(Figure 21 and 22). This approach enabled all the bases created for the conservation plan to be accessed from a single interface.

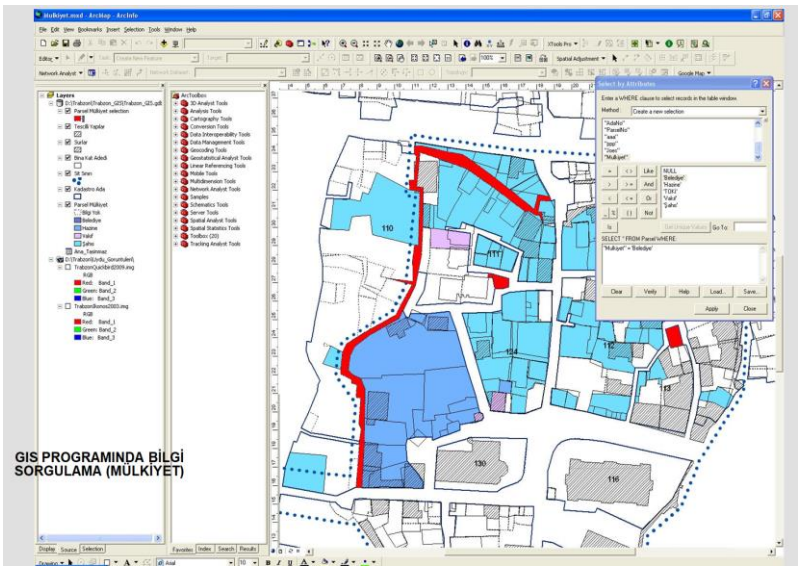


Figure 19. GIS data display (Authors Archive; Bimtaş, 2013)

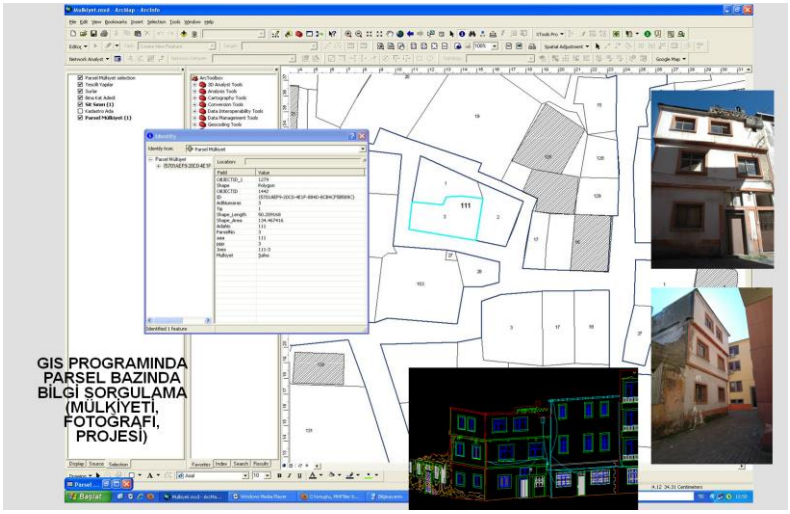


Figure 20. Registered building ınformation query from GIS screen (Authors Archive; Bimtaş, 2013)

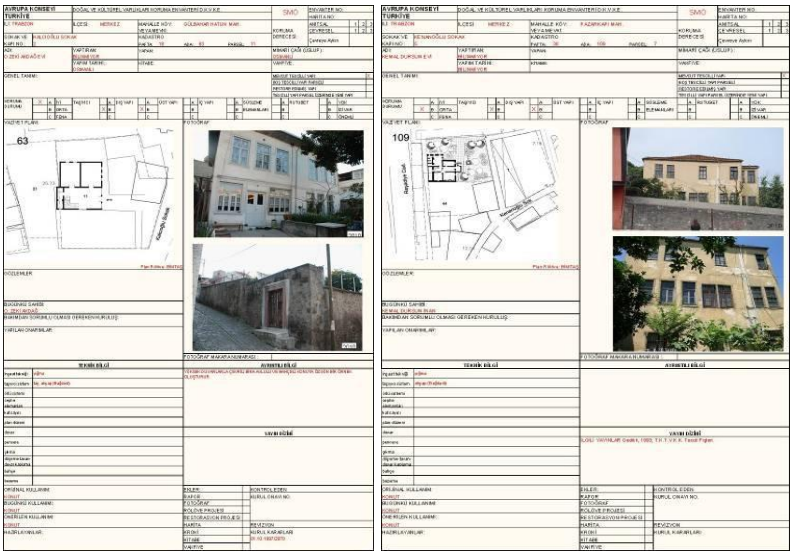


Figure 21. Registered building ınformation query from GIS screen (Authors Archive; Bimtaş, 2013)



Figure 22. Registered building ınformation query from GIS screen (Authors Archive; Bimtaş, 2013)

5. Conclusion and Suggestions

The social and cultural texture, architectural heritage and natural environment that cities have gained throughout the historical process are meaningful and worthy of preservation. It is therefore of great importance to protect and preserve historical environments to maintain the identity of cities. Notwithstanding the decline in its historical texture, the study area boasts several positive attributes, including a rich historical accumulation and historical structures, distinctive topographic data, proximity to urban transportation networks and the city center, characteristic flora, distinctive viewpoints and the production of recreational areas in the Zağnos and Tabakhane valleys (Figure 23).



Figure 23. Ortahisar City walls and conservation area from the Valley (By Authors, 2023)

The cultural texture of the area was elucidated through the documentation studies conducted in the urban sites of Trabzon Ortahisar I and II. The comprehensive data set yielded insights into the topography and urban settlement patterns of the area, establishing a robust foundation for infrastructure and engineering studies(Figure 24). The measurement studies conducted on the street continuity provided a foundation for the conservation of period-model structures that were compatible with the surrounding texture, as well as the registered structures. The data set was employed in urban design construction, with the plan for conservation purposes serving as the sole reference point. The street silhouettes and block-based plans were prepared in accordance with the current situation and design proposal and subsequently approved by the regional board.



Figure 24. Examples of traditional houses from the region (Bimtaş, 2013)

In the context of the current situation, the drawings of the island across the entire area were processed, and the ground floor plans of the registered buildings were extracted. The buildings whose plans are presented in the visual below are registered buildings. The buildings shaded in yellow were proposed for registration. Furthermore, the trees and empty areas in the area were determined (Figure 25).



Figure 25. Current situation on an block basis (By Authors)

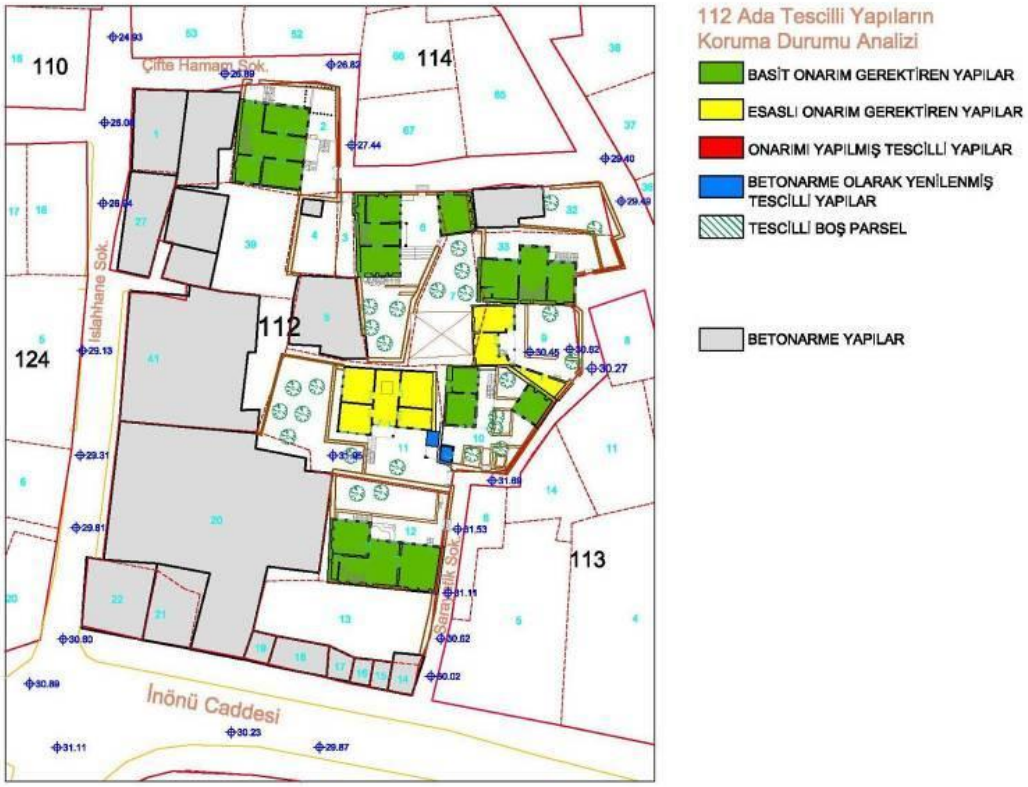


Figure 26. Current conservation status analysis on an block basis (By Authors)

In the studies conducted on an island basis, the registered buildings were also evaluated in terms of their conservation status. The image below illustrates the condition of the buildings, with those shown in green indicating good condition and requiring only simple repairs, those in yellow indicating buildings requiring major repairs, and those in red indicating buildings that have been repaired. The buildings shown in blue indicate those that have been reconstructed with reinforced concrete. It should be noted that the areas shown with green hatching indicate registered building parcels that do not exist (Figure 26).

3D City Model: A three-dimensional model is defined as a combination and presentation of data obtained from various data sets for the purpose of representing the Earth and artificial objects on the Earth, that is, the real world, as closely as possible to reality (Düzova, 2007). The city model of Ortahisar was created using laser scanning data. The current situation and suggestions were modelled in 3D on an island basis in order to test the holistic reflections of the designs within the scope of the proposal studies. This was done in order to test the designs in the context of the proposal, and to provide a visual aid for use during the board approval processes (Figure 29 and 30).



Figure 29. Building models in ortahisar based on 3D point cloud data (Authors Archive, Bimtaş, 2013)



Figure 30. Building models in Ortahisar based on 3D point (Authors Archive, Bimtaş, 2013)

The number and capacity of the tools employed in digital documentation methodologies have increased in number and capacity today. The advent of software has enabled the combination of photogrammetric and laser scanning methods. The Trabzon study is notable for its distinctive topography and comprehensive approach to the study area. The utilization of digital documentation tools in conservation studies must be conducted in accordance with the land planning recommendations of conservation experts. While these systems facilitate the collection of substantial data sets, they necessitate the utilization of robust hardware and software resources during the processing phase. In the Trabzon study, conservation experts adopted a holistic approach and employed the laser scanning method at the block and street levels, aiming to enhance efficiency by focusing on conventional techniques within the interior spaces of the buildings. The project encompasses solutions at the block level for the determination, documentation, and analysis of studies pertinent to the urban fabric that requires conservation. Additionally, it incorporates plans and urban design proposals for conservation purposes. The transfer of the project to the relevant institution, accompanied by the GIS system, has enabled the zoning status inquiry and public explanation processes to reach an advanced stage.

The Trabzon Ortahisar project required six months to produce drawings of existing street silhouettes, with two months dedicated to data acquisition and processing (33.33%), and a further four months to create the 2D street silhouettes (66.66%). The 3D modelling studies required four months in total, with one month dedicated to data processing (25%) and three months to the modelling itself (75%). The creation of a 3D city model encompassing an area of 19 hectares required a total of 10 months, with the data processing stage accounting for 3 months, representing 25% of the total time. The completion of the model itself took 7 months, representing 10% of the process. The modelling studies required a total of four months, with 25% of this period dedicated to data processing, representing 75% of the total time. The design proposals of street silhouettes were created using CAD drawings and required a total of 10 months. The GIS entries for all the studies were completed within a four-month period (Table 3).

Table 3. Scope and Time Table of Ortahisar Project (By Authors)

Process	**Total Time**	**Data Process**		**Drawing/modelling**	
			%		**%**
Drawing of current Street Facades	6 Months	2 Month	33.33	4 Months	66.66
Street Facade Design for modelling	10 Months	-	-	10 Months	100
Modelling	4 Months	1 Months	25.00	3 Months	75.
Virtual City Modelling	10 Months	3 Months	25.0	7 Months	75
GIS	4 Months	-		4 Months	100

The acquisition and processing of digital data accounts for approximately 25-35% of the total work process. The proportional size of the CAD drawing stages provides insight into the extent of the work completed. This study, which describes the processes involved in preparing a comprehensive documentation and conservation project in an urban setting, presents a workflow and methodology that can be applied in similar contexts.

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The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

The authors declare no conflict of interest.

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