The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLVIII-M-9-2025
30th CIPA Symposium “Heritage Conservation from Bits:
From Digital Documentation to Data-driven Heritage Conservation”, 25–29 August 2025, Seoul, Republic of Korea

Utilizing GIS for Sustainable Conservation and Management of Riverine Heritage Landscapes: ‘MeRiΔGIS’ for Menderes (Maeander) River Delta, Türkiye

Gökhan Okumuş[1], Ayşe Güliz Bilgin Altınöz[1], Gerdy Verschuure-Stuip[1,2]

[1]METU (Middle East Technical University), Department of Architecture, Graduate Program in Conservation of Cultural Heritage
06800 Ankara, Turkey - okumusg@metu.edu.tr, bilging@metu.edu.tr
[2]TU Delft (Delft University of Technology), Faculty of Architecture and the Built Environment, Delft, The Netherlands
-g.a.verschuure-stuip@tudelft.nl

Keywords: Heritage Information Management Systems, Geographic Information Systems (GIS), Sustainable Conservation and Management, Riverine Heritage Landscapes, Menderes (Maeander) Delta.

Abstract

Rivers, as powerful natural agents, have historically been not only sources of life and sustenance but also the creators and connectors of culture. From ancient civilizations that shaped agricultural lands and built their cities along riverbanks to the modern landscapes that have developed around them, rivers have always been central to the identity, sustainability, and evolution of human societies. The Menderes (Maeander) River in southwestern Anatolia presents a unique case of how a river can shape both natural and cultural landscapes. This river basin, often called the “Valley of Civilizations”, has played a crucial role in settlement development and cultural shaping throughout Anatolia’s history. As the landscape evolved, its water-related relationships—marked by the river’s fluctuating presence, scarcity, and abundance—have given rise to new heritage forms, further complicating management of this multi-layered landscape.

Addressing this complexity requires a heritage information management and decision support system capable of integrating multi-scale, multi-faceted data for sustainable management. In this regard, Geographic Information Systems (GIS) have proven to be valuable tools, creating comprehensive, interdisciplinary platforms to understand, analyze, and manage diverse layers of complex landscapes. Thereupon, MeRiΔGIS, a GIS-based heritage information management and decision support system, is established to understand and assess the multi-dimensional characteristics of the Menderes River Delta for its conservation and sustainable management. MeRiΔGIS provides a comprehensive understanding of the ongoing transformations in the riverine landscape, emphasizing the interaction between natural and cultural components, as well as the key human and more-than-human agents shaping its evolution.

Ultimately, the MeRiΔGIS serves as a tool to re-establish fragmented relationships between the river, its surrounding communities, and the landscape. This interdisciplinary, GIS-based approach offers a model for managing other riverine and water-linked landscapes, integrating heritage conservation with modern information management technologies to address the complexities of the natural-cultural nexus.

1. Introduction

The Menderes (Maeander) River in southwestern Anatolia has historically served not only as an ecological resource and a source of life but also as a main agent of culture that has shaped the landscape (Figure 1). Beyond providing natural and environmental importance for agriculture, transportation, and settlement history, the Menderes River has functioned as a generator and connector of culture, embodying symbolic meanings, sustaining rituals, and representing the vital relations between humans and the natural environment. Its water-related heritage reflects a profound connection between society and the river, providing a wealth of knowledge, traditions, and both tangible and intangible cultural components. From agricultural practices to industrial landscapes, from archaeological sites to rural and urban settlements, the river has been the lifeblood of the region. In that sense, known as the “Valley of Civilizations” (Göney, 1975; Başgelen, 2010; Büyük Menderes Basin Atlas, 2012) the Menderes River and landscape is one of the foremost examples of water-linked heritage and riverine landscapes that maintain continuity and integrity across scales—from the basin to the delta and the built environment in landscape. Accordingly, the Menderes riverine landscape emerges as a cultural landscape that brings together a wide range of values—natural, ecological, urban and architectural, archaeological, aesthetic, socio-cultural, socio-economic, technical, and technological—while also embodying ever-changing processes associated with water and the river itself.

The Menderes River, with the alluvium it carried over the ages, has created fertile agricultural lands that were a source of wealth for the societies in Anatolia (Göney 1975, Brückner et al. 2017). The fertile agricultural lands created by the river's progradation process supported thriving civilizations, making it an essential part of the region's economic and cultural identity, where natural, ecological, historical, socio-cultural, spiritual, and economic dimensions intersect. The alluvium carried by the river formed the Söke Alluvial Plain, and as a consequence, the sea passage was gradually closed to form Lake Bafa, and the Menderes Delta (Göney, 1975; Başgelen, 2010) (Figure 2). Menderes’ progradation process over time has changed and reshaped the complex interplay between societies and water, and their reflections and human-made solutions on the landscape. In that sense, as dynamic landscape, Menderes River carry deep cultural meanings, connecting people, histories, and ecosystems in a fluid narrative that spans time and space.

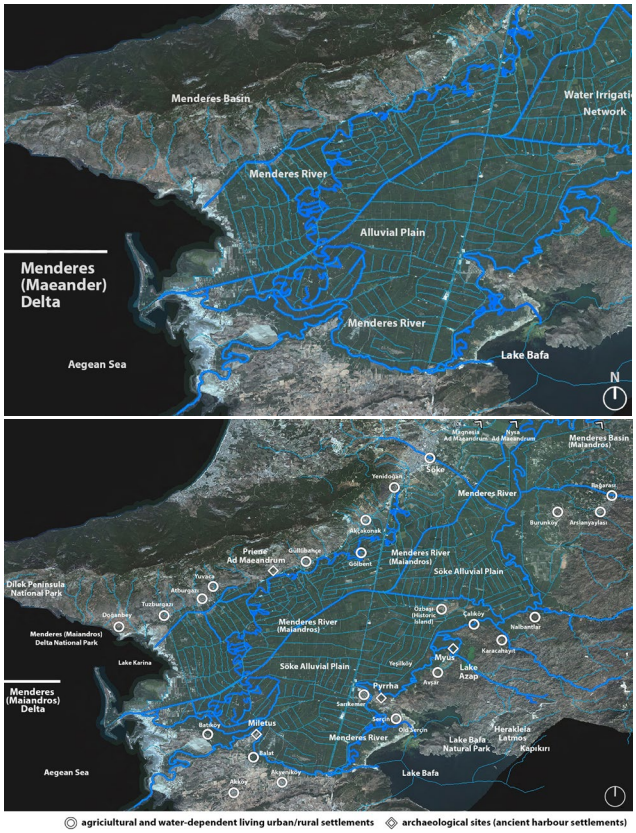


Figure 1. Menderes (Maeander) Delta and riverine landscape in southwestern Anatolia (Source: Gökhan Okumuş, based on Google Maps, 2024).

Despite the continued ecological importance of the river, its socio-cultural significance has diminished over time. The river, once deeply integrated into the daily lives of the surrounding communities, has gradually become disconnected from the settlements, both urban and rural. This loss of connection has fragmented the once-coherent narrative of the landscape, with settlements and archaeological sites now telling separate stories disconnected from the river that shaped them. Environmental changes, contemporary urban, industrial, and agricultural developments, fragmented conservation policies and planning practices, and legal and institutional disintegration have led to the disruption of these strong connections. Moreover, due to the nature-culture division in conservation and management policies, the Menderes River and its delta face significant challenges. In this context, the role of the river in cultural memory and everyday life has diminished, leading to fragmented heritage narratives and governance gaps. Moreover, the region is increasingly vulnerable to the impacts of climate change; challenges such as drought, flooding, water scarcity, and wildfire risks threaten not only ecological integrity but also socio-cultural resilience. Once a crucial carrier of civilizations and collective memory for centuries, the Menderes River and its delta now stand at the intersection of ecological degradation and cultural disintegration.

The ever-changing relationships with the river have further complicated the management of this multi-layered cultural landscape, as the landscape has changed over time. The ongoing nature-culture divide in heritage landscape conservation adds complexity, as it necessitates addressing differing legal, administrative, and practical issues related to the conservation and management of the landscape. In that sense, the Menderes River landscape is a network of relationships connected to water: its presence, absence, scarcity, and abundance; its changes in form and type, and its overlapping and/or conflicting values and dilemmas have created new types of heritage through space and time.

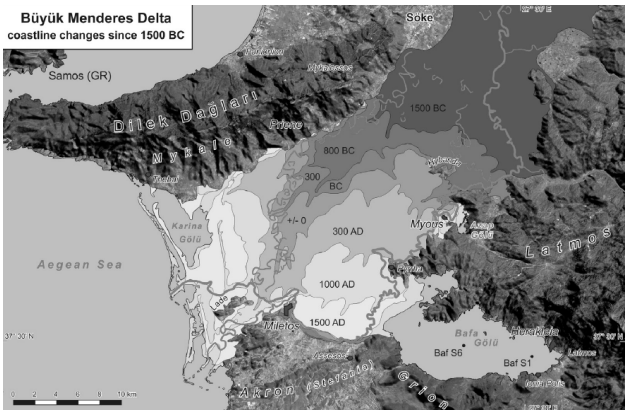


Figure 2. The progradation process -from 1500 BC until today- of the Menderes riverine heritage landscape shifts in the shoreline (Source: Brückner et al., 2017, p. 878, Fig. 1).

This situation shows the importance of the integration of natural and cultural heritage conservation and management and highlights the necessity of a more holistic framework. Accordingly, the preservation and sustainable management of the Menderes River landscape heritage require a dynamic and multi-dimensional approach that considers the diverse values and challenges extending from the tangible to the intangible and across multiple spatial scales. In addressing these challenges, the design and implementation of a heritage information management and decision support system capable of integrating multi-scale, multi-faceted data is essential for sustainable conservation and management.

At this point, Geographic Information Systems (GIS) emerge as an effective tool for addressing the complexities and multidimensional structure of such a landscape. In this regard, MeRiΔGIS has been developed to document and understand the multidimensional characteristics of the Menderes riverine landscape heritage. Accordingly, MeRiΔGIS facilitates the re-evaluation of a comprehensive and multidimensional dataset while identifying conservation and management policies and strategies that ensure the sustainability of the delta and river landscape as a living heritage site within the integrated nature–culture–landscape framework.

2. Research Process and Methodology

GIS serves as a multi-layered spatial information system, which organizes, stores, and queries data across various aspects of the landscape, including the natural environment, physical and spatial settings, socio-cultural and intangible narratives, economic contexts, and legal-administrative aspects. In this regard, information management and GIS are directly linked to and overlap with conservation and management processes. The integrated process formulated at this intersection and shared disciplinary consists of the following stages: 1) Defining the project for the conservation and management process and identifying the requirements for documentation and data collection; 2) Collecting and evaluating data and establishing interrelations among them; 3) Defining and designing heritage information system model following the adopted conservation approaches 4) Sharing and presenting information within the

framework of the conservation policies and strategies (Bilgin Altınöz 2002, 2011).

The approach was implemented through a three-stage methodological process: archival analysis and literature research, field survey and oral history research, and spatial-temporal mapping using GIS. Accordingly, studies focusing on various dimensions of the landscape were carried out in phases, based on the multi-layered, multifaced nature, characteristics, and values of the Menderes Delta and river landscape. Initially, a literature review and archival research were conducted to understand and conceptualize the Menderes Delta and its river landscape. Field studies were conducted to systematically identify and document the current values and challenges of the landscape. Through interviews and meetings with relevant stakeholders, the aim was to establish a spatial and historical information system concerning the values attributed to the landscape.

Accordingly, following field studies and social surveys, all collected data were integrated into a GIS-based heritage information management and decision-support system, leading to the development of the MeRiΔGIS Project within the framework of ‘Holistic and Sustainable Conservation and Management of the Menderes River Heritage and Landscape’. In this process, data were collected and spatially documented via the GIS database under the following thematic categories: natural environment, transportation, road network, physical and spatial settings, architectural fabric, archaeological sites, socio-cultural and socio-economic structures, and the legal-administrative framework. In the further phases of the study, a culture–nature linkage and spatio-temporal approach was adopted to enable the updating and evaluation of these datasets and to ensure that the information gathered could be used and monitored by various stakeholders and decision-makers.

2.1 Archival and Literature Research

In accordance with this methodology, a comprehensive archival research process was conducted. National and local libraries, relevant ministries and associations' archives, local municipalities and decision-makers, museum and non-governmental organizations' archives, and document and data collections from various institutions at different scales served as primary sources of reference (Figure 3). In addition, literature research was conducted on published studies related to the Menderes River and Delta. These publications were examined across three spatial scales—the Menderes Basin, the River, and the Delta—and were categorized under key thematic areas such as the natural and environmental characteristics and transformation processes of the river and landscape; the history of civilizations and settlements; the physical and spatial settings and their relationship with the river and landscape; socio-cultural and socio-economic dynamics; and the frameworks of conservation, planning, management, and legal-administrative structures.

Accordingly, old photographs, newspaper archives, aerial photographs/orthophotos obtained since the 1960s, historical maps, archaeological excavation records, research findings on the region’s natural environment, reports, and project documents from institutions and non-governmental organizations were compiled and documented. All collected data were systematically organized and integrated into the ArcGIS software, providing a flexible and continuously updatable environment that allows for the addition of new datasets over time.

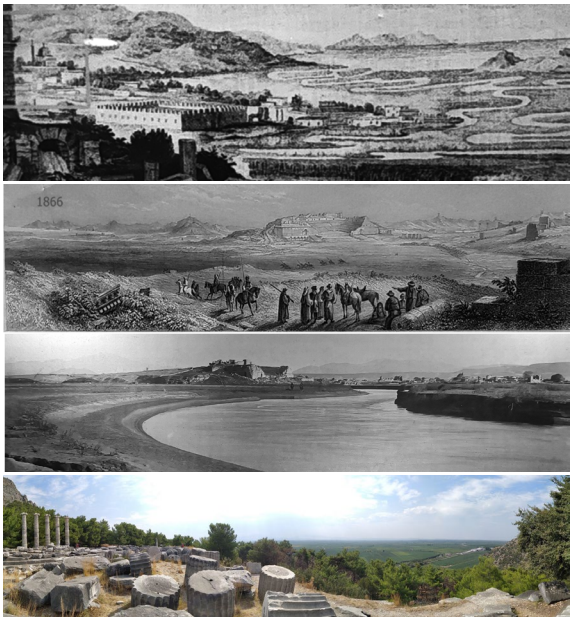
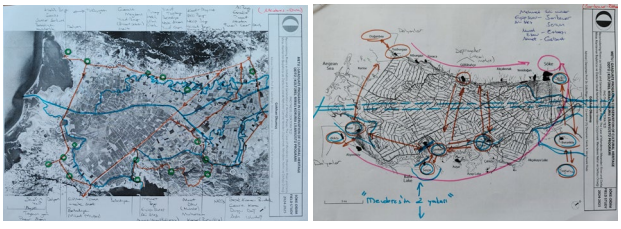


Figure 3. Menderes (Maeander) Delta in 1700s-1800s-1900s and 2020s. (First: Gouffier, 1782:181, Second-Third: Milet Museum Archive, Fourth: Okumuş, 2024).

2.2 Field Study and Social Survey

In addition to this multi-scalar and multidimensional archival and literature research, the field studies focus on the boundaries of the Menderes Delta, which has been formed by the alluvium carried by the river. In that sense, three field studies were planned to collect data related to the Menderes Delta and riverine landscape, and for integration into the GIS. These field studies were carried out in different seasons of the year to observe the relationships between the Menderes River, the landscape, settlements, and agricultural areas, as well as to monitor the reflections of the transformation processes.

For the field studies conducted between August 30–September 5, 2023; May 18–23, 2024; and October 25–30, 2024, survey sheets/ observation and data collection forms were prepared under the thematic categories of natural and built environment, settlements and physical-spatial settings, ancient cities/archaeological sites, socio-cultural structure, and socio-economic aspect (Figure 4). These forms were used during interviews with locals, local decision-makers and relevant stakeholders, directors of archaeological excavations, and representatives of related non-governmental organizations. The data collection processes were conducted through direct site observations, on-site studies, individual, group, and institutional in-depth interviews, as well as both in-person and remote online meetings.



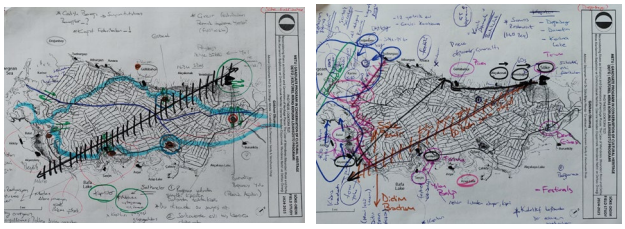


Figure 4. Examples of survey sheets/ observation, and data collection forms.

Additionally, field study activities—including social survey, in-depth interviews, and focus group discussions—were conducted with locals, relevant specific economic groups (fishers and fishing cooperatives, agricultural workers and cooperatives, industrial and tourism associations), local authorities, irrigation association and cooperatives, decision- and policy-makers, and NGOs (Figure 5). These narratives were thematically categorized—e.g., water-related local toponyms, mnemonic focal places, local festivals and events, agricultural and fishing focal places, changes in daily life with the river, transformations in land-use and irrigation practices, lost water rituals, flood plain and risk areas and their impacts, etc., as the components of socio-cultural and socio-economic structure, geospatially referenced as memory-based data.

In this process, the aim was to observe the tangible and intangible, cultural and natural components of the Menderes riverine landscape—along with the values, narratives, perceptions, and challenges attributed to these components by local communities—based on information obtained from literature and archival sources.

Figure 5. Field studies and social surveys addressing socio-spatial, socio-cultural, and socio-economic aspects in the Menderes Delta (Photos: Okumuş, 2024).

2.3 Spatio-temporal Approach Using Geographic Information System (GIS)

Within this approach, integrated environments and interfaces are necessary for holistic datasets generated from different spatial scales and contextual relations (Figure 6). GIS has emerged as an analytical and operational tool for multidimensional values and challenges inherent in managing complex heritage landscapes. Beyond documenting, analyzing, and presenting data as spatial information, GIS allows for the interrelation of all datasets, thus enabling holistic analysis and evaluation (Bilgin Altınöz 2002, 2011). In this regard, spatial data in different layers and scales can be integrated, stored, analyzed, investigated, and monitored within the geospatial environment, particularly for complex heritage landscapes. The MeRiΔGIS supports a multi-dimensional, multi-narrative, and multi-layered approach to the Menderes River landscape’s assessment.

Addressing such a complex heritage landscape, spatial data in various scales and statuses may have been produced at different times, by different actors/institutions and disciplines, with different purposes and focuses, and in different formats. Today, the landscape is home to many water-linked natural environments, and urban and rural settlements, some of which are listed as “natural,” “urban,” “archaeological” and “urban archaeological” conservation sites. In that sense, the Menderes riverine landscape heritage pattern encompasses its multi-scale and multi-layered physical transformations, the narratives and perception attached to it, and the dynamic human and natural forces that shape it. To (re)connect these water-related links, the components and integrity of the natural, historical, cultural, and constructed landscape —and the network of relationships among them— should be analyzed systematically with a spatiotemporal holistic approach (Hein et al., 2020). This integrated approach fosters the development of sustainable, climate-resilient strategies for heritage conservation, ensuring that the unique values of the Menderes River and its delta are preserved for future generations.

Accordingly, the Menderes Delta, considered a riverine heritage landscape, cannot be conceived without the integrity shaped by the river’s multi-scalar connections and contextual characteristics—those it has generated, ever-changing, and reshaped over time (Figure 6). All data related to these areas and structures can be systematically classified within a digital dataset and holistically stored in the GIS database along with the information obtained during field studies. In that sense, GIS offers an interdisciplinary geospatial framework capable of integrating social, cultural, ecological, legal, and mnemonic data layers, as well as information in various formats, in a way that allows for comprehensive analysis and effective sharing. The system functions as a multi-layered spatial information system that organizes, stores, and queries data related to different aspects of the landscape, including the natural environment, physical and spatial structure, socio-cultural and intangible narratives, economic contexts, and legal-administrative dimensions.

Furthermore, the Menderes River landscape is a dynamic, multi-layered, and ever-changing narrative shaped by the interactions between natural processes and human interventions across time and space. In this regard, a dynamic and flexible tool such as GIS is essential for addressing the Menderes Delta as a holistic riverine heritage landscape. The GIS database is of critical importance as a flexible and adaptable system that can be continuously updated, allows for the integration of new data, and is capable of encompassing future changes and developments in line with the outcome of the multi-layered nature of the landscape.

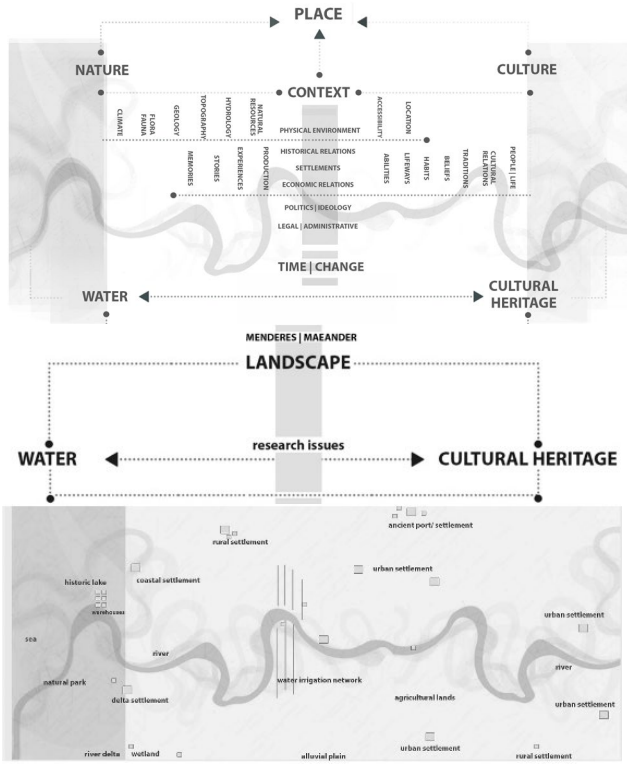


Figure 6. The spatio-temporal approach that addresses ‘Menderes River’ as a natural, physical, spatial, and sociocultural ‘connector’ for the heritage landscape.

3. Design of MeRiΔGIS: Decision Support System for Sustainable Conservation and Management of Menderes (Maeander) River Delta

Considering the holistic and sustainable conservation and management of the Menderes riverine heritage and landscape, the spatial documentation, storage, analysis, and presentation of the collected data were carried out using the “Esri ArcMap 10.4.1” GIS software and structured within the ArcGIS.

3.1 Defining and Creating the MeRiΔGIS

MeRiΔGIS is a heritage management and decision-support tool designed to provide a comprehensive understanding of the ongoing transformations in the river landscape by emphasizing both natural and cultural components, as well as the human and more-than-human agents that shape its evolution. The primary aim of MeRiΔGIS is to support the conservation and management of the Menderes riverine heritage and landscape—which face risks of loss, fragmentation, and discontinuity due to human, natural, developmental, and governance-related threats—by promoting a holistic perception of the landscape. To achieve this aim, all components of the landscape have been examined at multiple scales, and the resulting data have been structured for integration into the GIS database (Figure 7).

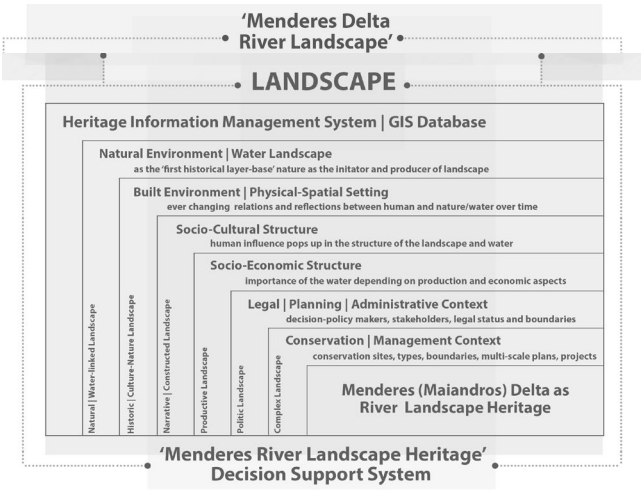
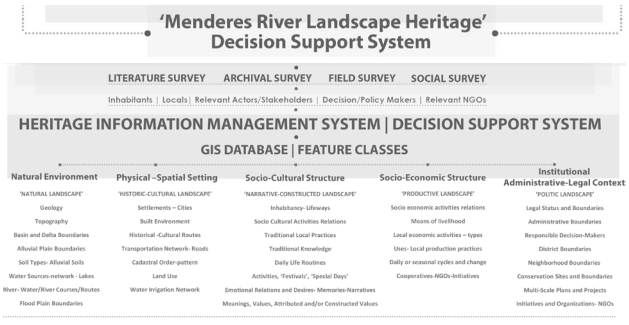


Figure 7. Creating the MeRiΔGIS databases structure and components.

During the design phase of the project, the definitions, descriptions, and attributes of the landscape and heritage were identified based on data obtained from archival/literature research and field studies. In this phase, the consistent structuring of data in line with the project’s objectives and methodological scope is of critical importance for ensuring the proper progression of data modeling, analysis, presentation, and sharing processes.

3.2 Development of Project Model

Before data entry into the system, materials obtained through archival research—such as aerial photographs, orthophotos, related CAD drawings, historical maps and drawings; components of the natural environment -e.g. topography, river flow models, water sources, courses, and networks, soil types and agricultural land boundaries within the landscape, land order, flood plains and risk areas; components of the physical and spatial setting -e.g. transportation routes and networks, built-up environment, and settlements, cadastral order, pattern, and land use and morphology; as the components of socio-cultural and socio-economic structure -e.g. demographic characteristics, mnemonic focal places, local festivals and events, agricultural and fishing focal places, industrial services, tourism focal places; as the components of administrative and legal aspects -e.g. legal and administrative boundaries, as well as information and maps related to archaeological sites, and the boundaries, legal statuses, and designations of officially conservation sites—were georeferenced according to the World Geodetic System 1984 (WGS84) and structured for integration into the database (Figure 8).



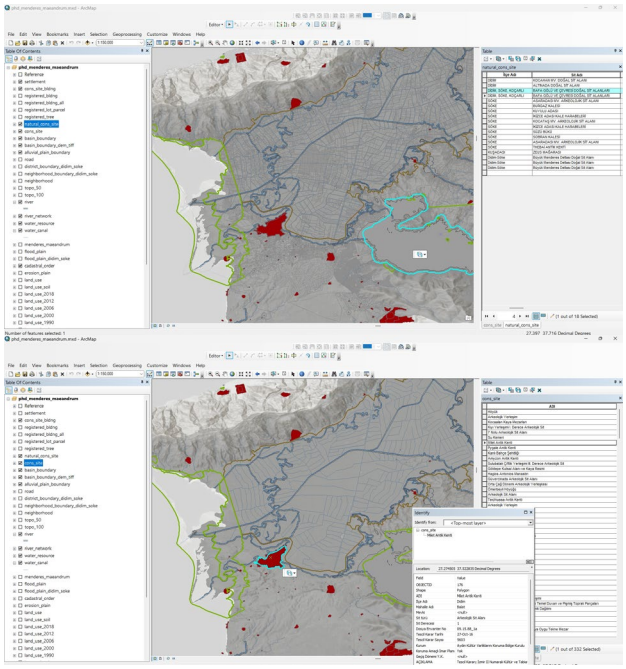


Figure 8. MeRiΔGIS Database Model: Attribute tables and feature classes used in the data entry process.

During the field studies, the visual representation method for each element to be transferred into the GIS was determined. Accordingly, ‘point’ features were used to represent the presence and location of data, ‘line’ features were used when defining physical boundaries, and ‘polygon’ features were used when defining an area. Photographs and visual materials taken during the field studies, as well as historical photographs and narratives obtained from institutional and personal archives, were georeferenced and integrated into the database. Before data entry into the GIS, the rectified materials were checked for potential errors, modifications, and other necessary adjustments. Furthermore, despite the existence of certain drawings, it was observed that, due to overlaps, incompatibility, and changes in some areas and features, multiple representations were required. Accordingly, various revisions—such as the addition of missing geometries—were carried out within the GIS.

3.3 Analyzing the Data

Following the data entry, the classified data was transformed into a database by utilizing ArcCatalog 10.4.1 software, which is a plugin of the Esri ArcMap 10.4.1. After the collected data were integrated, the system allowed for the multi-dimensional analysis of the landscape by combining diverse datasets, from the natural environment to physical and spatial continuity and mnemonic-based points. The system also offers a holistic structure that includes socio-cultural narratives, economic data, and legal-administrative regulations. In this context, one of the key strengths of the GIS environment lies in its ability to bring together and analyze various types of data from different sources within a holistic geo-spatially referenced framework.

In that sense, MeRiΔGIS enables a more thorough exploration of the interconnections between natural, historical, cultural, and constructed landscapes. Furthermore, it enhances the decision-making process by providing a comprehensive framework for analyzing the transformation processes and relationships within the landscape. Accordingly, both dataset and their interrelationships were analyzed (Figure 9). The correlation of risk and vulnerability data with value-based data, the integration of physical and spatial environment data with local narratives, memories, and stories, and the inclusion of decision-making data through a multi-scalar spatiotemporal approach have all contributed to identifying priorities for conservation and management policies and strategies in line with the proposed framework.

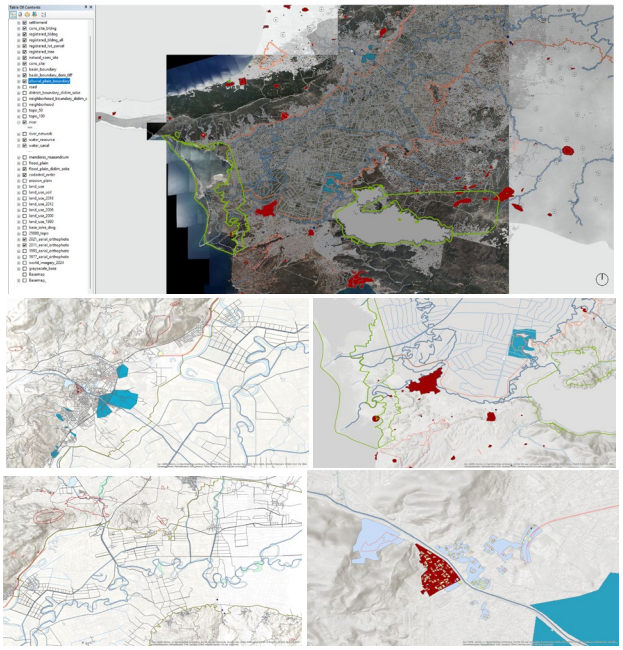


Figure 9. Inter-scale analyzing mapping from MeRiΔGIS, produced in ArcGIS.

3.4 Presenting and Sharing the Data

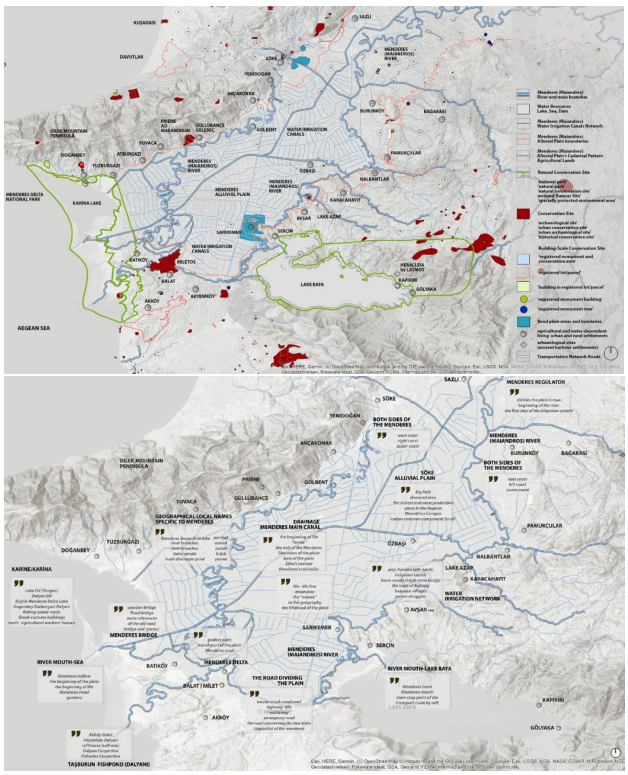
Within the MeRiΔGIS, analysis maps based on the metadata included in the geodatabase were produced using ArcGIS. Subsequently, additional maps were generated to visualize the relationships between different data sets (Figure 10). For instance, spatially referenced analyses were conducted on topics such as the relationship between agricultural areas and river-water systems and networks; the connection between river flow models, soil types, and agricultural areas; the interaction between settlement morphology and river flow models; the spatial linkages between ancient harbors and archaeological sites; the relationship between river flow and the progradation process; the correlation between legally designated conservation/management areas and socio-cultural or socio-economic reflections; as well as the intersections local narratives and mnemonic focal points derived from literature and archival research. Furthermore, the consistency and alignment of multi-scalar projects, reports, and documents were also examined.

Within this framework, the values, potentials, and challenges defined by the relevant decision-maker institutions, NGOs, and local communities concerning the landscape were transferred into the database and represented through mapping that reflects multi-dimensional and multi-layered relationships. Physical and spatial data obtained from archival and literature research were integrated with memory-based, mental, perceptual, cognitive, experiential, and oral history mappings generated during field studies, resulting in a participatory and multi-layered data representation. Ultimately, these multi-scalar and multi-dimensional analyses are works in developing a holistic and sustainable river landscape conservation and management

approach, which defines the principles, policies, strategies, and decision-making frameworks for preservation.

GIS also provides an integrated working environment that brings together various methods and interfaces, such as relational data management systems, computer-supported design processes, and three-dimensional modeling programs. In that sense, maps providing information on both the tangible and intangible components of the river landscape were produced using ArcGIS. In addition, three-dimensional analyses—such as topographical and geological relations, slope, elevation, river flow models, and floodplains—could also be easily visualized through the database.

During the study process, the comparison of data ranging from documents and information obtained from decision-makers and relevant stakeholders to local narratives has demonstrated that GIS is an effective tool for monitoring the multi-layered nature of the complex heritage landscapes, its ongoing processes of ever-change, transformation, as well as for identifying challenges and assessing necessities. In this regard, MeRiΔGIS and the results will be shared in database format with relevant institutions, organizations, and NGOs.



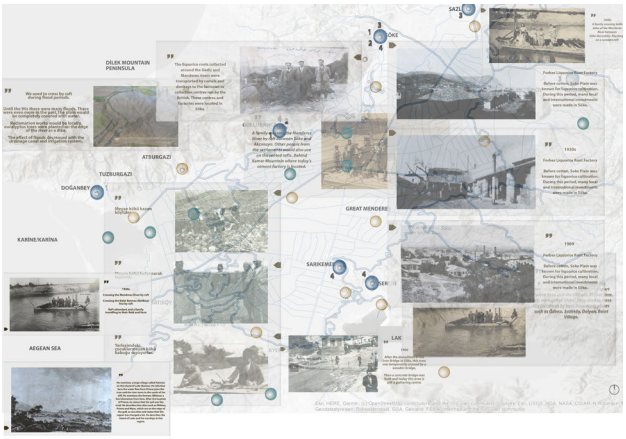


Figure 10. The maps from MeRiΔGIS, produced in ArcGIS.

4. Results and Discussions

Regarding the conservation and management of the Menderes River landscape, the MeRiΔGIS research positions ArcGIS as a vital component in the processes of storage, structuring, processing, analyzing, presenting, sharing, and monitoring spatial and complex data. The research has been designed as a flexible and adaptable system capable of accommodating future changes and developments in line with the contextual characteristics and multi-layered characteristics of the riverine heritage and landscape. Thanks to the software’s data storage and management capacity, a large amount of data related to the complex heritage landscape could be analyzed, visualized, and presented through thematic maps. The user interface of the software allows for the examination of relationships between data using techniques such as overlay analysis, classification, and the systematic arrangement of outputs. Within the ArcGIS platform, multiple elements can be mapped simultaneously and structured within a defined template.

Within the scope of the project, these superimposed maps have played a significant role in identifying values, issues, and potentials, thereby contributing to the development of a proactive approach. It offers significant advantages, including facilitating the integration of data from various sources, supporting collaboration among users, and providing access to online resources and materials. The MeRiΔGIS project has benefited from these advantages, particularly due to its multi-environment compatibility and its capacity for storing data at multiple scales. The designed database is open to new data entries, which ensures the adaptability and continuity of the system. On the other hand, certain limitations of ArcGIS were also encountered throughout the research process. Addressing compatibility issues during the integration of attribute data from different sources and formats requires additional time and effort. Furthermore, the geodatabase designed for such a complex and multidimensional study area necessitates a high level of storage capacity.

In this respect, ArcGIS has emerged as a guiding tool for the collection, processing, analysis, and sharing of diverse data obtained from various sources, aligning with the holistic approach of the research and supporting the development of conservation and management planning decisions. In this way, GIS functions as a critical and effective tool for understanding, analyzing, presenting, sharing, and monitoring information within the conservation and management processes of complex heritage landscapes.

Ultimately, by integrating these interconnected data layers, MeRiΔGIS offers insights into how the Menderes River Delta has evolved over time, supporting a well-informed and holistic approach to conservation and sustainable management.In this regard, it offers GIS-based heritage information management and decision-support system and model for the holistic conservation and management of the riverine heritage landscape along with all its components.

5. Conclusion

In the complex and multidimensional processes of heritage conservation and management, the role of ‘information’ and ‘information management’ has become increasingly critical. In that sense, Geographic Information Systems, with their adaptable structure, offer a suitable environment for addressing the multi-layered and multidimensional ‘Menderes riverine heritage landscape’. This interdisciplinary, GIS-based approach not only integrates heritage conservation with contemporary information management technologies but also provides a cohesive model capable of responding to the complexities of nature-culture interlinkages and the multi-layered nature of heritage landscapes. By reconnecting nature-culture, the system aims to facilitate the development of principles and strategies for a more integrated, sustainable management approach that honors both the cultural and natural heritage of the region.

MeRiΔGIS demonstrates to be a critical tool for the comprehensive collection and holistic presentation of all historical, visual, and textual sources in different formats/characteristics related to such complex heritage landscapes. By offering an integrated perspective on the heritage landscape, the system provides an efficient platform for the development of a holistic approach and the collective handling and sharing of multi-scalar and multidimensional data produced by various decision-makers. Rather than functioning merely as a data archive, the system operates as a heritage information management and decision-support tool that informs decision-making processes, contributes to policy development, and fosters collaboration among different stakeholders. In this way, the system not only supports the conservation and management of heritage but also enables its sustainable use and re-interpretation through social participation.

In conclusion, GIS has proven to be an effective tool in the efficient processing of comprehensive datasets, as shown in the case of the Menderes riverine heritage and landscape. Its high capacity for rapid data processing has shown that GIS is a vital instrument for managing large-scale data efforts conducted at the basin, delta, and landscape scales.

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