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ORIGINAL ARTICLE

Valuing Groundwater Heritage: the Historic Wells of Kadıovacık

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Abstract

The consideration of the subject of water resources, seen as a part of cultural heritage, generally includes water-related architectural structures such as bridges, aqueducts, and cisterns. Groundwater resources and related structures, however, receive little attention as heritage assets, and they are mostly forgotten together with the valuable information they hold. In this sense, this study aims to provide an accurate assessment of groundwater heritage and to suggest proposals for conservation through the case of the historic wells of Kadıovacık village in the Urla district of İzmir. Although the region where the village is located is rich in groundwater resources, the residents have suffered from drought for ages due to the specific geological characteristics of the Kadıovacık polje. The limited amount of water resources in Kadıovacık village have karstic characteristics and have shaped the life and topography of the region. To access and harvest this limited groundwater, a group of wells had been constructed on the ridge of the hill. These wells have been idle since 1980s with the supply of city main water. In line with the aim, a comprehensive heritage valuation by an interdisciplinary group of experts is essential to reveal the significance of the relatively humble wells. Accordingly, a multi-method system is used, including historical, social, cultural, architectural, geological, hydrogeological, and environmental aspects. The results show that although the wells are generally considered to be less important as heritage assets in terms of their physical features, an in-depth evaluation demonstrates their high significance for the village community.

Keywords Water heritage · Geoheritage · Groundwater · Heritage valuation · Kadıovacık

Introduction

Today, in the wake of climate change, water shortage is a major threat to human life. The European Water Charter of 1968 alerts the importance of raising awareness about the sources and use of water in our societies (Council of Europe 1968). International organisations such as the United Nations (UN), and the World Health Organisation (WHO), and others have considered this to be a global challenge (UN-WATER 2006; WHO 2006).

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Throughout history, water resources have affected the distribution and density of human settlements and are a reflection of the strong bond that we have established with the environment (Clark 1944). Small human settlements that started around water resources have evolved into complex urban settlements through the shaping of tangible elements such as infrastructure and built environment (Steenhuis 2015; Labanca Correa de Araujo 2015). To manage water, past cultures also developed rich, diverse, and often interconnected systems in plains, mountains, wetlands, deserts, farmlands, and urban networks. Today, archaeological and anthropological research studies on the remains of ancient aquatic societies, which can be found in almost every continent, guide us to the roots of existing cultural identities (Steenhuis 2015; Sugiura et al. 2015; Labanca Correa de Araujo 2015; Ghasemi et al. 2013, Hein et al. 2020). These studies show that the development of water structures from small-scale water collection systems to larger water pumping facilities, irrigation and drainage networks, and embankment systems are closely linked to the traditions, rituals, and narratives of societies (Steenhuis 2015; Labanca Correa de Araujo 2015). In other words, water resources and their impact on local practices have been important in the production of tangible and intangible heritage values for societies (McIntyre-Tamwoy 2011).

Although water resources and other aspects of culture are interconnected by complex relationships, most of the studies approach them individually, in which water resources have generally been considered with tangible aspects and through similar perspectives (Hein et al. 2020). There is a limited amount of research about the significance of water resources from a heritage perspective, which mainly focuses on the potential of water to connect habitats; the capacity of water heritage to connect the past, present, and future; and the role of water as a legacy in spatial developments (Hein et al. 2020). Some areas, such as investigating the relationship between water resources, valuing it as heritage with a multifaceted approach, and developing management strategies, still call for further research. Understanding past cultures' relation with water can also provide information that may help to develop sustainable water resource management practices (Lansing and Kremer 1993). Thus, multidisciplinary research on the technical aspects of water resources that link to complex dynamics of societies, especially in areas where water scarcity led to serious challenges in the past, is essential in the field of geo-heritage.

In the case of Turkey, water heritage mainly includes large-scale structures such as aqueducts, cisterns, fountains, and baths, including the ones in various archaeological sites, such as spring sanctuaries (Tanyeli and İkiz 2015). The structures that were built to access underground water resources such as wells are generally understudied as heritage and thus, related conservation measures are inadequate.

This study aims to provide a contribution to the existing literature through the valuation of traditional wells as groundwater heritage. It takes the historic wells of Kadıovacık Village in the Urla district of İzmir as a case study, an area that has witnessed water scarcity in the past, although being in a geologically rich area in terms of groundwater resources (Fig. 1). The surviving twenty-four wells of Kadıovacık village, details of which are provided in section three, are regarded as suitable examples for this study since they had been used by the inhabitants up until the 1980s due to the lack of an alternative supply, and these have not yet been studied (Fig. 2). Understanding the heritage values of the wells, increasing their visibility, and developing conservation measures will raise awareness about water resources heritage and make a significant contribution to the economy of the region. Examining the values of water heritage will contribute to the development of sustainable water resources management and thus to the quality of life and cultural growth of societies. To ensure a robust knowledge base for future generations, all values of the water heritage were determined through a multidisciplinary approach to establish an inclusive conservation proposal. As such, this study intends to form a key example for the valuation of groundwater resources as tangible and intangible heritage.

The study is structured under five main headings. Following the introduction, which presents the importance of the subject and the aims and objectives of the research, there is a relevant international and national literature review. In the third chapter, the materials and methods utilized in the research are explained, which later followed by the findings. The forth chapter discusses groundwater heritage valuation based on the results obtained, and finally, the results are presented.

Valuation of Water as Heritage

Heritage refers to the practices and values, both tangible and intangible that emerge as a result of the production of social identities and life experiences (Vecco 2010). In other words, historical artefacts and cultural practices are considered as heritage because of the values attributed to them (Muñoz Viñas 2005). Thus, they can be considered as a permanent source of knowledge about past societies, and their protection ensures the transfer of the knowledge they hold (Low and Altman 1992).

The values attributed to heritage assets are an important part of any conservation process. In addition to the technical challenges, the social and cultural dynamics need to be understood as seen by the local community. The complex set of values that heritage assets comprise require different expertise assessment and methodologies (Reher 2020), which can be brought together in the form of conservation

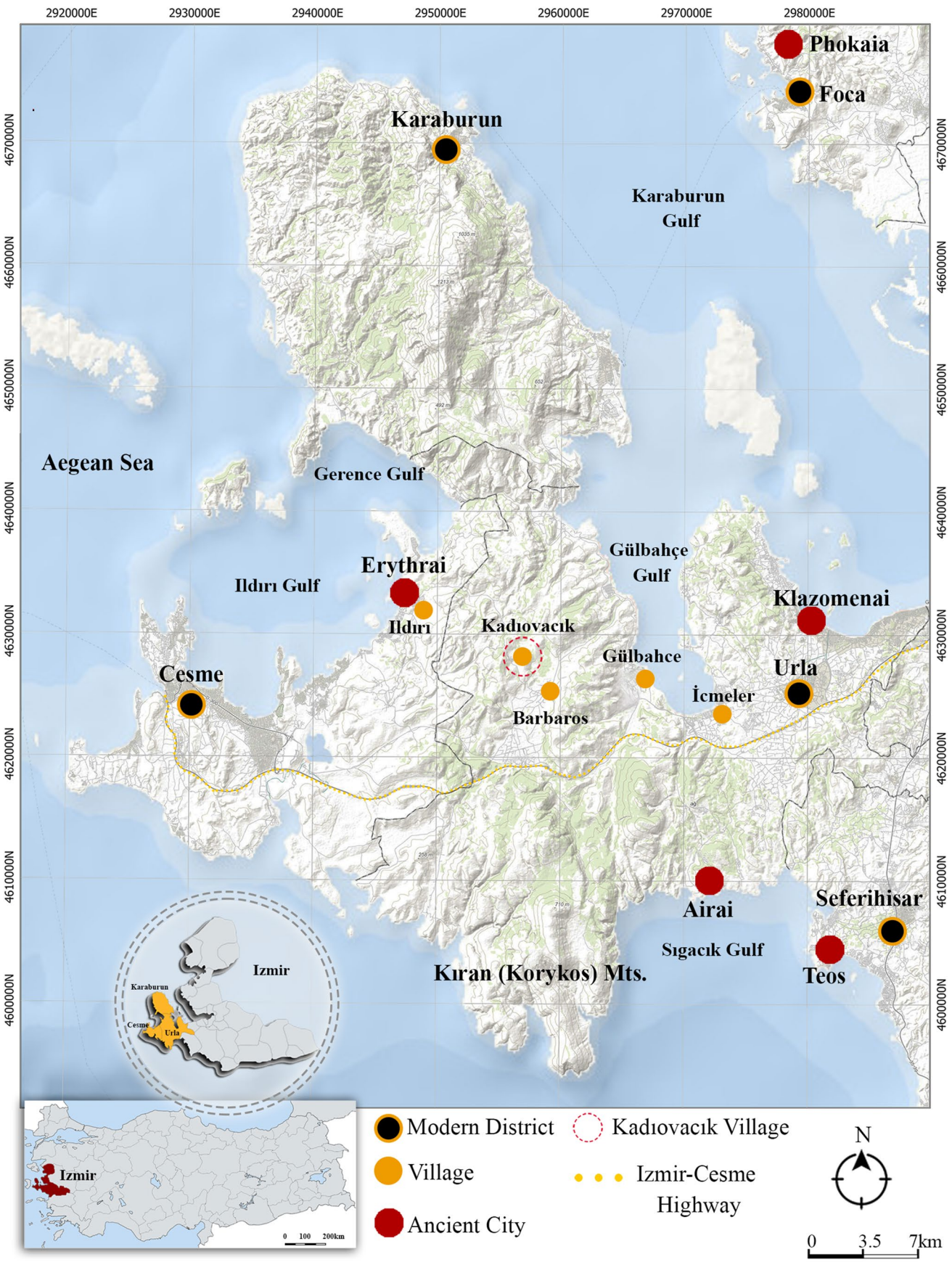

Fig. 1 Location of Kadıovacık Village

Fig. 2 General view of Kadıovacık wells

management strategies that aim to transfer values without any harm (Jokilehto 1999; Stubbs 2009; Araoz 2011; Glendinning 2013). In recent years, the conservation of heritage has been generally understood as a values-based activity that requires a more integrated approach to conservation management (Richmond and Bracker 2009; Tengberg et al. 2012). A values-based approach aims to identify, sustain, and enhance the significance of its constituent 'heritage values' (Fredheim and Khalaf 2016). Different types of values defined as 'value typologies' in the literature were addressed, initially with their tangible aspects, but over time they broadened their scope (Jokilehto 1999; Stubbs 2009; Araoz 2011; Glendinning 2013). A value-based conservation approach implies that the value of heritage assets may vary according to the type, context, and historical background of those assets.

Among the various types of heritage, those associated with water are regarded as life-sustaining and represent the productivity of societies and their ecosystems. They also indicate how societies balance geophysical, economic, and cultural knowledge (van Schaik et al. 2015) and transfer best practices and cultural memory to the next generations (Hein et al. 2020). The hydraulic network in Angkor, for example, is an important legacy that has witnessed both the physical infrastructure and the rituals of the sacred places (Hang 2015). In the Dutch delta, elements of the water management infrastructure, such as rivers, riverfronts, polders, locks, and suspension bridges, are valuable cultural heritage items that can be exemplified as icons of Dutch historical identity (Steenhuis 2015). In many regions of Turkey, people celebrate and welcome spring along the banks of rivers with recreation activities, including throwing paper with wishes written on them into the flowing water. The image of water is frequently used in Turkish mythology and is associated with holiness (Ökse 2006).

Regarding the wells, the studies show that the well motif in Turkey has interconnected and different functions in culture, literature, and mythology (Işık 2020; Bayat 2012). Işık's recent study suggests that the well motif is used as a source of water, a means of punishment, a passage from one world to another, for education and maturation, as a place of pilgrimage, as a tool in the making of rhetoric in classical literature, for helping to meet International organisations such as the need for food, helping to eliminate unwanted things, hosting dark emotions and thoughts, helping rebirth by functioning as a uterus, and being a place for meeting and socialization (Işık 2020). In this context, wells as heritage assets deserve a comprehensive valuation methodology.

Kadıovacık Village and Its Wells

General Description

Kadıovacık Village is in the Urla District of İzmir Province, which is the third-largest city of Turkey. The village is 63 km away from Izmir city centre. Due to its proximity to the Aegean Sea, the village has all the characteristics of the Mediterranean climate, being hot in summer and warm and rainy in winter. There is a prevailing wind throughout all seasons, which is particularly welcome on hot summer days. In line with the climatic conditions, the flora is typical of the region comprising maquis, olive, laurel, and myrtle. Regarding natural water resources, Kadıovacık and the neighbouring village Barbaros are housing wells, although they are surrounded by rich groundwater resources, such as the İçmeler and Gülbahçe springs that are significant geothermal resources and are currently in use. Also, Ildırı village towards north is rich in ground water resources that help to provide a water supply for the district of Çeşme.

Although the most popular villages of Urla are on the Aegean Sea coast, Kadıovacık village is located on the higher inland hills, forming a polje. The inclined settlement faces towards the east with a view of the polje and forests grown on the surrounding hills. The main road crossing the village connects it with Ildırı Village to the north and Barbaros Village to the south. The main public buildings and the coffee shop, where the village community meets, are concentrated around the village square. The wells of Kadıovacık Village are situated towards the northwest of the village on an inclined topography (Fig. 3).

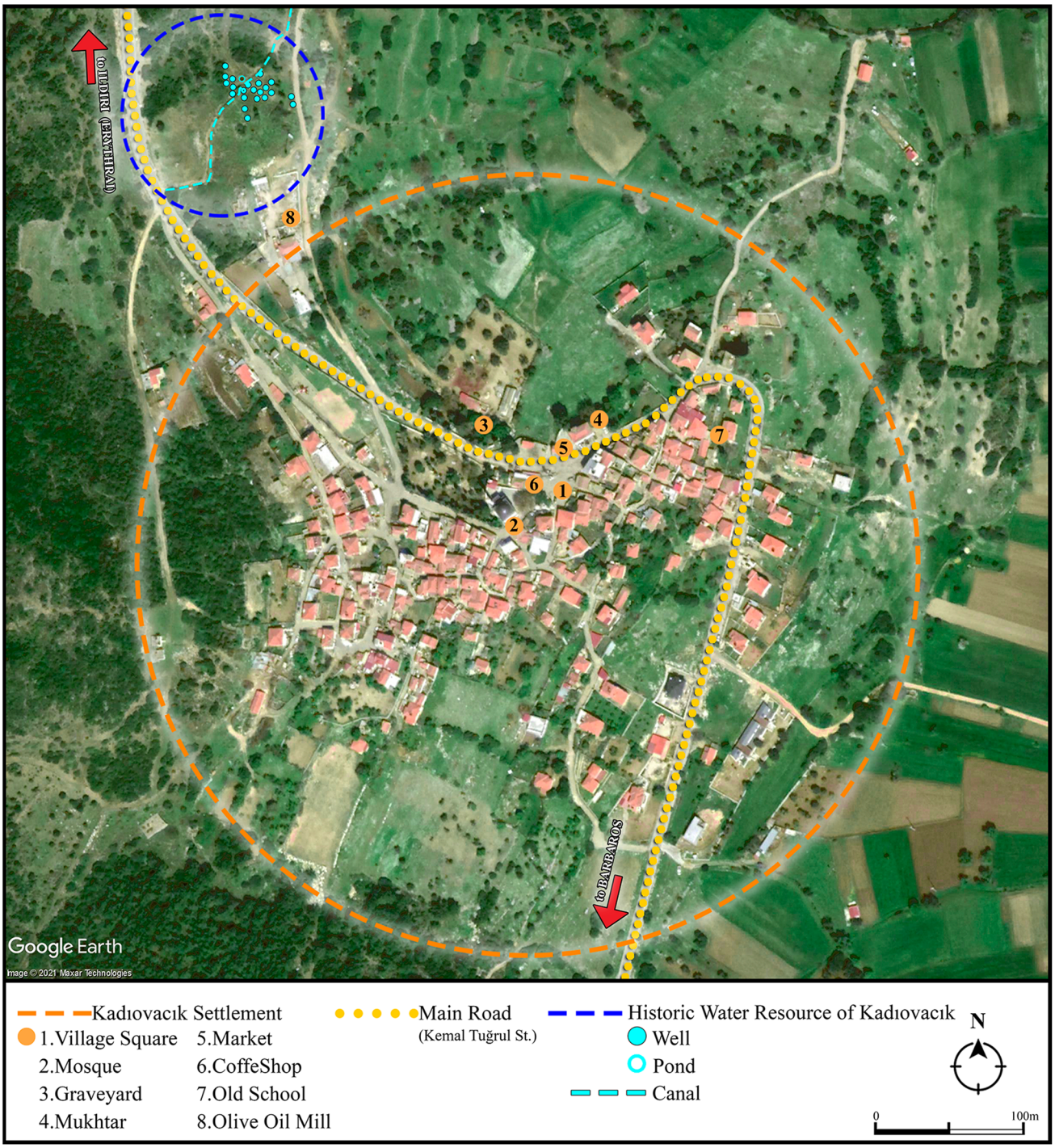

Fig. 3 Kadıovacık Village settlement

Historical Research

The historical research is conducted in two phases. First, the background of the region where the wells are located is examined at a larger scale through a literature review. Since Kadıovacık Village is only 11 km from the ancient city of Erythrai, the archeological reports of excavations in the area helped in revealing the importance of the region throughout the ages. Second, the history of Kadıovacık is examined through literature and national and local archives. There is no direct information about the history of the village in the literature; thus, the census results from the Ottoman were consulted together with period and earthquake statistics. The archives did not provide operational knowledge related to water and wells. Stemming from the lack of historical data about the Kadıovacık wells, we conducted an oral history exercise to gain insights into the past by utilizing locals' memories and oral testimonies. The research data obtained through historical documents and oral history are presented below.

Kadıovacık used to be a part of the Barbaros district of Çeşme at the beginning of the nineteenth century. In 1931, it became a neighbourhood by connecting administratively to Uzunkuyu and later to Urla in 1997 (Berber 2001). The name of the settlement is composed of the words *kadı* and *ovacık*. It is assumed that this name was derived from the plain around the village as *ovacık* refers to a small plain, and from the administrative chief *Kadı* to which the settlement was affiliated at the time it was established in the Ottoman period.

Although no archaeological finds have yet been found in Kadıovacık village, it lies in the former ancient Ionia region. There is an Ionian League (7th and 6th BC) of Greek cities such as Erythrai (Ildırı), Clazomenae (Urla), and Smyrna (İzmir) in its close vicinity (Fig. 1). The closest ancient city of Erythrai is 11 km away from the village towards the north of the seacoast. The existence of Erythrai is connected to the rich groundwater resources that are mentioned in several publications. Buresch (1892), for example, stated that he discovered a semi-circular planned artificial cave in the east of the Erythrai Acropolis and a total of four inscriptions around the cave during his visit in 1891 (Guray 2018). These inscriptions reported that the cave was dedicated to Sibyll and that there was a groundwater resource in it. The structure was collapsed, but the semi-circular wall about 2 m in radius, the canals and gutters that brought water to the cave, and the tank where the water was collected were still visible (Guray 2018). The groundwater resources of Ildırı (Erythrai) still provide the main water supply for the settlements in the region.

Apart from ancient civilizations, the studies show that the settlements in the region where Kadıovacık is located have a rich multi-layered cultural history dating back to the prehistoric period (Caymaz 2008). The town of Çeşme and the surrounding settlements have been taken from the Byzantines in the early fourteenth century by the Turks, first under the rule of the Aydınoğulları Principality and then the Ottoman Empire (Aktepe 1993). The oral history research carried out in this study shows that Kadıovacık has been a Nomad (Yörük) Village since the nineteenth century.

According to Başaran and Haykıran (2015), in a census conducted in 1842, which aim to determine the number of men for military service and tax amount, 44 men from Kadıovacık were registered. These records describe the physical characteristics of the men (height *medium*, *long*, beard *white beard*, *black beard*, *brown mustache*, *yellow mustache*, etc.), their professions (15 farmers, 2 junkers, 1 orator *mosque teacher*, 1 gulam *servant*), nicknames (Çakıroğlu, Eskicioğlu, etc.), age (average 25, the oldest person 110 years old), and kinship relations. Another data source about Kadıovacık history is the statistics after the Çeşme and Urla earthquakes on 15 October 1883. According to these, the reporter Forton stated that 28 houses were destroyed in Kadıovacık that led to 102 inhabitants without housing and two people died (Satılmış 2012). This information was published in The Eastern Express on 31 October 1883. In addition to the in-kind aid that started to be distributed immediately after the earthquake, money was distributed to the affected people three times via different sources. Kadıovacık received 6000 kurus (currency in Ottoman period) for 100 people from concert fees and 2520 kurus from kermis proceeds for 63 people (Satılmış 2012).

Based on these statistics and the information we obtained from the fieldwork, we can say that until recently, the main livelihood of the village was agriculture. Due to the properties of the special soil that the Kadıovacık polje has, the plants can easily grow without irrigation.

Within the framework of historical research, the relation of the village with water resources is also considered. The studies in İzmir and its surroundings reveal that there were water shortages, especially during the second half of the nineteenth century after İzmir became one of the most important port cities of the Mediterranean and therefore attracted migration that led to population increase.

Social and Cultural Characteristics

Cultural and social interwoven researches were conducted through in-depth interviews with the villagers about their everyday life practices and routines regarding water sources and wells. These took between 50 and 60 min, depending on the questions. However, the participants were allowed to expand the interviews where appropriate, which brought extra insights. The population of the village is approximately 255. In the end, 16 people, including the village official (mukhtar), opinion leaders, and some over the ages of 60

were interviewed. The oral testimonies of the village elders proved to be an important source of information.

According to the interviews, the twenty-four wells were excavated by the ancestors of the current inhabitants of Kadıovacık to exploit groundwater since there was no other water source in the area. Most of the wells were dug collectively (*imece usulü*) for the benefit of the community and were used for three primary reasons: drinking, washing clothes, and bathing. Due to the need for large amounts of water, the villagers had spent a considerable time building the wells. The plentiful water supply transformed their everyday routines and had a great impact on their life and culture.

The inhabitants had used the wells of Kadıovacık intensively until 1980, before connecting the city water pipeline. Before the 1980s, it was mostly the local women who went to the wells several times a day, often bringing their children along with them. They hung barrels called *Kırcak* on their donkeys to carry water to their houses. If the well water was not clean, they drained it with a cheesecloth and drank. Also, they threw gum bush (tincture) into the water to make it smell nicer. The locals used narrow-mouthed wells for the humans and the wide-mouthed wells for the herd animals. Washing the laundry by the wells was a laborious task. When detergent was not available and the water was limited, the laundry was washed with lye (*water and hardwood ash mixture*). This process is called *making boğata* (Italian bucato) (Tietze 2002).

The local people named some of the oldest wells in Kadıovacık, and the tales about them were transmitted through generations. One of the most famous of these is the tale of the Dudu well. Rumour has it that two girls had fallen in love with one of the village boys. The boy got engaged to one of these girls, Dudu. Thereupon, the other girl, Ayşe, had met with Dudu at the well and thrown her into the well out of jealousy. A while after, the villagers had heard the cries of Dudu and rescued her. In the end, she married her love, and Ayşe found herself another suitor.

Another famous well is the Halil Dede (Halil Grandpa) well, where henna ceremonies are held. Brides are brought on horseback to the well. Their hands are washed with water for hours. Then, people drink water from the brides' hands, believing that it would bring luck. Even today, this tradition continues (Fig. 4). Water and well-related practices, along with these tales, have been reflected in their oral traditions and language.

The Hasan well is the one most valued by the local people. They described these kinds of wells as *dug wells*. Dug wells, unlike other wells, are supplied by both rainwater and groundwater harvest.

The water wells in Kadıovacık were dug by the local people as a solution to water scarcity in the region. Their struggle to reach clean water has left deep traces in their memories. For this reason, they gave names to the wells they dug with great effort and narrated their experiences of the wells via folktales through generations. As a place for celebration (e.g., henna nights, weddings), these wells become an important part of their tangible and intangible cultural heritage.

In 1953, water was supplied to the village fountain from the cistern in the village. Following the development of water distribution infrastructures in the village in 1988, the wells have lost their functional value, but even so, preserved their symbolic value for the local people. The memories of collecting water via wells often evoke the torments of the past. Still, the locals view the wells as a safety measure in case of a potential water shortage, hence want to preserve them.

Fig. 4 Henna washing celebration before the wedding ceremony dating July 19, 2015

Geological and Hydrogeological Characteristics

A comprehensive data collection was conducted in the Kadıovacık region to characterize the geology, hydrology, and hydrogeology of the system. Necessary information about the groundwater aquifer and its environs was obtained from field studies and GIS-integrated assessments. The data loggers recorded physical groundwater parameters (temperature and conductivity). The manual measurement of temperature and electrical conductivity was done with multiparameter probes (HACH-LANGE HQ40d). The pH meter was calibrated with pH 4, pH 7, and pH 10 buffer solutions before commencing fieldwork. During fieldwork, groundwater samples were also collected from the dug wells in 2021 to characterize quality parameters. The concentrations of major ions and some heavy metals were determined in these water samples. In order to determine the variation in mineral content of the water samples, they were collected in unused 50 and 500 mL hard-plastic bottles. To prevent the formation of heavy metal complexes with oxygen, samples were acidified with HNO_3 to pH = 2. Acidified samples were analysed for major and trace elements with an inductively coupled plasma mass spectrometer (ICP-MS) at İzmir Institute of Technology Environmental Development, Application and Research Center. A non-acidified sample was used for anion analyses. Chlorine and HCO_3 were determined volumetrically and SO_4^{2-} by a gravimetric method in the Izmir Institute of Technology (IZTECH).

In line with the materials and methodology explained above, the geological, hydrogeological, and hydrogeochemical properties of the water resources in Kadıovacık Village are described, and the status of the wells are assessed. The study area is located in the Karaburun Peninsula. The basement rock of the Karaburun Peninsula is the Early–Middle Carboniferous marine sediments, which consists of limestones and dolomites (Erdoğan 1990). The unit is unconformably overlain by Triassic-Jurassic rocks of Karaburun Platform Carbonates and Upper Cretaceous to Paleocene rocks (clastic and carbonates) of Bornova Flysch Zone (Fig. 5a). These rocks are commonly intercalated with andesitic and dacitic lavas, volcaniclastic rocks (Robertson and Pickett 2000), submarine basaltic lavas, and basic pyroclastic and volcaniclastic rocks (Çakmakoğlu and Bilgin 2006; Erkül et al. 2008).

Miocene and younger units are generally used as cover rocks in the polje system. However, water supply can be provided where there are thick levels and where there are dense porous-fractured units. For this reason, these units are classified as hydrogeologically locally productive aquifers. Similarly, Cretaceous flysch units, which are exposed in certain locations in the field, are also included in this class.

Lower-Middle Miocene volcanics, which spread around Kadıovacık and Barbaros, has a character that allows infiltration from the surface and can form an aquifer with its fractured features (Fig. 5a). However, the most important groundwater aquifers in the field are Triassic-Jurassic aged limestone and dolomites. These units located in the basement were emplaced on the impermeable Carboniferous rocks. The units have formed poljes with their karstic properties and fault-fracture systems and therefore have significant potential in terms of important water resources.

Geological studies in the area revealed that significant levels of karstification were observed in the Karaburun Platform carbonates of the region, which resulted in the formation of a number of polje and uvala structures. Karst structures of the region are tectonically controlled, and tectonic zones are EW and NNE trending. The polje and underground structure in the region can be seen from the 2-D cross-section in Fig. 5b. Kadıovacık village is located on this karstic polje which is a flat-floored depression within karst limestone, whose long axis develops in parallel with major tectonic structures. The fault segment limiting Akdağ Hill from the northwest separates the limestones and the Post-Miocene deposits of the Kadıovacık Polje from each other. Due to these features, water is not stored in this area. This water directly recharges to the Ildırı Region, at the western part of the study area. Some springs emerge along the faults in the Ildırı region. The average flow of the major karst springs of the region is 420 l/s, and an additional 200 l/s of water is obtained from wells during summer periods (Baba et al. 2015; Yousef et al. 2017). Because of this karstification, many sites, such as Kadıovacık Village, located on a polje, have not reached the water resources (Fig. 5b), which led to may wells being dug here.

The hydrogeological properties of the study area were reviewed based on the above-described stratigraphic units with their hydrological properties. According to the results of the study carried out in the region, especially in the Gülbahçe Fault Zone and the surrounding area, faults and karstic fractures have created predominantly N-S, NE-SW, and NW–SE oriented apertures and pathways for water circulation (Uzelli et al. 2017). Although not having primary porosity, the limestone in the study has karst features, fissures, faults, joint sets, and open fractures that are the main factors controlling secondary permeability.

Three groundwater samples were collected in different wells in May 2021 to determine the general characteristics of groundwater in the study area. The results of groundwater samples are presented in Table 1. These show that the temperature of the groundwater ranges from 15 to 24 °C. The electrical conductivity (EC) values of the water resources have values ranging from 188 to 292 µS/cm. The pH value for all the wells was slightly higher than 6.5, indicating alkaline conditions, but most of them were within the normal pH range of 6.5–8.5 for groundwater. These values are of the range stated in national and international quality standards

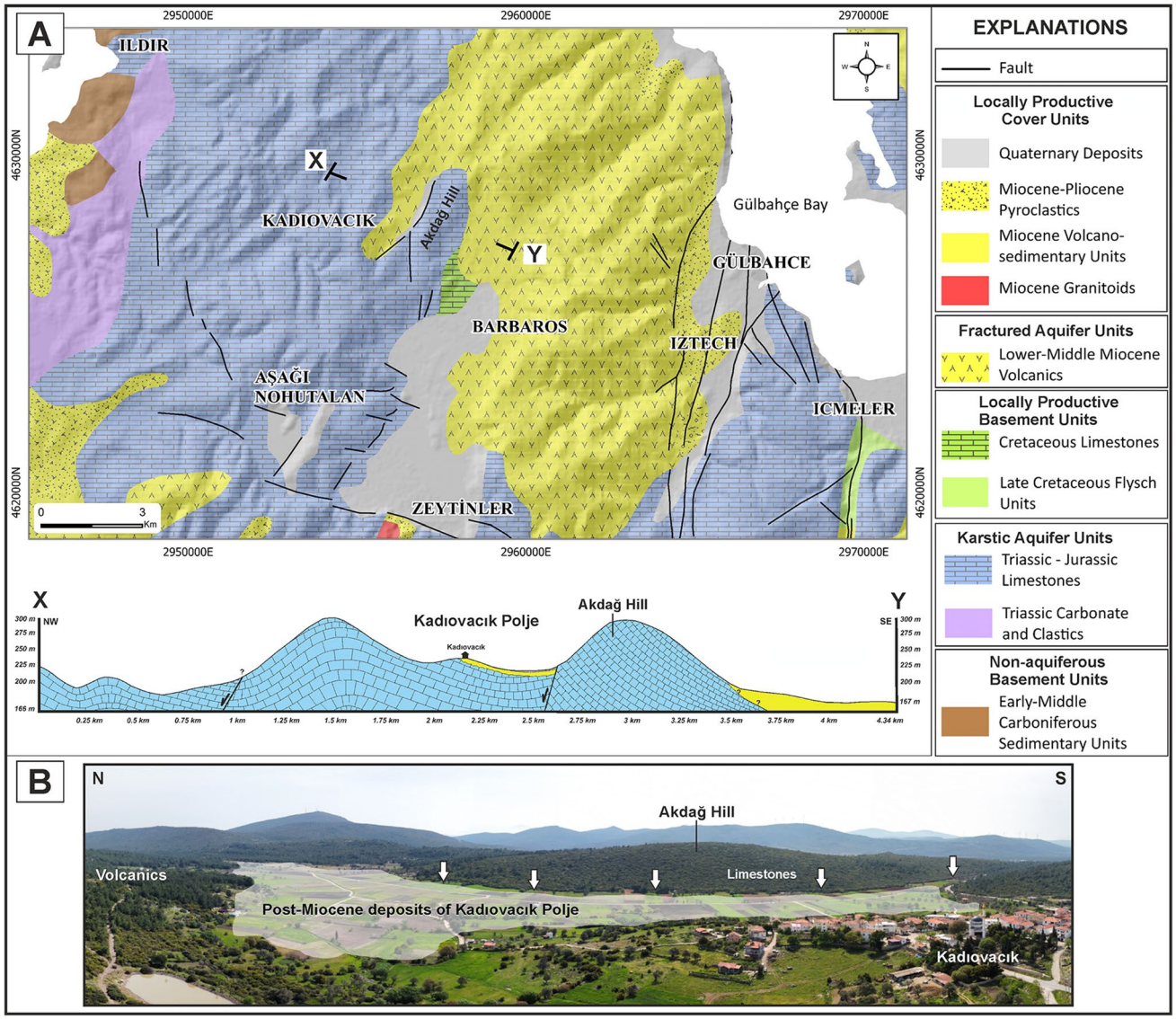

Fig. 5 **a** Geological map, hydrogeological properties and 2-D cross-section of Kadıovacik region (modifying from Çakmakoğlu and Bilgin 2006; Uzelli et al. 2017; Göktaş and Çakmakoğlu 2017). **b** Aerial image of the Kadıovacık Polje (white arrows show the possible fault trace)

(ITASHY 2005; EPA 2003) for drinking water. The physical and chemical properties of groundwater are within the health quality limits and may have long-term use potential for the region. When the changing precipitation regimes as a result of climate change and global warming begin to affect the water resources in the region, the existing water wells will regain their former importance for Kadıovacık and its surroundings in terms of storage, irrigation-use, and drinking water.

According to the IAH (International Association of Hydrogeologists) (1979) classification, all waters are of the Ca-HCO_3 type (Fig. 6). On the basis of major ion concentrations, the Piper and Schoeller diagrams of wells water are drawn and shown in Fig. 6. In the Schoeller semi-logarithmic diagram, waters with similar chemistry yield similar peaks. It is clearly seen that the waters in the study area have similar chemical characteristics, with $Ca > Mg > Na > K$ and $HCO_3 > SO_4 > Cl$ chemical compositions. Also, some toxic elements were measured. The levels of these elements were found not to exceed the maximum allowable limits stated in national and international standards for drinking-water quality.

Architectural Characteristics and Typology of Kadıovacık Wells

The architectural research comprises the study of the close vicinity of the wells in relation to the village settlement, the

Table 1 Physical and chemical properties of Kadıovacık wells water

Sample no	Well-5	Well-18	Well-21	WHO (2006)	EPA (2003)	TS (2005)
pH	7.93	6.75	6.67	6.5–9.5	6.5–8.5	6.5–8.5
EC (µS/cm)	291.6	191.6	188			1000
TDS (mg/L)	200	100	100			
Pb (µg/L)	0.5602	0.4120	1.734	10	15	10
Ba (µg/L)	62.35	55.96	67.58			
Cd (µg/L)	0.461	0.509	1.405			
Sr (µg/L)	119.9	76.25	87.42			
Se (µg/L)	2.794	2.4564	3.181			
As (µg/L)	3.108	0.7423	1.097	10	10	10
Zn (µg/L)	2.752	3.4340	8.735			
Cu (µg/L)	1.913	1.950	2.555			200
Ni (µg/L)	1.259	0.9781	1.870			20
Fe (µg/L)	4.529	4.411	6.536	300	300	200
Cr (µg/L)	0.919	0.612	1.888			0.05
Al (µg/L)	2.326	1.595	5.273	200	200	200
B (µg/L)	33.86	26.85	49.93			1000
Na (mg/L)	13.42	14.00	14.06	200		200
K (mg/L)	3.55	3.18	3.18			
Mg (mg/L)	9.27	5.15	5.13			
Ca (mg/L)	27.76	12.00	11.62			
F (mg/L)	0.18	0.09	0.09	1.5	2.0	1.5
Cl (mg/L)	16.25	15.48	15.29			200
Br (mg/L)	–-	0.03	0.04			
NO_3 (mg/L)	0.83	0.04	0.27	50	10	50
SO_4 (mg/L)	14.99	10.84	10.44	500	250	250
PO_4 (mg/L)	0.4233	–-	–-			
HCO_3 (mg/L)	102.766	54.621	54.205			

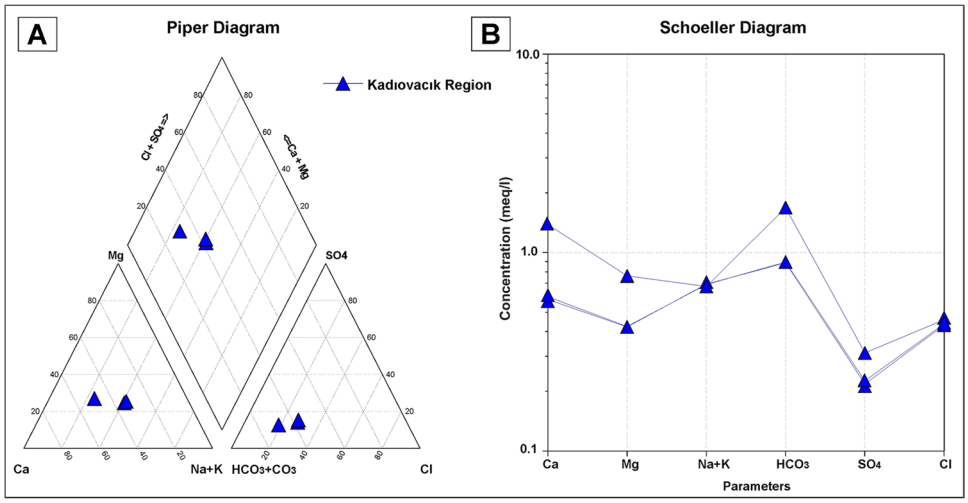

Fig. 6 **a** Piper and **b** Schoeller diagram for water samples around the Kadıovacık region

measurement of 24 wells, and the preparation of plan and section drawings of each well, including construction techniques and materials used. Measurements on-site scale are obtained via the total station, while the wells are measured via tape and laser devices, including a water level meter for depth. Construction techniques and materials are examined through a detailed survey of each well, especially two dry wells, which were helpful in observing the details. From the data obtained, 1/100 scale site plan and section, 1/20 scale plan and section drawings of each well, and 1/5 scale

construction detail drawings were prepared. This study also helped in revealing a typology of wells.

The wells of Kadıovacık were built throughout the ages as the sole suppliers of water. Towards the northwest of the village, the availability of groundwater resources, which was most probably discovered by the trials of inhabitants, led to the accumulation of the 24 dug wells in the same area. Regarding their location and proximity to each other, it is possible to trace that there is a logic that aims to collect as much water as possible without wasting the overflowing water. Thus, they are situated on the inclined ground around a naturally formed small water canal (now dry), and shallow water ditches are formed from one well to the other in order to collect overflowing water (Fig. 7). This system also helps to harvest rainwater and leaking groundwater that penetrates through the walls of dug wells.

The wells are in the form of cylindrical shafts dug into the soil, where the soil face was supported by embedding local stones. The dry masonry technique was used in their construction. The shaft stretches above ground, forming the headwalls that are also constructed in local stone. While some wells are covered with circular platforms, some well covers are square or rectangle. The diameters of the wells vary between 170 and 355 cm. The depths vary between 2 and 13 m.

Kadıovacık wells can be categorized according to the ways they are constructed. There are three types. The first is constructed adjacent to the existing rocks by using them as one border of the shaft. There are 4 wells for this type. The second type comprises of the wells dug directly into the soil, demonstrating variety in their top covers that are later interventions. There are 19 wells for the second type

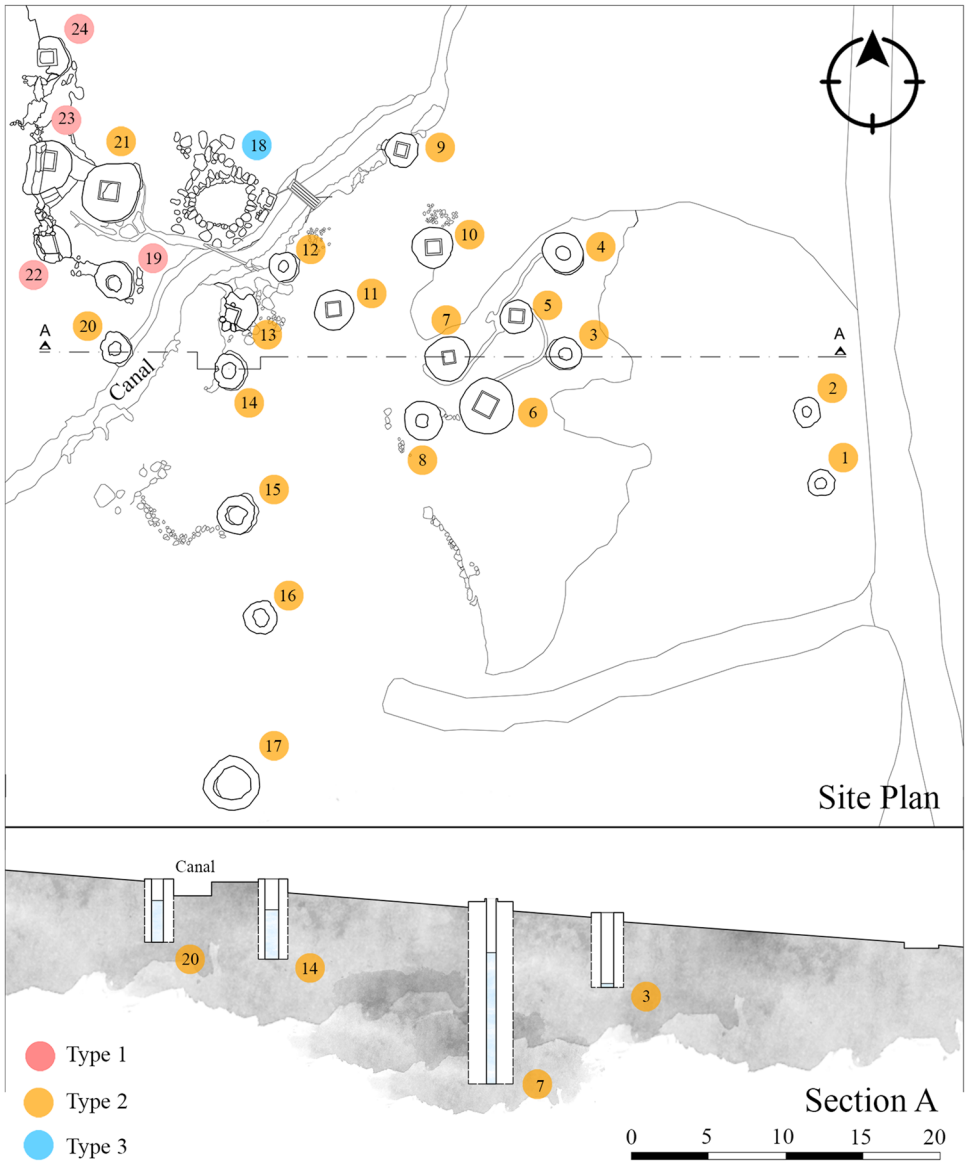

Fig. 7 Site plan, site section, and typology of the wells

constituting the majority (Fig. 8). The third type is exemplified by only one well that can be considered as a pond used mainly for washing clothes, yet it can also be used for drinking purposes in the case of water scarcity.

Environmental Characteristics

Information systems and digital data for cultural heritage have been utilized progressively in inventorying, conservation, and decision making. Among information systems, Geographic Information Systems (GIS) is the most revolutionary tool, especially for cultural landscapes (Yang and Han 2020). As the data about the Kadıovacık region is accumulating, a GIS spatial database (geodatabase) is established to store and integrate data on natural and cultural landscape features. The geodatabase is structured to store two major datasets:

First is the dataset that relates to the natural landscape, including land use (forest, agriculture, etc.), topography (slope, elevation), and the features that can exert major influences on hydrology and hence, wells, as mentioned in Geological and Hydrogeological Research.

Second is the dataset that relates to the cultural landscape. The wells data being collected in the field in latitude–longitude coordinates using GPS receivers. Ancient and historical locations in the vicinity, as mentioned in 'Historical Research', are digitized and stored. The road network, transportation corridors, touristic and recreational routes, and other attractions were acquired and stored.

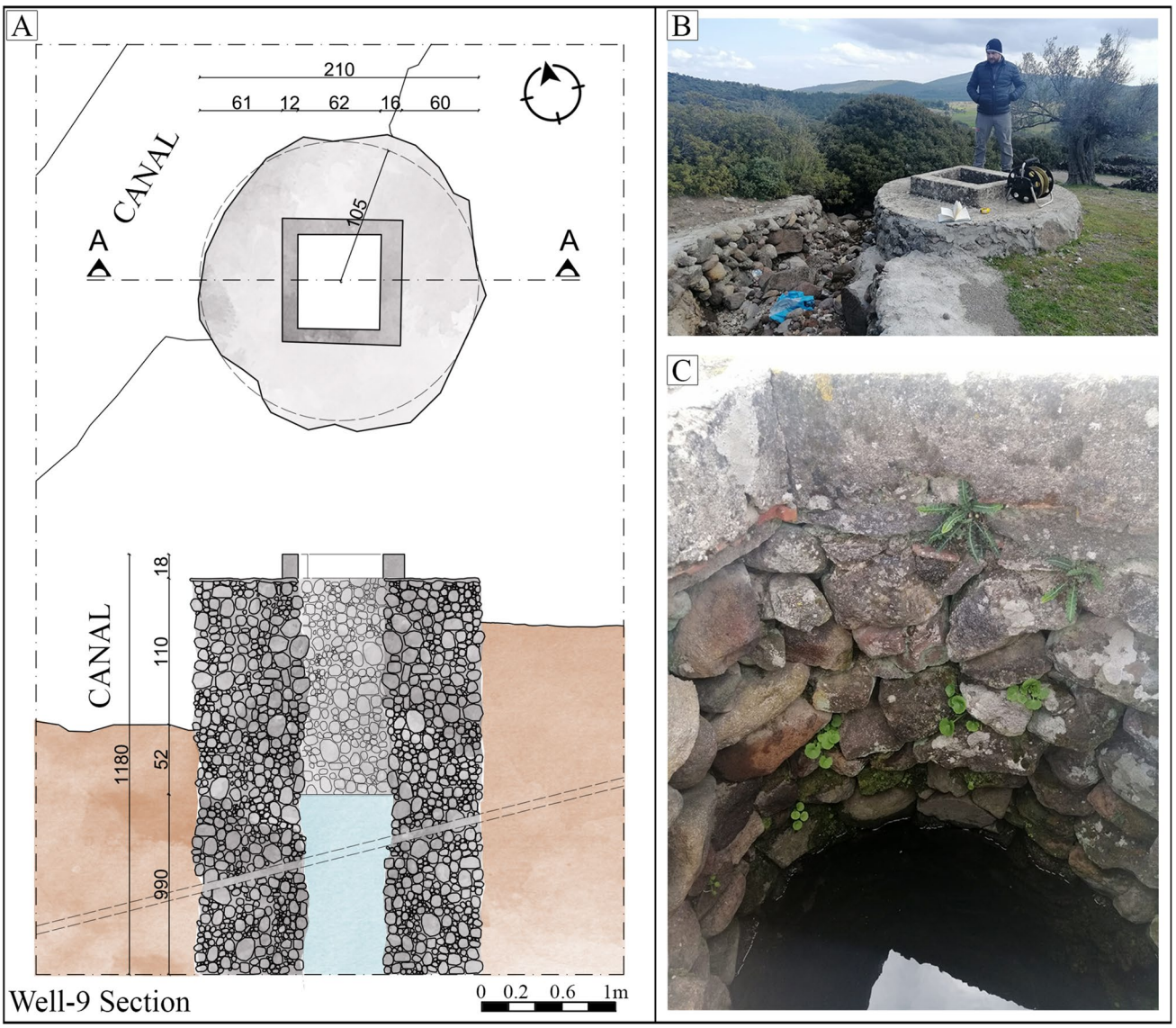

Fig. 8 **a** Plan and section drawings of the well-9. **b** General view of the well-9, April 3, 2021. **c** Inner shaft of the well-9, April 3, 2021

The geodatabase is structured to store two major datasets; the features of the natural and the cultural landscape are partially complete for the broader region that covers Kadıovacık and Barbaros wells and other locations with water resources of significance, namely, Malgaca-İçmeler and Gülbahçe springs.

Based on the initial assessments, the land cover of the region is dominated by Sclerophyllous vegetation that covers the typical maquis of the region with sparse trees. Villages of the region comprise settlements and complex cultivation patterns. There are also forest areas typically of coniferous trees and transitional woodlands with scattered trees (CORINE 2018). Due to the limitation of water and the capabilities of the soil, agriculture in the region is limited, and hence, the natural land cover of the region is beneficially not fragmented. With its typical Mediterranean landcover and clusters of coniferous forests, the region provides recreational potential. Villages, especially Kadıovacık, by preserving its rural dynamics, reveal authenticity with waterless agriculture.

The polje is surrounded by higher inland hills dominated by agriculture and a number of nearby villages. A major part of the road that connects Barbaros, Kadıovacık, and Ildırı passes through this plain topography and has the potential to develop alternative transportation such as bicycling and hiking.

By examining the settlement at a broader scale, it can be said that Kadıovacık, in particular, is not a part of the main transportation network. It is slightly more remote and contextually diverse from the touristic movements and activities in the broader region. As opposed to the mass tourism concentrated in the coastal regions of İzmir Peninsula, namely, Çeşme, Alaçatı, and Urla, the region is quiet and isolated. Kadıovacık is not acknowledged as one of the destinations/stops on ecotourism routes that focus on exploring the natural and cultural assets of The Izmir Peninsula (IZKA, 2014). The alternative tourism activities in the region and the routes: olive route, winery route, and bicycle routes, i.e., Eurovelo, olivelo, and hiking routes, hardly coincide or pass through the region. In this sense, the region is supposed to be rural, traditional and remote.

For Kadıovacık and environs, planning decisions are primarily based on the 1/10,000 and 1/25,000 scaled structure plans of the greater region. The Structure Plan is a long-term legislative framework used to guide the development of land to which local development and conservation plans must conform to. Accordingly, Kadıovacık village was designated as a rural settlement, and the neighbouring land where the historic wells are located is designated as agricultural land. Kadıovacık, with its small amount of agricultural land, is surrounded by forest land and is designated as natural protected areas. Kadıovacık and its environs are known to have no local scale development plan or any type of special-purpose plans, i.e., conservation plan and tourism development plan. There are currently no conservation measures for the region, which include the wells.

Discussion: Valuing the Kadıovacık Wells

In order to develop a long-term conservation approach, values must be identified together with the physical and social context of the heritage asset (Darvill 1995; Mason 2002). This value assessment requires extensive knowledge and should be determined using multi-criteria methods (Heras et al. 2013). In several studies, value assessment related to landscape, paleontological, touristic, archaeological, bibliographical, etc., has been developed. In line with this study, Pla and Maya discussed the importance of using multi-criteria in the assessment of hydraulic heritage assets, which mainly include irrigation systems and their landscape (Hermosilla Pla and Mayordomo Maya 2017).

This study contributes to the debates about the value assessment of cultural heritage and groundwater heritage in particular. Each heritage asset requires distinctive research that should be carried out by relevant experts. As such, the value attributed to heritage assets, which in this case are the Kadıovacık wells, can be properly assessed and form a base for conservation proposals on different scales. Our research on the different aspects of the wells demonstrates that they are examples of both intangible and tangible heritage with regard to the values presented below:

Historical Value Although their exact date of construction is unknown, the wells are said to be more than 200 years old. The oldest inhabitant of Kadıovacık (94) remembers that twenty-four wells were there when he was a child. These wells are evidence of past periods and provide tangible historical documents of the water usage of past communities. These issues together form the historical value of the wells for this case (Fig. 9).

Social and Cultural Value Kadıovacık is a humble village similar to others in the region. However, the water wells can be considered as something special for this village, providing a particular identity. Today, the wells are also symbolic and indigenous entities of the village for both locals and visitors. The inspirational importance of water for the life of inhabitants has given rise to the formation of traditions. These traditions that regard the holiness of water are still performed, such as drinking water from the hands of the bride. Thus, there is a continuity of these intangible practices. Cultural references to the water feature in the memories of locals as most of them remember how they carried water from the wells to their houses every day or how the women wash the clothes in the area that wells are located.

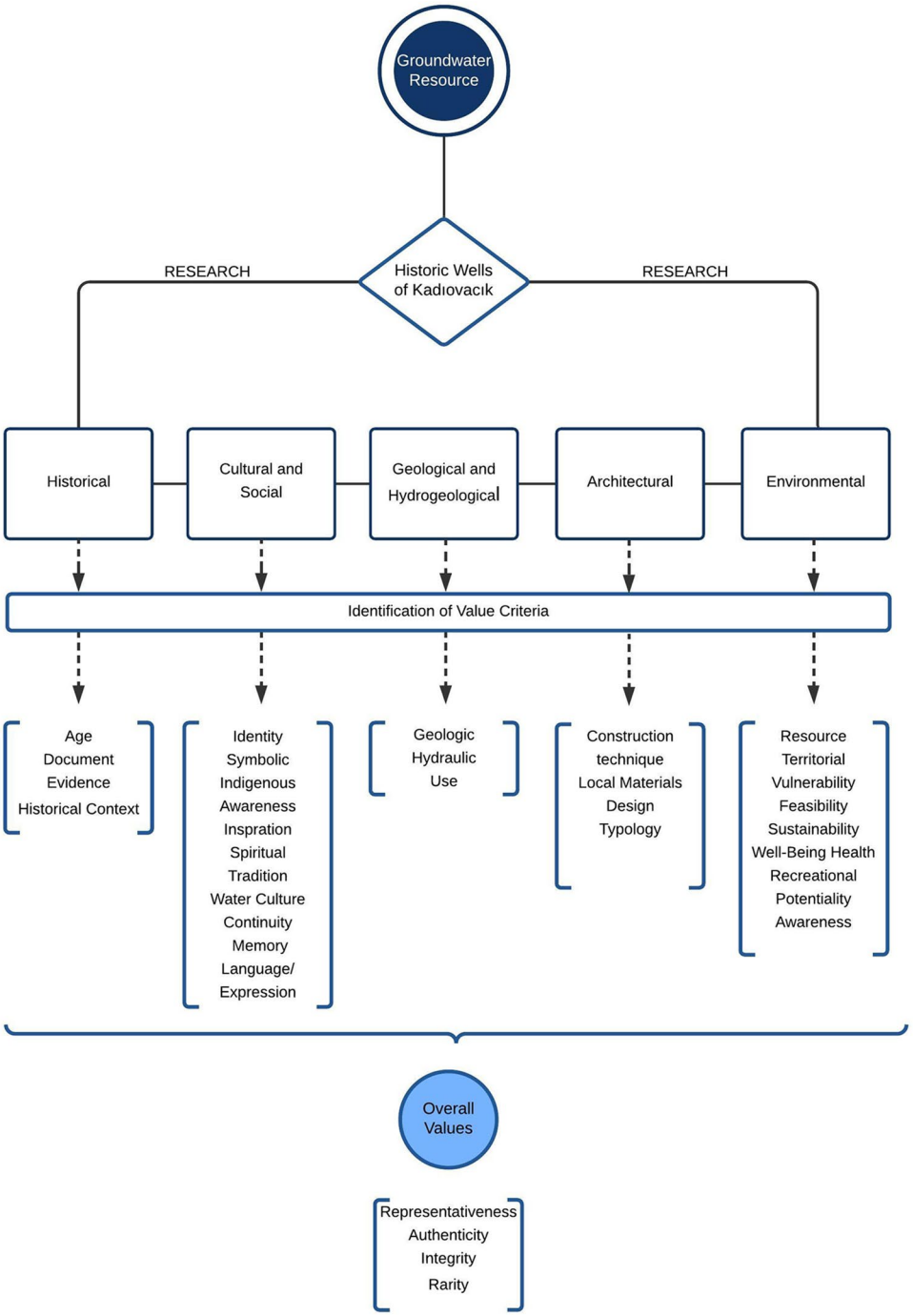

Fig. 9 Values and associated criteria derived through research for Kadıovacık wells

The water and wells also have effects on the language and local expressions. There are some special words known to be used in this area that only affiliate with wells and water. Water and wells are also used in poems. The stories/legends associated with the wells are still told to each other. It is also common to build wells for charitable purposes. These all together form the social and cultural value of the wells, which are highly significant when compared with other values (Fig. 9).

Geological and Hydrogeological Value The wells are evidence of the presence of groundwater that was important for the survival of inhabitants. They also represent the special character of geological properties, which allows infiltration from the surface to form an aquifer. The properties of rocks form a polje and fault-fracture systems providing potential for water resources. According to the results of the hydrogeological analysis, the water of the wells is possible to drink and use. These all together form the geological and hydrogeological value of the wells, which is important (Fig. 9).

It is important to protect and to draw protection zones for these wells.

Architectural Value The wells are constructed in a very simple and common technique with local materials. Their design with references to each other possesses a quality to collect as much water as possible. They do not establish rich typologies. These all together form the architectural value of the wells, which is rather less significant when compared with other values (Fig. 9).

Environmental Value Regarding their location in the village and the region, the wells contribute to forming a unique territory defining the availability of groundwater resources. Although they are usable today without giving any harm to human health, there is always the possibility of contamination which may be risky. In other words, today, they are feasible, but they are vulnerable to possible threats. They have the potential to be used as water resources as well as for recreational and touristic activities. However, it appears that the planning and policy implications of these wells in relation to past, present, and future has not yet been fully explored, as this should be integrated into sustainable development and conservation policies. These all together form the environmental value of the wells.

The significance of Kadıovacık wells instill in values they hold, which can be summarized as follows:

- providing ongoing access to a natural water supply,
- holding the past legacy that instils in the memories of the inhabitants,
- recording and preserving the forgotten information about *water*, which is in their memory and conveyed through oral culture.
- being a gathering place for ongoing traditional ceremonies,
- indicating the presence of groundwater resources,
- showing the ability of past societies to obtain water,
- contributing to the environment.

The overall values of the wells indicate that their authenticity and integrity are still valid. They are significant representatives of both water resources and the culture built around it. Their number and relation to each other in a specific location are rare (Fig. 9).

Conclusion: Suggestions for Conservation

As exemplified in this study, the valuing process stands as an important pillar in revealing the significance of cultural heritage for past, present, and future generations by means of historical, social, cultural, technical, and environmental aspects varying from one heritage asset to another. In the case of the historic wells of Kadıovacık, their significance is embodied within the context of the site itself, the specific geological and hydrogeological values hidden underground (community is mainly unaware of this), their relationship with the setting and environment, their use, cultural associations, memories, meanings for the community, and to a lesser degree their architectural characteristics. These values, which are not initially considered, truly reveal the importance of the wells as cultural heritage and call for urgent conservation measures and proposals at different scales.

Climate change can drastically affect the quantity and quality of water. İzmir is anticipated to be one of the most impacted provinces in Turkey from climate change and its consequences of a high risk of water stress. Harvesting the little amount of rain and limited groundwater with the wells has helped past generations survive the water scarcity they witnessed in the past.

Historic wells in the region have received little attention but are examples of the interaction between humans and the challenges that their environment brings, in this case, in relation to water. Rituals, traditions, and narratives related to water and wells in the region have been transmitted through generations, and it is important to understand the traditional culture that may erode and disappear in time. Increasing the visibility of the region can help the conservation of wells as tangible and intangible cultural heritage and contribute to local economies.

Kadıovacık village and the region it is in, including the wells, deserve to be understood in terms of its tangible and intangible values and its significance in coping with water stress and its potential to raise awareness on climate change. Considering the natural and cultural landscape of the region, its rural dynamics, and its location isolated from the urban fabric, there is the potential for the development of sustainable tourism — a growing sector globally (Mandic 2019). This may well require developing conservation plans and conservation measures. Making the region more visible, besides conserving the cultural heritage, requires a comprehensive assessment of the natural and cultural landscape. This study, analysing the region's hydrogeology, topography, and land cover was useful in understanding its natural and physical potential. The distribution of wells across the region and their spatial relationship with other cultural assets revealed that the region did not receive the attention it deserves. Although remote from the main transportation routes, its exclusion from the alternative touristic routes across the peninsula is questionable. Examining the regions potential led to the idea of an ecotourism route with the theme of water or 'the water route'. This route can broadly connect İçmeler-Gülbahçe-Barbaros-Kadıovacık-Ildırı, all of which are characterized by their diverse water resources.

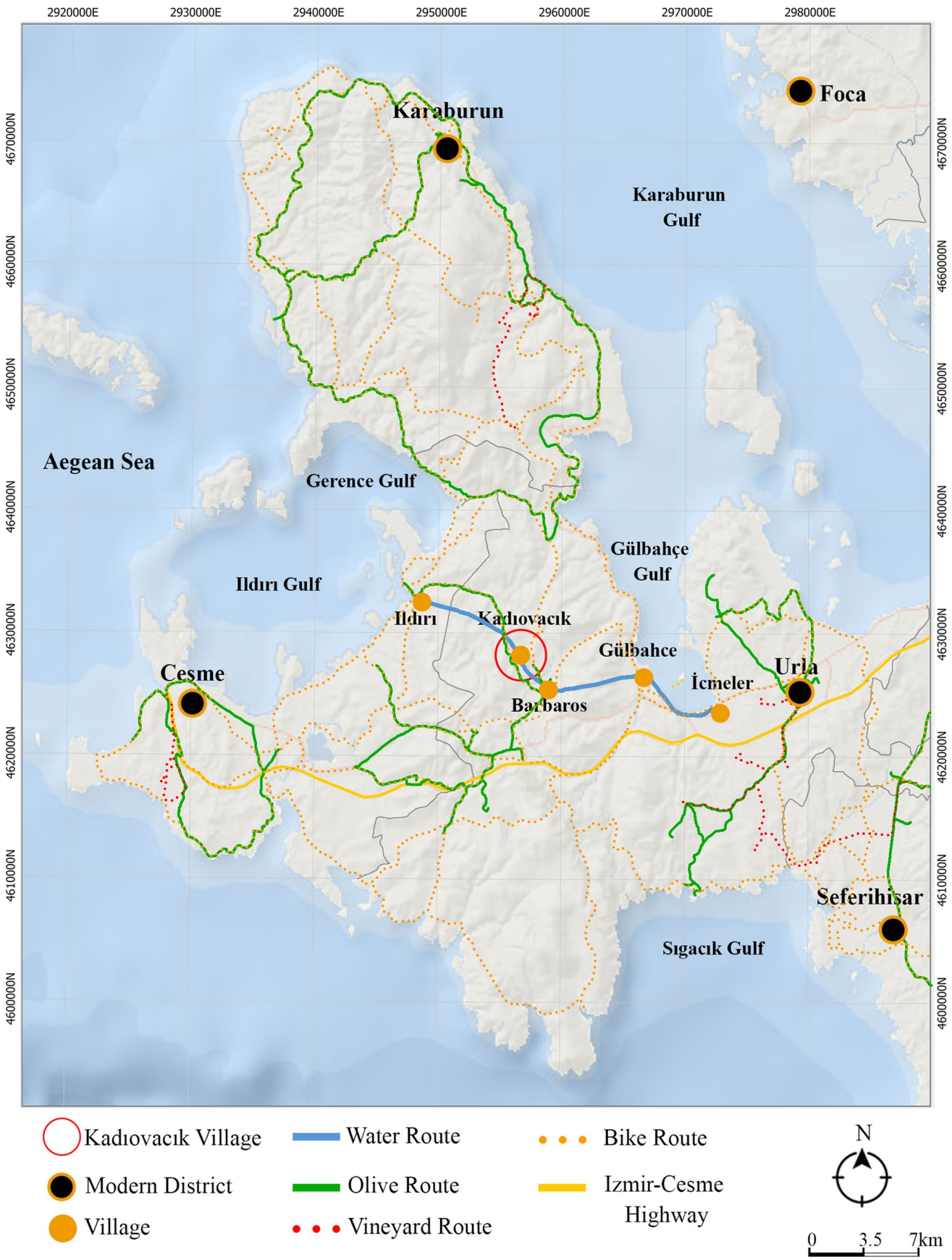

Fig. 10 Map showing the existing cultural routes and *Water Route*

Part of the route might include the Barbaros-Kadıovacık-Ildırı section as this is topographically suitable for recreational services such as cycling and hiking (Fig. 10).

The inter-disciplinary nature of this study referred to here as a holistic approach must include policies that recognize the inter-connected nature of the ecosystem. The demand for development in and around Izmir is increasing, as is the number of people relocating from Istanbul. It is Planning's job to prioritize these competing criteria. If the wells are to be maintained on a medium to long term basis, not only because of their 'heritage value' but because they are an ongoing resource in providing water for the livestock and the land, then this must be matched with other policy areas. At the moment, the physical and chemical properties of the Kadıovacık wells' water are recorded to be within the limits of human use (Table 1). Therefore, development control needs to ensure through both the application process and by supervision that anyone building nearby abides by strict rules to prevent building waste contaminating the watercourse, which will then go on to disrupt the whole ecosystem. The study demonstrated that this approach was supported by local people for whom the wells remain an important part of their lives. This form of cultural heritage will be transferred to future generations together with the myths and narratives handed down through history.

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Declarations

Conflict of Interest The authors declare no competing interests.

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