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Article

Investigation of old water supply system in the historic town of Beypazarı

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ABSTRACT

Throughout history, civilizations have improved water supply and management systems depending on new needs and innovations. Anatolia, home to many civilizations, showcases the development of water systems from the Neolithic period to the present. Beypazarı, located in Central Anatolia, demonstrates an advanced Ottoman-era water supply system with 19th and 20th-century water structures, such as fountains and riverbeds, despite many drying up today. However, infrastructure works have disrupted connections between water sources, fountains, and agricultural lands. Fountains have lost their function due to river drying, global warming, and man-made interventions. This study aims to understand Beypazarı's historical water supply system between the 19th and 20th centuries and the effect of interventions on increasing floods. Visible components, including natural water sources and fountains, were analyzed through site surveys, literature data, and unstructured interviews with locals. Lost components were examined using locals' narratives, old cadastral maps, and aerial photos. The whole system was determined by overlapping data and land slope using GIS. Results show that Beypazarı's historic water supply system during the Ottoman period was tailored to the purpose of water usage. Specific stream branches and springs provided drinking water, transported to fountain reservoirs via a closed pipe system for hygiene. All stream branches were distributed to agricultural lands through open runnels using gravity. The abandonment of this system has caused stream beds to exceed their capacity in winter, leading to floods.

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INTRODUCTION

Water has always become the primary need of every civilization throughout history. While many have preferred to settle near the water sources, this brought along requirements such as the distribution, transportation, and use of water or control of the water level. Thus, each civilization has given significance to developing a water supply and a management system to use water efficiently. Even the techniques and materials change according to technological innovations, and all historical systems and structures that have been transferred from the past reflect characteristics of the previous culture. Thus, historical water management systems generate the basis of current systems.

Anatolia, which has hosted many civilizations throughout

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history, makes it possible to investigate the development of water management systems inherited from the various former cultures until today. In Çatalhöyük, one of the oldest settlements in Anatolia, traces of irrigation channels and water wells were found during recent excavations (Baykan and Baykan 2015, 144).

In addition to biological needs, water had sacred significance for civilizations like the Hittites in Anatolia. They established settlements near a water source and sacred pools, called *pınar*, to collect water from these sources. Before entering their gods' presence, they used it for bodily and spiritual purification and created reliefs symbolizing rituals on the pool walls (Murat 2012, 126). While the water was transferred to the pools through underground channels with a triangular cross-section supported by stones, underground earthen pipes can also be dated back to the Hittite period (Uçar 2016, 74).

Urartians have a significant place in the history of Anatolia, especially with the advanced water systems they have established. They settled in the Eastern Anatolian Region of Turkey and ensured the region was called the "Region of Dams" (Kalmış 2017, 570). They also have built cisterns and wells to store and collect water in addition to dams. The collected water was used for various purposes like drinking and irrigation of the lands. Depending on the multifunctional purpose of the dams, Urartians have also built castles near the dams for their protection (Kalmış 2017, 572).

In addition to being the pioneer in the construction of dams, Urartians are also considered to be the founders of the piped irrigation system thanks to their advanced mining industry (Baykan and Baykan 2015, 148; Kalmış 2017, 571). While this system is called *kehriz* in some regions, like the East Anatolian Region of Turkey, it is also known as *kanat* (qanat) in the areas around Iran. The main purpose of this system was to transfer the underground water to the plains from the higher elevation with the principle of gravity. In this system, the well reaching the groundwater level is called the main well. Then, wells are drilled every 25 to 50 meters toward where the water will be transported. These wells are connected horizontally with a slight slope from the elevation where the main well reaches the groundwater level (Figure 1, left; Uçar 2016, 77). The underground water tunnel that connected wells is called *livas* in Anatolia (Figure 1, right; Uçar 2016, 82). While the water may be for public use, there is also the distribution of water to houses or agricultural areas (Uçar 2016, 78). *Kehriz* or qanat system and dams are still used for irrigation of some lands in Anatolia (Kalmış 2017, 571).

During the Hellenistic and Roman Periods, more developed water structures started to be built. While water has been transported between the valleys by aqueducts above the ground, and earthen pipes, have been used underground (Figures 2 and 3). In these systems, the main principle for the transportation of the water was gravity which allowed water to flow from a higher altitude to a lower altitude. On the other hand, a reverse siphon system has been developed to raise it from the lowest point of the valley to the top of the valley. The reverse siphon system was a method that worked as a result of bringing the waterway to the bottom of the valley by stone or lead pipes, continuing horizontally along the bottom of the valley, and bringing it to the top of the valley at the other end. In the operation of this system, two water reservoirs were built at the beginning and end of the valley. As a result of the fact that the reservoir located at the beginning was higher than the reservoir located at the end of the valley, the water flow was provided continuously (Yılmaz 2015, 200). In addition to these advanced water transportation systems, new water structures like baths, fountains, cisterns, and wells were built for public usage, and an advanced sewage system was established during Roman Period (Uçar 2016, 74).

In the Seljuk and Ottoman Periods, water structures like

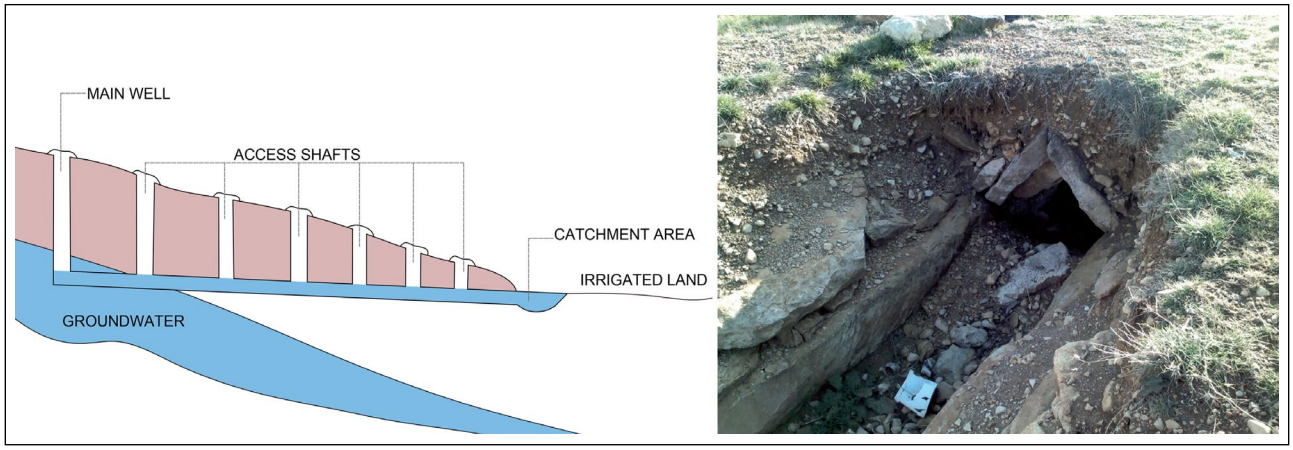

Figure 1. Schema of the qanat system (left, drawn by author after Uçar 2018, 27) and a livas in Gaziantep, Turkey (right, Uçar 2016, 82).

Figure 2. Akvadük Aqueducts in İzmir, Turkey (Eken Güney, 2020).

Figure 4. Ahmet Çelebi Kasteli in Gaziantep, Turkey (Uçar 2016, 91).

fountains, *sebil*, and *şadırvan* came to the forefront in addition to the existing structures of previous civilizations in Anatolia. After the 15th century, fountains started to build new types depending on the rise in population in Anatolia (Tekeli 2011, 227; Uçar 2016, 75). One of these types was based on establishing a fountain in front of the water storage and this storage was connected to a water source (Uçar 2016, 75).

Transportation tradition through earthen pipes continued during the Seljuk and Ottoman Periods. However, using lead pipes was also determined in the Ottoman Period in addition to earthen pipes (Uçar 2016, 75). Additionally, there were rock-cut underground water channel systems in Anatolia like the ones in Kayakapı district in Ürgüp, Cappadocia, kastels, and channels of Gaziantep city (Figure 4; Uçar 2016, 76).

At the beginning of the 16th century, the heyday period of the Ottoman Empire, Mimar Sinan, the most famous architect of the period, designed lots of waterways in Anatolia, especially in Edirne and İstanbul, through unique water structures that connected with established water ways (Diri Akyıldız 2018, 41). In underground systems, stone masonry water channels that collected the water from the various main streams finally joined to the water structures, called *maksem*, used for collecting and distributing water (Figure 5; Diri Akyıldız 2018, 42). In later periods, these structures developed containing separate underground pools, one collecting the water and the other distributing purified water to the city (Diri Akyıldız 2018, 43).

Although a water network has been established generally compatible with the land to advance by gravity, some cases require the transportation of water from a valley to the valley at an equal or higher height. In these cases, an inverted siphon system is operated by air pressure. Additionally, aqueducts were constructed between separated wider

Figure 3. Earthen water supply pipes in Ephesus, Turkey (Eken Güney, 2020).

Figure 5. Taksim Maksemi in İstanbul, Turkey (Source: SALT Research Kayıhan Türköz Archive).

valleys. These stone masonry structures included arches, narrow upward to allow only the transportation of water (Diri Akyıldız 2018, 43).

The fact that the Ottoman settlements were generally located on sloping lands at the foot of the mountain made it convenient for the surface waters to flow throughout the stone-covered streets. Water ditches were formed to control the flow of water, creating a triangular section in the middle of the streets. Although the pavement material of the roads has generally changed, this system can be seen in old photographs of historic settlements (Figure 6). While these surface waters were especially used for cooling, irrigation of the gardens and agricultural fields was provided through runnels located on one or two sides of the streets (Figure 7).

When all water management systems that continued to evolve and were used up to the Ottoman Period are evaluated, accumulated water in rivers, lake, barrages, or water wells were transported through water pipes, closed water channels, aqueducts, open water channels, and the surface of streets covered with stones (Figure 8). In most of these systems, the main principle is gravity as the sloping topography allows. Depending on the purpose of the usage, water was transported to lands or water structures like fountains, basins, pools, baths, etc. In the end, water accumulates again in the underground or sewage system and takes part in the natural hydrological cycle. This water network can be determined in lots of Ottoman Towns like Sa,franbolu, Cumalıkızık, and Beypazarı in Anatolia.

Situated northwest of the capital Ankara in the inner Anatolian region (Figure 9a), Beypazarı is a typical Ottoman town with its naturally sheltered location on the mountainside (Figure 9b), urbanization around the religious buildings and commercial center, and introverted housing structures (Cerasi, 1999, 120; Figure 9c). Even the current settlement was mostly shaped during the 19th and 20th centuries, the history of the Beypazarı settlement dates to 3000 BC through the first occupation of the Luwi

Figure 6. Water ditch that allows surface water to flow in historic streets of Beypazarı (Source: Beypazarı Municipality).

Figure 7. A historic water runnel in Safranbolu (Source: Haberts.com).

community, and the settlement was called "Lagania" in that period [1]. After the Luwi people, the region was respectively dominated by the Hittites, Phrygians, Galatians, Romans, Byzantines, Germiyanoğulları Principality, and Ottoman Empire. Considering developing a water network through various civilizations in Anatolia from the Neolithic Period until the Ottoman Period, such a network should also exist in Beypazarı as well. In addition to riverbeds around the settlement, many fountains, a few bridges, and bathes built between the 18th and 20th centuries also provide a clue about the existence of an improved water network during this period.

Although residents claimed that the water, the source of which was the streams in the vicinity, also flowed along the roads of Beypazarı through open channels and irrigated the agricultural lands in the past, there is no evidence of this information in the physical environment due to infrastructural interventions in the settlement until today. Although these studies have been carried out to prevent the increasing flood disasters in the region in recent years, the region is still exposed to flood disasters despite all the efforts.

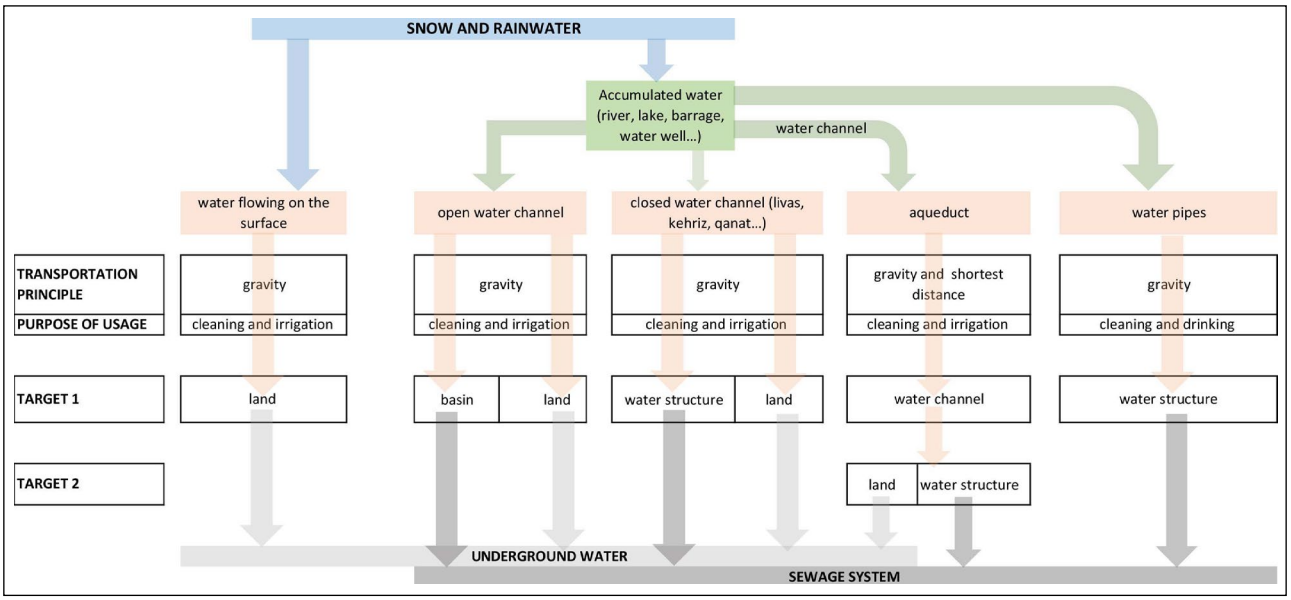

Figure 8. Type of historic water management system in Anatolia including transportation principle (prepared by the authors).

Even though all stream beds around the settlement, which are completely dry in summer, overflow with precipitation in winter and cause floods on the roads of the settlement. Thus, this article proposes to understand the water supply system and water structures in Beypazarı during the Ottoman Period, when the settlement was largely shaped, and the effect of the abandonment of the historic system on the floods. Thus, the article will seek answers to the following questions:

- What were the main sources of water to meet people's needs and the main principles of the water supply system in Beypazarı during the Ottoman Period?
- How did these resources reach people in Beypazarı during Ottoman Period?
- What are the main reasons behind the loss of some components of the historical water system today, and what is their role in flood disasters?

Depending on the aim and research questions, the article begins with the methodology that will be used to decipher the visible and invisible parts of the historic water supply system. Following, visible components of the system, including natural water sources and fountains, as the prominent water structures, were analyzed, focusing on the function, location, and architectural features of the fountains. Then, the study examines the lost components of the system that provided connections between water sources and fountains and the

Figure 9. **(a)** Location of historic Beypazarı town in Turkey (base map data © 2021 Google) **(b)** View of historic Beypazarı town from Hıdırlık Hill (Eken Güney, 2021) **(c)** View of a street of Beypazarı town (Eken Güney, 2021).

purpose of their usage of them. Lastly, the outputs of the study are discussed holistically with both visible and invisible elements of the historical water system and the effects of the reclamation of this system on floods. The study ends with a conclusion part.

METHODOLOGY

The article investigates the historic water supply system and water structures to serve the water to people in Beypazarı during Ottoman Period through a qualitative research method. To achieve this, a site survey was conducted in 2020, but this survey was limited to observations because of COVID-19 pandemic conditions. During the site survey, visible components of the historic water supply system, including natural water sources and water structures like bridges, fountains, and bathes, were mapped on the current cadastral map of Beypazarı. Additionally, their architectural features and physical conditions were analyzed. On the other hand, the book of Ethem Torun (2004), a local historian, was used as the main source to determine the system's invisible components and their relations with the water sources and water structures in the settlement. Additionally, impromptu interviews were conducted with a limited number of existing locals through phone calls in April 2019. Unstructured interviews were made with three people, MÜ (1947), HÇ (1960), and HA (1953). Although they were able to convey the situation of the settlement during the 1970s especially, they conveyed its previous situation through the memories of their ancestors.

Within the light of the gathered data, the aerial photos of Beypazarı from 1944 until today were superposed through GIS (Geographic Information System) to decipher all the streams that feed the water structures from the past to the present. Following, the branches of these streams that reached Beypazarı urban settlement were determined, and the altitudes of these branches and points where the water structures are located have been checked through Google Earth. Then, physical connections between the water sources and fountains in the settlement were determined according to narratives of locals and sources, traces from aerial photos, and the rule of gravity that was determined as the main water transportation principle during the Ottoman Period in Anatolia.

THE VISIBLE HISTORIC WATER COMPONENTS IN BEYPAZARI: MAIN STREAMS AND FOUNTAINS

Beypazarı is surrounded by Işık, Aladağ, and Köroğlu mountains and Teke Hill at the north, and Sündiken Mountains at the south. The area that lies between the northeast-southwest direction is called Beypazarı Plain. Within this large plain, the historic Beypazarı settlement is located at the foot of the northern mountains. Depending on tectonic movements in the north, limestone hills that detached from the movements created a mountainous region up to the historic settlement. Even though the altitude gradually decreases within the historic settlement from north to south, limestone hills like Hıdırlık, Karcıkaya, and Salihler, located in the city center, cause a sudden change in altitude (Figure 9b).

In addition to the north being covered with forests, the mountains in the north are also the source of many streams in Beypazarı and its surrounding area (Figure 10). Among them, the Koca River creates a natural border with Nallıhan at the west and feeds Sarıyer Barrage at the south. Lots of branches of the Koca River and other streams flow throughout the settlements and converge with the Kirmir River in the south. Additionally, some streams feed Çamlıdere Barrage, located northeast of Beypazarı.

Tributaries between these main streams starting from the north and pouring into the Kirmir River in the south form the main water resources of the Beypazarı settlement. Among these tributaries, İnözü Stream, which merges with Sabagoz, and Mundarcı Stream, which is a branch of Ilıman reaches the Beypazarı urban site (Figure 10, no. 1-6).

Depending on the existence of stream beds within the historic site, water structures like bridges and fountains stand out in number. Even though locals state that there were more than ten bridges in the past, at present, only two of them are still standing in their location. While one of them is located above Mundarcı Stream, the other, Hacılar Bridge, is located above İnözü Stream (Figure 11, no.18 and 19). Hacılar Bridge is the most historical stone bridge, and it is dated to the 17th century. According to narratives of locals and official records, there were also 29-grain mills throughout İnözü Stream in the past (Ankara Enstitüsü Vakfı 1995, 112). However, remaining of only one of them can be observed at present.

Fountains are significant structures that represent the direction of development in Ottoman towns. Especially during the 18th century, fountain construction in many Anatolian cities accelerated to attract immigrants in

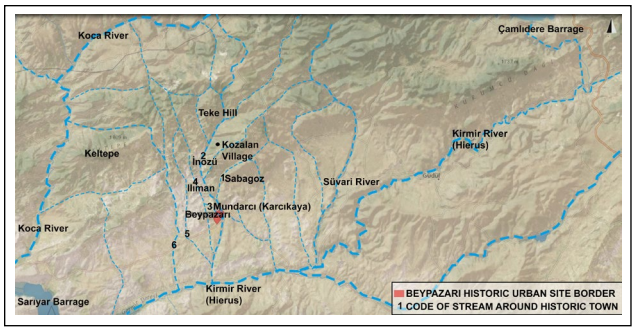

Figure 10. Main streams, their branches, and location of Beypazarı historic urban site on a macro scale (base map data © 2020 Google).

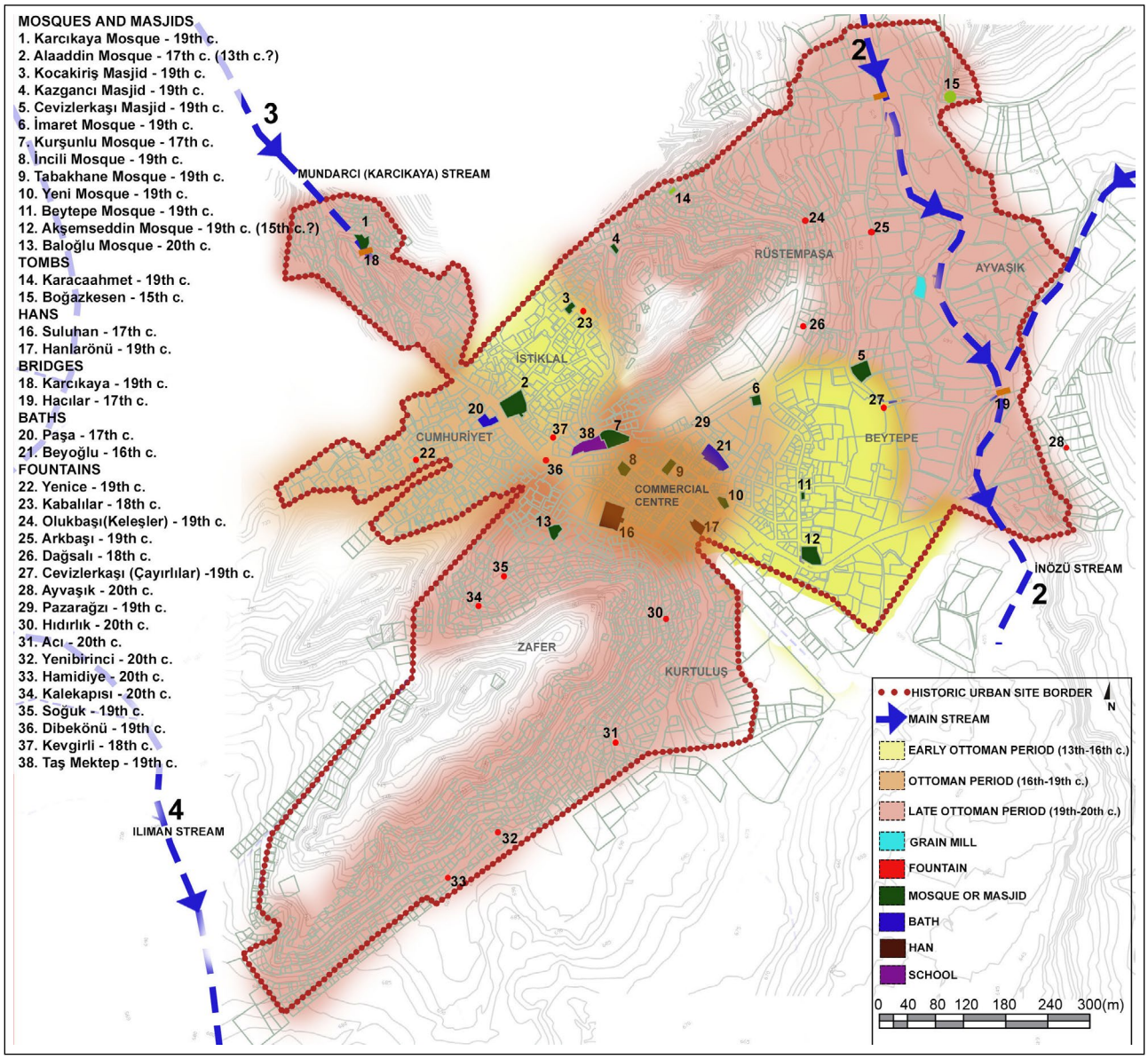

Figure 11. Historic development of Beypazarı in the Ottoman Period including current neighbourhood borders and monumental buildings with their construction period (on the cadastral map obtained from the Beypazarı Municipality).

addition to the supply demands of the existing locals (Cerasi 1999, 191). Within Beypazarı Urban Site, although some fountains are in bad condition at present, 15 fountains are still standing in their location (Bozkurt 2004, 193-234). While most of them were built in the 19th and 20th centuries, only three of them date back to the 18th century [4]. Thus, the location of these fountains, Kabalılar, Dağsalı, and Kevgirli, is an indication that the first residential settlements in the Ottoman period were formed around the commercial center (Figure 11).

In terms of the construction technique of fountains, apart from three fountains, all of them have been constructed as stone masonry rectangular reservoirs (Figures 12 and 13). The main construction material is rubble stone, and lime mortar was used as binding material. Earthen pipes that provide water supply are still observed within the walls of some reservoirs at present. Additionally, a wall of each reservoir has sight windows to control the level of water (Figure 14). However, these windows are closed with metal sheets in some fountains at present (Bozkurt 2004, 224). Although the exterior facades are not plastered, the inner facades of the reservoirs have been covered with Horasan plaster (Bozkurt 2004, 195). Even though the tops of reservoirs are seen as cement-based flat roofs today, they were originally covered with a barrel vault inside (Figure 13).

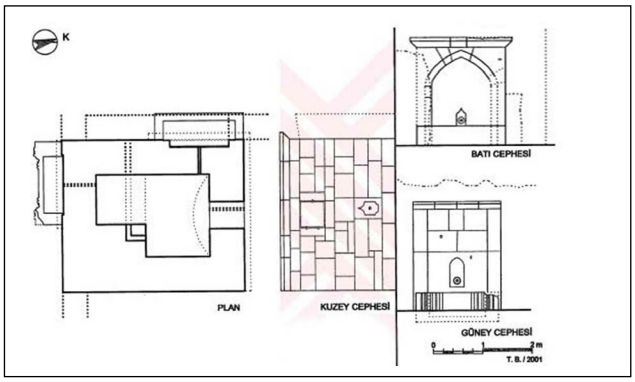

Figure 12. Plan and facades of Dağsalı Fountain (Bozkurt 2002, 357).

Depending on the location of the fountains, they can have more than one street facade to serve each street. Street facades differ from the reservoir by using cut stone (Table 1). The main hole where water is served is located on *ayna taşı*, which has been nearly placed in the middle of the facade. *Ayna taşı* can differ from other stones through ornamentations created as reliefs (Figure 15). Apart from the hole on this stone, there is also a *taşkan hole* on the upper level and a *tahliye* hole at the bottom level. While the *taşkan hole* prevents the water level from rising after a point, the *tahliye* hole provides the discharge of stored water for a long time (Bozkurt 2004, 193). All fountains have stone basins along the street facades. However, most of them are lost at present due to the elevation of the street level (Bozkurt 2004, 203).

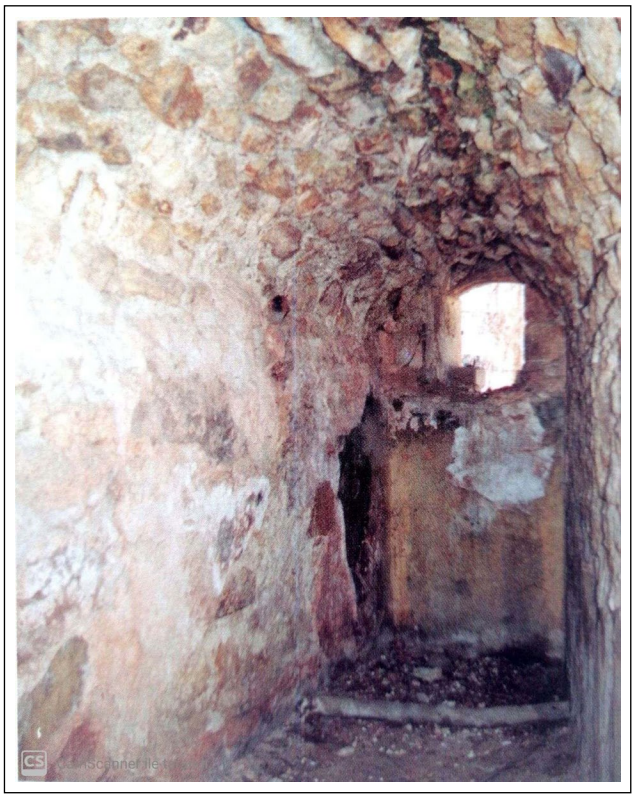

Figure 13. Reservoir of Cevizlerkaşı Fountain (Bozkurt 2004, 200).

Figure 14. Pazarağzı Fountain and Its Sight Window (Eken Güney, 2021).

Even though all fountains have lost their function today, large reservoirs behind the street facade and the earthen pipes embedded in the walls of reservoirs indicate that water came to these fountains from a source for a while. However, in the current situation, it is impossible to determine the water source for each fountain through observation.

While Torun claims that drinking water was transferred from Sabagoz Branch to all fountains located north of the main axis, all interviewees emphasize that drinking water was provided from Kozalan Village in the north of Beypazarı between 1950 and 1970 (Figure 16).

Transported drinking water from Kozalan was stored in two cisterns (more modest water collection and distribution structures than *maksem*) located in the Tepedelen region,

Figure 15. Ayna Taşı of Kevgirli Fountain (Eken Güney, 2021).

Table 1. Main characteristics of fountains within the historic urban site (location of the fountains can be seen in figure 11 through fountain numbers; Bozkurt 2004, 246; images are copyright of the authors)

No	Fountain Name	Construction Period	Location	Existence of reservoir	Number of façades	Current situation
22	Yenice	19th century	Cornet lot	+	2	
23	Kabalılar	18th century	Separated lot	+	1	
24	Olukbaşı (Keleşler)	19th century	Embedded in the garden wall	-	1	
25	Arkbaşı	19th century	Embedded in the garden wall	+	1	
26	Dağsalı	18th century	Separated lot	+	3	Could not be observed
27	Cevizlerkaşı (Çayırlılar)	19th century	Embedded in the garden wall	+	1	
28	Ayvaşık	20th century	Separated lot	+	1	
29	Pazarağzı	19th century	Corner lot	+	1	
30	Hıdırlık	20th century	Separated lot	+	1	Could not be observed
31	Acı	20th century	Corner lot	+	1	
32	Yenibirinci	20th century	Separated lot	+	1	Could not be observed
33	Hamidiye	20th	Separated lot	+	2	Could not be observed
34	Kalekapısı	20th (1916)	Corner lot	+	1	
35	Soğuk	19th century	Separated lot	+	1	
36	Dibekönü	19th century	Corner lot	-	1	
37	Kevgirli	18th century	Corner lot	-	1	

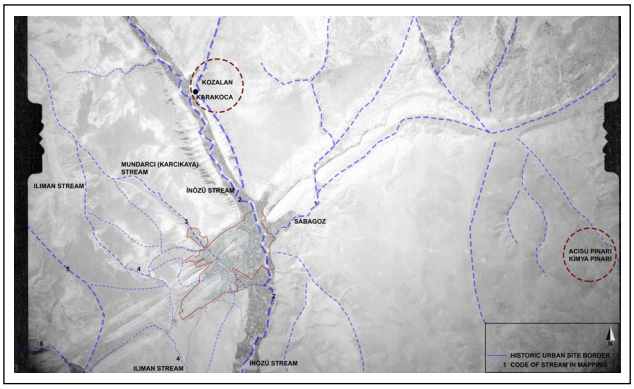

Figure 16. 1944 dated aerial photo of Beypazarı with the border of the historic urban site, main streams around, and significant water sources (1944 dated base map data © Archive of General Directorate of Maps).

within the border of Rüstempaşa Neighbourhood (Figure 11; MÜ, 15/04/2019). Then, it was transferred to fountains through earthen pipes with a diameter of 0.10 meters (Bozkurt 2004, 199). Then, residents of the settlement carried their drinking water from the fountains to their homes with copper jugs (Torun 2004, 436).

Karakoca District within Kozalan Village was also a significant mineral water source for the whole country (Figure 16). As HÇ stated (15/04/2019): *"Karakoca Water was also a branch of İnözü. Picnics were held around this water source and the children were bathed. When mixed with sugar and lemon salt, it would be 'soda'."* This mineral water is still distributed to the whole country by the factory that was established in the Karakoca district in 1957.

In addition to the natural water source in Kozalan Village, Kimya Spring was also a significant drinking water source for wealthy families in the settlement (Torun 2004, 436). This spring was located nearly 3 km east of the settlement around the Derbentçik and Acı locations (Figure 16). HÇ noted (15/04/2019): "*Our drinking water was Kimya Spring. We used to carry it with our knuckles. An uncle used to bring them in copper jars. The prominent people of Beypazarı drank from that water. It was bought with money*." At present, some families still use this source as drinking water, according to narratives of locals.

After the 1970s, depending on the increase in population and the number of houses, water that was transported from Kozalan became inadequate to meet all needs. Thus, after the 1980s, caisson wells were drilled around İnözü Valley, and new cisterns were constructed around the neighborhoods (Torun 2004, 222). Additionally, water from the Uşakgöl Region, located north of Kozalan, was also transferred to the settlement. The water carried by the underground pipe system from all these sources around the settlement is served to the houses with the modern pipe system after being treated in the treatment plants at present.

Although the historical earthen pipe systems embedded in the fountain walls still exist today, the water flow in these systems has stopped. Accordingly, the fountains are no longer used, and their structural integrity is being damaged day by day. Since 1984 all residences have been connected to the city water network (Torun 2004, 222).

THE LOST HISTORIC WATER COMPONENTS IN BEYPAZARI: WATER RUNNELS

Since agriculture was the main source of livelihood in the historical settlement of Beypazarı, as in many Ottoman settlements, the fact that agricultural lands could be irrigated with natural water sources had been one the main factors in the formation of the settlement. Tributaries between Koca and Kirmir Rivers were used as the main water source for irrigation of the lands throughout the history of the settlement.

According to the land use analysis prepared within the scope of the Conservation Aimed Development Plan in 2014, residential courtyards of houses cover the majority part of the traditional urban pattern (Beypazarı Municipality 2014, 43). Historic houses are located within large courtyards and gardens. Although the streets are covered with cobblestone, old photographs of the settlement show that the streets were covered with slate stone and included a water ditch that allowed surface water to follow.

In addition to residential courtyards and gardens, large gardens and vineyards without residences were generally located around the İnözü River. This positioning suggests that the gardens were irrigated directly from the river through gravity. However, the level of the stream bed is lower than the level of the gardens. Although an inverted siphon system was the common solution in that case since Roman Period, locals state that irrigation of gardens was provided thanks to runnels that transported water from the north side of the settlement to the streets during the 20th century. As MÜ stated (15/04/2019):

"Water weirs were kept on both sides of the İnözü Stream at the north of the settlement. Those weirs formed runnel groups. These runnel groups were divided into two and three, and they were poured into the İnözü Stream by stopping by the orchards. In the past, there were watermen, and those watermen used to give water to vineyards and gardens in turns."

Although these runnels are lost at present, they were open-top channels that received their sources from surface water depending on the presence of nearby streams. The flow of water was controlled by large stone blocks on both sides, and water was allowed to pass through any garden by opening the metal cover between the garden and the runnel. Additionally, this system would pass directly through private gardens to reach another street.

Depending on aerial photos, topographical characteristics, and narratives of locals, the runnel system that was fed by the İnözü Stream started from two points at the north of the settlement with an altitude of nearly 750 meters according to the hypothetical map prepared to illustrate the existing and possible streams, runnel beds and their altitudes (Figure 17). One of them proceeded to the south towards the commercial center, and it was divided into two branches. Then, they joined another wide runnel, which originated from the Mundarcı Stream, on the main axis within the settlement. Likewise, the other would proceed to the east, giving water to the street called Arkbaşı Street, move around the limestone hill called *Dinazor Sırtı* by locals, and merge with İnözü Stream at an altitude of nearly 650 meters [5].

Additionally, this runnel was divided into branches towards the east to provide water to gardens, and these runnel branches reached İnözü at an altitude of around 670 meters. Fountains like Keleşler, Arkbaşı, Pazarağzı, Cevizlerkaşı, and Kabalılar were located on branches of these two runnels (Figure 18, no. 23-24-25-27-29), and all of them had stone basins even though some of them are lost at present (Bozkurt 2004, 193-234).

Current locals emphasize that these basins were also used for washing clothes by the people who do not have a fountain in their residences. As MÜ noted (15/04/2019): "*Women used to go to the edge of İnözü Stream on Sundays to do laundry. Or there would be large areas made of stone in front of the neighborhood fountains. Laundry was also done there.*"

Mundarcı Stream reached the urban site at the northwest point and arrived at the main axis of the settlement flowing throughout Karcıkaya Neighbourhood and merging with a branch of Ilıman Stream at the west (Figure 17, stream no. 3). A wide runnel continues along the main axis where the historic commercial center is located, and water was finally poured into İnözü Stream at the eastern end. Although the main benefit of this wide runnel was transferring water from Mundarcı Stream to agricultural lands at the southeast

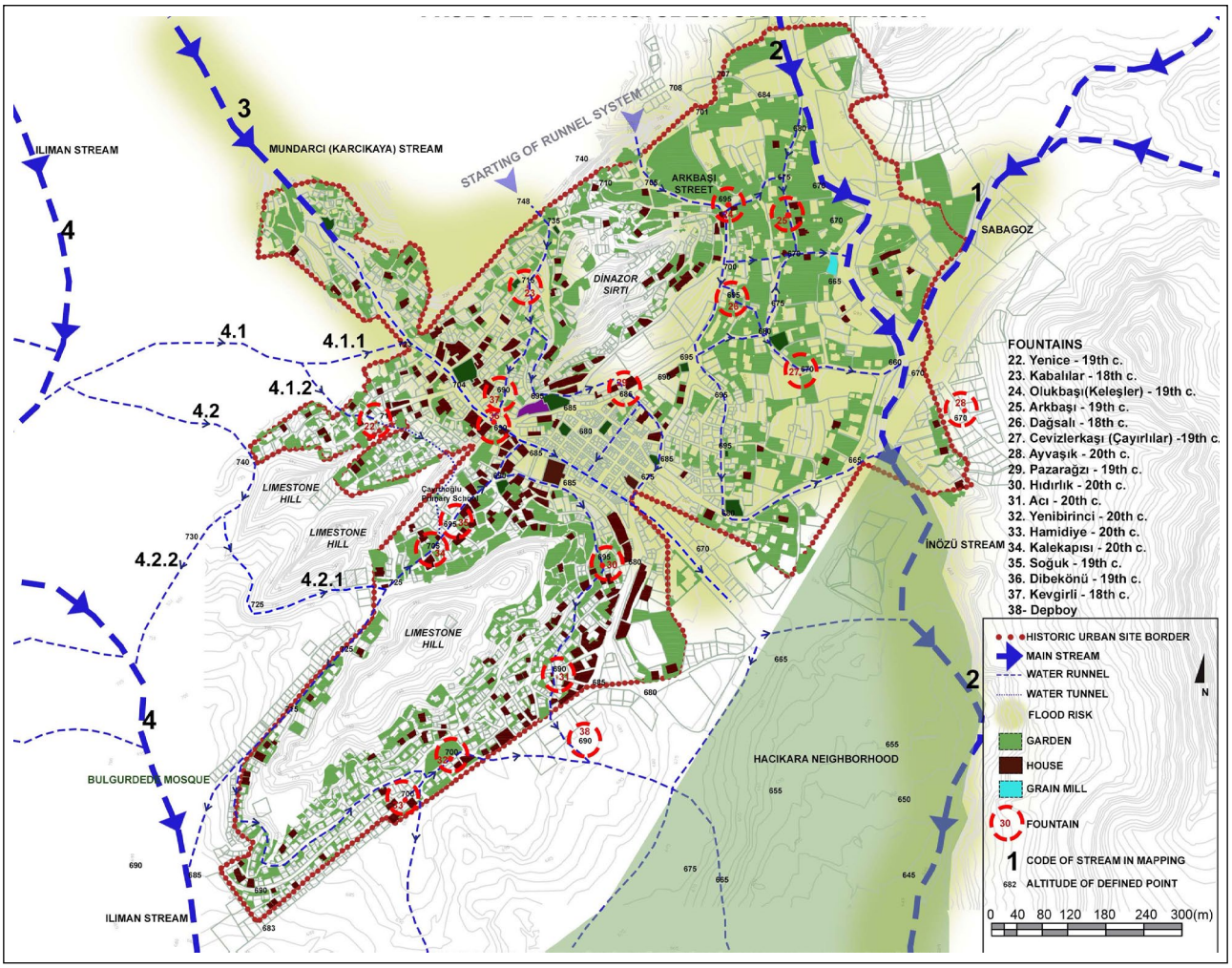

Figure 17. Map of the historic urban site with main streams, runnel system, and fountains (prepared by the authors on the cadastral map obtained from the Beypazarı Municipality).

of the settlement, it also provided coolness during summers for people in the commercial center. MÜ (15/04/2019) emphasized: "*One of those runnels flowed from the bazaar (the commercial center). To cool off, shopkeepers would sprinkle water in front of the shops with a stove shovel.*" Even though Dibekönü Fountain was located on this runnel, including a basin, it was used for cooling purposes only instead of washing clothes due to its positioning in the commercial zone.

Although Ilıman Stream flowed in the northwest-southeast direction outside of the historic urban site, this stream provided water to Hamidiye, Depboy, Soğuksu, Kalekapısı, and Hıdırlık Fountains (Figure 17, fountains no. 30, 33, 34, 35 and 38; Torun 2004, 219). Additionally, depending on the existence of gardens around limestone hills and stream bed traces observed in the aerial photo of 1944, there should be also a runnel system that transported water from Ilıman Stream (Figures 17, stream no:4). According to the narrative of Torun (2004, 219), Ilıman Stream was divided into two branches at the west of the settlement (Figure 17, branches no. 4.1 and 4.2).

One of these branches proceeded towards the main axis and was divided into two branches. While one of them merged with the wide runnel in the main axis, the other arrived at Yenice Fountain (Figure 17, fountain no.22 and branch no. 4.1.2). Then, the water transferred to the street where Kalekapısı and Soğuk Fountains located, through a water tunnel between two limestone hills (Figure 17). This branch continued to flow in the direction of the southeast from an altitude of 700 m and combined with the second branch of Ilıman Stream after providing water to Hıdırlık and Acı Fountains [6] (Figure 17, fountains no. 30 and 31).

The second branch of Ilıman Street was also divided into two branches. While one of them merged with Ilıman Street directly, the other transferred water to Kalekapısı and Soğuk Fountains (Figure 17, fountains no. 34 and 35). This branch also arrived at Yenibirinci and Hamidiye Fountains at the southwest point of the settlement flowing around the limestone hill (Figure 17, fountains no. 32 and 33). All branches of Mundarcı and Ilıman Streams arrived at Hacıkara Neighbourhood and joined with İnözü Stream after transporting water to agricultural lands and basins of fountains (Figure 17).

In addition to runnels that transport water from streams to the gardens, some houses located far from runnels had wells in their gardens. While winding wheels were being used for water extraction, then water pumps replaced these wheels (Torun 2004, 436). According to Torun (2004, 436), water in the wells was not used as drinking water [7]. However, MÜ (15/04/2019) stated that about fifty percent of the houses had their wells in the vineyard orchard houses along the İnözü Valley, and this water was drinkable.

Even though this system, organized for basic needs and irrigation of agricultural lands, was used for a long time in the settlement, it has become insufficient as water resources start to dry up with the effect of climate change. Additionally, water damns constructed between 1951 and 1985, Sarıyer at the southwest and Çamlıdere at the northeast of Beypazarı, may have caused the stream branches reaching the settlements around to dry up by diverting the stream beds in the north. Thus, especially during summer months, locals have started to irrigate their gardens and lands from the public water main and the wells they drilled. This situation led to the uncontrolled use of city water and groundwater. On the other hand, the runnels that lost their function were closed by the municipality, and the roads originally covered with slate stone were covered with cement-based stones.

In addition to the drought in the summer months, another negative effect of climate change on Beypazarı is the floods that occur because the precipitation in the winter months is above the seasonal normal. Although, while the structuring was in the center of the settlement during Ottoman Period, further away from the rivers, in time the structuring progressed towards the rivers and today continues in all directions, crossing the rivers. Heavy rains in winter cause the streams to overflow and the waters, which cannot find a place to flow due to rapid urbanization and closed runnels, fill the inside of the houses. As a solution to these disasters, which are frequently experienced, remediation works towards riverbeds have been ongoing since 2011 by the municipality. Although the stream improvements provide a temporary solution for floods, on the other hand, it eliminates the opportunity to benefit from natural water resources. Additionally, they have caused the waterway networks, which were a part of the historical water system, to be completely lost today.

DISCUSSION ON OUTPUTS OF THE STUDY AND CONCLUSION

Natural water sources have always been the most significant factor for people to settle in a region throughout history. Each civilization has developed water systems inherited from previous civilizations to use natural water resources efficiently.

This study focused on the investigation of the historic water supply system and distribution of water through water structures in Beypazarı, a historic town in Anatolia that was mostly shaped during the Ottoman Period. One of the main motivations for choosing Beypazarı as a case for this study is that the settlement reflects the traces of an improved water supply system by hosting various civilizations throughout history. The existence of agricultural production tradition, lots of water sources around, and many fountains in the settlement are the visible physical traces of this system. On the other hand, physical connections between the water

sources, gardens, and fountains are lost at present due to infrastructural interventions in the settlement until today.

The water supply system in Beypazarı during the Ottoman period was based on the distribution of river waters to the whole area with the gravity principle. However, in addition to the water source, distribution type also changes according to the purpose of the usage of water.

Supply of Drinking Water from The Fountains

Results of the study show that the spring water source in Kozalan Village at the north of the settlement was the main drinking water source until the 1970s. Water was transported through a pipe system and firstly stored in cisterns within the settlement, and then, it was delivered to the storage of fountains through earthen pipes that were embedded in the walls. In order not to pollute the water, the fountains that reach the water carried by a completely closed system were built, reconsidering the circulation of water. While the stored water is made available to people through the hole in the middle of the special stone called *ayna taşı* on the street façade of the fountain, the excess water in the tank is discharged through another hole at a higher level.

Water wells were also the drinking water source for the residents who settled close to İnözü Stream. Additionally, the springs around the settlement, like Kimya Spring, have also been a special source of drinking water that was generally used by wealthy families.

Supply of Water for Cleaning and Irrigation of The Lands Through Runnel Groups

On the other hand, tributaries around the settlement, like İnözü, Mundarcı, Ilıman, and Sabagoz, were the main water sources for the settlement for the cleaning activities and irrigation of the lands. There was a network of runnel that were constructed as open channels and carried water to all the gardens and fountains. While Mundarcı Stream flowed through a wide runnel along the main axis, runnels that were separated from İnözü and Ilıman Streams would transport water to the courtyards in the north and south of the main axis. Then, all of them were combined with İnözü Stream in Hacıkara Neighbourhood at the southeast of the settlement. In this system, gravity is the main water transportation principle in Beypazarı, like in lots of Ottoman towns. For the gardens of the houses far from the runnels, the main source is the wells.

While many fountains were located on the runnel network, water that was transported through the runnels was not stored in the reservoir of the fountains because of hygiene problems. It was used only for washing the clothes within the basins of these fountains. Thus, it can be said that the locations of the fountains were determined consciously to accumulate water in the basin.

Significance of The Historical Water Supply System Through Water Structures in Beypazarı and Its Current Condition

Although Beypazarı is dated to the Ottoman period with its monumental and civil architectural structures existing today and there is no structure dating from the previous periods, it is possible to see the traces of pre-Ottoman civilizations in Beypazarı through water distribution principles in the historical water system. Using wells for drinking water, seen even in Neolithic settlements, or distribution of the water to reservoirs or fountains through earthen pipes seen in lots of Roman settlements are the reflections of the regular development in the water supply system in Beypazarı. However, this ever-evolving system, which took its most developed form in the Ottoman period, lost its function at present with the decrease of water resources and infrastructural interventions over time.

In addition to the effects of global warming, the rivers have dried up by constructing dams close to the settlement and changing the flow direction of the river branches. Due to the drying of the rivers, infrastructural works such as the closing of runnels and changes of street coverings were carried out in the settlement. Unfortunately, these works caused the existing stream beds to increase their capacity after the rains and flooding in the region, especially in the winter months. With the effect of rapid urbanization across the riverbeds, citizens who live around stream beds or have a garden are adversely affected by this situation.

Even though this study is limited to understanding the historic water supply system in Beypazarı during the Ottoman Period, it can be an example to decipher the historic water supply system in the other settlements. By deciphering the historical waterways, which are invisible today, this study gives an idea about the regions in Beypazarı where there is a flood risk at present.

Notes

1. The meaning of "Lagania" is "rock peak country" in the Luwian language (Torun 2004, 16).
2. According to notes of Evliya Çelebi, there were twenty neighborhoods during the 17th century. There was Kebir Pasha Mosque in the commercial center. There were 3060 two-storied houses with mudbrick walls and exterior walls covered with wood. Madrasa, Darülhadis, Darülkurra, 70 schools, seven khans, baths, 600 shops. A khan was burned in the commercial center. A bazaar was established once a week by the stream in the bazaar. This stream flowed into Sakarya below the city (Torun 2004, 57-58).
3. The construction dates of the monumental structures range from the 15th to the 20th centuries. However, Şener (1997, 29) emphasizes that Alaaddin Mosque, dated to the 17th century, was first constructed during

the 13th century within a timber post and lintel system. Thus, this oldest mosque can be considered the Friday Mosque located in the commercial center according to Ottoman settlement tradition (Cerasi 1999, 103).

4. Some fountains have stone on the street façade that shows the construction date of the fountain. However, construction periods of the fountains that do not have inscription panels were assumed according to closed monumental buildings whose construction date is known and have similar construction techniques (Bozkurt 2004, 193-234).
5. "*Arkbaşı*" means "the beginning of runnel" in English. The name of the street also confirms that there was a runnel in the past. On the other hand, "*dinozor sırtı*" means "dinasour ridge". Limestone hills protruding from the settlement are likened to this by locals.
6. Torun states that the entrance of this tunnel is located behind Çayırlıoğlu Primary School at present, and it is dated to the Roman Period. However, there is no scientific data related existence of a tunnel yet (Torun 2004, 219).
7. Wells were also used to cool foods and beverages. These foods and beverages were dropped into the well with buckets or jugs, and after a while, it was pulled up again (Torun 2004, 436).

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