Ancient Service Systems in Historic Houses and Their Contribution to Sustainable Urban Development: The Case of Architect Sinan's House

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Abstract

The service systems of historic buildings, namely, heating, ventilation, cooling, lighting, and drainage play a critical role in the life cycle of buildings and sustainable urban development to preserve traditional knowledge systems. Therefore, a detailed investigation is required before, during, and after any preservation activity to ensure the historic integrity. Hence, this research aims to identify, investigate, and research the original service systems of a historic building, namely, the Architect Sinan's house in Ağırnas, Türkiye, to reveal and sustain these original passive survivability details to future generations and to learn from these details in present constructions. Main methods were site analysis, literature, archival research, and oral interviews. The findings showed that the case study building preserved most of its service systems, especially the lighting, ventilation, and heating details, but with minor or major destruction and deterioration. In conclusion, the study addressed a critical conservation problem in historic buildings, focusing particularly on original service systems of a case study building, and if not clearly identified, these details and traditional knowledge systems are prone to be lost.

Keywords: *Traditional Knowledge, Service Systems, Sustainability, Sinan's House, Ağırnas, Urban Development, Turkey, Türkiye*

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Received 3/23/23 – Revised 4/30/25 – Accepted 5/12/25

Introduction

Historic buildings are important architectural entities for the context of the cities in which they are located, but are also responsible for the transfer of knowledge about historic building systems and architectural construction details. Among them, building service systems, including heating, ventilation, cooling, lighting, roof drainage, and waste and clean water systems, are of great importance to make them functional, comfortable, efficient, and safe. Ancient building service systems, their application methods, materials, techniques, details, and working practices are considered part of traditional knowledge systems (TKS), a new term introduced by the International Centre for the Study of Conservation and Restoration of Cultural Property (ICCROM) for the preservation and management of cultural heritage (ICCROM, 2020). TKS were internationally recognized in the Convention on Biological Diversity in 1992 (United Nations-UN, 1992) and were first mentioned in the operational guidelines of the UNESCO World Heritage Committee in 2005 (UNESCO, 2021). Since then, they have become an important part of the management of World Heritage sites. TKS are proven, dynamic processes that represent traditional information, skills, knowledge, innovations, practices, and technologies that can provide and complement scientific solutions for contemporary life (ICCROM, 2020; United Nations-UN, 1992).

Similarly, ancient building service systems are indigenous traditional construction techniques that ensure the longevity of historic buildings. This research discusses the implementation of these systems in a historic house case in Agırnas, Kayseri. The context of the study is therefore to demonstrate the relationship between sustainable urban development and service systems in historic house buildings using a case study approach. The aim is to demonstrate the contribution of ancient service systems to sustainable urban development, to reveal natural construction solutions and passive survival means of the period, and to ensure their proper documentation and protection. In this way, it will be possible to pass this knowledge on to future generations and contribute to its preservation, as there is a direct link between sustainable urban development, built heritage and historical preservation (Al-Alawi et. al., 2022; Yawer et. al., 2023). Teklemariam (2024) and Zerrudo (2008) summarize this link as "awareness, appreciation, protection and utilization" and suggest that heritage preservation is an asset for urban revitalization that brings social and economic benefits, including the preservation of service systems. HaghighatBin et. al. (2024) further argue that the preservation of historical urban sites also contributes to the sustainability of collective memory, such that "the preservation of physical elements are the anchors of historical identity." Nursanty and Susilowati (2023) use the example of the village of Cirebon in Indonesia to show the importance of preserving a sense of place, which in turn supports the local environment and the development of a sustainable identity. In the same way, Karimi et. al. (2022) state that historic buildings have inherently sustainable properties. They keep collective memories alive and strengthen collective solidarity to achieve social, economic, and environmental sustainability. As Cudicio and Gardella (2024) stated, it should also be kept in mind that built urban heritage has both tangible and intangible values and that its preservation must protect both aspects for a sustainable future and collective identity. At the local level, heritage preservation can promote social and cultural sustainability by supporting cultural continuity and preserving the various traditional knowledge systems (Avrami, 2016). Similarly, the old service systems of historical buildings are part of the historical identity and cultural knowledge of the period in which they were built, so it is important to document and preserve them.

In Türkiye, there are few studies on historic building service systems, and the existing ones generally focus on monumental buildings such as historic hospitals /dar al-shifa, baths/ hammams, and historic houses in a limited number of cases (Ankaralıgil and Disli, 2021; Bilsel et al., 2002; Disli, 2018; Disli, 2014; Disli and Çelik, 2016; Disli and Özcan, 2016; Disli et al., 2019; Özcan and Disli, 2014; Disli and Atan, 2023; Disli and Ankaralıgil, 2023; Disli et. al., 2023; Çalıskan and Disli, 2022; Disli and Mankır, 2021). However, according to the official statistical data of the Ministry of Culture and Tourism of the Turkish Republic, among the total immovable cultural heritage in Türkiye (total number 127,287, as of the end of 2024), civic architecture (total number 78,167, as of the end of 2024), which mostly consists of historic houses, outweighs the other types of historic buildings (Turkish Republic Ministry of Culture and Tourism, 2025). Therefore, it is important to first introduce and make known the building service systems, which are mostly tiny architectural details and elements hidden in the walls, under the floors, or above the roofs of historic houses, and then raise awareness of the need to protect these details in any interventions. In addition, awareness of these systems can inspire contemporary constructions to develop passive solutions for heating, cooling, ventilation, and drainage and even sustainable healthy environments with their enlarged use in construction sector.

In this study, the fifteenth-century house of the Great Sinan, the Ottoman-era architect (1479-1588), the most famous of all Ottoman architects, in Agırnas in the Koramaz Valley was chosen as a case study. This is because many traditional indigenous techniques of the building, especially the service systems/passive means of survival, architectural construction details, and character-defining features have survived and can still be seen today. The building can be visited upon request, making it easy to examine as part of field studies. It is also associated with the ancient underground rock-cut city in the region. Although there are few studies on the traditional houses of Agırnas (Atak, 2009; Atak and Çagdas, 2015), the settlement has been evaluated in terms of its sustainability and traditional structure (Özbudak and Önal, 2019). The region has been intensely identified with the concept of Sinan's home and most research on the area has focused on this topic (Bilsel et al., 2002). Unlike the existing literature, this study discussed the architect Sinan's house in terms of all its ancient service/functional/utility systems, including heating, cooling, cleaning and sewage systems, lighting, ventilation, storage, and roof drainage, and examined their relationships. In this way, the study will provide a new perspective for understanding ancient service systems and offer guidance for contemporary architecture. Moreover, the study contributed to understanding the original service systems in Agırnas traditional residential area through a well-preserved case study. The study only covers the building currently used as a memorial museum on plots No. 806 and plot No. 3, but not the other interconnected buildings on the adjacent plots. The survey was based on field visits conducted five times in November and December 2020, January and May 2021, and in 2011. Oral interviews with Agırnas residents, archival research at the Conservation Board and university archives, and literature survey on traditional Agırnas houses and the case study building were the other methods used during the study. In this study, firstly, the historic service systems and the traditional architectural construction details/elements/solutions serving for heating, cooling, ventilation, lighting, waste and clean water systems, and roof drainage were examined in detail for their original location, material, and technology in both the stone masonry section (SMS) and the ancient rock-cut section (RCS) of the house. They were then divided into natural and direct supply systems, followed by an assessment of the reliability level of the information sources, especially those that could not be currently observed in situ.

The House of the Architect Sinan and Historical Context of the Agırnas Region

The building is located in the Agırnas district, on Oztas Street, on plot no. 806 and plot no. 3, in Melikgazi, Kayseri (Figure 1, Figure 2). The Kayseri Monument Protection Authority for the Protection of Cultural and Natural Assets registered the building as a cultural asset on September 17, 1996 (Kayseri Governorship, 2009). Draft drawings of the building were prepared in 2001 under the supervision of Kayseri, Erciyes University and the architect Nüvit Bayar completed the comprehensive projects including the measured drawings, restitution, and restoration projects in 2004 (Archives of Nüvit Bayar, 2004). The restoration was completed in 2008 and opened as a Memory House Museum. During this restoration work, some underground parts of the house were cleaned, remodelled, and opened for visits. The house, designed by the Architect Sinan, had an 'L'-shaped floor plan and was originally single-story. However, over time, it became a three-story building at the front, with more floors gradually added. Today, only the rear part of the building is one-story, and the original part is only on the first floor. The second floor was added in 1934 and the third floor in 1961 (Yaslıca and Çalısır , 2002). Since it was built over the rock-cut cave of the ancient underground city, the extension of the Koramaz Valley, it consists of two parts: a stone masonry building in the upper part and a former rock-cut cave below this unit. According to the survey of locals, the rock-cut part of the house is said to extend to the main church square of Agırnas district, which is 400-500 m long, and used as a gate and underground passage for escape during times of conflict (Yaslıca and Çalısır, 2002).

Figure 1. Location of the site of the house (shown in red color) of the Great Sinan, the architect, in Agırnas, Kayseri (Source: Kayseri Metropolitan Municipality Geographical Information System, 2025).

The last restoration works of the house, carried out in 2006-2008, also support this argument. It is believed that the part carved into the rock under the Great Sinan's House is transverse to the other houses in the area, forming an intricate underground city under the Agırnas region (Yamaç and Tok, 2015). In time, however, the owners of the houses closed the gates and connecting tunnels to prevent underground access to their homes (Anonymous, 2017). At present, the carved part under the house consists of four different sections, but it is believed that they were originally a single room, and given the round stone doors between these sections, it is also believed that the carved part could have been used for defensive purposes at least at one time (Anonymous, 2017). The original part of the stone masonry has thick walls of cut volcanic stone and a 0,25-0,30m thick ceiling supported by wooden posts and beams from juniper trees. The rear part of this section has an earthen roof with a 0,50-0,60m thick earthen floor, and the remaining parts have flat roofs.

Figure 2. General photos of the house of the Great Sinan. (Source: Photos by authors).

Agırnas, where the case study building is located, is in the province of Kayseri in Central Anatolia. The Koramaz Valley, which dates back to 2000 BC, has been included in the UNESCO Tentative List of World Heritage for 2020 due to its outstanding underground cities among residential areas, cave churches, dovecotes, and columbaria (UNESCO, 2022). The Koramaz valley is 16km long and extends from Küçük Bürüngüz up to Ispidin. It is the longest valley in Kayseri and even in the whole Cappadocia region. The valley includes seven villages with cliff dwellings, rock-carved structures, and underground cities (Yamaç, 2017). Agırnas means 'The Land of Altars' in the Luwi language of the Hittites and 'Serious Man' in the Arabic language (ÇEKÜL, 2015). The stratified settlement has traces of cultural heritage (i.e., underground cities, dwellings carved into rocks, and rock tombs) from various periods, including the Hittite, Cappadocian, Byzantine, Seljuk, and Ottoman civilizations, and has an interwoven formation of primitive cave settlements and traditional houses, most of which date to the second half of the nineteenth century (Bilsel et al., 2002). Historically, Agırnas was a region where both Muslim and non-Muslim communities lived together, so much so that, according to an archival register from 1500 AD, almost 95% of the inhabitants in Agırnas were non-Muslims (Koç, 2012). Agırnas and its surroundings are covered with red and white volcanic tufa, which have a rather soft texture and are therefore suitable for carving. As a result, there are many underground cities carved into the rock, churches, dovecotes, and rock tombs in the city. The underground settlements, which account for about 80% of the region, were expanded over time and used mainly between the first and thirteenth centuries AD (ÇEKÜL, 2005; Kayseri Governorship, 2011).

Historic Functional Systems in the House of the Architect Sinan

In the house of Great Architect Sinan, the functional systems have been examined and explained in detail under five different headings.

Traditional Heating Techniques and Tools in the Case Study Building

The case study building is located in a region where winters are cold and severe and summers are quite hot. Therefore, the outdoor temperature directly affects indoor conditions and user comfort, requiring appropriate solutions compatible with the regional climate. The part of the house carved in rock meets this requirement to a great extent so that it is warm in winter and cool in summer. The proper orientation of the living spaces, the window openings, and the local volcanic tuff material of the main walls in the upper part of the building also contributes to heating the spaces. The sun is the main source of natural heating in the upper parts of the house. Shallow or splayed window openings are used for this purpose. Furnaces and built-in fireplaces, on the other hand, were the direct heating elements located in different parts of the house. There were three types of heating devices: Tandoors for cooking and heating, built-in fireplaces with chimney pots in the rooms of the upper part for heating the rooms, and cast-iron furnaces for mining in the part of the house cut into the rock. The tandoor room, which opens onto the courtyard just outside the kitchen, was used during the day in summer as a semi-open extension of the kitchen for cooking. It was also used to heat the room and the body, especially at night. When it was used as a heater, a sliding cover made of metal or stone with a diameter of about 0,50-0,60m and a thickness of 0,10m, called duvak in the local language, covered its top

(Figure 3). A thick blanket was then spread over this cover, and people sat around the edge, using the indirect heat of the remaining embers (Cömert, 2005). In the case study house, a lantern-like roof/tüteklikli örtü covers this space above (Figure 3). In the traditional houses of Kayseri, braziers were another means of indirect heating. They were prepared either with pieces from the fire that turned into a fire from the oven or with charcoal that was specially prepared and burned in the courtyard. Then they were generally placed in the center to heat the living quarters. In some other cases, similar to the night use of tandoors, a wooden table was placed over the braziers and covered with a thick blanket so that users could warm their bodies. This mechanism is called isgembi (Imamoglu, 1992). Therefore, it is clear that in the building, the priority was to heat the body rather than the entire room in an effective manner, as in a traditional Anatolian house (Küçükerman, 1995). In the part of the house carved into the rock, there are casting furnaces with ash removal drains, which were used for mining purposes (Cömert, 2005). Therefore, it is assumed that this part might be used as an iron foundry (Anonymous, 2017). In the living rooms of the masonry part, there are also built-in furnaces located along the walls, with chimney extensions at the roof. The ovens, on the other hand, are located in the part of the house that is carved in stone, on the floor level, and are bordered with stone pieces. They were used either for heating the rooms or mainly for cooking. A ventilation hole can also be seen on the top cover, directly above these ovens (Figure 4, Figure 5). Another indirect source of heat for the rooms above the carved stables was the animals, so the small holes in the stone arches used to tether the animals support the animal husbandry in the rock-cut part of the building (Figure 6).

Figure 3. Tandoor pits (left & center) with their ash-discharge holes and stone sliding cover *(duvak)* & wooden lantern-roof/*tüteklikli örtü*. (right) Above the tandoor room in the stone masonry section. (Source: Photos by author).

Figure 4. Views of the tandoor (top left) and the oven (top center) with their ventilation holes (top right & lower left) on the ceiling and stone arches with small holes for tethering the animals, in the carved rock-carved (lower right). (Source: Photo by authors).

Figure 5. Built-in fireplaces (left) and interior views of their chimney extensions (right). (Source: Photos by authors).

Direct and indirect heating devices/elements	Natural heating and auxiliary elements
*** Built-in furnaces and their chimney extensions** *** Casting furnaces for mining** *** Ovens for cooking and heating the space/body** ***Tandoor for cooking** *** Tandoor for heating the space/body (*isgembi*)** *** Indirect heat gain from the animals in RCS**	*Sun, the orientation of spaces * Window openings *Construction materials (cut-stone, volcanic tuff, earth) * Construction techniques (rock carved spaces)

Figure 6. Main heating techniques/tools.

Waste and Clean Water Systems in Case Study Building

The information on waste and clean water systems is based largely on on-site surveys. In the case study building, wastewater was discharged through floor drains, open channels for surface water drainage, sewers, bathing areas, latrines, and washrooms. The surface slope in these areas was also the primary means of surface drainage. The original latrine of the building was located in the courtyard, but nothing remains of this unit except for some traces. In this courtyard, there are also traces of a pool, a well, and its channels that were connected to the main fountain of the area. There is also a stone basin of a fountain in the courtyard. The bathing room was built as a small niche, closed with a wooden door, inside the living area. In this small niche, there is a stone pedestal in the center where you can sit while bathing. A ceiling vent at the top ventilates this space (Figure 7). The original waste-water drain is no longer visible today. In another example, the bathing room opens to the main living area/hall/sofa and is separated from the sofa by wooden grilles. In this room is a *cag tası*, a rectangular or elliptical stone pedestal with small holes and drains, and/or in some cases with a raised central section used for bathing and ablution (Figure 7, Figure 8) (Çelebi, 2017).

In the building, there is also a sunken ablution space made of stone, located in the entrance area within the living area. The sewage is drained into the earth below with the help of the porous nature of the stone material. The central part of this washing stone is elevated, as in the bathing cabins, so that the splashing of the wastewater during washing does not disturb the users (Figure 8). In addition to these above-ground washing and bathing devices, there is another special solution for washing and cleaning facilities. In this case, the first step of the staircase connecting the ground floor with the upper floor was converted into a lavatory and ablution area. The drain is connected to the courtyard and is clearly visible on the facade of the building (Figure 9). There is also a lavatory on the wall of the cellar room behind the stairs. Its drain could not be discovered, but it could be hidden in the wall and located under the floor of the room. Kayseri was a region with a high potential for water sources throughout the centuries, but wells and cisterns were also used as alternative water sources both for providing clean water and for storing snow in winter, especially in the areas where water from rivers could not be used. Until recently, these alternative water sources could be observed in the courtyards of traditional houses in Kayseri (Karakus, 2000). Neither a well nor a cistern could be discovered in the case study building (Figure 10).

Figure 7. Left & 2nd from left, bathing areas. Third from left, lighting and ventilation shaft above the bathing area with its extension on the flat roof and (right) open gutters in the courtyard for surface drainage. (Source: Photos by authors).

Figure 8. Left, Ablution space with its stone base and cag tası for bathing and ablution purposes center & left. (Source: Photo by authors).

Figure 9. The staircase step also used as a sink and ablution space (a), and its drain in the wall (b-c) (Source: Photo by authors).

Wastewater system elements	Clean water system elements
***Latrine** ***Surface drain on the ground** ***Open channels on the ground for the discharge of surface water** ***Wastewater discharge channels inside the wall** ***Sunken ablution space and its stone base** *** Bathing cubicle** *** *Cağ taşı* for bathing and ablution**	*Ablution space and lavatories * Pool * Fountain * Clean water distribution channels

Figure 10. Traditional waste and clean water system solutions.

Traditional Ventilation and Lighting Solutions and Techniques in Case Study Building

In the case study building, both natural solutions and artificial elements were used for ventilation and lighting of the rooms. During the day, the sun was the main source of light. After sunset, indirect sources of lighting such as oil lamps, candles, or candlesticks were used, as well as fire in the fireplaces/furnaces and ovens on winter nights. Window and door openings, as well as ceiling openings, were the main architectural solutions for letting natural light into living spaces. Their dimensions, shapes, and numbers vary depending on the characteristics and location of the rooms. On the ground floor of the stone masonry, intended mainly for service spaces, almost all the windows have the form of small embrasures/splayed openings. On the upper floors, on the other hand, there are large rectangular windows for ventilation and lighting in the living rooms. In the stone masonry part of the building, there are built-in cellars under the stone staircase for food/grain storage. For their ventilation, there are some small holes in the steps of the staircase or some ornamented openings in the walls of the cellar rooms (Figure 11). In the rock-cut part, the ceiling holes/openings were the main means of ventilation and lighting. There are also some small-decorated niches on the wall surfaces called *serbetlik* to place the artificial lighting elements such as candles, candlesticks, or oil lamps. In some examples, there are even small holes at the bottom of these niches to place and fix these artificial lighting elements. Small holes in the walls, called *tembel delikleri,* served the same purpose, but also to place small objects such as matches, kindling, and firelighters (Figure 12). The case study building also had a light well that was used for both lighting and ventilation of the bathing rooms. There are no mechanical systems to ventilate the building; instead, natural ventilation and lighting are provided through architectural construction solutions. Chimney extensions of the built-in stoves also contribute to the ventilation of the rooms, especially on hot summer days (Figure 13). The chimneys are made of stone with a three-layer conical cap. On four sides of the chimneys, there are small square openings on the top level, so that cross ventilation is possible and wind can be caught from all sides on hot summer days, reminiscent of the principle of operation of Iranian *badgirs* (see Figure 2). In addition, there is a lantern-like roof/*tüteklikli örtü* above the tandoor room to ventilate the space and dissipate smoke and odors from the food during the cooking process (see Figure 3). In this type of roof, wooden beams are placed diagonally on top of each other to form a kind of dome with a small opening (about 0,50m) at the very top for smoke dissipation and lighting of the room (Akın, 1991).

Figure 11. Ventilation holes on the walls and steps specially built for ventilation of cellar spaces. (Source: Photos by authors).

Figure 12. Left wall niches, called tembel delikleri and center & right serbetlik. (Source: Photo by authors).

Natural ventilation/lighting and auxiliary elements	Architectural solutions for artificial lighting devices
*** Window and door openings** *** Small embrasure/splayed openings** *** Ceiling holes/vents** *** Chimneys of the furnaces** ***Lighting shafts** *** Laternen roofs/*tüteklikli örtü* above the tandoor rooms**	**Şerbetlikler*/ small-decorated niches on the wall surfaces to hold lighting devices **Tembel Delikleri*/ small niches on the wall surfaces to put some small objects

Figure 13. Traditional waste and clean water system solutions.

Food/Wheat Storage Solutions

Due to the harsh climate and conditions in the region, it was necessary to store food for long-term use. Therefore, in the traditional houses of Kayseri, it was essential to find additional solutions for storage, such as cellars, underground depots, and terracotta vessels (Figure 14) (Kaya, 2020). In the case study building, there are also some practical solutions for food storage both in the rock-cut part and in the upper floors made of stone masonry, which vary according to the type and characteristics of the food to be stored. On the first floor of the masonry part, there is a cellar room for food storage. Inside the cellar, there are two wheat storage units of different sizes, made of local volcanic tuff. This room is made of stone masonry with a wooden ceiling supported by wooden beams and posts (Figure 15). There are only small embrasures/splayed openings in the wall for ventilation. The floor of the cellar is covered with stones. Small niches on the walls of the cellar and the other living spaces, as well as under the lavatory, are the other storage options. Thanks to the cooling effect of the earth and the rock, the part of the house carved into the rock were mainly used over time as an underground storage room with special cellar solutions, including pits carved into the ground and terracotta jars of various sizes used to store food. In this area, there is a special storage solution called çardak in the local language (Figure 16). A staircase from the original masonry part of the house reaches this part. In the çardak storage technique, a small pit was dug into the earthen/stone soil and food was stored in these underground pits for long-term use. The upper part of the pit was closed with tight iron grates so that some kind of protection and ventilation was provided. Below the stone staircase, there were also closed cellars, which were used for storage purposes. Terracotta jars, either buried in the ground or standing on the surface, were the other portable storage containers.

Dovecotes, carved into the tufa, were also seen in the parts of the house carved into the rock. They have the shape of small holes about 0,25*0,25m in size on the rock surfaces and were used to collect and store pigeon manure. At the very top, there is a small hole called hazne çatısı through which the pigeons can enter. However, it was originally believed to be columbarium that was used to store the ashes and personal belongings of the dead (Figure 15) (Kaya, 2005). Pigeon lofts similar to dovecotes were built to support agricultural trade in Kayseri. By the mid-nineteenth century, Kayseri and the surrounding periphery were an important center for the trade of cehri plants, which were an important source of income for local people. Pigeon manure, collected from pigeon lofts or dovecotes, was an indispensable part of this trade, which ensured the efficient and rapid growth of the cehri (Büyükmıhçı, 2006).

Closed storage areas/devices	Open storage areas
***Cellars and stone storage units** ****Çardak* (underground storage pits)** ***Cellars beneath the stairs** *** Terracotta jars**	*Wall niches and the niches beneath the lavatory

Figure 14. Different storage solutions.

Figure 15. Left 2 pics, cellar room and storage room with connection passageway with the rock-cut areas and far right the pigeon lofts in the rock-cut area. (Source: Photos by authors).

Figure 16. A rectangular niche on the wall in the tandoor room (a) and food storage containers buried in the ground (b), called çardak in the local language, in a rock-carved part of the house. (Source: Photo by authors).

Roof Drainage Systems in Case Study Building

The building originally had a flat roof covered with a layer of earth, characteristic of traditional houses in Agırnas in the fifteenth and sixteenth centuries (Yaslıca and Çalısır, 2002). At present, however, most parts of the roof are covered with pebbles mixed with earth. The stone waterspouts located at certain intervals on the parapet level of the roof are the primary drainage elements used to drain rain and snow water accumulated on the roof surfaces (Figure 17). They protrude from the main walls at the parapet level and have a gutter in the center through which the water is drained directly to the street or courtyard. In this way, the main stonewalls of the building are protected from wetness and humidity on rainy days. Rain and snow water is directed to these water spouts made of volcanic tufa, through muddy surfaces formed in the earth layer of the roof, towards these drainage elements. The earth layer of the original earthen roof was compacted after the rainy and snowy days with *log tası*, a special type of oval stone with an iron handle. The waterspouts are used both as functional and decorative elements, some of them with special shapes. In some cases, the waterspouts do not protrude but are located on the same surface as the courtyard wall itself, and in another case, the waterspout is located directly above the fountain basin in the courtyard, serving a dual purpose (Figure 17). Parapet walls with copings sloping in two directions, stone cornices at the parapet level, and on the facades between floors are the other architectural elements of the building that serve to drain water and protect the wall surfaces (Figures 17-18).

Figure 17. Left 2 pics, roof waterspouts and center right courtyard walls to drain rainwater. (Source: Photos by authors).

Roof types	Roof/wall surface drainage/discharge elements
*Earthen Roof *Flat roof	*Waterspouts, * Roof slope * Parapet walls * Stone cornices at the eaves level * Stone cornices between the floors

Figure 18. Different roof types and roof drainage elements.

Discussion and Conclusion

The identification of functional systems and building elements preserved with the technology of the time in historic buildings and the protection of these systems/elements are important to ensure the sustainability of this cultural heritage, traditional building details, and especially traditional knowledge systems (TKS). In addition, it is important to better identify these original systems in traditional houses to understand and document these details and preserve them during conservation studies, as well as to learn the symbiotic relations with the old and modern technology for a better urban development. Therefore, the house of Great Architect Sinan has been chosen as the case study to discuss the set of service systems (heating, waste and clean water, lighting, ventilation, food storage, and roof drainage) in detail, because they are still present and mostly preserve their originality. The subject is important because it is a question of showing how the notions of comfort and well-being were treated by architects in the Middle Ages and what were architectural elements designed in historic buildings to fulfil this function. In addition, it aims to raise awareness of the service systems in this historic house, as they reveal traditional architectural solutions designed to provide maximum comfort at the time of construction under natural conditions. Their construction technology has been explained and the reliability level of the data obtained for these systems is shown in Figure 19. It should be noted that for the case study building, most of the data on the location, shape, dimensions, material, and details of the system elements came from the building itself. Oral information, literature searches, and comparative studies were the other sources of information.

The study shows that the bioclimatic design of comfortable houses is not a contemporary notion; but it has existed for several centuries and the solution used by the ancients are ingenious despite their apparent simplicity, especially in the choice of building materials, their implementation as well as the management of fluids and energies so the house is autonomous by the use of passive systems. In short, it is about building and living with the climate, accounting for the lifestyles and rhythms of the inhabitants who take advantage of favourable elements of the external environment while protecting themselves from the extreme elements. The example of the Architect Sinan's house, built over a rock-cut cave connected to the underground city in the Koramaz Valley, also shows that ancient building technology dates back to 2000 BC. and continued to evolve with new additions and alterations until the fifteenth century and then into the twentieth century. The capacity of domestic technology evolved from underground pits and ovens to built-in fireplaces and chimneys. For cooking and heating of the body and the space/room, some special arrangements were used, called isgembi. One can observe a stone pedestal that was used either for ablutions or for cleansing/bathing. In addition, there were special solutions for built-in spaces and basins/washbasins/wells/drains. In addition, it was not until the Ottoman Empire that traditional building techniques surpassed those of antiquity. One factor of this progress was that the underground cities of the region, built mainly for protection and defence purposes, were gradually abandoned and, with the change in the understanding of comfort, were mixed over time with the stone masonry buildings built over these rock-cut units. Thanks to the ease of working the volcanic tufa rock in the region, they were used both as rooms dug underground and as masonry buildings. Food and shelter, as the two basic needs of life, shaped domestic technology, so various architectural construction details and spaces were considered for food storage, cooking, heating, cooling, and cleaning of the body and rooms. Cellars, special rooms or depots, bathing cabins, latrines, sinks, basins, ablution spaces, and heating systems such as fireplaces, braziers, tandoors, and ovens, are all evidence of these concerns. Even if these service systems are no longer used for their original purpose, most of them have been preserved to this day. The use of local materials and traditional construction techniques along with the system details enhance the harmony of the building with its surroundings and ensure its survival for many years. The case study building was restored in 2008. It serves as a museum commemorating the Architect Sinan, but it is not open all the time and can be visited only upon request and with the help of local people.

Therefore, for further studies, it is important to give the building a permanent function, with special attention to the original system details, and to visit it at certain times of the day with a responsible person and security. Only in this way will it be possible to show the traditional building systems and construction details to a larger number of visitors. Otherwise, there is a risk that some of these details will be lost due to insufficient use and lack of constant care and maintenance. In addition, old traditional building systems are to be discussed as formative factors in history, and their adaptability and potential for applicability to contemporary buildings should be studied in depth.

Location:	Service System Elements	Building Service Systems						
		Clean Water	Waste Water	Roof Drainage	Lighting	Ventilation	Heating	Cooling
SMS	Fireplaces/built-in furnaces					X	X ⌂	X
RCS	Casting furnaces						X	
RCS	Ovens						X	
SMS, RCS	Tandoors for cooking and heating						X ■ ⌂	
SMS	Braziers						⌂ √	
SMS	*Isgembi*						⌂ √	
RCS	Indirect heat gain from the animals						X ■	
SMS	Latrine		Δ					
SMS	Surface drain on the ground		X					
SMS	Waste water discharge channels		X					
SMS	Sunken ablution space		X					
SMS	Bathing cubicle		X					
SMS	Lavatories		X					
SMS	Pool	Δ						
SMS	Fountain	Δ						
SMS	Clean water distribution channels	Δ ⌂						
SMS	Windows				X	X		
SMS	Doors				X	X		
SMS, RCS	Ceiling hole/vent				X	X		
SMS	Small embrasure/ splayed openings				X	X		
SMS	Chimneys of the furnaces					X		X
SMS	Lighting shafts				X √	X √		
SMS	*Şerbetlik*				X			
SMS	*Tembel Delikleri*				X			
SMS	Cellar							X
RCS	*Çardak*/ underground storage pits							X
SMS, RCS	Terracotta jars							X
RCS	Earthen roof			X				
RCS	Flat roof			X				
SMS	Waterspouts			X				
RSC	Parapet walls			X				
SMS, RCS	Roof slope			X				
Reliability Degree Assessment (from most reliable to the least)								
X	Data on location, form, dimension, material, and details of system elements are obtained from the building itself (system elements are already available and totally intact condition)							
Δ	Data on location, form, dimension, material, and details of system elements are obtained from the traces coming from the building (only the remains or traces of the system elements are available)							

Figure 19. Evaluation of service systems according to the degree of reliability of the obtained data (Rock Carved Section: RCS, Stone Masonry Section: SMS).

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