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Evaluation of current documentation methods: The case of Kültepe Karum Merchant Quarter

Leyla Kaderli [*1], **Mehmet Tarık Öğreten**[2], **Betül Gül Hüsrevoğlu**[3]

[1]*Erciyes University, Faculty of Architecture, Departmant of Architecture, Türkiye, leylakaderli@erciyes.edu.tr*
[2]*Ankara University, Faculty of Language and History-Geography, Departmant of Archaeology, Türkiye, tarikogreten@gmail.com*
[3]*Erciyes University, Faculty of Architecture, Departmant of Architecture, Türkiye, betulgulnny@gmail.com*

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Abstract

The primary objective of archaeology extends beyond uncovering remnants of the past to ensuring that the collected data is accurately documented and preserved for future generations. Cultural heritage serves as a vital element that illuminates a society's past and future, making its preservation essential through both traditional and modern methodologies. While traditional documentation methods are often time-consuming and complex, technological advancements such as photogrammetry and LiDAR scanning have enabled the rapid, precise, and comprehensive recording of archaeological sites. These methods are particularly critical for capturing detailed records of structural elements that are either physically inaccessible or entirely lost. This study focuses on a merchant house located in the northeastern part of the Lower City Karum in Kültepe, one of the significant Bronze Age settlements in Anatolia. By integrating photogrammetry and LiDAR scanning methods, the research offers a comprehensive framework for digitally documenting and preserving these structures. The generated three-dimensional models and orthophotos contribute not only to scientific research but also provide a robust data foundation for restoration and conservation projects. These digital outputs enable detailed analyses of spatial organization within its historical context, offering insights into the socio-economic transformations reflected in the architectural features of merchant houses. In conclusion, this study highlights the critical role of modern digital methods in the sustainable preservation and documentation of cultural heritage. The case of Kültepe demonstrates the practical, cost-effective, and transformative impact of integrating technological methods into archaeology, emphasizing the interdisciplinary utility of such approaches in cultural heritage management. This research serves as a valuable reference for future applications aimed at ensuring the effective protection and transmission of cultural heritage.

1. Introduction

The main goal of archaeology is not only to find remains from the past, but also to transmit the data obtained to future generations in an accurate and appropriate manner [1]. In this context, archaeological remains of various civilisations should be documented and taken under protection [2-11]. Repairs made to monuments should be evaluated and preserved as a document that sheds light on the urban and architectural features, construction techniques and social life of the period while aiming to keep the building standing and protect the integrity of the building [12].

Excavations in archaeological sites contribute directly to the documentation of the site [4,6,5,7]. Today, the documentation of historical monuments using different methods and three-dimensional modelling provides a permanent recording of data in the computer environment and forms the basis for the structural definition and restoration of structures [13]. Architectural documentation is a process carried out within a logical framework and it is possible to obtain data by different methods. The solutions developed offer significant advantages by enabling the architectural work to be used and organised digitally [14].

Documentation refers to the detailed recording of the physical and structural characteristics of a building. This process is carried out by obtaining information about the building or groups of buildings from photographs, maps, drawings and archive information [15,16]. The documentation process includes research, observation, description and other data collection methods. The aim of this complex process is to preserve historical and cultural assets for generations. Traditional documentation methods may require challenging, time-consuming and costly research [17-19]. However, the technology developed in recent years allows for different methods in documentation studies. Digital documentation offers the opportunity to protect cultural assets with historical past more effectively. In this context, technological tools such as terrestrial laser scanners, UAV and satellite photographs are used for the documentation of the site [20-22]. The photogrammetry method is applied through different digital programmes to create a three-dimensional model of the area using captured photographs [23-26]. This method offers a cost-effective and easily implemented documentation option.

Remote sensing methods have been developed by integrating with Geographic Information System (GIS). Light Detection and Ranging (LIDAR) is a scanning method used to obtain dense and geometric data in a faster and more practical way compared to photogrammetry [27]. To make this method more functional, extensions are used, such as the ViDoc RTK antenna, which can be mounted on mobile smart devices equipped with LiDAR sensors [28]. In this study, a merchant's house in the ancient city of Kültepe in Kayseri province in Central Anatolia was documented by Photogrammetry and LIDAR Scanning methods. In this context, traditional and modern methods used in archaeological documentation and conservation studies were integrated with a holistic approach. Among the traditional documentation methods, defining the geometry of the model object and creating drawings from reference sections have an important place [3,18]. In addition, the differences and positive aspects of the classical manual, topographic, photogrammetric and scanning methods used in cultural heritage documentation were evaluated [29,30].

This study focuses on the documentation and evaluation of the structural remains located in the northeastern part of the Lower City Karum in Kültepe, one of the significant settlements of the Hittite Period in central Anatolia. The architectural characteristics of the merchant house were analyzed based on the identified archaeological remains and findings, leading to the development of restitution proposals in the context of the region's historical framework. The findings provide tangible data for developing strategic approaches to the preservation of the structure and establish a comprehensive framework to guide restoration projects. In this context, the study aims to contribute to interventions that preserve the historical identity of the structures while aligning with contemporary principles of conservation and restoration.

1.1. Study area

Kültepe archaeological site stands out as a region that offers important information about the rich history of the Hittite Assyrian city of Anatolia. Kültepe is one of the earliest settlements of the region, which has hosted different civilisations throughout history. As mentioned in the Anitta texts, the settlement, formerly known as Kanesh or Nesa, is known as the centre of the Kanesh Kingdom, which was formed in the first quarter of the 2nd millennium BC. Kanesh, where settlement layers dating back to the 3rd millennium BC were found, gained intensity in the 2nd millennium BC [31] and It is accepted that it was a well-known centre not only in Anatolia but also in Syria and Mesopotamia [32,33]. In the Early Bronze Age and the Middle Bronze Age, Assyrian merchants accepted Kanesh, a large and fertile area, as a centre [34].

Today, Kültepe is located 21 km northeast of Kayseri city centre, 16 km south of the Kızılırmak River, at the foot of Mount Erciyes, within the borders of Karahöyük village [34,32]. Located at the foot of Mount Erciyes, Kültepe was built on a fertile plain surrounded by the alluvial deposits of the Sarımsaklı Stream, which merges with the waters of the Karasu River and flows into the Kızılırmak River (Fig. 2). The geographical location of Kültepe, at the intersection of trade and military routes, 1000 km northwest of Assyria and 124 km south of the Hittite capital Hattusas, has a strategic importance in the past [35]. In addition, its location on the roads coming from Western Anatolia, the Black Sea coast, the Euphrates region and Cilicia contributed to its position as a centre of trade and cultural interactions [36,32,37](Fig. 3). The location of Kültepe reflects its strategic importance in trade networks and the role it played throughout history [38,32,37].

Within the scope of this study, the documentation and evaluation of a merchant's residence and its surroundings located in the Lower City of Karum, where mostly merchants settled. The identified building is located at 38° 51' 16.7'' North, 35° 38' 15.1''' It is spread over an area of about 300 square metres on the eastern latitude, north-east of the Kanesh.

Figure 1. Map reflecting the strategic location of Kültepe [38].

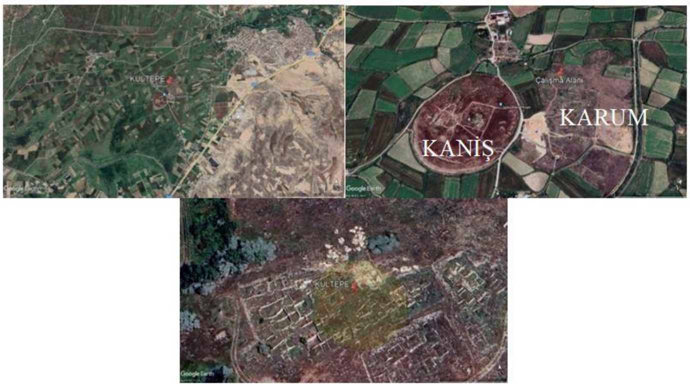


Figure 2. Close and distant location images of the merchant's house located in the study area Karum [39].

It is thought that the Mk9 section was exposed and turned into a square as a result of the fire and the entrance of the building before the destruction was from the side of the oven in the Mk9 section. Room Mk7 was identified as a burial chamber containing three graves. A hearth and various kitchen utensils were found in room Mk2. A total of 139 artefacts including 23 envelopes, 14 enveloped tablets, 102 tablets and 6 bullae were recovered from Room Mk6 [40]. These finds have played an important role in revealing the history and chronological order of the Assyrian Trade Colonies [41]. According to the 2001 findings, it was determined that the building bears the characteristic features of building level Ib and the construction technique was mudbrick walls on a stone foundation specific to building level Ib. The second floor houses were reinforced with stone pillars instead of wooden pillars [40]. Today, the building and its surroundings have been severely damaged and the remains of the walls, door sills and frames are partially legible (Fig. 1).

1.2. Historical development of Kültepe

The geographical location of Kültepe, whose historical development can be traced from the Early Bronze Age, and the political structure of the period facilitated the establishment of commercial, cultural and political relations with the surrounding cities since the middle of the 3rd millennium BC.

This process continued with the Assyrian Trade Colonies Period, the Hittite Period, the Old Hittite State, the Great Hittite Empire, the Phrygian Period, and then the Hellenistic and Roman periods, and each phase witnessed important transformations in the political, economic and social structure of the region and increased the importance of Kültepe in the regional and international context.

Although there is no conclusive evidence that Kültepe was inhabited from the Chalcolithic Age onwards, the discovery of Chalcolithic Age ceramics during the excavations at Sultan Höyük and Alisar in the neighbourhood suggests that Kültepe may have been inhabited during this period. The oldest known layers of Kültepe date back to the Early Bronze Age I-II-III phases dated to 3000-2000 BC [42]. This period is followed by the Assyrian Trade Colonies, which dates to 1950-1750 BC. This is a period in which Assyrian trade colonies in Mesopotamia and the Middle East were active [43]. The Assyrians made significant progress in their geography and established a wide trade network; thus Kanesh-Karum became an important trade centre of Anatolia. The introduction of cuneiform writing to Anatolia by Assyrian merchants has been accepted as the starting point of the historical ages in Kültepe [34,42]. At the beginning of the 2nd millennium BC, the Assyrian Trade Colonies Period started and settlement was observed in the Karum (Lower city) region [44]. With the Hittite period, state and temple structures were integrated with each other and these structures were built in accordance with the political and religious order of the period [45]. Fig. 3 shows the chronology of history in detail.

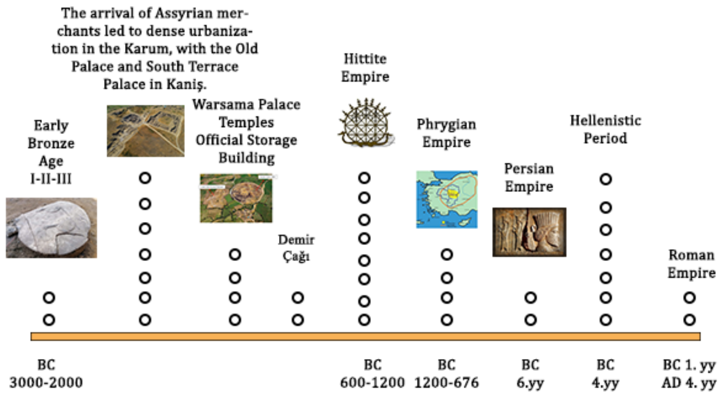


Figure 3. History of Kültepe (Produced by the authors).

Table 1. Kültepe stratigraphy and distinctive features of building levels [46].

No	Kanesh	Distinct Features	Karum
1	Rome	City walls	
2			
3	Hellenistic		
4	Iron Age	Relief Late Hittite Orthostats	
5			
6	Kanesh Kingdom: Capital of Assyrian Trade Colonies	The city of Kanesh and Karum were re-established shortly after and survived until the Babylonian King Samsu-iluna's reign. The monumental structures of Kanesh (Warsama Palace, temples, and the official storage building)	Ia
7			Ib
INTERIM			
8		Arrival of Assyrian merchants and the establishment of a trade system in Anatolia. Karum was also densely built. In Kanesh, the Old Palace and the Southern Terrace Palace were present.	
9		Hand-made monochrome ceramics and, for the first time, wheel-made ceramics were produced, marking the emergence of Hittite ceramics.	II
10			
11	Early Bronze Age III	Close relations with Mesopotamia, Northern Syria, and Western Anatolia; emergence of monumental buildings	III
12			IV
13			
14	Early Bronze Age II	Close relations with Mesopotamia, Northern Syria, and Cilicia; imported pottery from the Upper Euphrates region	
15			
16			
17			
18	Early Bronze Age I		

There is a stratification consisting of 18 building levels including Early Bronze Age (18-11), Assyrian Trade Colonies Age (10-6), Iron Age (5-4), Hellenistic Period (3) and Roman Period (2-1) [46] (Table 1). The Lower City consists of 4 building levels, the last of which has two phases, and was inhabited for about 250 years [47,48].

Kültepe is located in a strategic region that attracts attention with its rich historical past and high archaeological potential. The discovery of the archaeological importance of Kültepe began in 1881 when Th. G. Pinches found cuneiform tablets and mentioned the name Kanesh in these tablets [34,49,36,31,50]. This discovery played an important key role in understanding the commercial and cultural interactions between the Mesopotamian and Anatolian civilisations of the region.

Figure 4. Tablets in a container [34].

As shown in detail in Fig. 5, Cuneiform tablets discovered by Th. G. Pinches reveal that the kārum (Trade centre) at Kültepe-Kanesh was the centre of the Assyrian colonies established to develop international trade [51,31]. Most of the tablets found as a result of the excavations contain commercial correspondence between the Assyrians and Anatolia [52]. In order to resolve the uncertainties regarding the localisation of Kültepe, E. Chantre, during his research trip to Anatolia in 1893-1894, suggested that the tablets were located in the mound section, but his soundings did not yield any clear results. In 1901 W. Belck and in 1906 H. Winckler and H. Grothe carried out short-term excavations and soundings at Kültepe-Kanesh, but these studies did not yield any comprehensive findings [53]. After the establishment of the Republic of Turkey, systematic excavations were started in 1925 by a Czechoslovak team headed by B. Hrozny [31,54,55,34,56,50,57].

These excavations further reinforced the archaeological value of Kültepe. When the tablets could not be found during the excavations in the mound, it was decided to stop the excavations, but as a result of a tip-off, it was suggested that the excavations should be carried out in the fields on the outskirts of the mound. The excavations carried out in this new area resulted in the discovery of various cuneiform tablets as well as daily use items such as pots, bowls and pottery. Following the outbreak of an epidemic in the region, the excavation team returned to their home country and some of the finds were left to the Istanbul Archaeological Museum, while the other part was taken back to their home countries by the excavation team [32,58,31]. In 1935, B. Hrozny succeeded in deciphering the Hittite language through the tablets found in Kültepe. In the tablets, while the Hittites defined themselves as 'Nesa', it was determined that the language known as 'Kanesh' is Hittite today, and the names 'Kanesh/Nesa' point to the modern Kültepe region [52]. Until 1948, no excavations were carried out at the site, and during this time the area was severely damaged by the interventions of the local population and natural factors. In addition, many documents and artefacts were scattered to different parts of the world during this period [32,58,31]. The Kültepe cuneiform tablets are mainly classified into two sets. Close to 4,760 tablets were uncovered through unauthorized excavations at the end of the 19th century and the first half of the 20th century. Among these, some were obtained by scholars such as E. Chantre and B. Hrozny, who collected 1,034 tablets. Since 1948, regular archaeological campaigns have been conducted at Kültepe under the leadership of Professor T. Özgüç from Ankara University, with support from Professor K. Emre and funding from the Turkish Historical Society. Kültepe is recognized as one of the richest archaeological sites in the Ancient Near East, yielding new archives and hundreds of tablets each year. From 1948 to 2001, 17,549 Old Assyrian tablets were excavated and are now stored at the Museum of Anatolian Civilizations in Ankara. By early 2002, the total number of tablets discovered reached 22,300 [59].

The first scientific excavations were initiated by Turkish archaeologists in 1948. In this process, excavations were carried out under the direction of Prof. Dr. Tahsin Özgüç and Nimet Özgüç until 2006, and Prof. Dr. Kutlu Emre also participated in these excavations. Since 2006, Prof. Dr. Fikri Kulakoğlu has been the excavation director and he continues to serve in this position today [60,61]. According to the 1985 excavation results, city structures belonging to levels Ia-b and II were excavated at Karum.

The excavation results of 2019-2020 show that the excavations, which have been carried out without interruption since 1948, have been mainly concentrated on the mound after 2010. During the excavations carried out in 2017-2018, the megaron-planned building dating to Level 12 as well as the pilastered building belonging to Level II-b were excavated. These studies brought to light the historical richness of Kültepe and increased the importance of the region, especially with the discovery of thousands of tablets from the Assyrian Trade Colonies Period. Approximately 23,500 tablets have been unearthed to date, the majority of which come from the lower city of Karum. As the excavations continue, new finds are expected to be discovered [62,59].

Dating to the Assyrian Trade Colonies Period, these tablets provide important contributions to our understanding of the trade, culture and political relations of Anatolia and the ancient Near East [33,63,64]. The information recorded on the tablets illuminates the trade networks and diplomatic relations in the region and reveals the central role of Kültepe in international trade and cultural interactions.

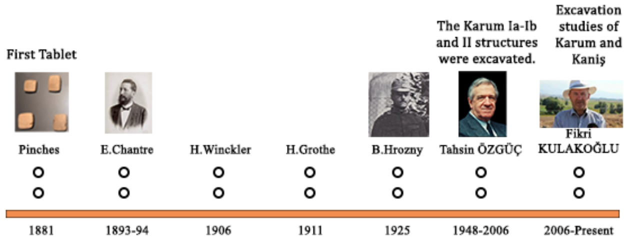


Figure 5. Excavation heads in the historical process(Produced by the authors).

Within the scope of the 2019-2020 excavations directed by Prof. Dr. Fikri Kulakoğlu in Kültepe, excavations were carried out in the southeast of the palace building of Karum in the fifth building layer in 2019 and in the seventh building layer in 2020. In the same period, excavations continued to complete the plan of the megaron-planned building dating to the 12th building layer of Kültepe and the partially excavated space in 2017-2018 [65]. Recent excavations in the southwest of the mound revealed the location of monumental buildings belonging to the Early Bronze Age III levels in Kültepe, and it was determined that these buildings were surrounded by small dwellings built on top of each other dating to the late 3rd millennium BC and early 2nd millennium BC. [44,64]. The 18 building layers identified during the excavations are associated with five different periods. The earliest phase is dated to the first phase of Early Bronze Age I and the latest phase to the Roman Period. [58,34,36].

These layers provide a comprehensive chronological sequence of the settlement history of Kültepe and reveal the architectural development of the region in different periods. The excavation results show that Kültepe was not only a trade centre, but also a region of architectural and cultural transformations. This situation demonstrates that Kültepe was established as a trade center and developed over time into an important administrative and religious hub. As seen in Anatolian settlements such as Mycenae, Assur, Sumer-Akkad, and Troy, as well as in later Hellenistic cities, it can be likened to an acropolis. The Upper City, where public, palace, and religious structures were concentrated, and the Lower City, which housed residences and workshops, also emphasized distinctions in social status [50,66].

Kültepe consists of two main parts: the lower city (Karum) and the upper city (Kanesh). The upper city, Kanesh, is approximately 500x550 metres in diameter and 21 metres high, and has a circular layout. The lower city covers an area of approximately 2.5 km in diameter and surrounds the mound in a half-moon shape. [34,42,46,67]. The hollowing out of the mound from the sides to the inner parts stands out as a remarkable topographical feature of the region. It is observed that public and religious buildings are predominantly located in Kanesh, while dwellings and workshops are mostly found in Karum (Fig. 6). This differentiation reflects the functional distinction of the settlement areas and the spatial organisation of the social structure.

Figure 6. Kültepe lower (Karum) and upper (Kanesh) city [68].

1.3. Housing architecture

In Hittite society, the dwelling is recognised as the smallest unit of production [69]. It is thought that these dwellings were not only used for the accommodation of family members, but were also units serving the palace and temples [70]. In the Neolithic Age, the first housing examples started to emerge with the transition of human beings from nomadic life to settled life. At first, round-based and simple dwellings were built under the influence of the Palaeolithic Age [71]. With this period, building materials such as stone, mudbrick and wood were started to be used in house construction. The foundations of the houses were generally built with stones placed on top of each other, and brushwood was used on the floors. The walls were made of twigs and twigs plastered with mud [72].

The fact that Hittite dwellings consist of three separate sections shows that they were built within a certain planning and architectural scheme. The first section is the entrance of the dwelling and is covered with stone pavements; the middle section includes a plastered area and an oven, while the last section functions as a space used for daily life [73]. There were no major differences in the materials used in this round-based plan type. In time, the buildings became quadrangular in form and their roofs started to be built with flat roofs. In the last stage of the Hittite dwellings, it was determined that they turned into stone-based, flat-roofed and multi-roomed buildings [73].

The effect of trade on architecture started to be observed in Kültepe with the Assyrian Trade Colonies Period. The dwellings used by Assyrian and local merchants have a complex layout with an increase in the number of rooms. The rooms are rectangular in form and are located around a central space in the centre [74,33,75].

With the Assyrian Trade Colonial Period, the effects of trade on architecture became evident in Kültepe. During this period, the increase in the number of rooms and the complexity of the spatial organisation in the residential buildings used by Assyrian and local merchants are noteworthy. The dwellings are generally rectangular in plan and offer a more developed interior layout with rooms arranged around a central space [74,33,75]. In the Kültepe settlement, the upper city is characterised by monumental buildings, public buildings, palaces, fortifications and temples, while the lower city is characterised by residential buildings surrounded by narrow streets. This architectural order points to the spatial distribution of social and commercial activities within the city [75].

The dwellings in Karum were built on stone foundations, as in the Hittite settlements at Kanesh, and this construction technique reflects the architectural characteristics of the period. There is archaeological evidence that an uninterrupted settlement process continued in the lower city from the Early Bronze Age until the end of the Hittite Imperial Period [75]. This situation shows that Kültepe maintained its continuity as both a settlement and a trade centre.

In this context, it is observed that the architectural developments in Kültepe are directly related to the commercial activities, and the spatial organisation of the dwellings became more complex with the increase in trade. Especially the combination of Assyrian colonies and local elements brought about a significant transformation in architectural designs.

In the lower city, two-storey dwellings opening to narrow streets with wide avenues were identified. The ground floors of these dwellings contain functional areas such as courtyards, stables, bakeries, burial chambers, archives and storerooms, while the upper floors are thought to contain living spaces. The roof terraces are thought to have been used for daily activities. The plans of the dwellings were shaped in line with the development of trade, and accordingly, in addition to the living areas, sections such as office rooms, burial chambers, warehouses and archives were added for commercial activities. Özgüç's studies have also revealed the existence of rooms filled with materials for trade and locked archive rooms. [33]. During the 2001 excavations, an important archive was discovered in the house, which had been severely damaged by fire and various other damages. The tablets, burial chambers and various other artefacts found in the dwelling indicate that this dwelling belonged to a wealthy and large family [76]. The different forms of terracotta vessels and similar artefacts recovered during the excavations indicate that the building has features belonging to the Karum Ib layer [76,63]. The first important findings on the building were published by Tahsin and Nimet Özgüç, who suggested that the building shows a six-room plan in accordance with the Ib building style. As the excavations progressed, it was determined that the building measured 14.00 x 21.50 metres and had a plan with nine rooms [76]. It consists of two main parts: the lower city (Karum) and the upper city (Kanesh). Kanesh, the upper city, is approximately 500x550 metres in diameter and 21 metres high and has a circular layout. The lower city covers an area of approximately 2.5 km in diameter and surrounds the mound in a half-moon shape [34,36,67,77]. The hollowing out of the mound from the sides to the inner parts stands out as a remarkable topographical feature of the region. It is observed that public and religious buildings are predominantly located in Kanesh, while dwellings and workshops are mostly found in Karum. This differentiation reflects the functional distinction of the settlement areas and the spatial organisation of the social structure.

1.5. Material and technique

The materials used in the construction of buildings are generally divided into three main categories: stone, adobe and wood [78]. The choice of building materials was largely shaped by the natural conditions of the geography and environmental factors, and the design of the buildings was shaped according to the aesthetic and functional preferences of that period [79,80]. Archaeological findings show that the dwellings were mostly built on stone foundations and the mudbrick walls were reinforced with wooden posts and beams to increase their durability. It is known that mudbrick, which was frequently used by the Hittites, is expressed by the ideogram 'kalpaššana-/purut' [81]. However, it is understood that the mudbrick deteriorated over time due to its organic structure and therefore the structural remains that have survived to the present day are limited.

It is understood from the archaeological findings that the dwellings were remodelled as a result of additions and renovations over time. Although the original height of the buildings is not known exactly, archaeological findings and experimental archaeological studies suggest that the dwellings may have been 250 cm high on average. However, some empirical studies suggest that this height may be higher depending on regional differences and the function of the building. As for the roofs, it is thought that they were built with flat roof technique in accordance with the geographical and climatic characteristics of Anatolia [82]. Although the archaeological data on the windows are limited, it is thought that they were made close to ground level, approximately 13-100 cm high and with wooden frames [78,82]. These structural features show that the construction techniques and use of materials of the period were compatible with the functional requirements.

Figure 7. Top view of Kültepe and excavation cite [76].

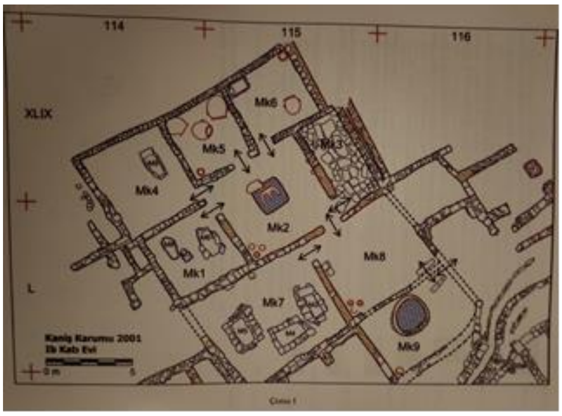


Figure 8. 2001 study and plan drawing of the building [76].

Building materials were selected based on the availability of natural resources and environmental conditions. Stone was generally used for foundations and walls, but also for courtyards and street pavements [33,82,83,48]. Wood, on the other hand, was used extensively due to its abundant availability and easy access in the neighbourhood. Particularly in the Lower Town, wood was used extensively for beams, posts and ceiling beams [34]. It was observed that different combination techniques of wood and stone materials were also used on the walls [82]. There is also evidence of the use of wood in door jambs and stairs [40,64,83,32].

In addition to the inferences, the documentation made in the light of modern technological documentation methods supports the archaeological inferences and it is confirmed in terms of the architectural plan that the lower city houses, which generally consist of three rooms, were used in different functions [32,84,48].

The building materials used since the Neolithic Age in Anatolia, such as stone, mudbrick, and wood, continued to be utilized in Kültepe Lower Town due to their local availability and easy processing. Social status did not affect material choice, as the same materials were used across all structures. Over time, construction techniques evolved, with improvements in stone craftsmanship and structural stability through elements like timber beams and posts. Limited window use reflected heating and security needs. Traditional structures like ovens and hearths, still seen in rural areas, served multiple functions, including metalworking. Kültepe's building practices offer valuable insights into the development of modern techniques, with traces of these traditions still evident in rural construction [48,83].

2. Method

The current documentation methods used to document the Kültepe Karum Merchant Quarter are discussed in the context of photogrammetry and LIDAR technologies and the advantages of these techniques are evaluated. The study examines the historical development of the term photogrammetry, which was introduced by architect Albrecht Meydenbauer and provides a 3D data source in cultural heritage sites, and its use in archaeological sites, while also analysing how LIDAR technology has developed and can be used as an effective documentation method.

Today, documentation studies carried out with different techniques enable modelling to be done quickly and easily. Thanks to the possibilities offered by technology, 3D models can be obtained through devices such as mobile phones and tablets [85]. With the development of modelling and documentation methods, the use of these techniques in different fields is becoming widespread [86]. In this study, two different methods, photogrammetry and LIDAR scanning, were used. In the photogrammetric method, detailed photographs taken in the area were recorded with an iPhone 13 mini mobile phone and these photographs were converted into modelling using Agisoft Metashape software. In the LIDAR scanning method, a 3D model was created by taking a video of the area with a tablet with LIDAR sensor.

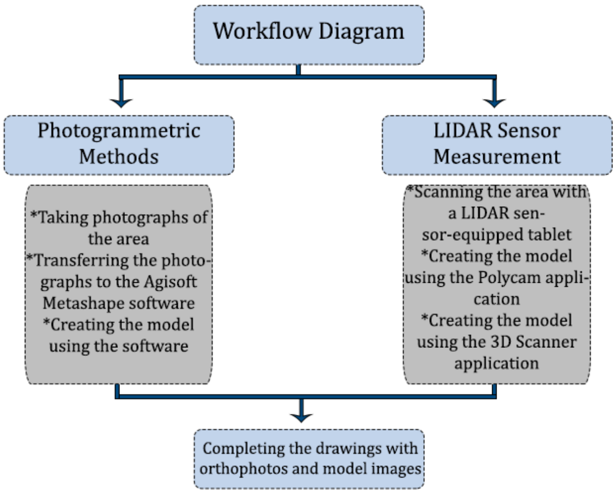


Figure 9. Work flow chart (Produced by the authors).

2.1. Photogrammetric method

Photogrammetric method plays an important role in the creation of 3D data source of cultural heritage artefacts. With the development of techniques, photogrammetry, which is a mapping method, converts 2D images into 3D models quickly and at low cost by using stereo vision principles [87,88]. Photogrammetric method is preferred because it provides speed and economy in the conservation and documentation of archaeological sites [89-93]. Photogrammetry is a method that creates visual data, geometric features, planar and spatial position, dimensions, material and texture information of architectural structures through photographs [18]. This method is used in various fields such as documentation of archaeological sites, creation of conservation development plans, protection, maintenance and repair of cultural assets, detection of structural defects and renovation of historical buildings [94].

In this study, after photographing the area in detail, 3D modelling was carried out in computer environment using Agisoft Metashape software. Technical specifications of the Asus laptop computer used for modelling are shown in Fig. 10.

Table 2. Computer Specifications Used for Agisoft Metashape Programme.

System Information	Details
Computer Name	ASUS-PC
Operating System	Windows 8.1 Single Language 64-bit
System Language	Turkish (Regional Setting: Turkish)
System Manufacturer	ASUSTeK COMPUTER INC.
System Model	N550JK
BIOS	N550JK.208
Processor	Intel(R) Core(TM) i7-4700HQ CPU @ 2.40GHz
Memory (RAM)	16384MB
Page File	7065MB used, 20575MB available
DirectX Version	DirectX 11
Graphics Adapter	NVIDIA GeForce GTX 850M
Manufacturer	NVIDIA
Chip Type	GeForce GTX 850M
DAC Type	Integrated RAMDAC
Device Type	Render-Only Display Device
Total Graphics Memory	Approx. 12139MB

2.2. Scanning with a tablet computer with LIDAR sensor

This paper provides a comprehensive review of fast and effective documentation methods using tablet computers with LIDAR sensors. LIDAR is a technology that works on the principle of light detection and distance sensing, and thanks to the advantages of this innovative method, it is possible to make detailed documentation in a short time [2]. In the study, it is emphasised that the advantages of LIDAR such as speed, ease of use in large areas and accessibility to various applications have popularised its use in documentation studies [95,96].

This research, which involved a comprehensive site analysis and documentation process, focused on the documentation of a dwelling in Kültepe. This process involved detailed photographing of the site, creating a 3D model using these photographs, reproducing the model a second time using LIDAR scanning and making the necessary drawings. Polycam and 3D Scanner applications were used in these documentation studies and the main focus of the study is to demonstrate the effectiveness of LIDAR technology and to comparatively evaluate the documentation of the Kültepe archaeological site with different methods. The technical specifications of the 12.9 inch Apple iPad Pro tablet used for LIDAR documentation are as follows: 214.9 mm width, 280.6 mm height, 6.4 mm thickness and 682 grams weight. The LIDAR sensor in this device measures distance using the impulse (TOF) technique. Technical details of the device can be found on the manufacturer's website [97](Fig. 10). The iPad Pro 12.9 device was used to create models of the building through Polycam and 3D Scanner applications.

The main purpose of this study is to systematically document the archaeological site of Kültepe using different documentation methods and to make a comparative evaluation of these methods. This evaluation is important in terms of documenting and analysing the archaeological site in detail and providing guidance for future research. In this context, the contributions of LIDAR technology to the documentation processes and the performance of the different applications used were examined in detail.

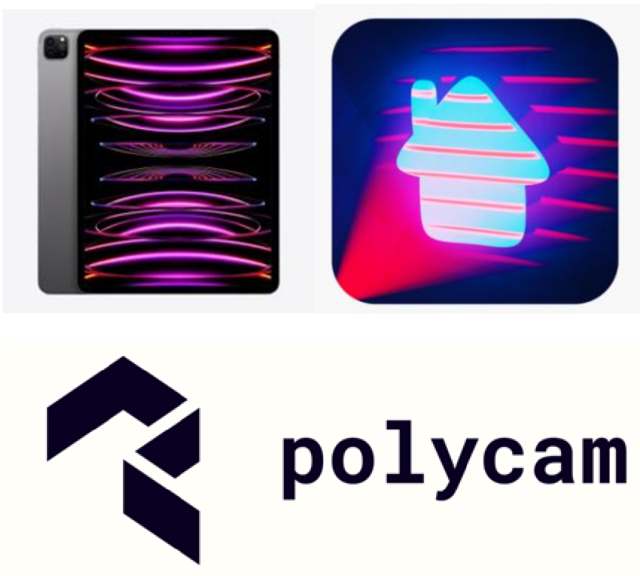


Figure 10. Respectively ipad pro 12.9 device images and symbols [97,98].

3. Results and Discussion

3.1. Documentation by photogrammetric methods

This study focuses on the detailed documentation of a merchant's house in Kültepe. During the photogrammetric documentation process, a total of 2975 vertical and overlapping photographs were taken and modelled using Agisoft Metashape software. The inclusion of corner joints in the photographs is critical for the correct assembly of the model. Of the 2975 photographs taken, 2947 were successfully integrated into the model and the resulting model consisted of a total of 1,927,665 points. In this process, the factors to be taken into consideration during photography are; shooting time, daylight conditions, shadow formation and the size of the working area.

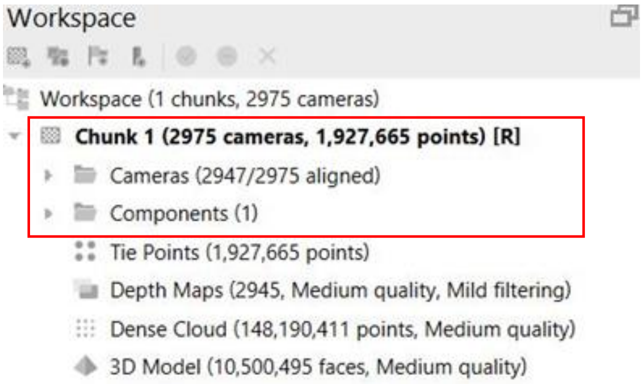


Figure 11. The number of photos transferred to the application and the points formed.

Figure 12. Schematic picture showing the photo shooting points.

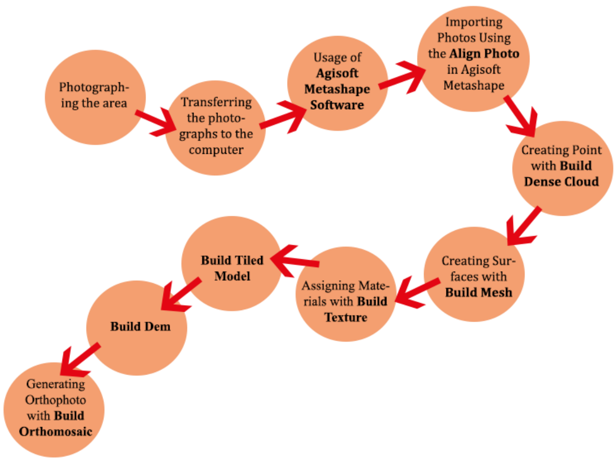


Figure 13. Operation scheme for photogrammetry and agisoft metashape programme.

In this context, it was observed that the size of the study area and the number of photographs taken increased the size of the model and also affected the model formation time. While the photography time took approximately 1 hour, it took approximately 30 hours to transfer the photographs to the programme and build the model. The steps followed in the programme are Align Photo, Build Dense Cloud, Build Mesh, Build Texture, Build Tiled Model, Build DEM and Build Orthomosaic (Fig. 13). With the Orthophoto command of the programme and the points placed on the model, images can be obtained from different perspectives. (Fig. 14). The programme shows the photo shooting points one by one on 3D (Fig. 12).

Figure 14. Model visuals created with Agisoft metashape programme.

Figure 15. Plan drawing drawn on orthophoto created with Agisoft metashape programme.

The plan drawing on the orthophoto obtained with the Agisoft Metashape programme was carried out by transferring the orthophotos to the Autocad programme. (Fig. 15). A sketch plan was quickly made on the orthophoto and the walls, doorways and the general structure of the building were examined in detail on this plan. (Fig. 16). The grave room, courtyard and oven units, which are the distinctive features of the building, are clearly marked on the plan. The other rooms are thought to be the living area, archive room, storage room and kitchen units. The shifts occurring at the points where the walls of the rooms adjoin show that the building contained additions in different periods. It is located on the northern border and southwestern part of the study area in areas that have not been investigated yet. Within the scope of the study, different restitution proposals were developed (Fig. 17).

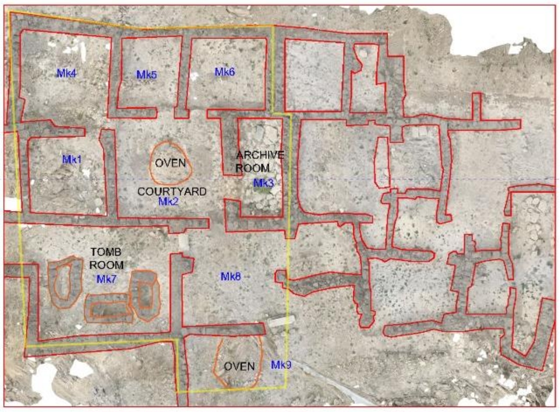


Figure 16. Sketch plan drawing over orthophoto created with Agisoft Metashape programme.

Figure 17. Restitution recommendations.

3.2. Scanning with a tablet computer with LIDAR sensor

3.2.1. Model created with Polycam application

In the methodological part of the study, the field survey using a tablet computer was successfully carried out after several trials using the Polycam application. The scanning time was approximately 30-40 minutes depending on the size of the area and the number of trials. In the first attempts, the video length problem was encountered due to the size of the area and this prevented the completion of the model as a whole. However, as a result of research on the Polycam application's website, the video was processed in parts and the model was successfully completed by making additions using the 'extend' feature of the application.

At this stage, the initial technical difficulties were overcome thanks to the improved features of the application and the use of internet resources. The 'extend' feature offered by the Polycam application facilitated the completion of the model and provided researchers with more comprehensive analysis and documentation. The resulting 3D model made it possible to take plans and sections, thus contributing to the detailed study of the archaeological site and the digital documentation of cultural heritage.

Figure 18. Image of the 3D model taken with Polycam programme in point cloud format.

Figure 19. 3D model images taken with Polycam programme.

The accuracy can be checked by taking measurements on the model created. After the measurements were checked from different places, it was seen that the measurements coincided (Fig. 20). It is visualised by sectioning directly through the programme (Fig. 21). Then drawing is made on this image (Fig. 22).

Figure 20. Comparison of the measurements taken with the Polycam programme and the measurements taken manually.

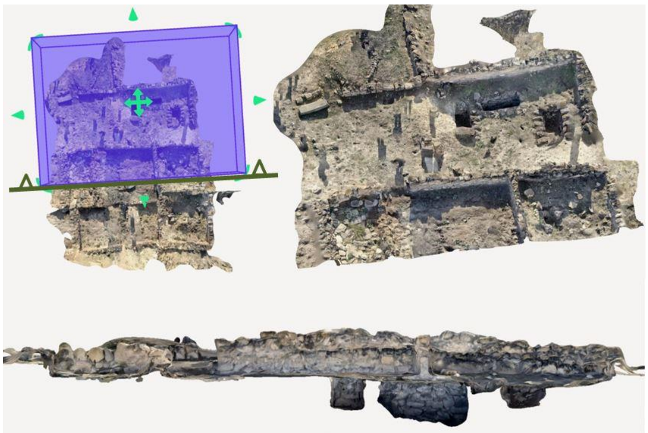


Figure 21. Sectional images taken with Polycam programme.

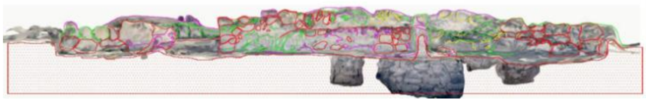


Figure 22. Section drawn in autocad environment over the orthophoto taken with Polycam programme.

3.2.1. Model created with 3D Scanner application

The methodological part of the study deals in detail with the field scanning carried out with the 3D Scanner application used on the tablet computer. The scanning process was completed in a short period of 30 minutes and the processing of the obtained data took approximately 1 minute. The three-dimensional model obtained in this process allowed the creation of orthophotos and plan images from various locations (Fig. 23 and 24). The scanning performed with the 3D Scanner application makes it possible to produce detailed and precise three-dimensional models, providing researchers with more advanced design, analysis and documentation opportunities. It should be noted that the study is in parallel with previous programmes working on similar principles. However, it is stated that the data obtained with this application differ in terms of resolution compared to the Polycam application. The 3D Scanner application has the potential to reach a different resolution level compared to Polycam even in single scans. This makes the data obtained more detailed and precise and provides researchers with more comprehensive analysis and documentation opportunities. In conclusion, the 3D Scanner application used on a tablet computer stands out as an effective tool in archaeological site documentation studies with its fast scanning times and high resolution capacity. The data obtained provide researchers with rich and detailed analysis opportunities and make significant contributions to the digital documentation of cultural heritage. Fig. 25 shows a comparison of the methods.

Figure 23. Plan taken with 3D Scanner application.

Figure 24. Orthophoto taken with 3D Scanner Application.

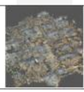
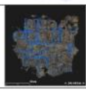
Method Feature	Lidar Sensor	Orthophoto	Plan	Devices Used	Scanning Type Duration	Model Formation Duration	Point Count
Agisoft Metashape Metashape	—			Phone Computer	Approximately 1 hour	30 Saat	2975 Photo 1.927.665 Cloud
Polycam polycam	+			Tablet Computer	Video Approximately 40 minute	2 Dakika	61.000 Cloud
3d Scanner	+			Tablet Computer	Video Approximately 30 minute	1 Dakika	359.000 Cloud

Figure 25. Comparison of methods (Produced by the authors).

4. Conclusion

This study evaluates the combined use of photogrammetry and LiDAR scanning methods in documenting the Kültepe Archaeological Site, representing a significant step forward in the digital documentation of cultural heritage. Despite the challenges and complexities inherent in archaeological documentation processes, the integrated application of these methods has provided notable advantages in terms of speed and accuracy. The use of photogrammetry and LiDAR techniques together offers a faster, more practical, and cost-effective documentation process compared to traditional methods, enabling the meticulous recording of historical layers and structural elements from various periods. These methods, in particular, have proven critical in digitally reconstructing cultural heritage elements that are physically damaged or entirely lost.

The three-dimensional models and orthophotos produced as part of the research have not only contributed to scientific studies but also established a robust informational infrastructure that can be referenced in restoration and conservation projects. These digital datasets have facilitated a detailed analysis of spatial organization within its historical context, providing deeper insights into the developmental phases of structures. For instance, functional transformations identified in the architectural plans of merchant houses have allowed for a detailed interpretation of spatial organization linked to economic and cultural shifts. Such findings offer concrete data for strategic planning aimed at preserving the archaeological site and passing it on to future generations.

Additionally, the restoration and reconstruction efforts undertaken at the Kültepe Archaeological Site have been presented to visitors as part of experimental archaeology initiatives, enhancing the comprehensibility of the area. The completed restoration of one house and the experimental reconstruction of other dwellings have showcased the historical significance of the site in a tangible way, while also promoting the cultural heritage to a broader audience. Furthermore, the addition of a visitor center has contributed to the site's security and increased its tourism potential. These developments underline the potential of Kültepe to serve as a model site for the integration of cultural heritage management and tourism.

While a scientific excavation may be defined as a meticulously recorded destruction, careful documentation during and after excavation is essential for interpreting and preserving the findings. Given the detrimental effects of nature, human activity, and time, leveraging modern technological methods is crucial for the sustainable preservation of cultural heritage. In this regard, the integration of photogrammetry and LiDAR scanning methods has not only accelerated archaeological data collection processes but also set new standards by generating highly accurate datasets.

In conclusion, this study has demonstrated the effective application of modern digital methods in documenting and interpreting the multilayered structure of Kültepe Karum. The combined use of photogrammetry and LiDAR scanning methods has provided archaeologists and cultural heritage experts with the opportunity to conduct comprehensive analyses across extensive areas. The cost-effective and practical nature of these methods opens new horizons for the preservation, documentation, and restoration of cultural heritage. The Kültepe case highlights the necessity of integrating digital technologies into archaeology and illustrates how these technologies can be effectively utilized in cultural heritage management through interdisciplinary approaches. The findings of this study serve as a significant reference for future research and practices aimed at the sustainable preservation of cultural heritage.

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Author contributions

Leyla Kaderli: Conceptualization, Methodology, Field study, Discussions, Writing-Reviewing and Editing **Mehmet Tarık Öğreten:** Conceptualization, Methodology, Field study, Discussions, Writing-Reviewing and Editing **Betül Gül Hüsrevoğlu:** Conceptualization, Methodology, Field study, Discussions, Writing-Reviewing and Editing

Conflicts of interest

The authors declare no conflicts of interest

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