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Rock-cut vernacular architecture in northeastern Kayseri: Architectural characteristics and conservation challenges

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Abstract

The rock-cut heritage of the Kayseri Valleys represents a distinctive vernacular tradition shaped by technological skill, social practices, and environmental adaptation. These systems, evolving from carved spaces to masonry and then reinforced concrete, represent both tangible and intangible heritage, connecting past construction knowledge with community identity and collective memory while adding to the valleys' unique cultural landscapes. This study examines the relationship between rock-cut construction techniques and the topographic context of the Koramaz and Gesi Valleys. Using archival research, field surveys, and systematic documentation, it records settlement forms, underground cities, hillside shelters, dovecotes, and related production areas, along with their connections to daily life and agricultural activities. Through on-site observations, spatial measurements, and photographs, the research shows how these features are spread across mound, slope, and basin settlements, illustrating the link between geological conditions and architectural practices. The analysis emphasizes how these spaces were organized, adapted, and combined over time, demonstrating the deep relationship between geology, settlement, and material culture. The findings highlight major conservation challenges, including abandonment due to demographic changes, functional shifts driven by modern needs, material decay from neglect, the loss of craftsmanship, and unregulated interventions that threaten structural integrity. Additionally, the near extinction of rock-cut building as a living practice endangers the continuity of related knowledge systems. Focusing on both their tangible and intangible aspects, the study advocates for conservation strategies based on socio-cultural continuity, community involvement, and sensitive adaptive reuse. This comprehensive approach is crucial to preserving the Kayseri Valleys as dynamic cultural landscapes while maintaining their relevance for future generations.

Keywords: historic buildings, memory, perception, physical experience, virtual reality experience

1. Introduction

Vernacular construction techniques represent some of humanity's most enduring responses to building locally available materials and deeply embedded knowledge systems (Oliver, 2006; Vellinga, 2013; Jokilehto, 2006). Developed through centuries of empirical practice, these methods reflect an intimate understanding of material behavior, structural principles, environmental conditions, and cultural needs (Rapoport, 1969; Asquith & Vellinga, 2006). Unlike formal architectural traditions grounded in written treatises and professional training, vernacular construction knowledge is transmitted through apprenticeship, community participation, and intergenerational practice (Rudofsky, 1964; Alexander et al., 1977).

The status of vernacular construction in heritage policy has expanded over recent decades. UNESCO's recognition of cultural landscapes and intangible heritage reframed traditional building methods as embodying both tangible and intangible values (UNESCO, 2003, 2011). This dual character complicates conservation efforts by requiring not only the material preservation of these practices but also the safeguarding of the knowledge systems and skills that sustain them (Smith, 2006; Harrison, 2013; Avrami et al., 2000).

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Recent scholarship highlights the alignment between vernacular construction and contemporary sustainability goals. Traditional techniques naturally incorporate principles of low-carbon building, circular resource use, and climate-responsive design (Zhai & Previtali, 2010; Fernandes et al., 2015). Their dependence on locally sourced materials and passive environmental control methods reduces embodied energy and strengthens place-based ecological knowledge (Elert et al., 2021). In this way, protecting vernacular practices also preserves environmentally smart knowledge crucial for shifting toward sustainable development models.

Beyond its environmental aspect, vernacular construction represents cultural sustainability through the ongoing transmission of tacit building knowledge, community-based craftsmanship, and locally rooted ways of life (Polanyi, 1966; Pallasmaa, 2009). Recognizing vernacular practices as living heritage highlights their role in maintaining place-based identities and collective memory (Smith, 2006; Harrison, 2013). International frameworks such as UNESCO's 2003 Convention on Intangible Cultural Heritage and the Historic Urban Landscape Recommendation (2011) explicitly support integrating these cultural practices into conservation efforts. Theoretical perspectives on vernacular environments have evolved from Rapoport's (1969) focus on house form and culture towards frameworks that examine the interplay of environmental adaptation, embodied knowledge, and spatial practice (Asquith & Vellinga, 2006). This literature underscores how vernacular techniques emerge from iterative problem-solving and reflect dynamic interactions between people, materials, and landscapes.

Among the environmental factors influencing vernacular construction, topography is particularly important yet often overlooked. While much research has focused on climate adaptation and material use, fewer studies have explored how terrain morphology, such as slopes, depressions, ridges, and valleys, affects building techniques and knowledge systems (Smith, 2006; Lawrence & Low, 1990). Topography shapes material access, foundation choices, structural stability, drainage methods, and microclimate adaptation, integrating environmental awareness into traditional construction practices. Recent research has started to fill this gap by documenting terrain-sensitive building practices through case studies of hillside, valley, and ridge settlements. Slope-adaptive construction uses terracing, stepped foundations, and gravity-fed infrastructure (Treacy & Denevan, 1994; Allen, 1969), while valley settlements feature advanced drainage systems, flood-resistant structures, and soil stabilisation techniques (Jackson, 1984; Morgan, 1990). Ridge and exposed-site construction employs wind-resistant detailing and logistical strategies for material transport under difficult conditions (Oliver, 2006). These examples show vernacular construction as an integrated response where environmental adaptation and cultural practice come together.

This study examines the rock-cut as a vernacular approach to settlements in the northeastern valleys of Kayseri, where these techniques are still visible in the structures and linked to local daily practices. It analyzes how rock-cut construction reflects the relationship between topography, environmental adaptation, and cultural traditions across mound, hill, and lowland settlements. The research also considers the conservation challenges these settlements face. Using field documentation, archival research, and spatial analysis, the study aims to develop strategies to preserve both their physical integrity and the traditional knowledge systems inherent in rock-cut architecture.

2. Vernacular Construction as Cultural Heritage: Conservation Treats

The recognition of vernacular construction within international heritage policy has gradually evolved, reflecting a shift from protecting monuments to acknowledging ordinary buildings and settlement ensembles. Early milestones, such as the World Heritage Convention (UNESCO, 1972) and the European Charter of the Architectural Heritage (CoE, 1975), marked an important change by expanding the definition of heritage to include "groups of buildings" and characteristic rural villages that embody regional identity.

By the 1980s and 1990s, focus shifted from just listing vernacular sites to protecting the knowledge that keeps them alive. The Granada Convention (CoE, 1985) emphasized support for "declining craft trades," while UNESCO's Recommendation on Traditional Culture and Folklore (1989) called for documenting and transmitting building-related skills. This approach was consolidated in the Vernacular Charter (ICOMOS, 1999), which underscored the dependence of vernacular heritage on the continuity of practice rather than the preservation of isolated forms. This broadened perspective provides an early framework for interpreting the Kayseri valleys, where rock-cut dwellings form landscape-scale ensembles shaped by their topographic contexts.

Since the 2000s, heritage policies have increasingly connected vernacular construction with broader cultural rights, sustainability, and landscape-based approaches. The Intangible Heritage Convention (UNESCO, 2003) formally acknowledged traditional craftsmanship, while the Faro Convention (CoE, 2005) reframed heritage as an evolving relationship between people and place. The Historic Urban Landscape Recommendation (UNESCO, 2011) and the ICOMOS-IFLA Principles concerning Rural Landscapes (2017) emphasized the ecological and social contexts that shape vernacular settlements and endorsed landscape-scale perspectives for their conservation. These perspectives are particularly useful for interpreting vernacular settlements situated within distinct geomorphological settings, where construction practices, spatial organisation, and environmental adaptation operate as interconnected systems.

Building on this policy context, a review of recent studies indexed in the Web of Science (WoS) database shows that conservation challenges related to vernacular architecture mainly revolve around five recurring themes: physical deterioration, rural abandonment, loss of craftsmanship and building knowledge, depletion of material resources, and inappropriate interventions. Together, these themes highlight the interconnected technical, social, cultural, and ecological aspects that influence conservation practice.

Physical deterioration remains one of the most visible threats, especially in earthen, stone, and timber structures that depend on regular maintenance. Mileto and López-Manzanares (2022) emphasize how earthen buildings are highly susceptible to weathering and how a lack of routine maintenance speeds up their decay. Similarly, Elert et al. (2021) discuss issues such as water infiltration and material erosion in traditional stone. Fouseki and Cassar (2014) connect climate-driven temperature and humidity changes to increased deterioration rates.

Alongside material decay, rural abandonment and depopulation disrupt the continuity of both buildings and the landscapes they anchor. Martínez et al. (2022) document how deserted villages in Spain experience simultaneous structural collapse and a loss of cultural identity, while Samalavicius and Gabrenas (2022) note that semi-urban vernacular buildings in Lithuania risk disappearance unless they are adaptively reused. Ellis Burnet et al. (2021) argue that abandonment erodes the cultural landscapes that give meaning to these settlements. These dynamics resonate with the situation in parts of the Kayseri valleys, where reduced permanent habitation diminishes routine upkeep and contributes to the gradual deterioration of rock-cut dwellings.

Loss of craftsmanship and construction knowledge poses a major challenge for the long-term continuity of vernacular environments. Philokyprou and Michael (2021) note that intergenerational knowledge transfer has diminished in Cyprus, worsened by a lack of formal training in traditional construction. Similar concerns appear in stone-based traditions, where the declining number of skilled artisans threatens the viability of specialised techniques (Elert et al., 2021). As Fathy (2010) emphasizes, knowledge embodies not only technical conservation but also maintaining local identity and memory.

The depletion of traditional material resources further complicates conservation difficulties. Studies note how the closure of local quarries or shifts toward industrial substitutes restrict the availability of materials compatible with historic construction systems (Elert et al., 2021; Baquedano et al., 2021). As Zong et al. (2024) warn, ignoring resource sustainability challenges ultimately risks long-term vernacular conservation strategies.

Finally, inappropriate interventions often accelerate the loss of vernacular character. Samalavicius and Gabrenas (2022) describe modernization-driven restorations in Lithuania that weaken vernacular character. Bahramifar et al. (2022) show how incompatible changes in Iran undermine both environmental adaptability and cultural coherence. Similarly, Zong et al. (2024) note how poorly planned restorations damage material integrity, and Arfa et al. (2022) connect such practices to disruptions in local aesthetics and spatial logic.

Taken together, recent literature clearly shows that conserving vernacular architecture extends far beyond addressing material decay or structural repair. It requires sustaining the socio-cultural processes, ecological relationships, and practical knowledge systems that enable these environments to function as living heritage. This closely aligns with the integrated vision outlined by UNESCO (2011) and ICOMOS-IFLA (2017), in which vernacular construction is viewed not only as a tangible heritage resource but also as a living practice that supports cultural continuity and long-term resilience.

This conceptual and policy-oriented framework provides a critical basis for interpreting the conditions observed in the Kayseri valleys. The deterioration mechanisms, demographic shifts, declining craftsmanship, and intervention pressures identified in global studies closely mirror the challenges facing the region's rock-cut settlements. At the same time, the literature's emphasis on knowledge continuity, landscape-based interpretation, and community–place relations help explain why Kayseri's vernacular environments cannot be understood solely through their physical form. Rather, they represent a topo-cultural system shaped by long-standing construction practices, ecological adaptation, and everyday use. This alignment between global debates and local evidence establishes the analytical foundation for the case study that follows.

3. Materials and Methods

Kayseri has served as a significant cultural and commercial hub since the Chalcolithic period, sustaining its prominence through the Assyrian, Hittite, Phrygian, Roman, Byzantine, Seljuk, and Ottoman eras. Historical sources document the establishment of Assyrian karums (trading colonies) connected to Kaniş-Karum in Kültepe (Yurt Ansiklopedisi, 1982), while population movements from the 11th century onwards, including Armenian relocations during the Byzantine period, reshaped the region's demographic composition (Kévorkian & Paboudjian, 2012). Over time, the coexistence of Greek, Armenian, and Turkish Christian communities fostered a complex cultural landscape that continues to define Kayseri's rural valleys (Özkan, 2000).

The study area encompasses the Koramaz and Gesi Valleys, located approximately 20 km northwest of Kayseri. Gesi Valley, situated between the Koramaz and Derevenk Valleys, includes Yeşilyurt, Bağyurdu, Bahçeli, Kayabağ, and Güzelköy, while Koramaz Valley comprises Bağpınar, Vekse, Turan, Ağırnas, Küçükbürüngüz, Subaşı, and Büyükbürüngüz (Figure 1). The Koramaz Valley, listed on the UNESCO Tentative List in 2020 (Criterion V), illustrates long-term human–environment interaction shaped by volcanic geology, agricultural potential, and distinctive rock-cut architecture, including underground cities, dovecotes, and rock-cut churches (UNESCO, n.d.; Güngör Açıkgöz, 2007).

Research on rock-cut heritage has largely prioritized monumental and archaeological contexts, focusing on material decay, analytical techniques (e.g., micro-Raman, petrography), and geotechnical risk (Pelosi et al., 2016; Özata et al., 2024; Tunusluoğlu & Zorlu, 2009). Studies in comparable regions, such as Cappadocia, emphasize the conservation of ecclesiastical rock-cut sites (La Russa et al., 2014). However, vernacular rock-cut settlements, encompassing inhabited cave clusters, domestic architecture, and production facilities, remain underexplored, particularly regarding their integration into living heritage and environmental adaptation systems.

To address this gap, the study adopted a three-stage qualitative methodology combining archival research, spatial analysis, and systematic field surveys. Archival sources established a

historical and typological framework for the valleys' settlements. Field documentation involved in-situ observations, photographic recording, spatial measurements, and material assessments of rock-cut and masonry structures. Production-related carved spaces (e.g., dovecotes, oil mills) and agricultural tools were also recorded to contextualize daily life practices within the built landscape.

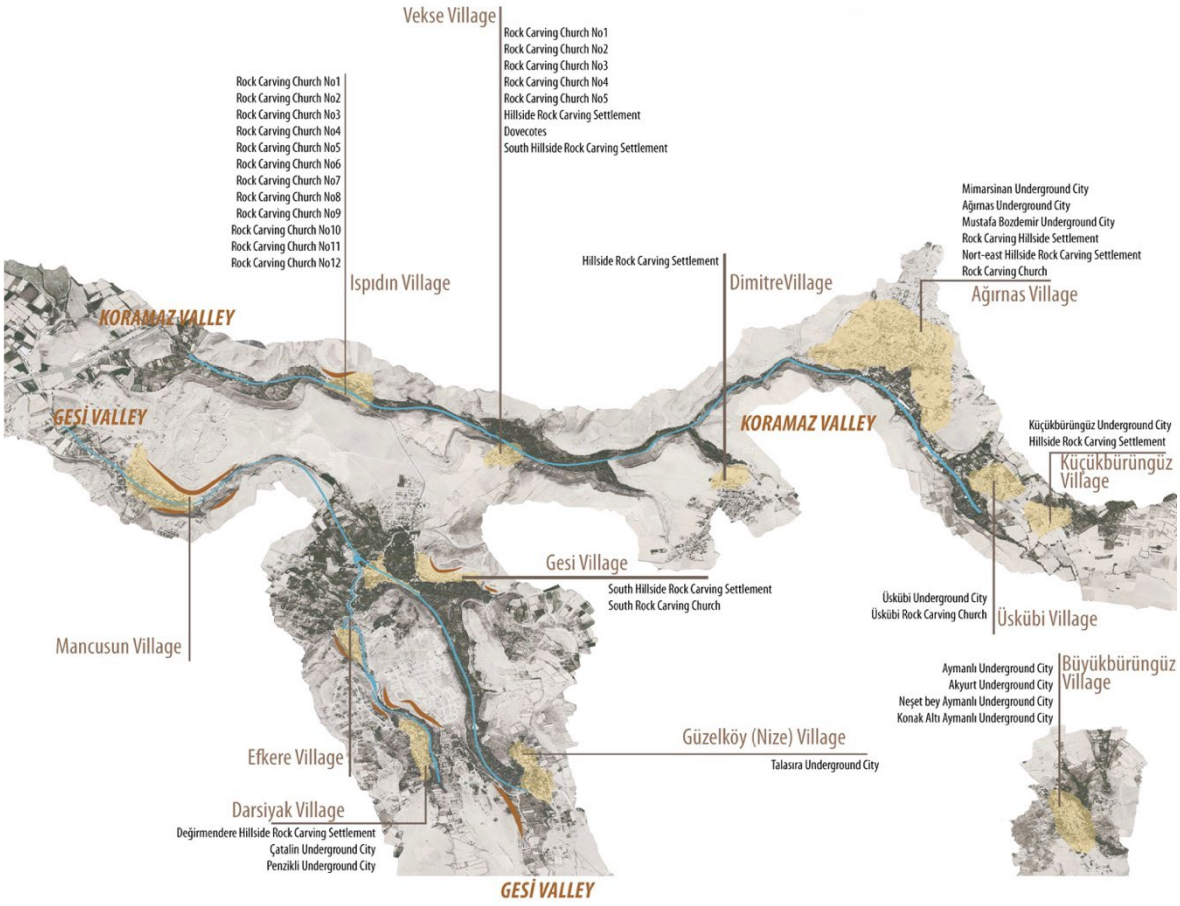

Figure 1 Map of settlements located in the Gesi and Koramaz valleys and their documented rock-cut structures

The data were analyzed comparatively, linking settlement typologies with geomorphological conditions such as valley slopes, volcanic tuff formations, and hydrological systems. Conservation threats, including material deterioration, unsympathetic alterations, and the erosion of traditional craftsmanship, were identified during fieldwork and cross-referenced with recent literature. Finally, findings were synthesized to develop context-sensitive conservation strategies that integrate local knowledge, ecological constraints, and sustainable heritage management practices.

4. Rock-Cut Construction System of Northeastern Kayseri

Rock-cut architecture represents one of the most striking examples of topographic adaptation and specialized construction techniques within vernacular traditions. Carved directly into geological formations, these settlements demonstrate an exceptional integration of site conditions with building practices (Ousterhout, 2017; Rodley, 1985). Unlike surface construction, rock-cut techniques required knowledge of geology, excavation methods, and structural behavior. Builders read rock stratigraphy, planned safe excavation sequences, and designed support systems suited to carved spaces (Bianca, 2000; Kostof, 1991; Heyman, 1995).

Beyond structure, these traditions employed the thermal mass of rock, natural ventilation, and moisture control to create stable interiors (Givoni, 1976). Carved spaces also carried symbolic and cultural significance, evident in their ritual alignments, acoustics, and visual connections to the landscape (Jackson, 1984; Cosgrove, 1984; Schafer, 1977; Pallasmaa, 2009).

To contextualize these traditions, the selected study area in Kayseri provides a unique example where geological conditions and cultural practices are deeply intertwined. Understanding these rock-cut traditions also involves examining the geological and geomorphological factors that have shaped both the landscape and settlement patterns of the region. The volcanic nature of Mount Erciyes has resulted in a karst-like topography. Eruptions that continued until approximately 2000 years ago formed the volcanic cones and rocks observed in the area today. The pyroclastic rocks, ejected from volcanoes and now covering nearly all of Kayseri, are mostly porous and easily eroded, such as tuff and ignimbrite. The mineral composition of these pyroclastic rocks, which range in color from light yellow to black, varies between eruptions (Yamaç, 2017). The eastern part of Kayseri is filled with valleys carved by streams flowing from high hills to the plain. Most of these valleys run parallel to each other from north to south, with occasional connecting branches created by stream bifurcations.

In this context, Binan's (1994) classification of Cappadocian settlement patterns into three groups, flat terrain, valley slope, and large volcanic tuff bases, and her identification of three rock-cut systems (underground, rock-cut, and slope-cut settlements) serve as a helpful reference. This typology aligns with patterns seen in the study area and will guide the comparative analysis of mound, slope, and hollow settlements. Using this approach, the connection between topography, construction techniques, and habitation practices in the study area can be critically discussed.

4.1. Layers of Rock-Cut Constructions

4.1.1. Underground Cities

The history of Kayseri, situated in the same geographical region as Cappadocia, stretches back thousands of years, with settlements in the area dating to the Neolithic period. Yet it remains unclear when the region's volcanic tuffs were first carved or when its inhabitants began to make the underground their home. The continuous use of these rock-cut spaces over millennia has made it nearly impossible to uncover clear archaeological answers to these questions.

Much like Cappadocia, this region is home to numerous underground cities that have yet to be fully explored or connected. Documenting these cave networks is particularly challenging because many lie directly beneath present-day towns and villages. The overlap between ancient underground spaces and modern settlement patterns creates complex difficulties for documentation and management, a challenge widely noted in the literature (Sani et al., 2012; Kilit & Dişli, 2022). Continuous occupation over centuries, later structural additions, and integration with surface parcels have further obscured their original layouts and purposes (Ulusay et al., 2006).

These underground cities are mostly concentrated in elevated and flat sections of the plateau, known as "mound settlements." According to the OBRUK Cave Research Group, ten such sites have been identified in the region. Seven are located in the neighborhoods of Büyükbürüngüz (2), Subaşı (1), Küçükbürüngüz (1), and Ağırnas (3), while three others are found in the Gesi Valley, in Kayabağ (2) and Güzelköy (1) (Kayseri Metropolitan Municipality, 2017, 2020). Research in the region, along with the discovery of "gate stones" sealing defensive tunnels, suggests that these underground settlements were built by Christian communities between the 7th and 10th centuries to protect themselves from Arab invasions (Kayseri Metropolitan Municipality, 2017, 2020).

As a prominent example, Ağırnas Underground City illustrates both the defensive function and the multi-layered nature of these rock-cut settlements (Figure 2). Covering an area of approximately 1,850 m², it features sliding stone doors, barrel-vaulted halls, storage spaces, and multi-level living areas typical of Cappadocian underground architecture. Excavation and cleaning works carried out between 2006 and 2008 led to the restoration and partial opening of the site to visitors. Today, the sections that have been cleared are accessible to the public, while other parts remain either unexplored or still locally used. This site vividly reflects the historical continuity of rock-cut habitation in the region (Yamaç, 2017).

Figure 2 Left: Ağırnas Mimarsinan House underground city, right: Ağırnas north-east hillside rock carving settlement (Kayseri Büyükşehir Belediyesi, 2020)

Figure 3 Carving spaces under and back to the masonry houses (Bağpınar)

Spatially, these underground cities are organized into interconnected narrow passages and low tunnels that open into larger "salon" spaces, typically spread across two or three levels. Unlike hillside settlements, they have no facades visible from the surface and are accessed only through hidden entrances. Ventilation is provided through vertical shafts reaching the surface (Yamaç, 2023). Altogether, these underground complexes tell a vivid story of adaptation to defensive needs, life carved into the earth, and the layered coexistence of history within living settlement patterns (Figure 3).

4.1.2. Rock-cut Hillside Shelters

Building on the typological framework outlined above, the second major formation seen in the valleys includes hillside settlements or shelters, which developed along the steep slopes typical of the study area. Carved into these inclines, they feature outward-facing facades and demonstrate how dwellings adapted to the rugged topography. The tradition of hillside settlement continued in a way that closely resembled the layout of today's neighborhoods until recent times. For centuries, most valley villages have been built on steep terrain, where modern houses often sit atop earlier rock-cut spaces, making it difficult to interpret their original purposes. Unlike underground cities, hillside settlements rarely have extensive tunnel networks; instead, short passages connect only a few interior spaces, with entrances opening directly from the valley's surface. These entrances are located at different elevations along the slopes, usually above watercourses and terrace gardens (Figure 4).

Figure 4 Rock-cut hillside shelters examples from Vekse (Koramaz Valley)

Beyond open spaces, hillside settlements include structures like churches, columbaria, pigeon lofts, livestock enclosures, defensive features, and storage rooms. Similar to underground cities, stone masonry walls serve as exterior boundaries and interior divisions, although many seem to be later additions. Most of these spaces are single-story, though there are also examples with two stories (Figure 5). Currently, 13 hillside settlements have been identified in the valleys. In Koramaz Valley, there are 11 such settlements: 1 in Subaşı, 1 in Küçükbürüngüz, 4 in Ağırnas, 1 in Turan, 1 in Vekse, and 3 in Bağpınar. In the Gesi Valley, 2 hillside settlements are located in Kayabağ and Güney (Kayseri Metropolitan Municipality, 2017, 2020).

Figure 5 Left and middle: Entrances of Değirmendere hillside rock carvings, right: Entrances of rock carving spaces (Bağpınar)

In addition to these settlements, isolated rock-cut structures are also present on the valley slopes. Among them, churches and columbaria stand out as the most prominent. Numerous undergrounds and above-ground churches belonging to different sects and ethnic groups reflect the region's historical and demographic diversity (Güngör Açıkgöz, 2007). Today, these churches are registered and protected by the Kayseri Regional Council for the Conservation of Cultural Property, although many have been damaged by treasure-hunting activities. They vary greatly in size and decorative details, similar to those in Cappadocia. Another notable type is the rock-cut columbaria, funerary structures dating back to the Roman Empire, several of which have been identified in the valleys. These consist of conical chambers with small niches carved into the walls

to hold urns of cremated remains. Because they resemble pigeon lofts, which were used as agricultural storage facilities, they can be hard to tell apart. In Koramaz Valley alone, 42 rock-cut churches, 11 Roman tombs, and 6 likely columbaria have been documented (Yamaç, 2023).

4.1.3. Rock-cut Daily Life Elements

One of the most common structures in the valleys is the dovecote. Unlike similar examples elsewhere in Anatolia, these pigeon lofts evolved locally as specialized production structures adapted to the region's environmental and socio-economic conditions (Figure 6). They provide insights into agriculture, trade, and daily life during the Ottoman period, particularly through their association with vineyards and buckthorn cultivation, when dove manure had notable economic value (İnceköse, 2019). As water availability declined, pigeon breeding ceased, and the structures were abandoned, becoming prominent cultural landscape markers, especially in Gesi and Koramaz Valleys. Architecturally, dovecotes combine carved chambers with stone-masonry chimneys serving as bird entrances. Many former rock-cut spaces, including churches, Roman tombs, and columbaria, were later converted into dovecotes, complicating dating efforts and obscuring stratigraphic evidence (Yamaç, 2023).

Figure 6 Yeşilyurt (Mancusun) dovecotes, middle: Inside of dovecote, right: A changed carving space as dovecote (Kayabağ)

Documentation studies also addressed daily-use objects shaped from rock, illustrating the adaptation of natural resources to local production (Figure 7). These include animal-husbandry structures (barns, stables), plant-based facilities (dye houses, oil mills), and carved agricultural tools. Bezirhane processed linseed oil for food, lighting, and craft uses, while şırahane served as communal sites for molasses making. Tools such as seten (vertical millstone), soku (stone mortar), and dorak (dairy container) supported grain milling and dairy processing, reflecting how subsistence practices shaped rock-carving traditions (Kevseroğlu et al., 2021).

Figure 7 Left to right: Oil mill (Bezirhane), vertical millstone (Seten), stone basin (Sirahane), stone mortar (Soku)

4.2. Underground Valley Morphology and Settlement Typologies

Valley orientation and topographic slope are naturally decisive factors in determining settlement locations. In such terrains, proximity to transportation routes or water sources is typically prioritized (Sümerkan, 1990). However, in the Koramaz and Gesi valleys of Kayseri, the presence of rock-cut construction systems is also observed to influence site selection. While these valleys differ in residential patterns, they share similar topographic and morphological

characteristics. Fertile flatlands near water sources are generally allocated for vineyards and garden agriculture, whereas the rocky mid-slopes are designated for cehri (Rhamnus petiolaris) cultivation. At higher elevations, dovecotes are found. Areas outside these zones, particularly mounds and flat lands, have historically been used for agricultural production.

Accordingly, settlements within the valleys can be categorized into three main morphological types: hillside, plateau, and basin (depression) settlements. While the organization of productive areas exhibits continuity across all types, the relationship between settlements and the topography, and thus the configuration of rock-cut spaces, varies significantly (Figure 8).

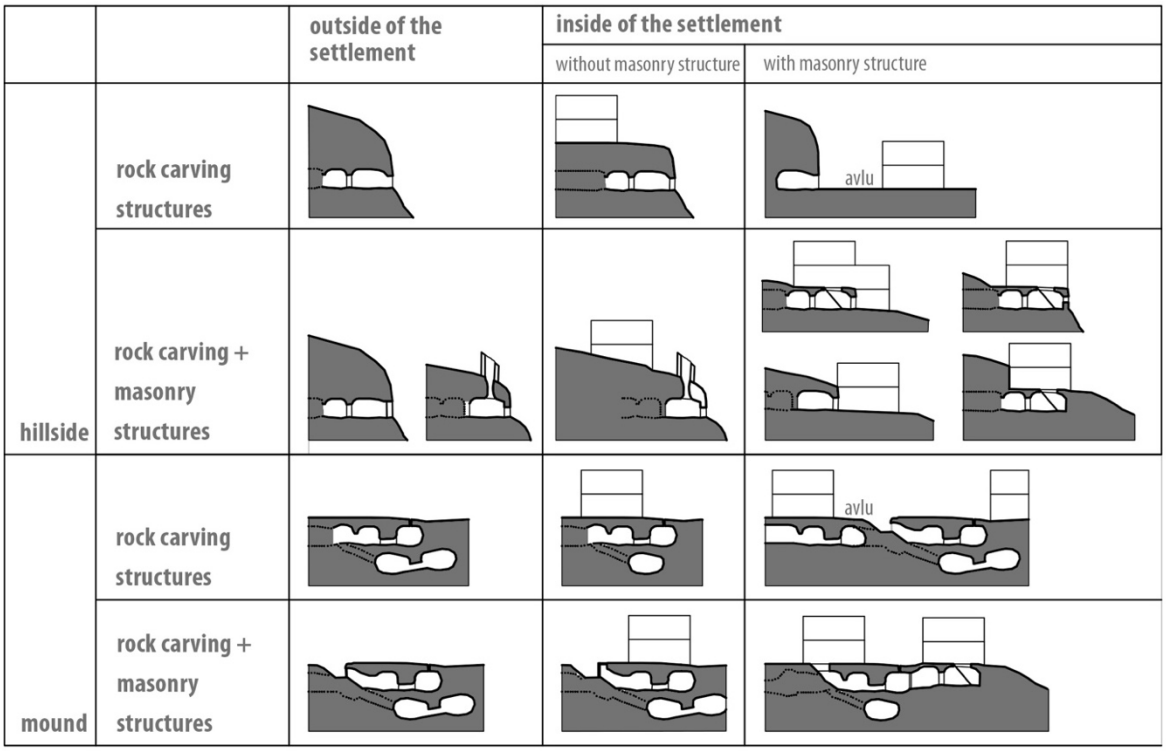

Figure 8 Rock carving relation with the settlement on the hillside and mound

Figure 9 Hillside shelter rock-cut settlement relationship

Hillside settlements exhibit a morphology that extends the tradition of rock-cut slope dwellings. Contemporary masonry houses are built atop or adjacent to earlier carved spaces, resulting in a hybrid typology. These houses often incorporate “in” spaces, rock-cut units, independent or shared, divided by masonry walls. Cubic masonry structures are aligned perpendicularly to the streets on narrow plots, with façades facing the valley. Although they appear two-storied from the street, the terrain slope causes them to read as three or four stories from the valley side. Lower levels house service spaces such as stables, cellars, or storerooms, all physically connected to upper-level living

areas through vertical and horizontal circulation elements. Carved spaces may be attached behind, below, or alongside the masonry buildings, often integrated at different levels or separated by small courtyards. Additions and reinforcement walls introduced over time complicate the identification of original functions. Due to their microclimatic advantages, particularly constant humidity and temperature, many of these carved areas are still used for storage today. Isolated shelters located further from the core settlements often serve as barns or haylofts (Figure 9).

Figure 10 Hillside settlement example from Bağpınar (Koramaz Valley)

Hillside settlements also provide insights into the evolution of morphology over time. Abandoned structures in Bağpınar and Vekse indicate earlier phases of expansion, while newer masonry buildings reflect subsequent growth. Present-day settlements now extend to the flat upper agricultural lands. In Ağırnas, however, former hillside areas have been almost entirely abandoned, with recent development concentrated on flatter terrain (Figure 10).

Plateau settlements, exemplified by Ağırnas and Büyükbürüngüz, are located in high and level areas and are closely associated with underground cities. Two-story stone masonry houses are arranged around large plots and courtyards, opening onto wide roads and squares. Unlike the shared gardens seen in hillside villages, each household in plateau settlements typically has its own private garden. Beneath these settlements, extensive underground spaces, sometimes reaching under homes, gardens, and roads, form expansive cave systems. Access is usually provided through vertical circulation shafts descending from courtyards or gardens. Masonry walls observed in these underground spaces suggest a subdivision pattern that reflects the above-ground parcel layout. However, there is no clear morphological continuity between underground and surface structures. Due to the lack of systematic documentation, most available data come from individual studies. Compared to the isolated, small-scale shelters found in hillside or basin contexts, the rock-cut spaces in Ağırnas and Büyükbürüngüz are larger, more complex, and more directly integrated with surface architecture (Figure 11).

Figure 11 Plateau settlement example from Büyükbürüngüz (Koramaz Valley)

Figure 12 Basin settlement example from Mancusun (Gesi Valley)

Basin settlements, represented solely by Yeşilyurt, differ from the others due to their position at the lowest point of the valley, near water sources and gardens. Although the terrain is not completely flat, it is more gently sloped than elsewhere. In the upper parts of the village, narrow and deep plots are arranged along stepped streets, forming a dense and continuous urban fabric. In contrast, the lower sections feature broader, near-square plots with larger houses and extensive gardens. No integrated carved spaces are observed within the masonry fabric of basin settlements,

though isolated rock-cut shelters exist along the valley slopes, generally serving as storage or agricultural service areas (Elagöz Timur et al., 2018). Unlike hillside and plateau types, basin settlements show little to no direct relationship with rock-cut traditions (Figure 12).

In sum, hillside settlements exhibit continuity with carved slope spaces; plateau settlements are more closely linked to underground cities; and basin settlements largely diverge from the rock-cut tradition. Nevertheless, shared elements such as water sources, cehri (Rhamnus petiolaris) gardens, dovecotes, and agricultural land create a unified cultural landscape across all settlement types.

5. Results and Findings

The heritage importance of vernacular construction techniques can be assessed using established cultural heritage evaluation frameworks adapted to intangible dimensions, recognizing their dual role as technical knowledge systems and community-rooted cultural practices (Australia ICOMOS, 2013; Mason, 2002). The rock-cut heritage of the Kayseri Valleys exemplifies this duality. These structures preserve evidence of historical technological development, from carved spaces to later masonry and reinforced concrete, while also reflecting long-term cultural adaptation shaped by local economies and social organisation. They also represent empirical knowledge systems grounded in a sophisticated understanding of local stone materials, carved-space construction, environmental regulation, and site-specific adaptation, insights highly relevant to sustainable building and climate-responsive design. Aesthetically, these techniques contribute to distinctive landscapes shaped by cultural preferences, material availability, and environmental conditions, producing authentic expressions of place-based identity.

As discussed in Section II, the main conservation challenges affecting vernacular systems include physical deterioration, abandonment, loss of craftsmanship, depletion of material resources, and inappropriate interventions (Figure 13 and Figure 14). Fieldwork in the Kayseri valleys confirms the presence of all five, but in forms shaped specifically by the region's rock-cut construction logic and topography. Abandonment emerges as the most influential driver, triggering cascading effects such as reduced maintenance, structural exposure, and the erosion of craft knowledge.

Figure 13 Various deterioration due to the natural and human-induced effects

A second phase of abandonment has emerged as rock-cut structures have increasingly failed to meet modern living standards. Independent carved spaces are no longer in use, though hybrid structures combining masonry and rock-cut elements remain partially inhabited. Functional changes have also taken place: spaces used for production, religion, or residence were repurposed for animal husbandry or storage; rock-cut tombs became dovecotes (Yamaç, 2023). The later decline in pigeon breeding and bans on animal husbandry under urban reclassification led to further abandonment. Field observations indicate that fully carved units located on steep slopes with limited access are predominantly vacant, whereas hybrid structures on more accessible terraces continue to be used. These changes are reflected in physical traces such as blocked openings, soot accumulation, and surface abrasion, which provide direct spatial evidence of how changing use patterns have accelerated abandonment (Figure 15).

Figure 14 Conservation problems due to the abandonment

Rock-cut techniques, which have a unique construction logic and spatial organization, often conflict with modern needs (Elagöz Timur & Asiliskender, 2024). Although adaptive reuse has helped preserve them, unregulated modifications, such as subdividing or reinforcing weakened underground areas, have compromised archaeological integrity. Field observations reveal that such interventions are particularly evident in hybrid structures, where later masonry additions and infrastructural adjustments disrupt the original spatial continuity of carved spaces. Urban infrastructure projects, like road widening and heavy vehicle traffic, have caused collapses and uncontrolled infill (Figure 15).

Figure 15 Inappropriate interventions

Material decay, mainly caused by deterioration and interventions, includes erosion, salt efflorescence, soot deposits, moisture issues, and biological growth, although no major structural failures were observed. Field observations conducted in the valleys confirm that these forms of decay are most evident in carved interiors subjected to altered use patterns and limited maintenance. Their scattered distribution also makes them susceptible to vandalism. This spatial dispersion, particularly in isolated hillside and peripheral units, complicates regular monitoring and preventive conservation. Meanwhile, the near disappearance of rock-cut construction as a living craft has resulted in knowledge loss, even though favorable geological conditions could support its revival. The absence of skilled practitioners restricts informed repair practices and increases reliance on incompatible materials and techniques. However, recent architectural reinterpretations indicate that such knowledge gaps are not irreversible. For example, modern reinterpretations of rock-cut architecture, such as the Kültepe Tablet Museum (Bağpınar), demonstrate how new techniques can connect with traditional principles.

Conservation strategies should prioritize sustaining vernacular heritage through local communities, operating within existing socio-cultural frameworks rather than relying on externally imposed user groups. In the Kayseri valleys, this implies supporting user-based maintenance models that build on existing patterns of partial use, particularly in hybrid rock-cut–masonry structures that

remain inhabited. Interventions must follow ICOMOS and Burra Charter principles, allowing only minimal and reversible adaptations. Adaptive reuse compatible with traditional patterns, such as converting barns or dovecotes into storage or residential spaces, should preserve carved spatial continuity and avoid subdivision or incompatible surface treatments. Community engagement models suitable for the Koramaz Valley may include locally coordinated stewardship schemes and basic training initiatives for the maintenance of carved spaces, integrating traditional knowledge with contemporary safety and comfort requirements.

Future research should build on the qualitative and spatial findings of this study by incorporating detailed structural assessments of rock-cut units, particularly within hybrid rock-cut–masonry contexts where inappropriate reinforcements were observed. Quantitative analyses focusing on stability, moisture behavior, and the long-term impact of infrastructure-related stresses would support more precise risk-based conservation planning. In parallel, applied research on the documentation, transmission, and potential revival of rock-cut construction knowledge, through pilot training programs or experimental conservation interventions, could help bridge the gap between heritage documentation and practice. Comparative studies across different Anatolian rock-cut landscapes may further clarify whether the conservation challenges identified in the Kayseri valleys reflect broader regional patterns or are shaped by context-specific environmental and socio-cultural conditions.

6. Conculusion

In the specific case of the Kayseri valleys, vernacular rock-cut techniques, although now rarely practised, represent a significant architectural tradition that should be understood and conserved primarily as an element of living and intangible heritage. Simultaneously, the Koramaz and Gesi Valleys, with their layered archaeological, architectural, social, and cultural values, constitute a tangible heritage landscape of exceptional local and regional importance. The conservation of these valleys, therefore, necessitates an approach that balances material preservation with the continuation of everyday use, local knowledge, and user-based adaptation strategies. This study examined the link between vernacular rock-cut construction methods and the topography of the Kayseri valleys, highlighting how settlement morphology, material practices, and spatial organisation are shaped by terrain and long-term cultural adaptation. By identifying conservation challenges through field-based spatial and technical evidence, the research underscores the need for context-sensitive conservation approaches grounded in the principles of living heritage. Framing rock-cut settlements as evolving cultural landscapes offers a more sustainable approach to safeguarding their historical identity while responding to contemporary needs.

CRediT Authorship Contribution Statement

Bahar Elagöz Timur: Writing – review & editing, Writing – original draft, Methodology, Investigation, Analysis, Data curation, Conceptualization, Data visualization. Özlem Kevseroğlu Kurban: Writing – original draft, Methodology, Investigation, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Ethics Committee Approval

Ethics committee permission is not required.

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