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RESILIENCE AND ENVIRONMENTAL ADAPTATION OF TIMBER-FRAMED VERNACULAR ARCHITECTURE IN THE ALTITUDINAL ZONES OF SÜRMENE, TURKEY

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Abstract: *This study explores the typological diversity of timber-framed wall construction in the vernacular architecture of Sürmene, a district located in the Eastern Black Sea region of Turkey. The region features a complex settlement structure composed of coastal towns, rural villages, hamlets, and highland pastures – each shaped by distinct topographic conditions and seasonal use patterns. Within these local zones, five timber-framed wall systems – Taraba, Bağdadi, Çatkı (Stone), Çatkı (Brick), Gözdolma, and Muskalıdolma – were identified, each associated with a specific altitudinal level. The research aims to establish a correlation between settlement altitudes and timber wall typologies, identifying how environmental and socio-cultural factors influence construction techniques. Field data were obtained through on-site documentation in eight villages and analysed using Geographic Information System (GIS). A CRITIC-based multi-criteria investigation approach was employed to assess wall systems across five criteria: material availability, climatic adaptation, ease of construction, dismantlability, and structural integrity. The findings show that each wall type corresponds to distinct altitudinal patterns, shaped by topographic context, environmental pressures, and cultural preferences. The results highlight the adaptive capacity of timber construction in response to environmental gradients, illustrating how vernacular knowledge integrates resilience, material logic, and sustainable spatial organisation in the Eastern Black Sea region.*

Key words: *timber-framed wall, infill technique, altitudinal zone, vernacular resilience, environmental adaptation.*

1. Introduction

Vernacular architecture is an adaptive cultural process through which communities develop construction systems that respond to environmental

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and socio-economic constraints. Rather than being a static form of heritage, it embodies resilience by showing the capacity to withstand environmental challenges while maintaining functional and cultural continuity. From this perspective, integrating environmental adaptation and material intelligence is crucial to understanding how traditional structures endure change over time. The relationship between vernacular architecture and climate is grounded in environmental logic. The integration of thermal comfort, material efficiency, and local craftsmanship establishes a construction culture that is inherently compatible with its surroundings [20]. The relationship between traditional construction knowledge and sustainable design can be explained through the interaction between material innovation and environmental balance. This accumulated knowledge supports both the efficient use of local resources and long-term structural resilience in building production [1]. The continuity of vernacular architecture is maintained through the ability to anticipate environmental risks and preserve cultural identity, forming a dynamic model capable of adapting to changing conditions [44]. Studies on Anatolian settlement patterns demonstrate that construction logic evolved as a system directly responding to topographic and climatic diversity, where each region developed its own adaptive strategies [42]. These theoretical insights find tangible expression in the vernacular architecture of the Eastern Black Sea region, where local construction practices reveal direct environmental adaptation.

The vernacular architecture of the Eastern Black Sea region of Turkey is characterised by its intimate response to the natural environment, socio-cultural practices, and patterns of seasonal mobility. Within this regional context, the district of *Sürmene* exemplifies a particularly diverse settlement structure, including permanent coastal towns, dispersed rural villages, transitional hamlets, and seasonal highland dwellings. Each of these settlement types has developed distinct architectural responses to topography, climate, and material availability. This investigation aims to document heritage construction practices by mapping the relationship between construction logic and geographical conditions. As the primary construction material, timber plays a central role in shaping the region's architectural identity. Traditional dwellings feature timber-framed wall systems combined with various infill methods, forming unique facade compositions and structural solutions. These techniques, such as *Gözdolma, Muskalıdolma, Taraba,* and *Bağdadi*, vary in construction logic and resilience to climatic conditions.

Within the descriptive richness of previous studies on the vernacular architecture of the Black Sea region, researchers such as Erenman [18], Sümerkan [38], Sözen and Eruzun [37], and Çakır [8] have pointed out a connection between settlement level and construction techniques (Table 1).

Literature review on wood wall techniques Table 1

Source	Method Summary	Contribution to this study
Erenman [18]	Investigates traditional timber construction systems in the Eastern Black Sea region through local examples.	Provides historical and morphological information about local applications.
Sümerkan [38]	Evaluates factors affecting structural characteristics in rural houses of the Eastern Black Sea region.	Explains the impact of geographical and environmental factors on the structure.
Eruzun and Sözen [37]	Analyses rural settlement forms and construction techniques in the Black Sea region.	Supports the contextual reading of wall techniques through environmental and cultural determinants.
Çakır [8]	Analyses traditional timber housing systems in the Black Sea region in terms of contemporary technology.	Contributes to the integration of systems with modern technology.
Avlar [5]	A model study evaluating the feasibility of timber housing construction in Turkey.	Provides resources for building systems and sustainability-based commentary.
Çobancaoğlu [9]	Evaluates and classifies traditional timber house systems in Turkey.	Contributes to the typological grouping of wall systems.
Güler and Bilge [23]	Documents construction techniques used in traditional buildings of the Eastern Black Sea region.	Contributes to the understanding of regional technical diversity.
Güçhan [22]	The construction techniques used in traditional wooden houses are classified systematically.	Technical data such as material usage, joint details, and structural system components can be evaluated.
Erarslan [17]	Examines traditional timber construction systems in Anatolia with technical details.	Provides references for comparisons of production techniques.
Var and Kobayashi [43]	74 buildings are documented in Sürmene and preservation potential is analysed through public participation surveys.	Provides a supportive field data model based on the current state of the building stock and social awareness of protection.
Yalçınkaya [46]	85 buildings in Uğurlu are classified by façade characteristics and typological clusters are created using SPSS.	Provides a method for typological analysis in relation to the layout type and facade arrangement of wall systems.

Bekaroğlu [6]	15 buildings in Dirlik Neighbourhood are typologically classified.	It is a pioneering study in terms of field-based documentation and classification of wooden wall techniques.
Turan [42]	Analyses vernacular architecture in Anatolia in relation to climate, geography, and adaptation patterns.	Provides the theoretical basis for linking construction logic with environmental adaptation.
Fathy [20]	Discusses the environmental reasoning and energy efficiency of vernacular construction.	Introduces the concept of environmental logic in traditional design.
Achenza et al. [1]	Examines sustainable construction principles in vernacular architecture across different regions.	Connects vernacular knowledge with contemporary sustainability frameworks.
Tonelli and Grimaudo [39]	Investigates thermal inertia and summer performance of timber buildings in the Mediterranean climate.	Provides comparative data on timber's thermal behaviour relevant to climatic adaptation.
Oikonomou and Bougiatioti [31]	Analyses the architectural structure and environmental performance of traditional buildings in Greece.	Highlights passive design and orientation strategies comparable to the Sürmene case.
Dangel [12]	Reviews sustainable timber construction traditions in Alpine architecture.	Reveals how craftsmanship and ecology merge in timber-based building culture.
Sanagustín-Fons et al. (2025) [35]	Studies socio-environmental adaptation in Mediterranean heritage architecture.	Links resilience and cultural continuity with climatic adaptation strategies.
Aktürk and Fluck [2]	Traditional timber houses are analysed in terms of climate resilience and sustainable future strategies are proposed.	Contributes to the interpretation of the study in the context of climate data and resilience.
Dalkıran [11]	Thermal and vapour permeability of four different timber-framed wall systems are analysed based on the TS 825 standard.	Evaluates traditional systems in terms of heat transfer coefficient and moisture permeability.
Lakot et.al. [28]	Energy-efficient improvement scenarios of a traditional house in Trabzon are proposed with thermal analysis.	Supports the evaluation of traditional systems in terms of thermal insulation and energy loss.

However, no study has systematically addressed this relationship within a contextual framework. The starting point of the present study is to fill this gap by evaluating these construction techniques within a typological framework in relation to settlement types and topographic zones. The hypothesis of this study was developed based on the correlation between the location of settlements and the applied wall construction techniques in terms of core design values such as material availability, climatic adaptation, ease of assembly, portability/disassemblability, durability, and structural integrity. The objective is to explore this relationship through data gathered from site surveys, supported by a systematic classification of construction techniques.

Studies conducted in different parts of the world reveal that similar principles of environmental adaptation have been developed across diverse geographical contexts. Research in Mediterranean climates emphasises the thermal inertia and indoor comfort potential of timber structures [39]. Analyses carried out in the Balkan region demonstrate that design decisions such as orientation, mass ratio, and microclimatic regulation directly influence the environmental efficiency of buildings [31]. Studies on Alpine architecture [12] show that timber serves as a means of sustaining cultural continuity and environmental sensitivity within building traditions. Recent investigations [35] in the Mediterranean context explain the socio-environmental resilience of traditional buildings through the reciprocal relationship between local knowledge and climatic adaptation. This global perspective indicates that vernacular buildings across different climates and terrains have developed comparable mechanisms of environmental adaptation. In this context, the Sürmene case represents a distinctive example of northern Anatolian architectural tradition, integrating principles of environmental adaptation, material intelligence, and cultural continuity.

2. Materials and Methods

2.1. General Description

This study adopts a three-stage analytical framework to investigate the relationship between timber-framed wall types and settlement patterns across altitude-based zones in the *Sürmene* region. To analyse this relationship in a structured and data-driven manner, the CRITIC (Criteria Importance Through Intercriteria Correlation) method was employed. The CRITIC technique allows for a theoretical interpretation of the correlative logic embedded in traditional construction systems shaped by varying geographical and functional conditions. Specifically, it provides insight into how architectural decisions are shaped by local priorities such as material availability, climatic adaptation, or structural durability, by evaluating both the statistical variance of each design criterion and its correlation with others.

In operational terms, CRITIC is used here as a bridge between quantitative weighting and the resilience-oriented reading of vernacular construction, aligning data-driven priorities with environmental adaptation, structural performance, and cultural continuity. This alignment follows the resilience perspective advanced in contemporary vernacular studies, ensuring that weighting results are interpretable within a sustainability and risk framework.

An effective application of the CRITIC method is presented by Ogunkah and Yang [30], who used it in their study on sustainable housing delivery to evaluate vernacular building materials. Their work emphasises how factors such as durability, climatic response, and ease of construction intersect in material selection. This example highlights the method's capacity to capture context-specific architectural priorities within a multi-criteria decision-making framework. Building on these insights, this study employs CRITIC to interpret the relative importance of design criteria in timber-framed wall systems, based on empirical field data from *Sürmene*. The resulting weights are subsequently integrated with spatial data for comparative evaluation across settlement typologies. Accordingly, the methodological design couples CRITIC outputs with GIS layers to produce zone-specific priority profiles for each wall technique.

In the first stage, the settlements in the Sürmene region were classified into four categories: coastal (*L1*), slope (*L2*), ridge (*L3*), and highland (*L4*), based on altitude, topographic position, and morphological features. This classification was conducted with the support of Geographic Information System (GIS) and verified through topographic maps. Eight settlements were analysed in situ and recorded via ArcGIS. Seasonal conditions, terrain slope, and building density were assessed through field observation and photographic surveys to validate the settlement typologies. This zonation constitutes the spatial index against which technique-level weights are compared, enabling a direct reading of environmental gradients and construction choices.

The second stage involved field documentation of vernacular buildings that preserved original timber-framed wall structures. At this phase, purposive sampling was adopted to ensure the inclusion of structures that best represent the constructional and typological characteristics under study. Only buildings with intact, observable wall systems were included, while those with altered or rebuilt façades were excluded to preserve typological precision. This sampling strategy, as applied in previous vernacular architecture studies [26, 36, 45], supports focused and representative data collection. Primary data were collected through fieldwork and literature review. Facades and joints were photographed, wall sections were hand-measured, and joinery details were noted.

A structured inventory form was used to record wall materials, infill composition, framing pattern, orientation, and functional role.

The wall types encountered in the field were then classified into six main categories:

- *Taraba* (*T1*);
- *Bağdadi* (*T2*);
- *Çatkı*/Brick Filled (*T3*);
- *Çatkı*/Stone Filled (*T4*);
- *Gözdolma* (*T5*);
- *Muskalıdolma* (*T6*).

Additionally, a thermal resistance calculation was performed on a selected wall type to quantify its material performance; the resulting thermal resistance value was treated as a dependent variable. Inventory variables were selected to reflect both environmental fitness (e.g., exposure, orientation) and constructional logic (e.g., jointing, framing rhythm), ensuring consistency between field observations and the analytical criteria.

In the third and final stage, the relationship between the settlement types and the identified wall systems was analysed using the CRITIC method.

The wall types were evaluated based on five key design criteria:

- Material availability (*C1*);
- Climatic adaptation (*C2*);
- Ease of assembly (*C3*);
- Portability/disassemblability (*C4*);
- Durability (*C5*).

Through CRITIC, the objective weight of each criterion was calculated based on its variance and correlation. These weights were then integrated with settlement data within a GIS environment, enabling a targeted analysis of the dominant design values associated with each settlement type. This integration allowed for a context-sensitive and data-driven interpretation of how local environmental conditions and functional needs influence construction preferences. Finally, technique-by-zone matrices were generated to visualise dominant priorities per altitudinal band, clarifying how timber wall systems embody adaptation logics under varying environmental pressures.

2.2. Stage 1 – Identification of Settlement and Altitudinal Diversity

Understanding the physical geography of the Sürmene district is essential for interpreting how traditional building techniques, particularly timber-framed wall systems, have evolved in response to environmental constraints. Topography, climate, and vegetation cover collectively influence settlement distribution, construction practices, and the architectural diversity observed across the region.

Sürmene is a coastal district in the Trabzon province of the Eastern Black Sea region, situated approximately at 40º55' latitude and 40º05' longitude. It stretches from a 20-kilometer shoreline southward into the high ridges of the Eastern Black Sea Mountains, with elevations reaching up to 2,860 meters [34]. *Madur* Hill (2,742 m) and *Zarha* Hill (865 m) are prominent elevations that contribute to sharp climatic gradients within a relatively narrow spatial range [14]. These significant topographic variations form the spatial basis for studying settlement differentiation in the district.

The area is marked by deep valleys carved by rivers descending rapidly from the mountains toward the sea. These landforms fragment the terrain into distinct ecological zones and influence how settlements are organised (Figure 1). Ridges such as those between the *Küçükdere* and *Manahoz* streams demarcate micro-regions, while the north-south elevation gain results in variable wind exposure and slope orientation. These topographic features are key determinants of building form, site layout, and material adaptation, especially in timber-based constructions.

The climate of *Sürmene* is shaped by both the Black Sea and the enclosing mountain ranges. The coastal zone experiences a mild, humid climate, while inland and higher elevations receive significant snowfall in winter and more pronounced temperature variation [21]. Annual precipitation is high, and orographic effects create microclimates over short distances. Average coastal temperatures range from 11.8°C in winter to 18.2°C in summer, with no month falling below 7.4°C [29]. These climatic dynamics are crucial for understanding material durability, insulation needs, and weather-responsive building features in traditional architecture.

Vegetation zones change significantly with altitude. From sea level to 300 meters, dense shrub and deciduous tree cover dominate. Between 800 and 1,300 meters, mixed forests transition to coniferous formations, eventually giving way to alpine meadows beyond 2,000 meters, where agricultural practices also shift from horticulture to animal husbandry [47]. These ecological thresholds influence the availability of building timber types and determine the seasonal use of settlement zones (Figure 2).

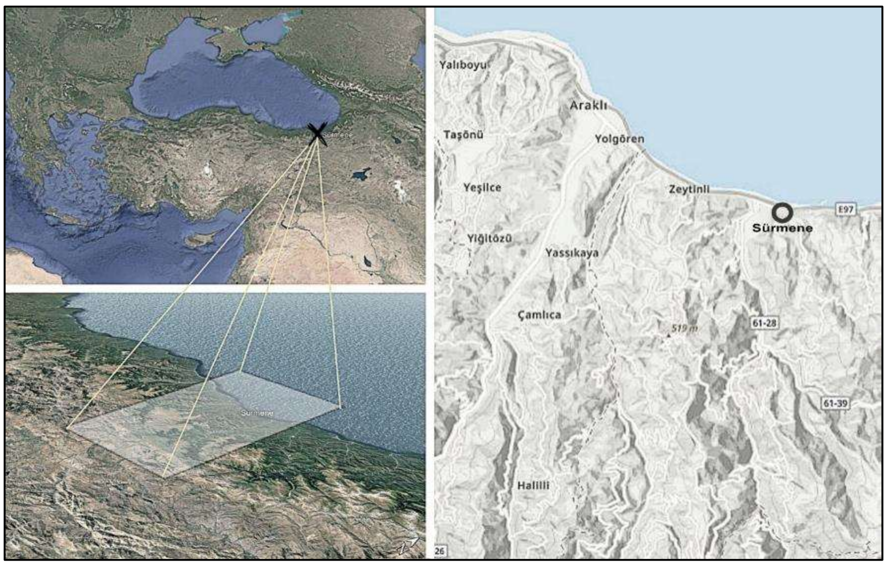


Fig. 1. *A 3D satellite image showing the geographical location of Sürmene and its elevation gradient from the Black Sea coast to the inner mountainous regions [3]*

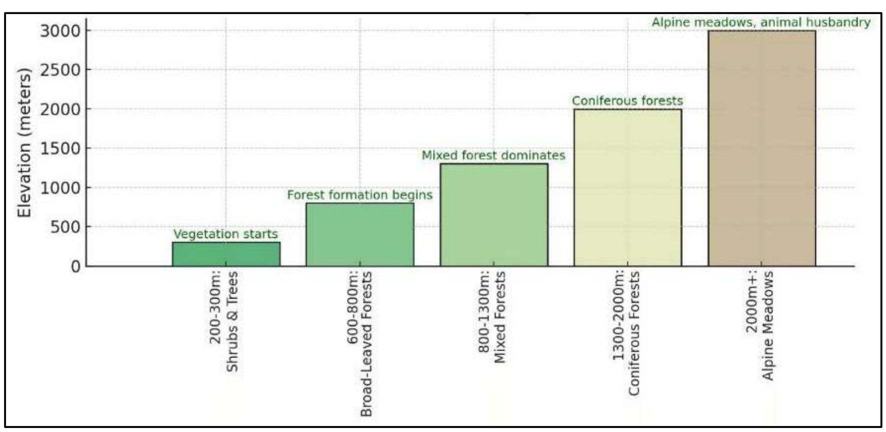


Fig. 2. *Diagram illustrating the distribution of vegetation types and ecological zones in relation to settlement altitudes within the district*

The altitude of settlements contributes to the diversity of building patterns in *Sürmene* vernacular architecture. Housing typology varies depending on the continuity of seasonal residency periods in the area. Permanent settlements are located from the coastal areas up to elevations of 1,500-1,600 m, while hamlets between 1,500-2,000 m and plateaus between 1,800-2,800 m serve as temporary settlements [12]. Coastal and mountain villages are positioned in valleys opening to the sea, on slopes, and on ridges between valleys and ridges. Settlement density increases significantly between the 200 m and 600 m elevation levels [31]. Settlement areas are clearly differentiated in terms of altitude (Figure 3).

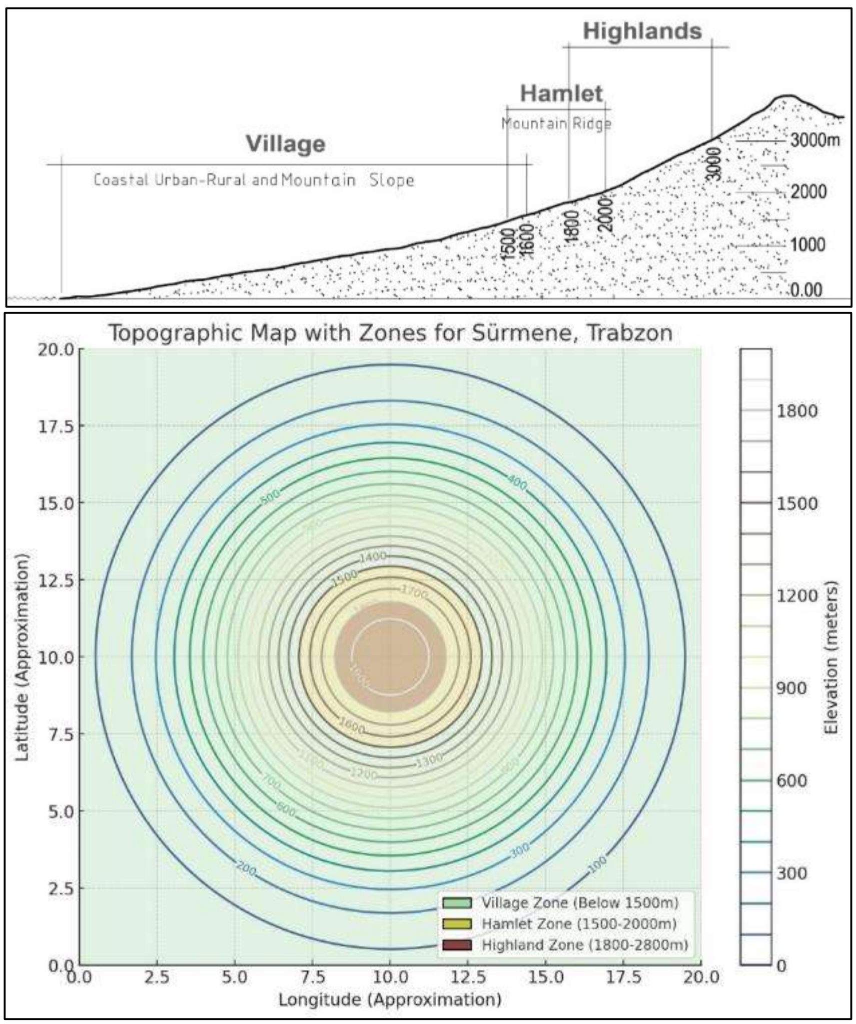


Fig. 3. *Types of settlements: a. settlement altitudes according to Sümerkan [1]; b. topographic map zones of Sürmene*

The mountainous terrain has given rise to distinct ecological zones, each fostering unique livelihood patterns influenced by elevation. In the coastal and lowland areas, agriculture and fishing constitute the main sources of income. On the mountain slopes aligned parallel to the coastline, subsistence farming shapes a dispersed settlement pattern. The humid-temperate climate favours the cultivation of crops such as hazelnuts, corn, and tea. In contrast, the higher altitudes are characterised by livestock rearing and transhumant practices as dominant economic activities. This vertical stratification of livelihoods directly informs the functional use of settlement types across the landscape.

The use of hamlet dwellings as transitional spaces between villages and highland pastures is a notable local tradition. This dual usage results in two major settlement types: *permanent* and *temporary.* The length and seasonality of habitation in these buildings are key factors influencing the layering and construction of their external walls. Furthermore, the orientation of houses - mainly towards the sea and prevailing winds, with a dominant eastward alignment, indicates a strong adaptation to climatic conditions [25]. Climatic diversity across the region, modulated by topography, shapes distinct seasonal usage patterns, reinforcing the structural differentiation among settlement types.

In the *Sürmene* district, four primary settlement types are observed: *Coastal Urban-Rural, Mountain Slope/Village, Mountain Ridge/Hamlet,* and *Highland.* Each reflects a unique ecological and topographic condition, which in turn influences architectural configuration and spatial usage.

L1 – Coastal urban-rural settlements: The settlement pattern in coastal areas is largely dispersed, shaped by geographical elements such as valleys, slopes, and hills. The North Anatolian Mountains, extending parallel to the coastline, create steep morphological transitions. Consequently, rural communities tend to cluster in river valleys, forming a distinct rural-urban belt [24]. Within this structure, kinship-based housing clusters – comprising five to 10 households within a neighbourhood boundary – contribute to the permanence and continuity of these settlements.

Agricultural cultivation along this belt is diverse, with hazelnuts being the region's dominant crop. Hazelnut farming, which has become widespread over the last century, provides the main source of income for many residents [47]. Additionally, coastal fishing, boat carpentry, and commercial or artisanal activities practiced in town centres further enrich the socioeconomic fabric.

On flat or sloped terrain, houses commonly consist of two stories and include two to four rooms. The ground floor is typically reserved for storage or commercial use, while the upper floor functions as the primary living space. These structures display an apart settlement layout. Many feature a pronounced central bay on the upper floor plan, blending characteristics of both rural and small-town residential typologies.

L2 – Mountain slope / village settlements: The rugged terrain contributes to a scattered settlement layout, with houses spread over a wide area, complicating the delineation of village boundaries [33]. The selection of building sites on mountain slopes is influenced by geomorphology, slope direction, vegetation, and water availability. Houses are often isolated or grouped in kin-based clusters, accompanied by auxiliary buildings. They are typically placed at elevated points on the terrain to maintain visual control over agricultural plots. Besides hazelnut orchards, these areas also include vegetable gardens and limited tea cultivation.

In these mountain slope villages, houses are composed of one to three rooms. Basement levels function as stables, given the terrain, while the level connected to higher ground serves as the main living space. Roofs often act as ventilated storage lofts. These dwellings are occupied throughout the winter, whereas during summer, livestock owners migrate to hamlet and highland pastures.

L3 – Mountain ridge / hamlet settlements: Hamlets serve as intermediate settlements located between villages and plateaus. They are used for short-term agricultural and livestock activities, especially during transitional periods in spring and fall. Located on mountain ridges, they allow residents to delay their ascent to highlands until snow cover melts, offering both logistical convenience and seasonal flexibility [41]. During this period, animals graze in nearby forests and are fed with tree foliage, depending on the availability of pasture in higher elevations. Hamlet settlements, often comprising one to five dwellings, are classified as *sub-village* types. Dwellings in these zones generally consist of a single-roomed space that serves as both kitchen and living area. They act as intermediary residential forms between stand-alone houses and clustered village units. The nucleus typically includes the main shelter and support structures such as barns or storerooms [10]. These spatial nuclei reflect the essentialism and self-sufficiency required for transitional living.

L4 – Highland settlements: Plateaus mark the highest residential limit, where forested land gives way to open alpine zones. Despite their physical distance from villages, plateaus function as socio-economic extensions of village life. During the hot and humid summer months, they offer a cooler environment for temporary settlement.

In transhumance, the upper parts of the mountains, which are unsuitable for cultivation, and the forest edges become critical livestock pastures. These areas, reached from agriculturally active valleys, represent the core of plateau-based economies [13]. Above 2,000 meters, the climate is humid and rainy, supporting diverse alpine vegetation. For centuries, these meadows, though unfit for agriculture, have played an essential role in seasonal grazing patterns [41]. Such sustained usage illustrates a deep-rooted adaptation of local communities to climatic constraints.

Compared to villages and hamlets, plateaus experience harsher climatic conditions. Buildings here are designed accordingly- stone is often used on rain-exposed façades, and the structures are generally single-storied on flat terrain or elevated on slopes. Openings such as windows are minimised in size and number to resist wind and heat loss.

In this study, spatial zones were identified and examined to understand the relationship between settlement location and wall construction methods (Figure 4). For the coastal rural texture, *Balıklı (Civra)* and *Çarşı (Humurgan)* were selected. Slope and foothill settlements included *Aksu (Aso), Dirlik (Cida),* and *Gültepe (Gucara),* reflecting diverse applications of stone wall typologies. Hamlet-type settlements like *Fındıcak (Horhor)* and *Aşağıovalı (Vizara),* located at the lower exit of *Limonsuyu* Plateau, provided insight into transitional architecture. Finally, the highland settlement of *Taşlı (Tab)* served as the study's representative case for plateau housing.

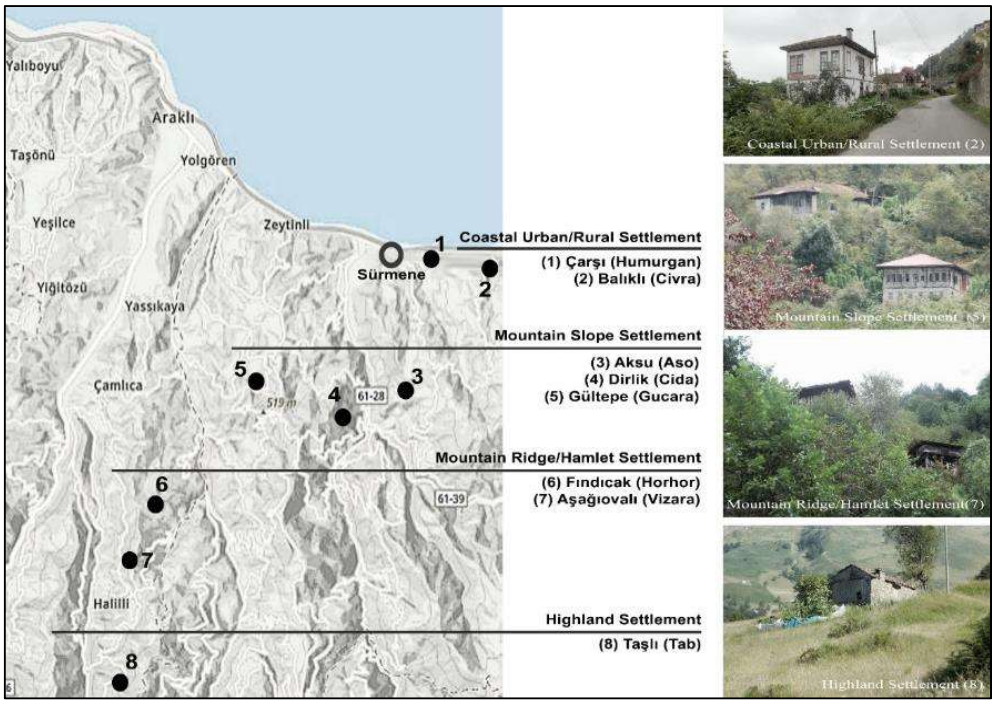


Fig. 4. *Identified settlement locations and classification zones*

These stratified settlement types not only reflect the environmental adaptation of vernacular architecture but also illustrate the socio-cultural logic behind spatial production in *Sürmene.* The architectural language of each type emerges from a dynamic interaction between topography, seasonal habitation, and livelihood strategies.

2.3. Stage 2 – Classification of Timber-Framed Wall Construction Techniques

Just as settlements at different altitudes exhibit distinct patterns of use and lifestyle, the types of wall construction also display considerable diversity. A variety of wall construction techniques can be observed within the district boundaries, shaped by the topographic conditions and the availability of local materials. In traditional vernacular architecture, stone and wood are the predominant building materials, and the structures are generally two stories high. The ground level, commonly referred to as *ahırbağı*, is constructed with stone and typically serves as a stable or storage area. On top of this masonry base, wooden floor beams are laid -often cut from the durable heartwood of oak trees. These beams are highly resistant to decay and form the structural base for the timber-framed upper floor [15]. This structural transition from stone to timber is not only functional but also reveals a clear stratification of material use and spatial hierarchy within vernacular buildings.

The main floor's interior and exterior walls are built using a timber framing technique known regionally as the *çatma* system. This system, unique to the Eastern Black Sea Region, is designed to distribute loads over relatively short spans and to transfer them uniformly to the ground [4]. The framework is composed of vertical posts interconnected by horizontal elements. The primary structural components consist of vertical, horizontal, and diagonal elements, usually measuring 15×15 cm or 10×10 cm in section. Vertical posts are typically spaced 25-35 cm apart, and corner posts - as well as those terminating internal walls- are designed with larger cross-sections for added strength [7]. To resist lateral loads, diagonal braces; *payanda* are placed between the posts and the foundation at angles around 60°. In buildings with lower ceiling heights, this inclination is often reduced to about 45° [9]. These diagonal members, referred to locally as *çalman*, function as key stabilising elements, ensuring lateral rigidity from both directions. Additionally, the spacing of vertical posts often corresponds to the width of windows, leading to a modular organisation that defines the facade rhythm and spatial composition.

The configuration and infill of the *çatma* frames generate a diversity of wall types. The structural voids formed between posts are filled using a range of materials- such as wattle, stone, or mudbrick- selected for their thermal and structural properties. Depending on the framing geometry, these infills may appear in square, triangular or hybrid compositions. Square-filled frames are called *gözdolma*, while triangular patterns lacking plaster finish are locally known as *muska,* or *muskalı* [43]. The variation in frame typologies and infill techniques informs both the visual character and structural coherence of vernacular houses in Sürmene.

W1 – Stud Frame with Timber Board Infill/ *Taraba*: One of the prominent timber construction techniques observed in the Eastern Black Sea Region is the *Taraba* system, characterised by the integration of a stud frame with timber board infill. In this system, vertical posts- locally referred to as *armoz*- are positioned at the corners and intermediate points to create a stable load-bearing framework. The infill panels consist of wooden boards that are inserted into vertical grooves carved into the posts, providing both structural cohesion and surface continuity [18]. This method reflects a practical understanding of material behaviour and local carpentry traditions, enabling both flexibility and ease of construction. However, it requires a larger quantity of timber in the production process.

The timber infill panels typically measure 2-6 cm in thickness and 25-35 cm in width and are designed to span lengths matching or exceeding the room's dimensions. When panel lengths surpass standard sizes, grooves are extended to accommodate overlapping joints or additional boards [38].

This dimensioning strategy indicates a clear sensitivity to room scale and load distribution within the framework. This modular approach allows for flexibility in room size and facilitates the incremental expansion of dwellings. Consequently, the *taraba* system has become particularly suitable for accommodating the evolving spatial needs of extended family structures [37]. Its adaptive use in vernacular housing illustrates how construction techniques are shaped by familial and social dynamics.

Due to its straightforward assembly and minimal labour requirements, the *taraba* technique is widely adopted in forest villages for its economic and adaptable nature. The lightweight timber boards are easy to mount onto the structural frame, and the system's repeatable components offer consistency in construction. However, despite its functional advantages, the system provides limited thermal insulation (Figure 5).

While this construction method aligns with the material availability and craft traditions of the region, it offers minimal thermal efficiency and is therefore more suited to seasonal or temporary use rather than continuous year-round occupancy. *Taraba* walling is predominantly used in seasonal structures - such as *yayla* (plateau) houses and *mezire* (hamlet) dwellings- that are occupied during the summer months, where climatic demands are moderate.

W2 – Stud Frame + Lath + Plaster = *Bağdadi*: In this construction technique, wall surfaces are clad with thin wooden laths (locally known as *bağdadi*) fixed horizontally onto a timber frame composed of vertical posts spaced at 40–50 cm intervals [17]. These laths, typically 2-3 cm thick, are closely aligned on both sides of the structural frame to form a continuous surface suitable for plastering.

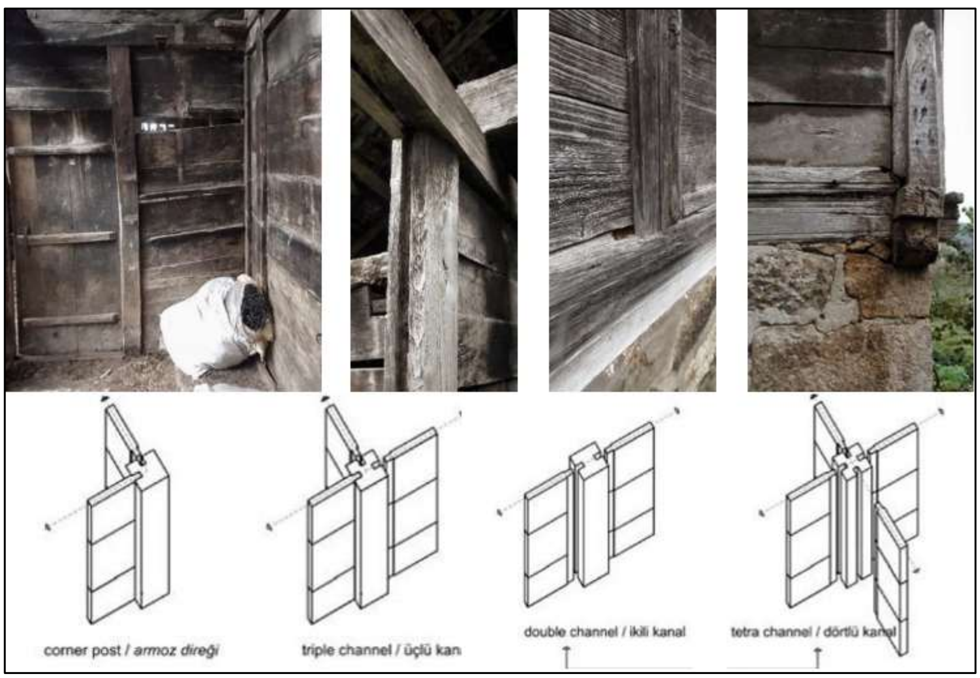
A traditional mixture of mud and straw is applied over this lath surface, creating a breathable and insulating wall layer. Although the method originated in the construction of lightweight dome coverings, its adaptation for vertical wall panels is relatively recent [27]. The *bağdadi* system is commonly preferred in cantilevered bays of coastal buildings due to its lightweight and practicality, especially where rural building traditions have faded. The double-sided lath and plaster construction results in a hollow wall core, making the system significantly lighter than other infill types. This feature has made it especially practical in upper floor elements and projecting bays in traditional houses of the Eastern Black Sea Region. The technique offers structural efficiency in timber-framed façades.

In the *bağdadi* wall system the space between the laths remains unfilled, functioning as a still air cavity. Based on this configuration and standard material properties, the wall achieves a thermal performance compared to exposed timber surfaces alone, ensuring the efficient use of available resources (Figure 6).

W3 – Stud Frame + Stone Filling = *Çatkı*: In this construction technique, the timber framework is infilled with masonry materials such as stone. The system consists of vertical and horizontal members, complemented by diagonal bracing elements placed at the corners to provide additional lateral stability.

Layer	Thickness [m]	Thermal conductivity, λ [W/m·K]	Thermal resistance, R [m²K/W]
Solid wood infill	0.03	0.13	0.103
Total R-Value	-	-	0.103
U-Value (1/R)	-	-	9.71 W/m²K

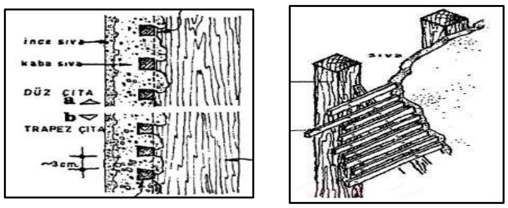
a. c.



b.

Fig. 5. *Timber-frame and board-infill configuration of the taraba wall system (Selected building from Cida): a. photographs of wall junction details (Author, 2024); b. technical drawing of wall connections [22]; c. layered wall section and calculation of thermal transmittance resistance*

a.



b.

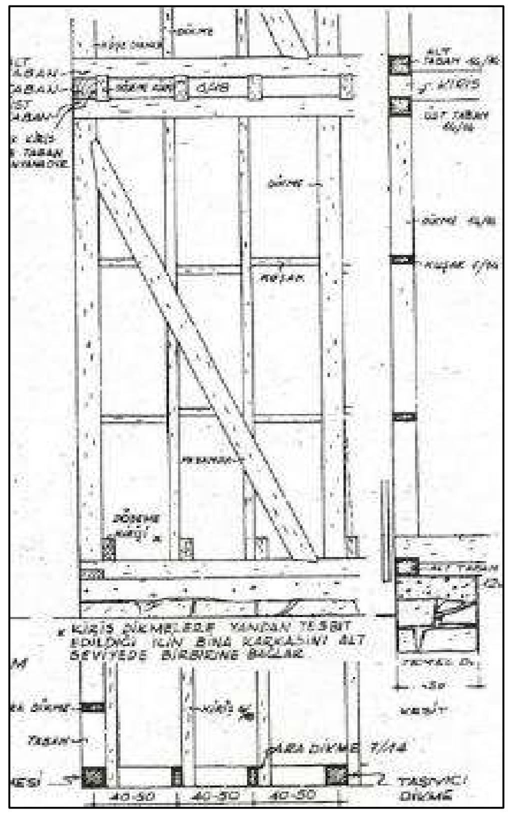
Layer	Thickness [m]	Thermal conductivity, λ [W/m·K]	Thermal resistance, R [m²K/W]
Interior plaster	0.015	0.70	0.021
Interior wooden lath	0.02	0.14	0.143
Air cavity (unfilled)	0.03	0.18	0.167
Exterior wooden lath	0.02	0.14	0.143
Exterior plaster	0.015	0.70	0.021
Total R-Value	—	—	0.495
U-Value (1/R)	—	—	2.02 W/m²K

c.

Fig. 6. *Timber-frame and board-infill configuration of the bağdadi wall system (Selected building from Çarşı): a. photographs of wall junction details (Author, 2024); b. technical drawing of wall connections [5]; c. layered wall section and calculation of thermal transmittance resistance*

Mid-height horizontal members, of similar dimensions to timber laths, connect the vertical posts and contribute to the integrity of the wall. Diagonal bracings are typically installed in the corners to resist seismic forces and enhance structural resilience. The infill is applied using tightly packed rubble stone or brick, bonded with thick mud or lime mortar. Closely spaced vertical posts prevent the development of "X"-shaped cracking and reduce the risk of the infill detaching from the frame [4]. Depending on the size of the infill stones, spacing between vertical members is adjusted or mortar content is increased to ensure cohesion. While single-piece stones may be used in the infill, it is also common to construct the wall using smaller, fragmented stones that are easier to obtain. In this configuration, the wall typically consists of stone infill and plaster, offering a moderate level of thermal insulation (Figure 7). For this reason, material can be sourced easily in almost every settlement area.

a.



b.

Layer	Thickness [m]	Thermal conductivity, λ [W/m·K]	Thermal resistance, R [m²K/W]
Plaster	0.015	0.70	0.021
Stone infill within timber frame	0.25	1.50	0.167
Total R-Value	—	—	0.188
U-Value (1/R)	—	—	5.32 W/m²K

c.

Fig. 7. *Configuration of the stone-infilled çatkı wall system (Selected building from Vizara): a. photographs of wall junction details (Author, 2024); b. technical drawing of wall connections [16]; c. layered wall section and calculation of thermal transmittance resistance*

W4 – Stud Frame + Brick Filling = *Çatkı*: In brick-infill variations, bricks are arranged either in straight courses or diagonally within modular bays defined by 25-35 cm spaced intermediate posts. In certain applications, vertical spacing can vary between 20 cm – allowing a single brick to be placed diagonally or linearly – and up to 60-90 cm to accommodate multiple courses aligned horizontally [32]. Such flexibility allows the system to adapt to material availability and construction preferences.

In this configuration, the wall features a timber frame structure filled with fired clay brick and finished with both interior and exterior lime-based plaster layers. This composite assembly reflects a widespread technique in Sürmene's vernacular architecture, combining structural wood with mass-based infill and protective coatings. This value shows better insulation performance compared to stone infill systems (Figure 8). The use of stone infill is widespread in rural areas where stone is abundant and accessible, while brick infill is more common in coastal zones and near urban centres where brick production and transportation are logistically viable.

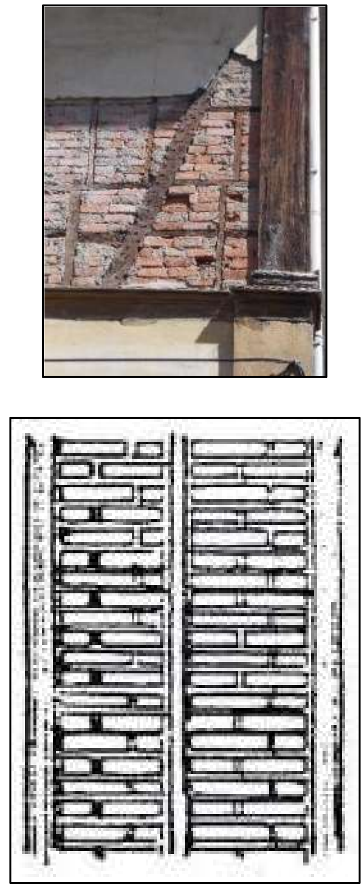
W5 – Grid Frame + Stone Filling: *Gözdolma*/ Eyefilling-Cellfilling: The façade is organised into a grid structure composed of nearly square panels, which are further subdivided by horizontal members placed at 17–20 cm intervals along vertical supports [37]. This tight and repetitive subdivision reflects a construction logic that prioritises stability and modular control over the infill surfaces. In this system, the vertical members are relatively thin in cross-section but closely spaced, resulting in a higher number of posts. This configuration enhances the structural integrity of the infill material, particularly in resisting external forces.

The primary reason for narrowing the spacing between members is to stabilise the infill, which typically consists of stone fragments.

These quadrangular units- referred to as *göz* (meaning "eye" or "cell") -are generally filled with crushed stones. Alternatively, locally sourced river stones, which are shaped and smoothed, may be used as solid, individual blocks. Mortar is applied around the perimeter of these stones to secure them in place, thereby improving both stability and durability [38]. Such use of river stones, combined with the binding function of mortar, indicates a material-conscious design approach aimed at prolonging façade durability under regional climatic stress.

In the *gözdolma* system, wooden components are joined with precise interlocking techniques, such as mortise and tenon joints. The main load-bearing frame often incorporates tongue-and-groove connections, demonstrating the high level of craftsmanship required. These complex joints are a hallmark of traditional craftsmanship and emphasise the labour-intensive nature of the system. The use of single-piece stone infill, combined with the elaborate joinery, contributes to the increased cost and construction complexity of the system. On the other hand, this technique requires a greater amount of timber for the frame, and sourcing large, single-piece stones for the infill becomes necessary (Figure 9).

a.

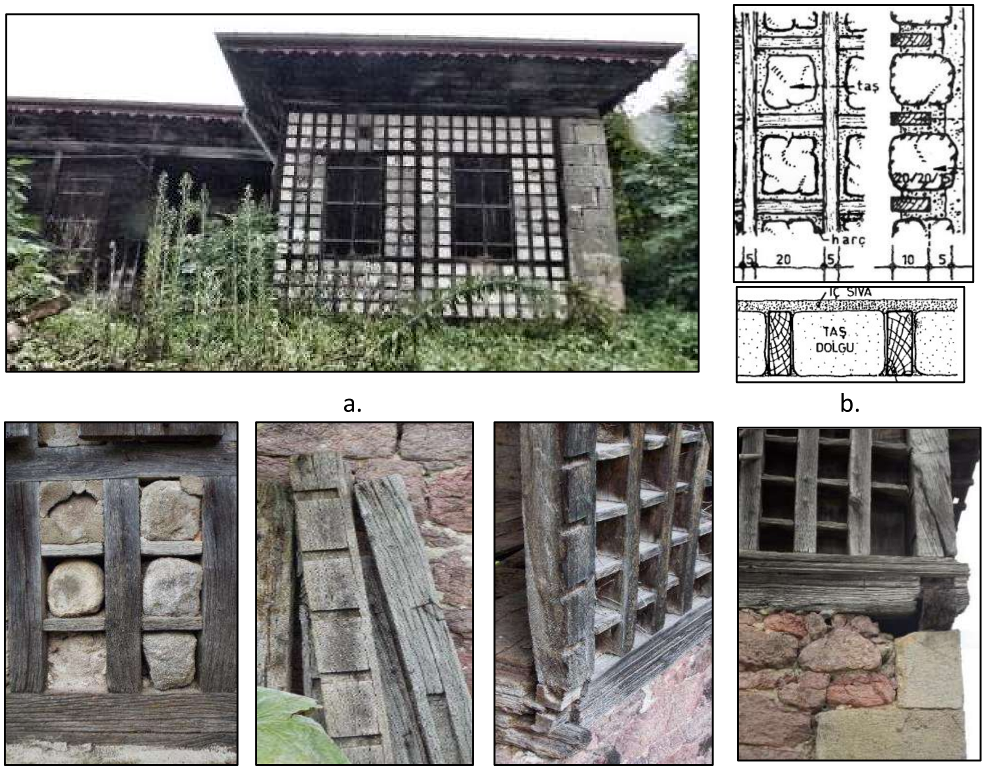


b.

Layer	Thickness [m]	Thermal conductivity, λ [W/m·K]	Thermal resistance, R [m²K/W]
Interior plaster	0.015	0.70	0.021
Brick infill within timber frame	0.20	0.70	0.286
Exterior plaster	0.015	0.70	0.021
Total R-Value	—	—	0.328
U-Value (1/R)	—	—	3.05 W/m²K

c.

Fig. 8. *Configuration of the brick-infilled çatkı wall system (Selected building from Balıklı): a. photographs of wall junction details (Author, 2024); b. technical drawing of wall connections [7]; c. layered wall section and calculation of thermal transmittance resistance*



Layer	Thickness [m]	Thermal conductivity, λ [W/m·K]	Thermal resistance, R [m²K/W]
Interior plaster	0.015	0.70	0.021
Gözdolma infill (stone + mortar)	0.15	1.60	0.219
Total R-Value	—	—	0.240
U-Value (1/R)	—	—	4.17 W/m²K

d.

Fig. 9. *Timber-frame and board-infill configuration of the gözdolma wall system (Selected building from Aksu/Aso): a. photographs of wall junction details (Author, 2024); b. and c. technical drawing of wall connections [32, 38]; d. layered wall section and calculation of thermal transmittance resistance*

This construction method is particularly well-suited to the climatic and geographical conditions of the region. The block stones, held within the timber framework, are typically coated with mortar to improve resistance against weathering. This protective layer acts as a climatic buffer, shielding the infill from moisture ingress and erosion over time.

Furthermore, this system offers superior performance against lateral forces compared to alternative techniques [2].

Such structural advantage suggests the system's robustness in coastal and slope regions exposed to seismic activity or high winds.

Traditionally, the *gözdolma* system has been associated with wealth and social status due to its demand for skilled labour and high-quality materials. It is mostly used in konaks- large, elegant mansions or estate houses- and is prevalent in coastal settlements with village-town characteristics, as well as in some mountain villages. However, in temporary high-altitude settlements, the scarcity of river stones and the logistical difficulties of applying this technique have greatly limited its use, resulting in very few examples in such areas.

This spatial distribution also reflects how resource accessibility and seasonal settlement patterns shaped material culture and architectural expressions.

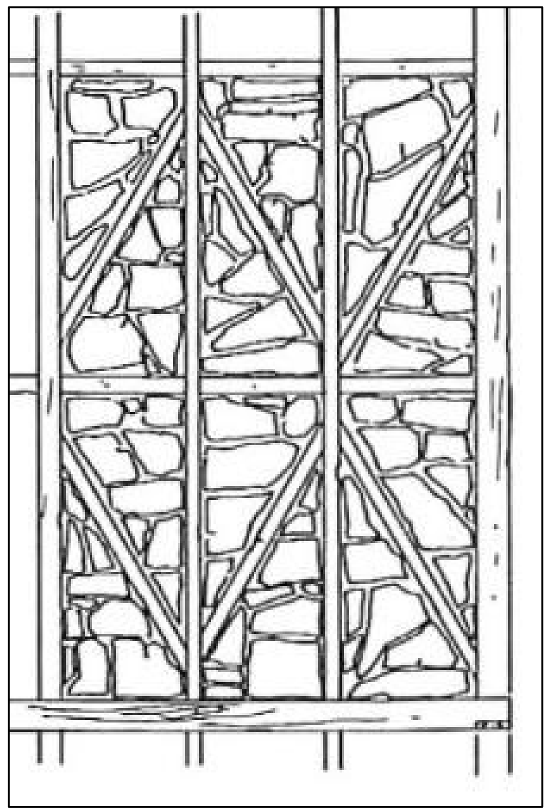
W6 – Diagrid Frame + Stone Filling: *Muskalıdolma* / Amulet Filling: This construction system, as with other cell infill methods, consists of vertical and horizontal structural members, but distinguishes itself by incorporating diagonal elements that create triangular infill cells instead of the usual rectangular ones. These diagonals, positioned at approximately 45-degree angles, connect the vertical posts and divide the façade into symmetrical triangular sections. The voids defined by these structural triangles are filled with river stones of various sizes, which are dry-fitted or set in mortar. This infill pattern not only provides a visual rhythm to the façade but also improves the structure's resistance to lateral loads [8]. *Muskalıdolma* wall system employs a diagrid timber frame filled with small-sized crushed stones combined with lime-based mortar. The use of diagonal components contributes to a highly cohesive and braced wall form, enhancing overall earthquake resilience.

Nails are employed to fasten the structural members in this system, which is locally referred to as *muskalıdolma,* or amulet filling. Although this technique deviates from traditional joinery methods, it offers a more expedient means of assembly, especially when labour resources are limited (Figure 10). Compared to monolithic stone-filled systems, this configuration offers slightly worse thermal performance due to micro air voids and mortar joints.

Vertical posts, spaced between 20 and 35 cm apart, are subdivided by diagonal braces, *payanda* that intersect the frame at a 45-degree angle, thereby forming modular triangular zones. These braces prepare the structure for masonry infill while increasing its rigidity [38]. As minor errors in angle or length can be adjusted by slightly modifying the placement of the diagonals, the system also allows for a degree of constructional flexibility, especially in adapting to terrain irregularities.

The use of modular triangular frames and diagonal members enables variations in span width and facilitates the application of modular systems, particularly above the basement level where span adaptability is crucial [23]. However, the introduction of nails-while simplifying labour and reducing construction time- also eliminates the possibility of reversible assembly, which is a key characteristic of traditional wooden architecture [37]. This loss of reversibility and artisanal complexity represents a compromise between speed and traditional authenticity. Nonetheless, the cost-effectiveness and practicality of this method have led to its widespread adoption across both permanent and temporary rural settlements. Due to its economic efficiency, ease of construction, and structural advantages, this construction technique is encountered across various types of settlement areas.

a.

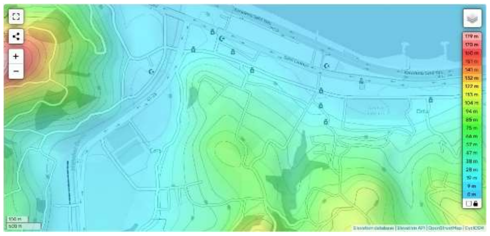


b.

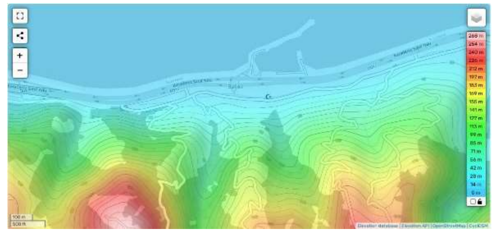
Layer	Thickness [m]	Thermal conductivity, λ [W/m·K]	Thermal resistance, R [m²K/W]
Interior plaster	0.015	0.70	0.021
Muskalıdolma infill (crushed stone + mortar)	0.15	1.40	0.107
Total R-Value	—	—	0.128
U-Value (1/R)	—	—	7.81 W/m²K

c.

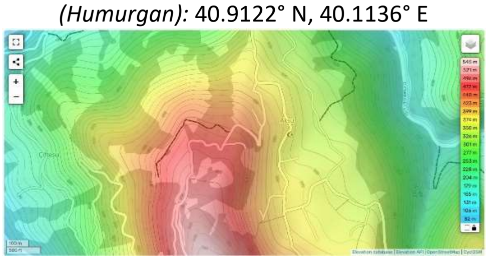
Fig. 10. *Timber-frame and board-infill configuration of the Muskalıdolma wall system (Selected building from Gültepe/Gucara): a. photographs of wall junction details (Author, 2024); b. technical drawing of wall [33]; c. layered wall section and calculation of thermal transmittance resistance*



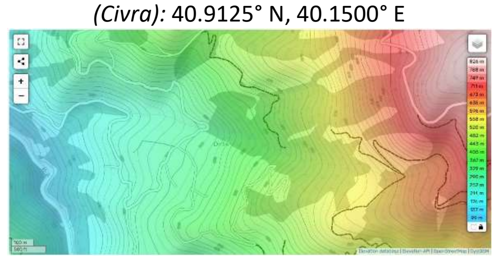
(1) Coastal urban/Rural settlement: *Çarşı (Humurgan):* 40.9122° N, 40.1136° E



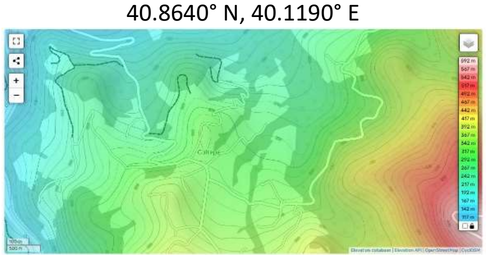
(2) Coastal urban/Rural settlement: *Balıklı (Civra):* 40.9125° N, 40.1500° E



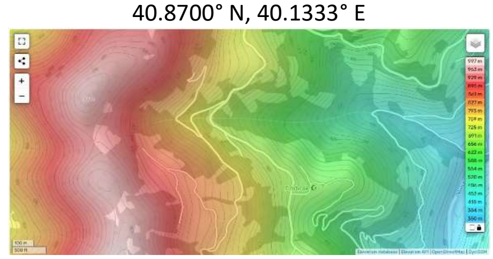
(3) Mountain slope settlement: *Aksu (Aso):* 40.8640° N, 40.1190° E



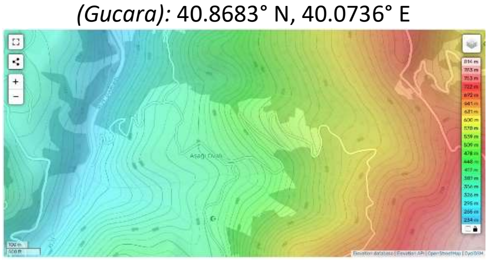
(4) Mountain slope settlement: *Dirlik (Cida):* 40.8700° N, 40.1333° E



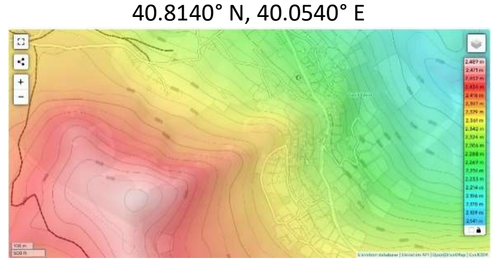
(5) Mountain slope settlement: *Gültepe (Gucara):* 40.8683° N, 40.0736° E



(6) Mountain ridge settlement: *Fındıcak (Horhor):* 40.8140° N, 40.0540° E



(7) Mountain ridge settlement: *Aşağıovalı (Vizara):* 40.8346° N, 40.0800° E



(8) Highland settlement: *Taşlı (Tab):* 40.63576° N, 40.05461° E

Construction technique	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
a. Stud frame + Timber board filling = *Taraba*	Ø	Ø	3	4	3	1	5	9
b. Stud frame + Lath + Plaster = *Bağdadi*	5	2	Ø	Ø	Ø	Ø	Ø	Ø
c1. Stud frame + Stone filling = *Çatkı*	10	5	6	8	5	8	5	3
c2. Stud frame + Brick filling = *Çatkı*	7	3	Ø	Ø	Ø	Ø	Ø	Ø
d. Grid frame + Stone filling = *Gözdolma*	4	7	5	2	3	2	Ø	Ø
f. Diagrid frame + Stone filling = *Muskalıdolma*	3	5	2	4	3	5	5	2
Total	29	22	13	20	14	16	15	14

Fig. 11. *Topographic map extracts [48] showing the geographical characteristics of selected settlements*

Overall, the wide spectrum of timber-framed wall types in *Sürmene* reflects a complex interplay between craftsmanship, environmental adaptation, material availability, and evolving spatial practices.

2.4. Stage 3 – Interpretation of the Key Criteria Influencing the Relationship Between Altitude and Construction Technique

In Stage 3, the analysis focuses on interpreting the key criteria that influence the correlation between altitudinal variation and the distribution of timber-framed construction techniques. Initially, the surface morphology of the eight selected settlements was examined through topographic profiling to identify elevation patterns, slope orientations, and landscape constraints.

This spatial understanding provided the basis for assessing how environmental conditions shape vernacular building responses. Following this, the total number of timber-framed structures, the diversity of construction techniques employed, and their proportional distribution across the settlement types were systematically recorded (Figure 11). By combining these spatial and typological datasets, this stage aims to reveal how topography interacts with material availability, structural preference, and functional priorities in shaping the architectural fabric of each zone (Figure 12).

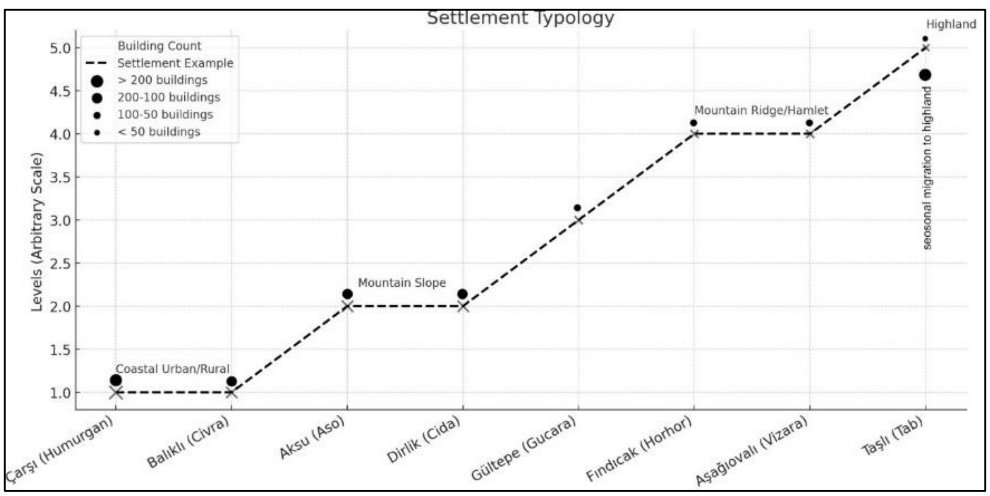


Fig. 12. *The building density and the general distribution of vernacular structures*

To systematically assess the appropriateness of timber-framed wall techniques across different settlement types in *Sürmene,* a set of five qualitative criteria was established. Each criterion reflects a distinct dimension of architectural decision-making that responds to environmental, functional, and cultural requirements. These criteria were applied consistently across each settlement-technique combination:

K1 – Availability of Materials: This criterion evaluates how easily the construction materials (timber, stone, brick, mortar) required for each wall technique can be sourced locally. In high-altitude settlements, material accessibility with transportation is limited, directly influencing construction choices. In addition, the availability of forest resources and local stone potential influences the choice of materials used in both the structural frame and the infill.

K2 – Climatic Adaptation: Assesses the technique's capacity to function effectively under specific climatic conditions such as high humidity, rainfall, snowfall, and wind exposure. The technique of wall systems varies in their ability to resist moisture, provide thermal inertia, or enable adequate ventilation.

K3 – Ease of Assembly: Refers to the simplicity and speed of construction. Techniques that require fewer skilled labourers or that can be erected with minimal tooling allow for easier and more cost-effective production.

K4 – Portability/Disassemblability: Indicates whether the system is suitable for seasonal migration or transitional use. While interlocking (joinery-based) systems offer flexible solutions, nailed systems are more rigid and fixed in nature.

K5 – Durability and Structural Integrity: Evaluates the long-term resilience of the wall system against environmental stress, structural degradation, and maintenance demands.

Each criterion was scored on a qualitative scale (×, ○ or *o* depending on settlement intensity), reflecting interpretations based on fieldwork, literature, and architectural observation.

To deepen the understanding of how vernacular timber-framed wall techniques correlate with geographical and environmental conditions in *Sürmene,* a typological evaluation matrix was developed. This matrix consolidates information from eight surveyed settlements, representing four topographic categories: coastal, mountain slope, ridge, and highland. Each technique was examined in relation to its settlement context, usage purpose (permanent or temporary), and five architectural evaluation criteria. Additionally, the number of identified structures per technique was included based on field survey data consistent with Table 2.

This interpretive stage builds on the environmental logic previously identified in vernacular theory [1, 20, 42, 44] and integrates it with a structured decision-making framework. By applying the CRITIC method [30], the study quantifies how altitude-related environmental pressures such as material logistics, humidity variation, and slope morphology affect architectural priorities. Each design criterion (*K1-K5*) thus becomes a measurable indicator of adaptation capacity, linking spatial differentiation to construction logic. The analytical outcome demonstrates that the correlation between settlement elevation and wall typology is not random but organised through a hierarchy of environmental, functional, and structural determinants.

Table 2

Distribution of timber-framed wall construction techniques across settlement types in Sürmene and their performance evaluation based on five design criteria

No.	Settlement category	Specific settlement name	Construction technique	Use type	Building number	K1	K2	K3	K4	K5
1	Coastal	Çarşı (Humurgan)	Bağdadi	Permanent	5	○	○	×	×	○
1	Coastal	Çarşı (Humurgan)	Çatkı (Stone)	Permanent	10	○	○	×	×	○
1	Coastal	Çarşı (Humurgan)	Çatkı (Brick)	Permanent	7	○	○	×	×	○
1	Coastal	Çarşı (Humurgan)	Gözdolma	Permanent	4	○	○	×	×	○
1	Coastal	Çarşı (Humurgan)	Muskalıdolma	Permanent	3	○	○	×	×	○
2	Coastal	Balıklı (Civra)	Bağdadi	Permanent	2	○	○	×	×	○
2	Coastal	Balıklı (Civra)	Çatkı (Stone)	Permanent	5	○	○	×	×	○
2	Coastal	Balıklı (Civra)	Çatkı (Brick)	Permanent	3	○	○	×	×	○
2	Coastal	Balıklı (Civra)	Gözdolma	Permanent	7	○	○	×	×	○
2	Coastal	Balıklı (Civra)	Muskalıdolma	Permanent	5	○	○	×	×	○
3	Slope	Aksu (Aso)	Taraba	Permanent	3	○	×	○	○	○
3	Slope	Aksu (Aso)	Çatkı (Stone)	Permanent	6	○	○	×	×	○
3	Slope	Aksu (Aso)	Gözdolma	Permanent	5	○	○	×	×	○
3	Slope	Aksu (Aso)	Muskalıdolma	Permanent	2	○	○	×	×	○
4	Slope	Dirlik (Cida)	Taraba	Permanent	4	○	×	○	○	○
4	Slope	Dirlik (Cida)	Çatkı (Stone)	Permanent	8	○	○	×	×	○
4	Slope	Dirlik (Cida)	Gözdolma	Permanent	2	○	○	×	×	○
4	Slope	Dirlik (Cida)	Muskalıdolma	Permanent	4	○	○	×	×	○
5	Slope	Gültepe (Gucara)	Taraba	Permanent	3	○	×	○	○	○
5	Slope	Gültepe (Gucara)	Çatkı (Stone)	Permanent	5	○	○	×	×	○
5	Slope	Gültepe (Gucara)	Gözdolma	Permanent	3	○	○	×	×	○
5	Slope	Gültepe (Gucara)	Muskalıdolma	Permanent	3	○	○	×	×	○
6	Ridge	Fındıcak (Horhor)	Taraba	Temporary	1	○	×	○	○	○
6	Ridge	Fındıcak (Horhor)	Çatkı (Stone)	Permanent	8	○	○	×	×	○
6	Ridge	Fındıcak (Horhor)	Gözdolma	Permanent	2	○	○	×	×	○
6	Ridge	Fındıcak (Horhor)	Muskalıdolma	Permanent	5	○	○	×	×	○
7	Ridge	Aşağıovalı (Vizara)	Taraba	Temporary	5	○	×	○	○	○
7	Ridge	Aşağıovalı (Vizara)	Çatkı (Stone)	Permanent	5	○	○	×	×	○
7	Ridge	Aşağıovalı (Vizara)	Muskalıdolma	Permanent	5	○	○	×	×	○
8	Highland	Taşlı (Tab)	Taraba	Temporary	9	○	×	○	○	○

8	Highland	Taşlı (Tab)	Çatkı (Stone)	Temporary	3	○	○	×	×	○
8	Highland	Taşlı (Tab)	Muskalıdolma	Temporary	2	○	○	×	×	○

Note: The table presents the identified wall systems (e.g., *Taraba*, *Bağdadi*, *Çatkı*, *Gözdolma*, *Muskalıdolma*) observed in eight settlements, categorised under four settlement zones (Coastal, Slope, Ridge, Highland). Each construction technique is listed along with its use type (permanent/temporary) and the number of buildings documented in the field. Wall systems are evaluated across five design criteria: *K1* – Availability of Materials, *K2* – Climatic Adaptation, *K3* – Ease of Assembly, *K4* – Portability/Disassemblability, *K5* – Durability and Structural Integrity. Symbols indicate effectiveness: "○" = highly effective, "○" = moderately effective, "×" = not effective.

As revealed by the matrix, certain techniques such as *çatkı* (stone) and *muskalıdolma* display a wide geographical distribution, which may be attributed to their structural flexibility and adaptability to diverse environmental conditions. In contrast, techniques like *Taraba* are observed only in high-altitude or ridge areas, suggesting a possible association with rapid construction and temporary use. The absence of *bağdadi* and *çatkı* (brick) in mountainous zones highlights the decisive role of factors such as material logistics, labour availability, and construction tradition. The structural frequency data further reinforce the typological distinctions among settlement areas. This multi-criteria matrix provides an analytical basis for the study's findings, offering a means to interpret how construction decisions in timber-framed architecture are shaped by environmental and cultural influences.

3. Results

The architectural features of timber-framed walls in *Sürmene* are deeply shaped by the district's geography, climatic variation, and environmental conditions. The position of mountains and changes in altitude significantly influence humidity and temperature across the region. These environmental factors, combined with seasonal settlement patterns, have resulted in the emergence of distinct wall construction techniques in coastal, mountain slope, ridge, and highland settlements. In particular, the availability of material resources and climate-driven needs have played a critical role in shaping local construction practices.

The findings derived from the CRITIC-based evaluation provide a measurable interpretation of this relationship, clarifying how altitude, environmental stress, and material logistics collectively determine construction preferences. By integrating statistical weighting with spatial mapping, the analysis reveals a resilience-oriented hierarchy among wall techniques, where material efficiency and climatic adaptation emerge as the dominant decision criteria.

To examine the relationship between settlement location and wall construction techniques, several representative zones were surveyed in situ. Non-vernacular buildings within the selected neighbourhoods were excluded from the scope. Subsequently, the general distribution and density of timber-framed load-bearing structures were analysed.

In coastal settlements such as *Balıklı (Civra)* and *Çarşı (Humurgan),* proximity to transportation networks and access to construction materials have increased both the variety and quality of infill techniques

[8]. The craftsmanship tradition rooted in boatbuilding along the coast is also reflected in detailed woodworking practices. Here, masonry infill types—especially brick and stone—along with the *bağdadi* technique dominate the architectural texture, offering enhanced resistance to moisture and rainfall. In contrast, the *taraba* system is notably absent, likely due to the limited availability of forest resources in coastal zones.

In mountain slope settlements such as *Aksu (Aso)* and *Dirlik (Cida),* where access to materials is more restricted due to the rugged topography, construction practices rely heavily on locally sourced timber and stone. A hybrid approach using both materials is common, aiming to withstand harsh weather conditions. The prevalence of techniques like *gözdolma* (eye infill) and *muskalıdolma* (amulet infill) reflects the adaptation of structural forms to both environmental demands and topographic limitations. These systems offer improved stability and thermal performance [19]. Moreover, the infill material contributes to increased thermal inertia and section strength. As elevation increases, timber walls tend to lose heat more rapidly at junction points; however, their low thermal conductivity compared to masonry prevents internal condensation and supports natural ventilation, especially under humid climatic conditions [28]. This underlines the functional advantage of timber systems in managing internal humidity, particularly in regions where precipitation and condensation risks are high.

In ridge-level hamlet settlements like *Aşağıovalı (Vizara),* multiple wall techniques are typically used in the same structure. Orientation plays a critical role in material choice: while timber systems with lighter profiles are used in sun-exposed façades, walls facing wind-driven rain are reinforced with moisture-resistant stone and hardwood [48]. These findings suggest that wall construction in transitional settlement types is not only climate-responsive but also highly sensitive to façade direction and exposure.

At the highest altitudes, in highland settlements such as *Taşlı (Tab),* the *Taraba* technique is predominant. Its widespread use in this context highlights the importance of lightweight, easily assembled components in short-term seasonal dwellings. These structures are primarily used during transitory periods and thus emphasise portability and quick construction over long-term durability. Accordingly, permanent buildings employ more robust systems, whereas temporary dwellings prioritise ease of installation.

When comparing the thermal insulation performance of various timber-framed wall techniques, the *bağdadi* system stands out as the most effective, owing to its multi-layered construction and ventilated cavity, which enhance its ability to resist heat transfer. At the opposite end, the *Taraba* system demonstrates the weakest performance, primarily due to its lightweight structure composed of thin wooden boards with minimal mass or layering, resulting in high thermal permeability. The brick-infilled *çatkı* system offers a balanced level of insulation, outperforming its stone-infilled counterpart, which, although denser, proves less efficient in reducing heat flow. The *gözdolma* wall provides a moderate level of insulation performance. Despite its use of heavy materials, the *muskalıdolma* system does not translate this mass into effective thermal resistance. These observations suggest that wall types typically employed in seasonal or low-demand environments tend to prioritise ease of assembly and structural economy, whereas more thermally efficient systems, such as *bağdadi,* better reflect contemporary standards for energy performance.

To evaluate the correlation between settlement types and wall techniques, the distribution of buildings was first assessed, followed by an analysis of which construction systems were preferred in each context (Figure 13).

4. Discussion

The graph that synthesises this data shows the variety of wall techniques deployed across settlement types. For example, *çatkı* (stone infill) appears in all zones, attesting to its adaptability and reliability. *Taraba* becomes dominant in highland settlements, underlining its relevance for lightweight and temporary usage. *Muskalıdolma* is more frequently found in mountain slope and ridge settlements, where its diagonally braced connections allow for increased structural flexibility.

Conversely, *bağdadi* (lath and plaster) is found exclusively in coastal settlements, suggesting a relationship with urban influences or historical traditions. *Çatkı* with brick infill also appears almost exclusively along the coast, likely due to improved transportation infrastructure enabling brick supply. The *gözdolma* technique, while demanding in terms of skilled labour and materials, shows increased frequency at mid-elevations where material availability and cultural investment allow for such elaboration.

However, it is rarely used in highland areas due to construction logistics (Figure 14). While some wall techniques are geographically concentrated, others are more diffusely distributed across settlement types. This pattern clearly illustrates the role of environmental and geographical factors as determinants in construction preferences and architectural expression.

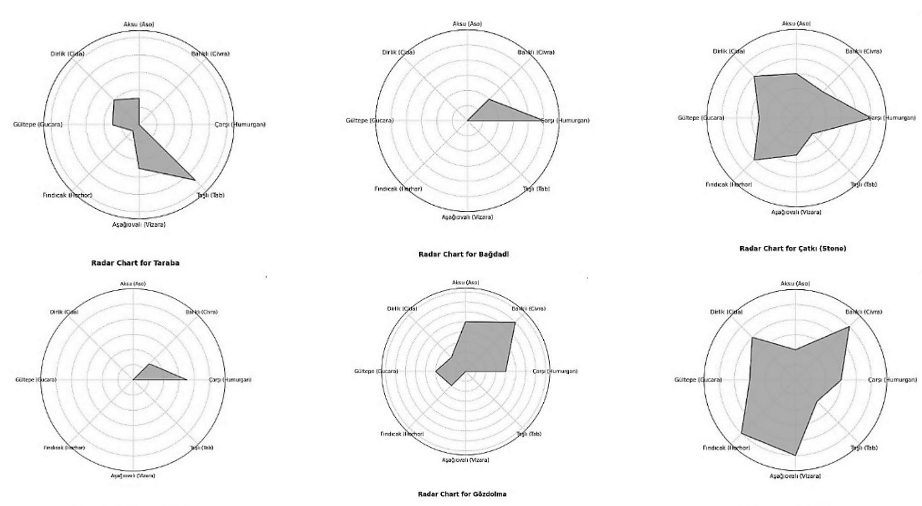


Fig. 13. *Spatial distribution of timber-framed wall construction techniques across selected settlements*

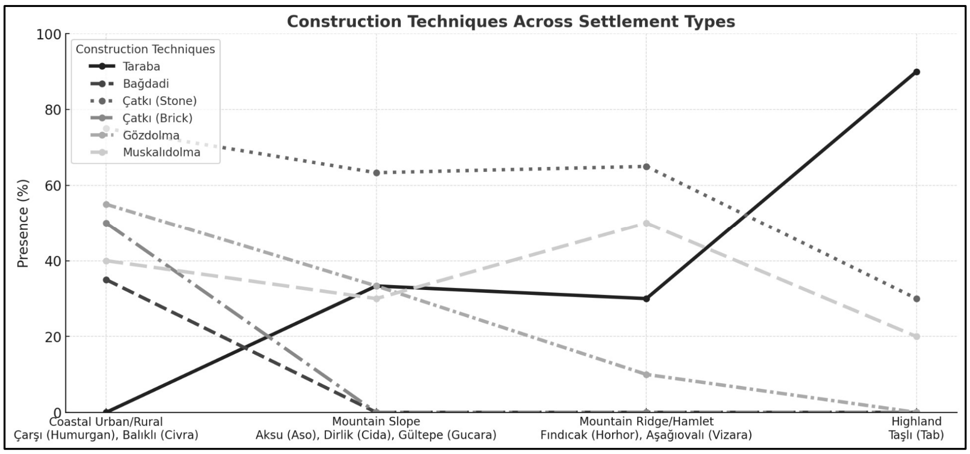


Fig. 14. *Classification of regional differences in construction practice in settlements*

5. Conclusions

The vernacular architecture of *Sürmene* embodies a profound integration of environmental, geographical, and cultural dynamics. From coastal plains to high mountain plateaus, the timber-framed wall techniques and material selections demonstrate a sensitive adaptation to the region's diverse topographic and climatic conditions. Each settlement type – coastal, hillside, ridge, and plateau – reveals distinct architectural responses shaped by altitude, humidity, and seasonal migration patterns.

The strategic use of locally available materials such as timber and stone, governed by accessibility and transportation constraints, has fostered a construction logic rooted in sustainability and material efficiency. Techniques like *gözdolma*, *muskalıdolma*, *taraba*, and *bağdadi* reflect not only the craftsmanship of local builders but also the region's adaptive intelligence in meeting functional demands. These systems address environmental challenges such as moisture, thermal variability, and structural stability, while offering varying degrees of energy performance based on material configuration and intended use.

The comparative thermal performance of wall systems – ranging from high-resistance techniques like *bağdadi* to structurally robust but poorly insulated methods like *gözdolma* – further illustrates how material logic aligns with environmental context and intended use.

More than mere functional structures, the buildings of *Sürmene* represent a cultural landscape where aesthetic sensibility, ecological awareness, and construction pragmatism intersect. They serve as enduring evidence of how traditional knowledge systems can yield environmentally responsive and resilient spatial practices.

In an era where sustainable design has become a global imperative, the architectural heritage of *Sürmene* provides critical lessons and design intelligence. Revisiting these practices through analytical and respectful lenses can offer modern architecture valuable pathways for integrating functionality, sustainability, and cultural continuity.

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